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## A contribution to unemployment dynamics

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## DISCUSSION PAPER SERIES

No. 1176

### A CONTRIBUTION TO UNEMPLOYMENT DYNAMICS

Dennis J Snower and Marika Karanassou

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**Centre for Economic Policy Research**

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Discussion Paper No. 1176

May 1995

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May 1995

## ABSTRACT

### A Contribution to Unemployment Dynamics\*

This paper views movements in unemployment as the result of the interaction between: (a) lags in labour market decisions; and (b) labour market shocks with temporary and permanent components. Two features of unemployment dynamics are examined: (i) 'unemployment persistence', arising when temporary shocks have persistent effects on unemployment; and (ii) 'imperfect unemployment responsiveness', arising when the full effects of permanent shocks are delayed. An empirical model of aggregate labour market activity in Germany, the United Kingdom, and the United States is constructed, and the sources of persistence and imperfect responsiveness are evaluated in this context.

JEL Classification: J21, J23, J31, J64, J68

Keywords: unemployment, employment, wage setting, labour force participation, labour market dynamics, unemployment persistence, imperfect unemployment responsiveness

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Submitted 30 March 1995

## NON-TECHNICAL SUMMARY

There is a growing realization that the dominant theory of unemployment, the natural rate theory, has difficulty accounting for the European unemployment experience of the 1980s. According to this theory, unemployment can be decomposed into two separate, largely independent, components: the Natural Rate of Unemployment (NRU) and cyclical variations of unemployment around this natural rate. Economists are increasingly coming to recognize, however, that these 'components' of unemployment are so interdependent as to make their interactions more significant than the distinctions between them. The oft-quoted observation that cyclical unemployment in Europe 'turns into' structural unemployment is a clear reflection of this idea.

The process of disinflation in the early 1980s was accompanied by a much larger rise in unemployment in the European Community than in the United States, and once inflation had stabilized in the mid-1980s the EC unemployment rate remained far above that in United States. From this, many economists have inferred that the NRU must have risen in the EC while it stayed roughly constant in the United States. But it is hard to understand where this relative rise should have come from. After all, the 1980s were characterized by deregulation, privatization, decline in union density, and partial dismantling of job protection in a number of European countries. If anything, one would have expected the NRU to *fall* under these circumstances. It is clear that high oil prices, followed by high interest rates and long-delayed after-effects of the build-up of the welfare state in the 1960s and 1970s have had a role to play here, but they cannot tell the full story.

This paper takes a different approach. It views movements in unemployment as the outcome of: (a) how various lags in labour market behaviour interact with one another; and (b) how these lags interact with labour market shocks containing temporary and permanent components. In empirical estimation, significant lagged endogenous variables in employment, wage setting, and labour force participation equations are common, with lags extending over periods of one or more years. In labour market theory, a wide variety of models provide rationales for such lags. Moreover, when employers, employees, and the unemployed interact in the labour market, the lags in their decision-making processes interact as well, and thus it could take unemployment much longer to return to its long-run equilibrium after a shock than the period spanned by any individual lag. Whereas the natural rate literature does not give primary attention to these lags, over the past decade

the literature on hysteresis and unemployment persistence has focused on how temporary labour demand shocks can have long-lasting effects on unemployment. Much of this literature, however, suffers from two major problems:

(1) It concentrates on temporary shocks and ignores the permanent ones. But in practice shocks with permanent components (such as changes in productivity, taxes, interest rates, or changes in union density and job security legislation) are quite common.

(2) The existing literature is highly aggregative, focusing on the overall delayed responses of unemployment to random shocks, rather than analysing the lags in employment, wage setting, and labour force participation that are responsible for these delayed responses. But the identification and measurement of these underlying behavioural lags is crucially important for policy purposes, since different policy variables affect different labour market lags.

This paper provides a methodology for tackling these problems. It recognizes two dimensions of the unemployment problem: (i) the *persistent* effects of *temporary* labour market shocks; and (ii) the *delayed* effects of *permanent* shocks. The first is called *unemployment persistence*; the second we call *imperfect unemployment responsiveness*. Focusing on three countries – Germany, the United Kingdom and the United States – the paper identifies important lags in labour demand, wage setting, and labour force participation behaviour, and measures the degree to which these lags are responsible for unemployment persistence and imperfect responsiveness.

Our empirical analysis shows that countries displaying a comparatively high degree of unemployment persistence need not necessarily display a comparatively high degree of unemployment under-responsiveness as well. In other words, the fact that temporary shocks have prolonged effects on unemployment, does not mean that the full effects of permanent shocks will be slow to manifest themselves. This result suggests that different policies may be required to deal with temporary and permanent shocks. In short, policy-makers' assessments of the *durability* of labour market shocks have an important role to play in the appropriate design of labour market policies.

Second, our analysis indicates that within a particular country, different labour market lags have quite different effects on unemployment persistence and imperfect responsiveness. This is significant for policy formulation since different labour market policies affect different lags. Thus it appears vital to

assess the empirical importance of the various lags before policy decisions are reached.

Finally, our analysis shows that a particular lagged effect can have quite different implications for unemployment dynamics in different countries. As we have seen, a particular lag may amplify unemployment persistence in one country and dampen it in another; it may amplify over-responsiveness in one country and amplify under-responsiveness in another. The reason, of course, is that the unemployment effect of any particular lag depends crucially on its interactions with the other lags in the labour market system, and the latter vary from country to country. This result, too, is potentially important for policy, since it implies that different countries may require quite different policies to deal with the same unemployment problem.

## 1. Introduction

Much of the existing macroeconomic literature views unemployment as the sum of separate, largely independent components, such as "cyclical" and "structural" unemployment. This decomposition is a salient feature of the natural rate theory, according to which (a) the natural rate of unemployment (NRU) is determined by the behavioral and institutional structure of the economy and (b) fluctuations of actual unemployment around its natural rate are due to errors in people's wage-price expectations or intertemporal substitution. The conventional wisdom links the natural rate to the NAIRU (the non-accelerating inflation rate of unemployment), so that inflationary pressures are alleged to build up when actual unemployment falls beneath its natural rate, and conversely for deflationary pressures. For this reason it has become common for macroeconomists to infer whether unemployment is above or below its natural rate by observing whether inflation is rising or falling.

Although much of the profession supports this view, many realize that it is becoming increasingly difficult to defend, particularly in Europe. It is widely recognized that the different "components" of unemployment are so interdependent as to make their interactions more significant than the distinctions between them. The oft-quoted observation that cyclical unemployment in Europe "turns into" structural unemployment is a clear reflection of this idea.

The natural rate theory has difficulty accounting for the European unemployment experience of the 1980s. The process of disinflation in the early 1980s was accompanied by a much larger rise in unemployment in the European Community than in the US, and once inflation had stabilized in the mid-1980s the EC unemployment rate remained far above that in US. From this, most economists have inferred that the NRU must have risen in the EC while it stayed roughly constant in the US. But it is hard to understand where this relative rise should have come from. After all, the 1980s were characterized by deregulation, privatization, decline in union density, and partial dismantling of job protection in a number of European countries. If anything, one would have expected the NRU to fall under these circumstances. It is clear that high oil prices, followed by high interest rates and long-delayed after-effects of the build-up of the welfare state in the 1960s and 1970s have had a role to play here,<sup>1</sup> but they cannot tell the full story.<sup>2</sup>

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<sup>1</sup>See, for example, Lindbeck (1994) and Phelps (1993) for arguments along these lines.

<sup>2</sup>Oil prices came down while unemployment went up in the first part of the 1980s; the timing of the interest rate rises does not mesh well with the timing of the unemployment rises; and extremely long and powerful lags are necessary to explain rising unemployment in the 1980s as the outcome of welfare state measures a decade before.

This paper takes a different approach. It views movements in unemployment as the outcome of (a) how various lags in labor market behavior interact with one another and (b) how these lags interact with labor market shocks containing temporary and permanent components. In empirical estimation, significant lagged endogenous variables in employment, wage setting, and labor force participation equations are common, with lages extending over periods of one or more years.<sup>3</sup> In labor market theory, a wide variety of models explain why current employment, wage, and participation decisions should depend on their past values.<sup>4</sup> Moreover, when employers, employees, and the unemployed interact in the labor market, the lags in their decision making processes interact as well, and thus it could take unemployment much longer to return to its long-run equilibrium after a shock than the period spanned by any individual lag.<sup>5</sup>

The natural rate literature does not give primary attention to these lags. But over the past decade a growing literature on hysteresis and unemployment persistence<sup>6</sup> has focused on how temporary labor demand shocks can have long-lasting effects on unemployment. Much of this literature, however, suffers from two major problems:

- (1) It concentrates on temporary shocks and ignores the permanent ones. But in practice shocks with permanent components (such as changes in productivity, taxes, interest rates or change in union density and job security legislation) are quite common.
- (2) The existing literature is highly aggregative, focusing on the overall delayed responses of unemployment to random shocks, rather than analyzing the lags in employment, wage setting, and labor force participation that are responsible for these delayed responses. But the identification and measurement of these underlying behavioral lags is crucially important for policy purposes, since different policy variables affect

<sup>3</sup>See, for example, Alogoskoufis and Manning (1998), Bean, Layard, and Nickell (1986), and Layard, Nickell, and Jackman (1991).

<sup>4</sup>For example, costs of hiring, training, and firing make current employment decisions depend on past employment; staggered wage setting makes the current wage decisions depend on past wages; the relatively low search effort by the long-term unemployed makes current wages depend on past unemployment; the costs of entering and exiting from the labor force make current labor force participation decisions depend on the past labor force; and the exercise of market power by incumbent employees (insiders) in wage negotiations make current wages depend on the insider workforce, which depends on past employment. (References to this literature are given below.)

<sup>5</sup>For instance, labor turnover costs lead a current fall in labor demand to depress employment in the future. If the people who thereby become long-term unemployed search for jobs less intensively than before, this will depress employment in the more distant future. Labour turnover costs will then cause employment to be depressed in the even more distant future, and so on.

<sup>6</sup>See, for example, Blanchard and Summers (1986), Gottfries and Horn (1987), and Lindbeck and Snower (1987).

different labor market lags.<sup>7</sup>

This paper provides a methodology for tackling these problems. It recognizes two dimensions of the unemployment problem: (i) the *persistent* effects of *temporary* labor market shocks and (ii) the *delayed* effects of *permanent* shocks. The first is called *unemployment persistence*; the second we call *imperfect unemployment responsiveness*. Focusing on three countries - Germany, the United Kingdom, and the United States - the paper identifies important lags in labor demand, wage setting, and labor force participation behavior, and measures the degree to which these lags are responsible for unemployment persistence and imperfect responsiveness.

The paper is organized as follows. Section 2 contains an illustrative theoretical model that provides a convenient conceptual basis for our analysis unemployment dynamics. Section 3 presents our aggregate measures of unemployment persistence and imperfect responsiveness. Section 4 is devoted to measuring the sources of these phenomena. Section 5 describes our empirical methodology. Finally, Section 6 summarizes our empirical results and highlights some policy implications.

## 2. An Illustrative Theoretical Model

Our theoretical model provides a simple illustration of how specific labor market rigidities influence the activities of workers and firms and thereby generate the unemployment persistence and imperfect responsiveness that we analyze in the subsequent sections.<sup>8</sup> It also illustrates how government policies can influence agents' lagged behavior patterns and thereby affect unemployment dynamics.

Let  $L$  be the aggregate labor force, which is the sum of employment ( $N$ ) and unemployment ( $U$ ):

$$L = N + U \quad (1)$$

To be unemployed, workers must be jobless and searching for jobs. Those not searching are "inactive". Let  $P$  be the working-age population; then the number of inactive people

<sup>7</sup>For example, changes in job security legislation affects the degree to which current employment depends on past employment (via labor turnover costs), while government support for wage indexation agreements influences the degree to which current real wages depend on past real wages.

<sup>8</sup>Since the model is meant to be illustrative and simple, it does not to provide a comprehensive account of all the main lags in employment, wage setting and labor force participation behavior.

is  $(P - L)$ .

Let each firm face a production function  $q = an$ , where  $q$  is output,  $n$  is employment, and  $a$  (labor productivity) is a random variable, uniformly distributed over  $(0, A)$ ,  $0 \leq A \leq 1$ . Let  $w$  be the real wage and let  $h$  and  $f$  (both constants) be the firm's hiring and firing costs per worker, respectively. The firm makes its employment decisions, given knowledge of  $h$ ,  $f$ , and the realized value of  $a$ . Thus hiring occurs when  $a \cdot w > h$ , and firing occurs when  $a \cdot w < f$ . The corresponding hiring rate ( $\rho$ , the probability that a job search is hired) and firing rate ( $\phi$ , the probability that an employee is fired) are:

$$\rho = \frac{1}{A}(1 - w - h) \quad \text{and} \quad \phi = \frac{1}{A}(w - f) \quad (2)$$

respectively.

Let  $\sigma$  be the survival rate, a constant ( $0 \leq \sigma \leq 1$ ) across all workers. The population is constant through time; thus, in each period,  $(1 - \sigma)P$  people enter and  $(1 - \sigma)P$  die. The aggregate number of incumbent employees (insiders) that the economy carries forward from the previous time period is  $\sigma N_{-1}$ , where  $N_{-1}$  is last period's employment. Thus the number of people fired is  $\phi \sigma N_{-1}$ . The number of job searchers  $(L - \sigma N_{-1})$  and, of those, the number hired is  $\rho(L - \sigma N_{-1})$ . The change in employment  $(N - N_{-1})$  is the difference between the number hired  $(\rho(L - \sigma N_{-1}))$  and the number fired  $(\phi \sigma N_{-1})$ . Thus, for a stochastic environment, we may express our employment equation as

$$N = \rho L + (1 - \sigma(\rho + \phi))N_{-1} + \epsilon \quad (3)$$

where  $\epsilon$  is an error term (representing, say, employers' imperfect control over employment).

Suppose that wages are determined before the realized value of productivity  $a$  is known (but given knowledge of the distribution of  $a$ ). For simplicity, let insiders have complete market power so set the wage so as to maximize their expected wage income,  $y = (1 - \phi)(w - t) + \phi b$ , where  $t$  is a tax and  $b$  is an unemployment benefit. Then we may write the wage equation as:

$$w = \frac{1}{2}(A + b + f + t) + e \quad (4)$$

where  $e$  is an error term.

The labor force participation decision depends on the returns from job search. Let

each inactive person's cost of entering the labor force be a random variable  $z$ , uniformly distributed over the interval  $(0, Z)$ . Then the person enters the labor force when the return exceeds the entry cost:  $\rho(w-t) + (1-\rho)b > z$ . Thus the entry rate into the labor force (the probability that an inactive person enters the labor force) is  $\theta = (1/Z)[\rho(w-t) + (1-\rho)b]$ . The number of inactive people at the beginning of the period is  $(P - \sigma L_{-1})$ . Thus the number of entrants to the labor force is  $\theta(P - \sigma L_{-1})$ . In line with our previous assumption that each person faces an exogenous survival probability  $\sigma$ , we assume that the cost of exit from the labor force is stochastic: with probability  $\sigma$  it is zero and with probability  $(1-\sigma)$  it is infinite. The change in the labor force  $(L - L_{-1})$  is the difference between the number entering it  $(\theta(P - \sigma L_{-1}))$  and the number exiting from it  $((1-\sigma)L_{-1})$ . Thus the labor force participation equation may be expressed as:

$$L = \theta P + \sigma(1-\theta)L_{-1} + \mu \quad (5)$$

where  $\mu$  is an error term.

The system (1) - (5) describes equilibrium labor market activity. In this context, unemployment persistence arises when a temporary labor demand shock (the temporary component of  $\varepsilon_1$ ) has long-lasting effects on unemployment, and unemployment is "imperfectly responsive" when the long-term effects of a permanent shock (the permanent component of  $\varepsilon_1$ ) are delayed. These phenomena - that indicate how resilient the labor market is in the presence of shocks with temporary and permanent components - are analyzed in the next section. Suffice it here to say that unemployment persistence and imperfect responsiveness clearly cannot occur unless labor market behavior is characterized by lags such as the ones in our employment and labor force participation equations. In the absence of these lags, there is no way to prolong the unemployment effects of temporary shocks or to delay the effects of permanent ones.

The model above suggests ways in which employment policies may influence these lagged effects and thereby affect the resilience of the labor market. For instance, job counselling may reduce the cost of entering the labor force (e.g. it may reduce  $Z$ ), and thereby raise the entry rate into the labor force and reduce the degree to which the current labor force depends on its past level.<sup>9</sup> Moreover, a relaxation of job security legislation that reduces the firing cost  $f$  will not only raise the current level of employment for given levels of past employment  $N_{-1}$ , but will also reduce the degree to which current employment depends on past employment.<sup>10</sup>

<sup>9</sup>This is given by  $(\partial L / \partial Z) = \sigma(1-\theta)$  in equation (5), where  $(\partial \theta / \partial Z) < 0$ .

<sup>10</sup>This is given by  $\xi = (\partial N / \partial N_{-1}) = 1 - \sigma(\rho + \phi)$  in equation (3). By (2),  $(\partial \xi / \partial f) = \sigma / A > 0$ . In addition, the reduction in the firing cost  $f$  reduces the wage  $w$  and thereby raises the degree to which the current labor force depends on its past level.

In these ways the model above provides a convenient conceptual basis for the analysis of unemployment persistence and imperfect responsiveness in Sections 3-5 and the policy implications in Section 6.

### 3. Measuring Aggregate Persistence and Imperfect Responsiveness

Since unemployment persistence arises when a temporary shock has prolonged effects on unemployment, it is natural to measure this phenomenon in terms of the sum of the differences, through time, between unemployment in the presence and absence of the shock, after the shock itself has disappeared. Specifically, consider a temporary drop in labor demand, whereby the transient component of the error term  $\epsilon_t$  falls in period  $t=1$  and then returns to its original value. Then "unemployment persistence" exists when, in periods  $t>1$ , unemployment in the presence of the temporary shock differs from unemployment in the absence of the shock. Then, clearly, the effects of the shock are felt after the shock itself has disappeared.

Let  $u'_t = U'_t/L'_t$  and  $u_t = U_t/L_t$  (for  $t \geq 1$ ) be the unemployment rate in the presence and absence of the shock, respectively. Let  $\Delta u_t = u'_t - u_t$  (for  $t \geq 1$ ) be the corresponding unemployment increments. Normalizing each increment by the size of the shock  $\Delta \epsilon_1$  and summing the resulting terms  $(\Delta u_t / \Delta \epsilon_1)$  over all periods subsequent to the shock ( $t > 1$ ), we obtain our measure of unemployment persistence:

$$\pi = \sum_{t=2}^{\infty} \frac{u'_t - u_t}{\Delta \epsilon_1} = \sum_{t=2}^{\infty} \frac{\Delta u_t}{\Delta \epsilon_1} \quad (6)$$

If the temporary labor demand shock in period  $t=1$  affects unemployment only in period  $t=1$ , so that there are no long-lasting unemployment effects, then the subsequent unemployment increments  $\Delta u_t$ , for  $t > 1$ , will be zero, and thus our measure of unemployment persistence will be zero as well:  $\pi=0$ . In general, the temporary shock can give rise to positive or negative unemployment increments, and if the normalized sum of these increments is positive, there is "positive persistence" ( $\pi > 0$ ), and if this sum is negative, there is "negative persistence" ( $\pi < 0$ ). The special case of "hysteresis" is characterized by an infinite  $\pi$ .

Imperfect unemployment responsiveness can be measured analogously. Since it arises when the long-term effects of a permanent shock are delayed, it is natural to measure it in terms of the sum of the differences, through time, between the long-run and actual unemployment following the shock. Specifically, consider a permanent drop in labor

demand, whereby the permanent component of the error term  $\epsilon$  falls in period  $t=1$  and remains at its new level thereafter. Then "imperfect unemployment responsiveness" exists when, in periods  $t \geq 1$ , unemployment in the presence of the temporary shock differs from unemployment in the absence of the shock, so that the full effect of the shock is postponed. Let  $u_t''$  and  $u_t$  (for  $t \geq 1$ ) be the unemployment rate in the presence and the absence of this permanent shock, respectively. Let  $u'' = \lim_{t \rightarrow \infty} u_t''$  and  $\bar{u} = \lim_{t \rightarrow \infty} u_t$  be the

long-run equilibrium unemployment rate in the presence and absence of the permanent shock, respectively. If unemployment is initially at its long-run level ( $u_0 = \bar{u}$ ), then imperfect responsiveness can be measured simply as the sum of the differences between actual and long-run unemployment in the presence of the shock, normalized by the size of the shock. Denoting these differences by  $Du_t'' = u_t'' - \bar{u}$  for  $t \geq 1$ , the responsiveness measure becomes:

$$\sigma = \sum_{t=1}^{\infty} \frac{u_t'' - \bar{u}}{\Delta \epsilon_1} = \sum_{t=1}^{\infty} \frac{Du_t''}{\Delta \epsilon_1} \quad (7)$$

If however unemployment is not initially at its long-run level ( $u_0 \neq \bar{u}$ ), this measure is inadequate, since it will capture not only the influence of the permanent shock on unemployment, but also the after-effects of the movement of unemployment towards its initial equilibrium. To exclude these after-effects, we then can measure imperfect unemployment responsiveness in terms of the differences, through time, between (a) the discrepancy between actual and long-run unemployment in the presence of the shock ( $Du_t'' = u_t'' - \bar{u}$ ) and (b) this discrepancy in the absence of the shock ( $Du_t = u_t - \bar{u}$ ). Thus, our general measure of imperfect unemployment responsiveness becomes:

$$\sigma = \sum_{t=1}^{\infty} \left( \frac{u_t'' - \bar{u}}{\Delta \epsilon_1} - \frac{u_t - \bar{u}}{\Delta \epsilon_1} \right) = \sum_{t=1}^{\infty} \frac{Du_t'' - Du_t}{\Delta \epsilon_1} \quad (7')$$

If unemployment were perfectly responsive,  $u_t''$  would be equal to  $\bar{u}$  in every period since the shock ( $t \geq 1$ ); then  $\sigma = 0$ . If the full effects of the permanent shock make themselves felt only gradually, so that the short-run effect of the shock on unemployment is less than the long-run effect, then  $u_t''$  will be less than  $\bar{u}$  for a number of periods after the shock, and thus our measure of imperfect unemployment responsiveness is negative:  $\sigma < 0$ , and unemployment is "under-responsive". If unemployment overshoots its long-run equilibrium, then our measure may turn positive, so

that unemployment is "over-responsive".

A simplified version of our theoretical model in Section 2 can be used to provide transparent analytical solutions for our measures of persistence and imperfect responsiveness. Suppose that the cost of entry into the labor force is  $z=0$ . Then all people of working age will participate in the labor force ( $L=P$ ) and the employment equation becomes  $N = \rho P + [1 - \sigma(\rho+\phi)]N_{-1} + \varepsilon_1$ . The corresponding equation for the unemployment rate is  $u = [\phi - \rho(1-\sigma)] + \alpha u_{-1} - \varepsilon_1/L$ , where  $\alpha = [1 - \sigma(\rho+\phi)]$ . In this context, the effect of the temporary shock on unemployment is  $\Delta u_t = \alpha^t \cdot d(\varepsilon_1/L)$ . Taking the sum of these differences (normalized by the size of the shock), yields the following measure of unemployment persistence:  $\pi = \alpha/(1-\alpha)$ .

The effect of the permanent shock on unemployment is  $\Delta u_t = (1 - \alpha^{t-1})/(1 - \alpha)\Delta(\varepsilon_1/L)$ . The effect on the long-run unemployment level is  $\bar{\Delta u} = [1/(1-\alpha)]\Delta(\varepsilon_1/L)$ . The normalized sum of the difference between these two effects over all periods yields our measure of imperfect responsiveness:  $\sigma = -\alpha/(1-\alpha)^2$ .

It is easy to see that when unemployment is a first-order autoregressive process, as above, it displays both positive persistence ( $0 < \pi < 1$ ) and under-responsiveness ( $\sigma < 0$ ). Furthermore, the greater the coefficient  $\alpha$ , the greater the degree of persistence and under-responsiveness. However, for higher-order dynamic processes, unemployment persistence and imperfect responsiveness are no longer tied to one another in this way, as our empirical models below will show.

#### 4. Measuring the Sources of Unemployment Persistence and Imperfect Responsiveness

The theoretical model of Section 2 was not meant to provide an account of the all the major lags in employment, wage setting, and labor force participation behavior; a wide variety of other lags have been analyzed in the recent theoretical literature, but it is beyond the scope of this paper to explore them all. For an empirical analysis of the sources of unemployment persistence and imperfect responsiveness, it is nevertheless desirable to extend the model above by incorporating several other major lags. In particular, consider the following model:<sup>11</sup>

- employment equation:  $N_t = B_1 X_{1t} + \sum_i \alpha_{1i} N_{t-i} + \alpha_2 w_t + \varepsilon_t$ ,
- wage setting equation:  $w_t = B_2 X_{2t} + \sum_j \beta_{1j} w_{t-j} + \sum_k \beta_{2k} n_{t-k} + \sum_h \beta_{3h} u_{t-h} + e_t$ ,

<sup>11</sup>All variables here, except the unemployment rate, are in logs.

• labor force participation equation:  $L_t = B_3 X_{3t} + \sum_g \gamma_{1g} L_{t-g} + \gamma_2 w_t + \gamma_3 N_t + \mu_t$

• definition of unemployment:<sup>12</sup>  $u_t = L_t - N_t$ ,

where  $X_{it}$ ,  $i=1,2,3$ , are vectors of exogenous variables and  $(\epsilon_t, e_t, \mu_t)$  are white noise.

In this context,  $\epsilon_t$  may be viewed as the origin of the temporary shocks generating unemployment persistence, while the permanent component of  $B_1 X_{1t}$  may be seen as the origin of the permanent shocks generating imperfect unemployment responsiveness.

The lags in the labour market system above are major "sources" of unemployment persistence and imperfect responsiveness. Instead of describing the full range of possible lagged effects, the equations above focus on some of the main effects that our subsequent empirical analysis identifies as significant. For expositional purposes, it will be convenient to assign names to these effects:<sup>13</sup>

(i) The lagged employment terms in the employment equation we call the "*employment adjustment effect*" (EA), for when firms face costs of adjusting employment, their labor demand decisions generally depend on their past employment.<sup>14</sup>

(ii) The lagged employment terms in the wage setting equation are called the "*insider membership effect*" (IM), since the size of firms' insider workforces affect the insiders' objectives in the wage setting process.<sup>15</sup>

(iii) The lagged real wage terms in the wage setting equation are the "*wage staggering effect*" (WS), since staggered wage setting makes current real wages depend on their past values.<sup>16</sup>

(iv) The lagged unemployment terms in the wage setting equation are the "*long-term unemployment effect*" (LU), since the long-term unemployed tend to search less intensively for jobs and thus have less influence on the wage setting process than the short-term unemployed.<sup>17</sup>

(v) The lagged labor force terms in the labor force equation are the "*labor force adjustment effect*" (LF), since costs of entry to and exit from the labor force often make the current labor force depend on its past magnitudes.

Since these lagged effects interact with one another, it is impossible to isolate the separate contribution of each to unemployment persistence and imperfect

<sup>12</sup>Since  $L_t$  and  $N_t$  are now in logs, this is an approximation.

<sup>13</sup>The names are merely a heuristic device; they do not imply, of course, that the lagged terms could not arise for reasons other than the named ones.

<sup>14</sup>See, for example, Nickell (1978).

<sup>15</sup>See, for example, Blanchard and Summers (1986) and Lindbeck and Snower (1987a).

<sup>16</sup>See, for example, Taylor (1979).

<sup>17</sup>See, for example, Bean and Layard (1988).

responsiveness. Rather, we examine what difference each individual lagged effect makes to the unemployment time path, given the presence of the other effects.<sup>18</sup>

#### 4a. Measuring the Sources of Unemployment Persistence

To derive the effect of source  $i$  ( $i = \text{EA, IM, WS, LU, LF}$ ) on unemployment persistence, we first eliminate the lags corresponding to source  $i$  and simulate the resulting system. For example, if  $i = \text{EA}$ , we eliminate the effect of the lagged employment terms in the employment equation by transforming this equation as follows:

$$n_t = B_1 X_{1t} + \sum_j \alpha_{1j} n_t + \alpha_2 w_t + \varepsilon_{1t} = \frac{1}{(1 - \sum_j \alpha_{1j})} (B_1 X_{1t} + \alpha_2 w_t + \varepsilon_{1t})$$

Retaining all the other lags and simulating the resulting labor market system, yields the time path of the unemployment rate in the absence of source  $i$ :  $u_t(i)$ . Next impose the temporary labor demand shock on this system and thereby generate the unemployment time path  $u'_t(i)$ . Define the difference between unemployment in the presence and absence of the shock, in the system without source  $i$  as  $\Delta u_t(i) \equiv u'_t(i) - u_t(i)$ . Recall that  $\Delta u_t = u'_t - u_t$  is the difference between unemployment in the presence and absence of the shock in the system containing all the sources of persistence. Then the unemployment increment, at any time  $t$ , that is attributable to source  $i$  may be expressed as  $\Delta u_t - \Delta u_t(i)$ . Normalizing these increments ( $\Delta u_t - \Delta u_t(i)$ ) by the size of the shock and summing over all periods subsequent to the shock ( $t \geq 1$ ), we obtain our measure of the degree of unemployment persistence attributable to source  $i$ :

$$\pi(i) = \sum_{t=2}^{\infty} \frac{\Delta u_t - \Delta u_t(i)}{\Delta \varepsilon_1} \quad (8)$$

#### 4b. Measuring the Sources of Imperfect Unemployment Responsiveness

Analogously, to derive the effect of source  $i$  on imperfect unemployment responsiveness, we eliminate the lags corresponding to source  $i$ , retain all the other lags, impose the permanent labor demand shock, and simulate the resulting system. The associated time path for unemployment is  $u''_t(i)$  for  $t \geq 0$  and the long-run value is  $\bar{u}''(i)$

<sup>18</sup>For this reason our empirical estimates of the sources of unemployment persistence and imperfect responsiveness (given below) to not add up to our aggregate estimates of persistence and responsiveness.

$= \lim_{t \rightarrow \infty} u_t''(i)$ . Let the difference between actual and long-run unemployment in the presence of the permanent shock be  $Du_t''(i) = u_t''(i) - \bar{u}''(i)$ . The corresponding difference between actual and long-run unemployment in the absence shock is  $Du_t(i) = u_t(i) - \bar{u}(i)$ . Then the sum of the differences  $Du_t''(i) - Du_t(i)$ , normalized by the size of the shock, measures imperfect unemployment responsiveness in the absence of source  $i$ :

$$\sigma(\sim i) = \sum_{t=1}^{\infty} \frac{\left[ u_t''(i) - \bar{u}''(i) \right] - \left[ u_t(i) - \bar{u}(i) \right]}{\Delta \varepsilon_1} = \sum_{t=1}^{\infty} \frac{Du_t''(i) - Du_t(i)}{\Delta \varepsilon_1} \quad (9)$$

Then the imperfect unemployment responsiveness which is attributable to source  $i$  - in the presence of all the other sources of responsiveness - may be expressed as the difference between unemployment responsiveness in the presence of all sources and unemployment responsiveness in the absence of source  $i$ :<sup>19</sup>

$$\sigma(i) = \sigma - \sigma(\sim i) = \sum_{t=1}^{\infty} \frac{\left[ u_t'' - u_t \right] - \left[ u_t''(i) - u_t(i) \right]}{\Delta \varepsilon_1} \quad (9')$$

## 5. Empirical Methodology

To estimate the labor market model for each of the three countries under consideration - Germany, the UK, and the US - we used the following five-step procedure:

*Step 1:* We applied the Dickey-Fuller tests and decided to treat all the variables in each model as I(1). We then followed the Johansen procedure and found evidence of cointegration (i.e. some linear combinations of our variables are stationary).

*Step 2:* We estimated several versions of the employment, wage setting, and labor force equations independently through OLS. We tested for the stationarity of the residuals by standard unit-root tests and conducted a full range of misspecification tests (for serial correlation, homoskedasticity, linearity, and normality). In addition, we tested for structural stability with the CUSUM and CUSUMSQ tests, based on the residuals from recursive estimation of the equations.

*Step 3:* Among the well-specified versions of the estimated equations, we selected the ones for our labor market models on the basis of a Likelihood-Ratio test, F-test, or the Schwartz Posterior Odds criterion. In this way we ensured that our selected

<sup>19</sup>Note that  $\bar{u}'' = \bar{u}''(i)$  and  $\bar{u} = \bar{u}(i)$ .

equations consist of stationary, well-specified linear combinations of the variables involved.

*Step 4:* We estimated our selected equations using 2SLS and all of them passed Sargan's test for overidentifying restrictions. The Wu-Hausman test revealed that the variables other than the dependent ones could be treated as exogenous.<sup>20</sup> We also tested for cross-equation correlation by looking at the statistical significance of the residuals from each equation when used as a regressor in the others.

*Step 5:* We decided on the estimation method of the preferred specifications on the basis of the results in Step 4. When neither endogeneity nor cross-equation correlation is detected OLS is preferred (since OLS is consistent and fully efficient); otherwise we proceeded with iterative 3SLS.

This procedure ensures that our structural model is consistent with an underlying cointegrating VAR. To see this, observe that our equations have the following structural form:

$$A_0 Y_t + A_1 Y_{t-1} + A_2 Y_{t-2} + B X_t = \varepsilon_t \quad (10)$$

where  $Y_t = [y_t, l_t, w_t]'$  is a vector of endogenous variables,  $x_t$  is a vector of exogenous variables, and  $\varepsilon_t$  is a white-noise process. Furthermore, note that the reduced form of our structural equation system (10) is simply the VAR model:

$$Y_t = -A_0^{-1}A_1 Y_{t-1} - A_0^{-1}A_2 Y_{t-2} - A_0^{-1}B X_t + u_t \quad (11)$$

Reparameterizing this system, we obtain the vector error correction (VEC) form:

$$\Delta Y_t = C Y_{t-1} + F \Delta Y_{t-1} + G \Delta X_t + u_t \quad (11')$$

where  $C = -A_0^{-1}A_1 - A_0^{-1}A_2 - I$ . The full reduced form of this system is

$$Z_t = B_1 Z_{t-1} + B_2 Z_{t-2} + e_t \quad (12)$$

where  $Z_t' = [Y_t, X_t]$ , and reparameterizing, we again obtain its VEC form:

$$\Delta Z_t = \theta_1 Z_{t-1} + \theta_2 \Delta Z_{t-2} + e_t \quad (12')$$

<sup>20</sup>In some cases where our dependent variables are used as explanatory variables, the Wu-Hausman test did not reveal their endogeneity.

The results of our Dickey-Fuller tests and Johansen procedure (in steps (1) and (2) of our procedure above) indicated that the elements of  $Z_t$  cointegrate, implying that (12), or equivalently (12'), is the appropriate statistical framework.

To proceed from this general specification (12) to (11) we need to separate  $Z_t$  into endogenous and exogenous components. This was done through the Wu-Hausman test (Step 4).

To move from (11) to (10), we need to impose various overidentifying restrictions on (11), the validity of which was confirmed by Sargan's test (Step 4).

Consequently, we think of our structural model in terms of a cointegrating VAR. However, the advantage of following the 5-step procedure above and using (10) is that the parameters we estimate have a straightforward economic interpretation.<sup>21</sup>

## 6. Empirical Results and Policy Implications

The estimations below are based on OECD data for the period 1964-92 in the UK and the US, and for 1964-90 in Germany. (All the variables used are defined in Table 5.)

Table 1 presents the estimated equations for the German, UK, and US labor markets. Equations (1)-(9) were estimated by OLS. All of them pass the CUSUM and CUSUMSQ tests for structural stability. The results of the misspecification tests, and Sargan's test for the above equations, along with the unit-root tests on their residuals,<sup>22</sup> are presented in Table 2.

For the UK and US equations, none of the regressors was found to be endogenous and when the residuals from each equation were included in the right-hand side of the other equations, they were not statistically significant. However, this was not the case for the German equations. Taking into consideration the endogeneity and cross-equation correlation, we estimated the German labor market equations as a system using iterative 3SLS (equations (10)-(12) in Table 1).

Two features of these equations deserve special mention. First, whereas employment depends inversely on the real wage in the German employment equation, it depends positively on the real wage in the UK and US employment equations. These results are readily interpreted in terms of the recent theoretical literature demonstrating that although the labor demand curve is generally downward-sloping under full capacity and diminishing returns to labor, but it may be flat or upward-sloping under excess capital capacity.<sup>23</sup> The reason is that, in the presence of unused capital, a rise in employment

<sup>21</sup>In addition, we are skeptical about the validity of the Johansen results in view of the few degrees of freedom in the Johansen estimation of our models.

<sup>22</sup>The order of the DF test was chosen so that the underlying regression was free of serial correlation.

<sup>23</sup>See, for example, Lindbeck and Snower (1994).

is generally accompanied by a rise in the amount of capital used, and thereby returns to scale - rather than returns to labor - come to play a dominant role in determining the slope of the labor demand curve.

Second, the insider membership effect is negative in the US wage equation, but positive in the German wage equation. These results are interpretable through the insider-outsider literature showing that the insider membership effect may be positive or negative, depending on the relative strength of two countervailing effects: (i) For any given distribution of labor demand shocks, the smaller is the insider workforce of a firm, the greater will be the insiders' job security at any given real wage, and consequently the higher the negotiated wage will be.<sup>24</sup> (ii) The smaller is the insider workforce, the smaller will be the bargaining power of the insiders (because, for example, the weaker are the threats that the insiders make to the firms in case of bargaining disagreement), and therefore the lower the negotiated wage will be.<sup>25</sup> If the size of the current insider workforce depends on past employment, the negotiated wage will depend on past employment as well.

To derive our measure of unemployment persistence, we conduct simulation exercises on each country's labor market system. To generate the time series for unemployment in the absence of the shock ( $u_t$ ), each system is solved from 1992 up to the period in which the system reaches its long-run equilibrium, using the 1992 values of all exogenous variables.<sup>26</sup> Next, to generate the time series for unemployment in the presence of the temporary shock, we reduce the constant term in the employment equation by 0.01005 in year 1992 only<sup>27</sup> and solve the resulting system forwards. The sum of the differences  $\Delta u_t = u_t' - u_t$ , normalized by the size of the shock, yields our measures of unemployment persistence in Table 3.

Observe that all of the labor market systems under consideration exhibit positive persistence. By our calculations, unemployment persistence is much greater in the UK than in Germany (i.e. a temporary shock has a more long-lasting effect on unemployment in the UK than in Germany); and Germany's unemployment, in turn, is more persistent than US unemployment.

Regarding the sources of unemployment persistence, observe that the employment

<sup>24</sup>See, for example, Blanchard and Summers (1986) and Lindbeck and Snower (1987a).

<sup>25</sup>See, for example, Lindbeck and Snower (1987b).

<sup>26</sup>The German system was solved forward from 1990, using the 1990 values of the exogenous variables. Note, however, that since all the systems are linear, the values of the exogenous variables have no influence on our measures of unemployment persistence and imperfect responsiveness, since they do not affect the *difference* between unemployment in the presence and absence of a temporary shock or the *difference* between actual unemployment under a permanent shock and long-run unemployment.

<sup>27</sup>This is equivalent to a 1% reduction in the constant term of the corresponding equation expressed in absolute terms, rather than logs.

adjustment effect ( $\pi(EA)$ ) augments the degree of persistence in all three countries, whereas the labor force adjustment effect ( $\pi(LF)$ ) pulls in the opposite direction. The insider membership effect ( $\pi(IM)$ ) dampens persistence in the US and Germany. On the other hand, the wage staggering effect ( $\pi(WS)$ ) does not pull in the same direction in all three countries: it augments persistence in the US, but dampens it in the UK and Germany.

To derive measure of imperfect unemployment responsiveness, we impose a permanent shock whereby the constant term in the employment equation is reduced by 0.01005 (the equivalent of a 1% exogenous reduction in employment) for all years from 1992 until the system achieves its long-run equilibrium, holding all exogenous variables constant at their 1992 values.<sup>28</sup> The resulting unemployment time series is  $u_t^*$ . Taking the sum of the differences between the actual effect of the permanent shock  $((u_t^* - u_t)/\Delta \varepsilon_1)$  and the long-run effect of the shock  $((\bar{u}^* - \bar{u})/\Delta \varepsilon_1)$ , we obtain our measure of imperfect unemployment responsiveness in Table 5.

Note that whereas the US exhibits *over-responsiveness* (unemployment overshooting), the UK and Germany display *under-responsiveness* (unemployment inertia). Furthermore, the table shows UK unemployment to be more under-responsive than German unemployment, i.e. the full effects of a permanent shock take longer to manifest themselves in the UK than in Germany.

Regarding the sources of imperfect unemployment responsiveness, we find that the employment adjustment effect ( $\sigma(EA)$ ) makes unemployment more under-responsive in all three countries, whereas the labor force adjustment effect ( $\sigma(LF)$ ) has the opposite influence. Furthermore, the insider membership effect ( $\sigma(IM)$ ) contributes positively to unemployment responsiveness in the US and Germany. By contrast, the wage staggering effect ( $\pi(WS)$ ) reduces responsiveness in the UK and increases responsiveness in the US and Germany.

This paper's approach to the analysis of unemployment has potentially important policy implications. Much of the current literature concentrates exclusively on how supply-side policies shift the natural rate of unemployment and how demand-side policies drive a temporary wedge between the actual and natural rates of unemployment. By contrast, our analysis seeks to promote a broader recognition of the role these policies play in influencing the dynamic response of unemployment to temporary and permanent shocks.

The empirical analysis shows that countries displaying a comparatively high degree of unemployment persistence need not necessarily display a comparatively high degree of

<sup>28</sup>For Germany, the shock is imposed from 1990 and the exogenous variables are held at their 1990 values.

unemployment under-responsiveness as well. The fact that temporary shocks have prolonged effects on unemployment, does not mean that the full effects of permanent shocks will be slow to manifest themselves. This result has profound policy implications, since it suggests that different policies may be required to deal with temporary and permanent shocks. In short, policy makers' assessments of the *durability* of labor market shocks have an important role to play in the appropriate design of labor market policies.

Our analysis has also indicated that, within a particular country, different labor market lags have quite different effects on unemployment persistence and imperfect responsiveness. This is significant for policy formulation since different labor market policies affect different lags. Thus it appears vital to assess the empirical importance of the various lags before policy decisions are reached.

Finally, our analysis showed that a particular lagged effect can have quite different implications for unemployment dynamics in different countries. As we have seen, a particular lag may amplify unemployment persistence in one country and dampen it in another; it may amplify over-responsiveness in one country and amplify under-responsiveness in another. The reason, of course, is that the unemployment effect of any particular lag depends crucially on its interactions with the other lags in the labor market system, and the latter vary from country to country. This result, too, is potentially important for policy, since it implies that different countries may require quite different policies to deal with the same unemployment problem.

The upshot of all these implications that the appropriate design of unemployment policy is not an easy matter. We need to make judgments on the durability of the shocks, relative importance of different labor market lags, and their interaction before we can formulate the appropriate policies. This is a tall order. But if it were easy, the European unemployment problem would have been brought under control by now.

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TABLE 1

**UK, OLS**

[1]  $\Delta N_t = 3.21 - 0.34N_{t-2} + 0.07w_t + 4.40k_t - 6.70k_{t-1} + 2.44k_{t-2} - 0.39\tau_t^1 - 0.07c_t, \quad R^2 = 0.91$   
 (0.72) (0.06) (0.03) (0.52) (0.91) (0.47) (0.13) (0.03)

[2]  $\Delta w_t = -1.10 - 0.19w_{t-2} + 0.11b_t - 0.02\Omega_t, \quad R^2 = 0.44$   
 (0.30) (0.06) (0.03) (0.01)

[3]  $\Delta L_t = -0.39 - 0.47L_{t-2} + 0.49P_t - 0.21\Delta u_t + 0.03w_{t-1}, \quad R^2 = 0.70$   
 (0.78) (0.08) (0.11) (0.07) (0.01)

**US, OLS**

[4]  $N_t = 3.45 + 0.56N_{t-1} + 0.23w_t + 1.20k_t - 2.37k_{t-1} + 1.37k_{t-2} - 0.02\Omega_t - 2.43\tau_t^1, \quad R^2 = 0.9$   
 (0.80) (0.12) (0.10) (0.37) (0.53) (0.28) (0.003) (0.46)

[5]  $\Delta w_t = 1.86 - 0.28w_{t-2} - 0.20N_{t-1} + 0.07b_t + 0.37\tau_t^D - 0.85\tau_t^1 + 0.20i_t, \quad R^2 = 0.79$   
 (0.09) (0.07) (0.03) (0.01) (0.16) (0.32) (0.05)

[6]  $L_t = -2.09 + 0.64L_t + 0.53P_t - 0.18u_t, \quad R^2 = 0.99$   
 (0.28) (0.04) (0.06) (0.05)

**GE, OLS**

[7]  $\Delta N_t = 2.11 - 0.33N_{t-2} - 0.12w_t + 2.37k_t - 3.23k_{t-1} + 0.99k_{t-2} + 0.05\Delta r_t, \quad R^2 = 0.85$   
 (0.89) (0.10) (0.06) (0.33) (0.66) (0.36) (0.02)

[8]  $w_t = -4.15 + 0.37w_{t-1} - 0.60u_t + 0.44u_{t-1} + 0.24N_{t-1} + 0.29c_t, \quad R^2 = 0.99$   
 (0.94) (0.1) (0.19) (0.17) (0.08) (0.05)

[9]  $\Delta L_t = -2.25 - 0.38L_{t-2} + 0.58P_t - 0.62u_t + 0.33u_{t-1} + 0.02w_{t-1}, \quad R^2 = 0.85$   
 (0.57) (0.07) (0.07) (0.09) (0.09) (0.01)

(standard errors in parentheses)

**GE, Iterative 3SLS**

[10]  $\Delta N_t = 2.53 - 0.37N_{t-2} - 0.12w_t + 1.87k_t - 2.07k_{t-1} + 0.35k_{t-2} + 0.04\Delta r_t, \quad R^2 = 0.82$   
 (0.62) (0.06) (0.04) (0.22) (0.38) (0.21) (0.01)

[11]  $w_t = -3.68 + 0.45w_{t-1} - 1.06u_t + 0.86u_{t-1} + 0.22N_{t-1} + 0.26c_t, \quad R^2 = 0.99$   
 (0.83) (0.07) (0.18) (0.17) (0.08) (0.03)

[12]  $\Delta L_t = -2.32 - 0.41L_{t-1} + 0.61P_t - 0.54u_t + 0.24u_{t-1} - 0.02w_{t-1}, \quad R^2 = 0.86$   
 (0.50) (0.05) (0.05) (0.08) (0.08) (0.01)

(asymptotic standard errors in parentheses)

**TABLE 2**

Equations	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
SC[Chi-Sq(1)]	3.79	0.07	0.1	0.54	0.01	0.64	1.08	0.88	0.26
LIN[Chi-Sq(1)]	1.63	0.21	0.15	2.22	3.54	2.26	2.28	0.02	1.09
NOR[Chi-Sq(2)]	0.16	0.62	0.61	0.74	1.86	0.01	0.01	3.36	1.21
HET[Chi-Sq(1)]	0.76	1.19	2.55	1.24	2.87	0.28	0.16	0.61	0.13
Sargan's test	6.43	9.83	12.81	8.45	10.52	13.04	8.84	3.24	13.2
Critical value	14.07	19.68	18.31	14.07	15.51	19.68	11.07	12.59	12.59
U-Root test	-6.55	-5.58	-5.49	-5.66	-6.16	-4.64	-5.71	-6.04	-6.44
Critical value	-5.35	-4.51	-4.93	-5.35	-5.35	-4.51	-5.41	-5.38	-5.41

Note: the critical values for Chi-Sq(1) and Chi-Sq(2) are 3.84 and 5.99 respectively

Sargan's test was computed using the results from the 2SLS estimation of the equations. It follows a Chi-Square distribution with degrees of freedom the number of overidentifying restrictions.

The size of the test is 0.05

**TABLE 3**

	$\pi$	$\pi(\text{EA})$	$\pi(\text{WS})$	$\pi(\text{LU})$	$\pi(\text{IM})$	$\pi(\text{LF})$
UK	2.17	1.95	-1.17			-0.12
US	0.26	0.29	0.05		-0.03	-0.14
GE	0.73	0.16	-0.32	0.31	-0.03	-0.2

EA: employment adjustment effect

WS: wage staggering effect

LU: long-term unemployment effect

IM: insider membership effect

LF: labor force adjustment effect

**TABLE 4**

	$\sigma$	$\sigma(\text{EA})$	$\sigma(\text{WS})$	$\sigma(\text{LU})$	$\sigma(\text{IM})$	$\sigma(\text{LF})$
UK	-4.25	-0.96	-0.69			0.003
US	0.37	-2.43	0.49		0.31	0.65
GE	-1	-0.27	0.15	-0.27	0.13	0.25

**TABLE 5**

N:	employment
w:	real wage
L:	labor force
k:	real capital stock, business sector
r:	competitiveness defined as (imports deflator/GDP deflator)
u:	unemployment rate defined as L-N
c:	real social security contributions
b:	real social security benefits
$\Omega$ :	real oil price
i:	real long-term interest rate
P:	working-age population
$\tau^D$ :	direct tax-rate defined as (direct taxes/GDP)
$\tau^I$ :	indirect tax-rate defined as (indirect taxes/GDP)

Note: all variables are in natural logs except of interest- and tax-rate