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The Natural Rate, Scarring, Cycles, Shocks, Persistence, and Hysteresis

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The findings of this paper are the sole responsibility of the authors.

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There is a tide in the affairs of men, which,
taken at the flood leads onto fortune.
Omitted, all the voyage of their life
is bound in shallows and in miseries.

Julius Caesar V-iii-218

Introduction

Nearly 20 years ago Arthur Okun indicated that "The choice of an aggregate target of resource utilization remains one of the key issues facing policy makers and macroeconomists. Obviously, fuller utilization of labour and capital brings benefits in the form of extra income, output and jobs; at the same time it clearly imposes costs by increasing inflationary tendencies. Various economists see these benefits and costs very differently."[1] Okun went on to stress that "unemployment was merely the tip of the iceberg that forms in a cold economy . . . in a cold economy a downgrading of labour occurs." In a cold economy, high quality workers avoid unemployment by accepting low quality and/or less productive jobs. In a high pressure economy a process of ladder climbing is possible. Individuals formerly in poorer jobs move into better ones, making way for those in less well-paying pursuits. In a cold economy, the ladder is not there, and even if it is the rungs are broken, leading to less opportunity for advancement and worse still an erosion of human capital, a reduction in labour force attachment and/or, for those affected, a permanent reduction in job retention rates.

Labour market economists have long thought that what Okun described in 1973, was the correct paradigm. The presence of opportunity is a key factor in not only the long run, but also the short run. Conditions in the labour market for a young individual could have a permanent impact on life cycle employment. A well-functioning economy would leave a young age group better prepared to weather future shocks or cycles.

Okun cited Henry Wallich,[2] who once suggested that macroeconomists could be classified into advocates of high pressure and low pressure operation of the economy. Milton Freedman in his 1968 Presidential Address to the American Economics Association tossed out an idea which off and on has dominated public policy discussions between these two groups.[3] Even today, the common ground for debate between these two groups continues to focus on Milton Freedman's concept of the natural rate of unemployment. More recently the natural rate has become a major anchor in the formulation of public policy in Canada.

Macroeconomic policy in the late 1980s, if anything, has been (and remains today) guided by the anchor of the natural rate. More recently, monetary policy during the period 1987-90 has been guided by the belief that the natural rate is influenced only by structural change. Fundamental to this point of view is a belief that the business cycle does not influence the equilibrium or natural rate of unemployment. Thus, opening the output gap (causing unemployment) as a way to control inflation is thought to have only temporary effects, no long-run permanent consequences can result. In short, the transitional costs to a lower rate of inflation are outweighed by the long-run benefits. A natural rate, impervious to demand-side shocks and cycles seems inconsistent with Okun's notions as to what a cold economy spawns in its depths – that is, fundamental change in labour force attachment, skill level, and opportunity, where the impact of such change could have the horizon of a generation.

Part of the inconsistency between a policy which uses the natural rate as an anchor and the implication as to what a cold economy might do to that anchor, is bound up in the time scale of those who make policy. For policy-makers the time horizon is usually short; what Okun had in mind could take a generation to incubate. On such a time scale, it is not easy to equate cause and effect.

In its pure sense, equilibrium is a timeless concept. The fact that it is timeless is the very reason why it is an attractive anchor. There are, however, problems that arise on three levels. *First*, a demand-side shock could drive an economy and its unemployment rate away from its natural rate (leaving the natural rate unaffected), but the time horizon required to return to equilibrium could be long, say five to ten years or perhaps longer. *Second*, a shock or a cycle could not only drive the economy away from its natural rate, but it could affect the natural rate itself for some finite period of time. This problem becomes critical if the time it takes for equilibrium (the natural rate) and the economy to re-establish itself at its previous position is lengthy.[4] The *third*, is the most serious. Here, once the economy and the natural rate are disturbed by a demand-side shock, they may never return to their previous position because equilibrium itself has changed forever.

The first level of problem is called *persistence*. The long tail on the unemployment rate which occurred in the late 1950s and early 1960s and which reoccurred following the 1981-82 downturn are examples. The second level can be called *pseudo hysteresis*. It differs from the first, because a demand-side shock affects the natural rate itself and the horizon back to the *original position of equilibrium* is lengthy – in our case a generation. The most serious problem, of course, is *pure hysteresis* – the idea that a disturbance can permanently affect equilibrium forever.[5]

In a regime of persistence, the cost of controlling inflation by opening the output gap is finite, and if the output gap is closed quickly, the costs of using this method to reduce inflation are tolerable. In a regime of pseudo hysteresis, the costs of gap opening not only increase dramatically, but can easily be misjudged. In a regime of pure hysteresis the costs are infinite inasmuch as the unemployment rate never returns to its original level.

The problem of a slippery natural rate has in the recent past been tied to structural changes on the supply side that have slowly altered the equilibrium rate over time. But, the idea that the natural rate is sensitive to the cycle has been systematically rejected. Under a regime of pseudo hysteresis, cycles or shocks from the demand side, if the time horizon is long enough, do not affect the natural rate, but under such circumstances, as the time horizon shortens the natural rate itself becomes a slippery anchor, perhaps intertwined and not distinguishable from the actual rate of unemployment. Under such circumstances, the size of the *effective gap* opened for the control of inflation may not be equal to the size of the *expected gap.*

In this paper, we present a natural rate model that is disaggregated by age group, which in the aggregate produces pseudo hysteresis on a time scale, which leaves in doubt the validity of a policy of gap opening as a way to control inflation. The model has a number of important policy implications. It suggests that this method of inflation control is too costly. On the other hand, the implications for job training, skill level at time of entry into the labour market, and human resource development as an ongoing feature of labour market policy are fundamental to the results.

An Outline of the Paper

We begin with a simple observation of fact. Data from the Labour Force Survey in Canada when "stacked" by age and sex suggest that $\text{Log}(u_t^{ws}) = \text{Log}(u_{t-1}^{ws}) + \text{Log}(n_t)$ where u_t^{ws} is a weighted "stacked" unemployment rate (by age and sex) and $\log(n_t)$ is error with $E\{\log(n_t)\} = E\{\log(n_t), \log(n_{t-1})\} = 0$. This points to history rather than the attracting force of equilibrium as what determines u_t^{ws}.[6]

We then introduce a theoretical model of the unemployment rate that is age-group based. This model is calibrated and simulated. A fundamental result from this exercise is that a trendless input signal (the business cycle) produces an output signal (the unemployment rate) that has a trend.

The next section examines some econometric implications which arise when aggregating age group unemployment rates generated from this model. If the assumptions of the underlying model hold, then the aggregate unemployment rate generated by this model has a structure and a backward-looking time horizon that is dependent on "history." In particular, *the history* or labour market experience at entry of an age group plays a key role in determining the current and future aggregate unemployment rate in this model.

In the next section, we estimate a variant of this model, using seemingly unrelated variable techniques, which builds on the principles set out in the theoretical model. The model is novel because the data source on unemployment rates is *only* the Labour Force Survey. The model estimated is a natural rate model disaggregated by age and by sex, for the period 1953-90. The novel result of the empirical work is the statistical significance of a variable that yields a positive long-run elasticity between a current age group's unemployment rate and the same group's unemployment rate 10 years ago, which suggests that the unemployment rate of a generation depends upon the *previous unemployment experience of this same generation.*

Thus, the experience of 25-to-34 year olds depends, among other things, on the experience of 15-to-24 year olds 10 years ago and so on. The statistical significance of this coefficient holds in the presence of the lagged dependent variable and in the presence of cyclical and structural variables. The implication is that the aggregate unemployment rate specifically depends upon the past job history of those that make up the labour force today, in particular, the unemployment rate of each group at entry, weighted by the (current) share of that age group in the labour force.

The next section of the paper deals with the dynamic implications of this structure for the aggregate natural rate equation in the presence of outside shocks and cycles. The key result here follows directly from the dependency effect (on the entering age group). Although the structure does not deny the existence of *a very long-run* equilibrium rate of unemployment (the natural rate), to which the model does return if left undisturbed after an initial shock, the age group dependency structure produces pseudo hysteresis on a time scale that is not distinguishable from the real thing, if the policy horizon is only a decade or perhaps less. Both peaks and troughs of the actual unemployment rate and the natural rate are lifted above equilibrium, in the presence of repeated cyclical shocks. In addition, upon their eventual return to equilibrium, both the natural rate and the actual unemployment rate become intertwined. Under these conditions, the *effective size* of the gap is not necessarily the *observed size* of the gap.

The last section deals with the implications of these findings for public policy. The implications are fundamental for demand management. The presence of pseudo hysteresis leaves the natural rate as a slippery anchor. The question of scarring at entry provides support for labour market policies directed at training, solid educational achievement prior to labour force entry, and macroeconomic management that avoids gap opening as a means of fighting inflation. The implication is that a consensus about the pitfalls of inflation is a much better way to deal with the cure. This, of course, does not deny monetary policy a key role in the *prevention of inflation.* It does suggest the *cure must be found in a policy other than one that focuses on gap opening.*

Some Observed Facts

If the Labour Force Survey Data (for unemployment) are stacked by age and sex (weighting each observation by its labour force share) in a single column (year by year for 1973 to 1990) the log/log regression of u_t^{ws} on u_{t-1}^{ws} (with the constant suppressed) yields an elasticity of 0.995 (t = 131). When the constant is included it yields 0.998 (t = 89.6), with an insignificant constant of 0.01269 (t = 0.47).

This suggests that

$$\text{Log}(u_t^{ws}) = \text{Log}(u_{t-1}^{ws}) + \text{shock}. \quad (1)$$

The implication is that unemployment rates in Canada are whatever they were last year plus a shock. If the shock is *iid* with zero mean, then $\text{Log}(u_t^{ws})$ would follow a random walk.[7]

The idea that unemployment rates are a random walk is inconsistent with the notion that there is a natural rate of unemployment u^* that is impervious to shocks on the demand side, but sensitive only to slow moving pressure on the supply side. Models of the natural rate deny the cycle any impact on equilibrium. In this sense the natural rate is a timeless concept independent of the number of cycles endured or the position of the current cycle.

Under these circumstances, given an elasticity of 1.0 for u_t^{ws} *WST* u_{t-1}^{ws}, those who support the natural rate hypothesis would endeavour to find correlations that reduce the value of the coefficient on the lagged dependent variable to less than 1. If this turns out to be the case then for

$$\begin{aligned} &\text{Log}(u_t^{ws}) = \beta\ \text{Log}(u_{t-1}^{ws}) + \lambda\ \text{Log}(\text{cycle}_t) + \alpha + v_t \\ &\text{and } u_t^{ws} = u_{t-1}^{ws} = u^*. \end{aligned} \quad (2)$$

$$\text{Log}(u^*) = \alpha(1-\beta)^{-1} + (1-\beta)^{-1}\ \lambda\ \text{Log}(\text{cycle}_t) + v_t^*. \quad (3)$$

By imposing the condition that the cycle be at its peak where $C^* = (1-\beta)^{-1}$ λ Log (peak) we have,

$$\text{Log}(u^*) = \alpha\ (1-\beta)^{-1} + C^*. \quad (4)$$

Thus, u^* is sensitive to forces that bear only on α. However, when we add Log(cycle$_t$)[8] to the original regression and free the constant, the following equation results:

$$\text{Log}(u_t^{ws}) = \underset{(96)}{0.995}\,\text{Log}(u_{t-1}^{ws}) - \underset{(6.1)}{2.100}\,\text{Log}(\text{cycle}_t) + \underset{(6.1)}{9.291} \qquad (5)$$

$\bar{R}^2 = 0.9783$

$SEE = 0.2454$

$DW = 2.34.$

This result is startling as it indicates that controlling for the cycle does not reduce the coefficient on the lagged dependent variable. Once again u_t^{ws} seems to be a random walk pushed around by the cycle, but with no tendency to gravitate to a unique equilibrium. When the cycle is set at its peak, the unemployment rate is still influenced by what it was last year with elasticity 1. Thus, the idea of the natural rate seems to be rejected by the data – what seems to matter is history. It is the purpose of this paper to show that both the idea that history matters and the timeless concept of the natural rate can coexist, but living with history makes the natural rate much less natural than it has been thought to be in the past.

The Theoretical Model

The theory rests on a simple idea. In addition to the state of the business cycle and/or the presence or absence of structural change, the unemployment rate for a specific age group – say age 35 – depends on three (different) pieces of information concerning the state of the labour market. We use 35-year-olds as an illustration. Among other things it depends on (1) the unemployment rate of those *35 years old one year ago*, (2) the unemployment rate of those *34 years old one year ago*, and (3) the unemployment rate of those *15 years old 20 years ago*. Those 15 years old 20 years ago are now 35 years old and those 34 years old one year ago are now 35 years old. These two variables capture the historical experience of those who entered the labour force at a point in time as opposed to the lagged value of the unemployment rate for 35-year-olds which captures the adjustment process, but not the history of the age group. *It is the separation of the adjustment process which has been a regular feature of natural rate models from the impact of history at entry (or at any other point) that is novel in this model.*[9]

For example, let $u(i)$ be the unemployment rate for age group i, let $u(i-1)$ be that of age group i–1 (in the same time period), let $u(i)_{-1}$ be that of the ith age group last year and let $u(i-1)_{-1}$ be the rate for age group i–1 last year. Note that $u(i-1)_{-1}$ and $u(i)$ are rates representative of the same group of individuals, individuals who in the historical sense have had the same experience in the labour market. This is not the case of $u(i)$ and $u(i)_{-1}$. Those who make up $u(i)$ are not the same group as those who make up $u(i)_{-1}$ since those who were 35 last year are 36 this year. This idea is key to the analysis.

The analogy is that of a man with a video camera at a fixed point, taking pictures of a moving line of people. He only records what happens at a point in time for different groups as they pass by the point. Even if he has two camera's (the current and lagged dependent variable) positioned at different points in the line, he cannot say much about the "history" of any one group. To do this he needs a video camera mounted on tracks that moves with the line (at the same speed). This permits him to record the complete history of an age group from entry to exit. With this sort of record, the cameraman can determine if what is happening now has its roots in what went on previously in a specific group that is constant in its membership (or nearly so). Once again the distinction is between $u(i)$ and $u(i)_{-1}$ as compared to $u(i)$ and $u(i-1)_{-1}$.

For a labour market with n age groups the equation system would be (all variables in logarithms):

$$\begin{aligned} u(1) &= c(1) + \alpha(1)\, CUR + v(1) \\ u(i) &= \lambda(i)\left[c(i) + \alpha(i)\, CUR + \beta(i)\;\; u(i-1)_{-1} + \varepsilon(i)\;\; u(1)_{-i+1}\right] \qquad (6) \\ &\quad + (1-\lambda(i))\;\; u(i)_{-1} + v(i) \\ &\qquad\qquad i = 2 \ldots n. \end{aligned}$$

Where $u(1)$ is the unemployment rate for the entering age group (youth unemployment), CUR represents the cycle and the $v(i)$ are random disturbances $E(v(i)_t) = 0$, $E(v(i)_t, v(i-1)_t) = 0$, $E(v(i)_t, v(i)_{t-1}) = 0$). Note that $u(1)$ depends only on the cycle, CUR. The $i = 2 \ldots n$ are older age groups who entered the labour market at some previous date. Key to the structure of this model are the variables $u(i-1)_{-1}$ and $u(1)_{-i+1}$. This model is recursive, both in the time index t and in the age group index i. As a result, it can be simulated quite easily once the $c(i)$, $\alpha(i)$, $\beta(i)$, $\varepsilon(i)$ and $\lambda(i)$ are known.

To illustrate a key dynamic response of this model, we assume $\alpha(i) = 2.0$, $\beta(i) = 0.35$, $\varepsilon(i) = 1.0$ and $\lambda(i) = 0.7$. Once these are set (we also set CUR, the rate of capacity utilization, 4 points above its mean), the system can be calibrated to the 1990 unemployment rates for the age groups 15 to 24, 25 to 34, 35 to 44, 45 to 54, and 55 and up. Under these circumstances the calibrated model produces an equilibrium unemployment rate of about 7.5 per cent.

A startling result is obtained when this model is subjected to two consecutive and identical 30-year periods of cyclical perturbation. These two 30-year periods are, in fact, the path for observed capacity utilization from 1960 to

1990. The cycle represents the only input signal to the model other than the $v(i)$ which are *iid* with mean zero. Note the input signal has no trend. On the other hand, the output signal (or unemployment rate) obtained by equally weighting the unemployment rate of all age groups has a very interesting property. This result is clearly illustrated in Figure 1 (see Figures at end of text).

The peaks and troughs not only move away from the equilibrium or natural rate, but the second peak is higher than the first as is the case for the second trough in comparison to the first. Finally, the return to equilibrium takes about 40 years (a generation) to occur. This result raises a number of fundamental questions, the most obvious of which concerns the structure of the aggregate natural rate equation in the presence of such a process at work at the level of the individual age group.

The Aggregate Natural Rate Equation

The aggregate natural rate equation can be obtained from (6) by weighting each age group by its percentage of members in the total labour force and then adding across age groups. To keep things simple, we have assumed that all age groups have equal weight. Aggregation (for the 41 age group scheme used to obtain the results reported in Figure 1) produces:

$$\sum_{i=1}^{41} u(i) = c(i) + \alpha CUR + \lambda\left[\sum_{i=2}^{41} c(i) + \beta \sum_{i=2}^{41} u(i-1)_{-1} + \varepsilon \sum_{i=2}^{41} u(1)_{-i+1} + \alpha \sum_{i=2}^{41} CUR\right] + (1-\lambda)\left[\sum_{i=2}^{41} u(i)_{-1}\right] + V \ . \tag{7}$$

After some manipulation (see Appendix A), we obtain the following result:

$$u = \left[c(1) - \lambda\, c(1) + \sum_{i=1}^{41} c(i)\right] / 41 + \left[(\alpha + 40\alpha\, \lambda) / 41\right] CUR + \left[(\lambda\, \beta + 1 - \lambda) / 41\right] u_{-1} + \left[\varepsilon\, \lambda \,/\, 41\right] \sum_{i=2}^{41} u(1)_{-i+1} - \left[\lambda\, \beta / 41\right] u(41)_{-1} - \left[(1-\lambda)/41\right] u(1)_{-1} + V. \tag{8}$$

What is important is the appearance of

$$\frac{1}{41} \sum_{i=2}^{41} u(1)_{-i+1} = URC \tag{9}$$

in the aggregate natural rate equation. If we had not used constant weights then this variable would have looked like

$$\sum_{i=2}^{41} w(i)\ u(1)_{-i+1}, \tag{10}$$

where the $w(i)$ are weights related to the *current* distribution of the labour force across age groups. This result in itself is interesting. We call this variable the *age group composite* variable. It is not the lagged dependent variable, but a moving historical record of conditions at entry for all of those in the labour force at time t. It should be clear that the information contained in this variable is much different than that contained in the lagged dependent variable which also appears in (8). It should also be clear that although we have chosen entry as the point of observation, one can focus on any point in the past for the group in question. Under these circumstances the index for the age group composite variable would simply slip from 1 to say k. The same holds true if the partitioning of the labour force is in broad groups such as those contained in the Labour Force Survey, for example 15-24 or 25-44.

To demonstrate just how important the age group composite variable is in the aggregate natural rate equation implied by this example, we use the data generated from 100 separate stochastically perturbed dynamic simulations from (6). In each dynamic simulation the $v(i)$ are *iid* with mean zero and constant variance. For each of 100 trials (for the 124 periods beginning at $t = 41$) we fit two least squares regressions. From these 100 trials we derived the expected values for the coefficients on u_{-1}, URC, CUR, and the constant. The results are recorded below in equation form, with the expected value for each coefficient recorded for each of the variables in question.

$$u = 0.74u_{-1} - 1.21CUR + 5.95. \tag{11}$$

$$u = 0.54u_{-1} + 0.64URC - 1.34CUR - \left[(0.7\ x\ 0.35)/41\right]u55up_{-1} - [0.3/41]u15_{-1} + 5.39. \tag{12}$$

During the 100 trials we restrained the coefficients on $u55up_{-1}$ and $u15_{-1}$ to their expected value as we are interested in only the relationship between the coefficient on u_{-1} and URC.[10] There are two important results here.

First, URC (the age group composite variable) makes an important contribution in explaining the variance of u in the presence of both the cyclical variable and the lagged dependent variable. This is unremarkable as the underlying structure indicates this to be the case. Second, from (8) we obtain an indication of what the aggregate coefficients of (12) should be. The expectation of the value of the coefficient of u_{-1} is $\lambda\beta + 1 - \lambda = 0.7 \times 0.35 + 1 - 0.7 = 0.54$. That of *URC* is $\lambda\varepsilon = 0.7 \times 1 = 0.7$ and that of *CUR* is $(\alpha + 40\ \alpha\lambda)/41 = (2.0 + 40 \times 2.0 \times 0.7)/41 = 1.41$. Even if the aggregate equation is correctly specified, there remain some econometric problems no doubt related to serial correlation in i, the age index and t the time index and its impact on the coefficient of u_{-1}. There are, however, serious problems which also develop when *URC* is excluded as a regressor.

For example, in the equation that excludes *URC*, the estimated value for the coefficient on the lagged dependent variable (0.74) is nearly 40 per cent greater than the expected value of 0.54. The implication is clear. The absence of the age group composite variable in this example seriously biases the coefficient of u_{-1}.

It is our conjecture that since most natural rate models have relied on u_{-1} and excluded the age group composite variable they are suspect – perhaps even useless. The implications of this fact are, nevertheless, much more profound. If the age group composite variable in observed data (such as Labour Force Survey data) is found to be significant, it suggests that something akin to hysteresis is present in the data.

We now turn to the development of a natural rate model which contains a variant of this structure that can be estimated using Labour Force Survey data by age and sex.

Data Sources

The estimate of this age group specific natural rate model begins where Burns left off.[11] In the natural rate model reported in Burns, the aggregate unemployment rate was related to a number of structural and cyclical variables and its own lagged dependent variable. His preferred specification included a number of cyclical and structural variables, all of which are identified in his data appendix and reproduced in Table 1. His dependent variable was a Perry-weighted aggregate unemployment rate. In the current model we are interested in relating unemployment rates by age/sex over time to Burns' cyclical and structural variables.

A number of problems arise because the theory calls for very long time series and for a very detailed age/sex breakdown. The detail available from the Labour Force Survey includes only the age groups set out in Table 1. There are additional problems that stem from the lack of individual detail available prior to 1974. For the male and female age groups 15-24, data are available back to 1953, as is the case for the male and female age groups 25-44, 45-64, 55-64 and 65 and up. However, detailed data for the age group 25-34 are only available after 1974.

Table 1

Data sources – Model estimation

	Name and period	
Labour Force Survey data for:		
Unemployment rate	@UR__C	
Number of unemployed	@UE__C	
Unemployment rate (natural)[1]	@NUR__C	
Number of unemployed (natural)[1]	@NUE__C	
Labour force share	@LFS__C	
Labour force	@LF__C	
Employment for the following cohorts:	@NE__C	
Males 15-24	__M15-24_	1953-90
Females 15-24	__F15-24_	1953-90
Males 25-34	__M25-34_	1975-90
Females 25-34	__F25-34_	1975-90
Males 25-44	__M25-44_	1953-90
Females 25-44	__F25-44_	1953-90
Males 45-64	__M45-64_	1953-90
Females 45-64	__F45-64_	1953-90
Males 55-64	__M55-64_	1953-90
Females 55-64	__F55-64_	1953-90
Males 65 and up	__M65 UP_	1953-90
Females 65 and up	__F65 UP_	1953-90
Bank of Canada industrial capital utilization rate	CUR	1963-90
Employment dispersion variable	SIG_C	1963-90
Difference between U.S. unemployment rate and the *WEFA* Group's estimated U.S. natural rate	USCAP	1963-90
Difference between rate of growth of energy price index and CPI rate of growth	ENERGSHK	1963-90
Energy price index divided by CPI index	RLPEWERG	1963-90
Weighted average of Canadian provincial minimum wages divided by average industrial wage	WMR	1963-90
Percentage of nonfarm labour force who are members of unions	UNION	1963-90
Male youth school enrolment rate	MSERM	1963-90
Federal direct taxes on business divided by GDP	BDTAX	1963-90
Dummy for age group 45-64	D45-64	
Dummy for females	FEMALE	
Dummy for males	MALE	

1 Model simulation only.

To make maximum use of all information available, as many observations as possible from 1953 through 1990 for each age group were employed in the estimation procedure. The technique employed was that of seemingly unrelated variables. Our first step was to stack the time series by age group. Excluding the male and female age groups 25-34, the stack included 38 observations for both males and females in age groups 15-24, 25-44, 45-64, 55-64 and 65 and up. As for the age group 25-34, there were only 16 observations, for a total of 588 observations for the period 1953-90. Because of the long lags, only 210 data points entered the regression, but all lags were used.

Because age groups differed in the number of individuals contained therein, we weighted the unemployment rates for each age group by the ratio of labour force in each age group to the total labour force. In addition, because some age groups overlap, for example, 25-44 overlaps 25-34 and 45-64 overlaps 55-64, we adjusted the weighting associated to both males and females so as to avoid double counting. Half the weight associated with the 25-34-year-olds and the 55-64-year-olds was allocated to the smaller group, while the other half of the weight was allocated to the larger group (25-44 or 45-64, as the case may be). In addition, wherever an unemployment rate was used on the right-hand side of an equation, it was also weighted using the same procedure. The dependent and independent variables were then stacked accordingly.

In the final regression, a male-female dummy was used to permit a coefficient on a single explanatory variable like capacity utilization to take on separate values. In some cases, coefficients related to specific age groups within the male-female breakdown were also permitted to take on unique values. Use of a seemingly unrelated variable technique, such as this, was a key factor in permitting the age group composite variable, identified in the previous section to enter the estimation procedure. Note that the age group composite variable is always associated with the age group "one down," but the age group one down is in fact a partition – or a group of individuals whose ages are all within the same range. Thus the age group 15-24 forms the group composite that drives the age group 25-44.

Thus, two unemployment rates appear as independent variables. The first is the lagged dependent variable associated with the age group in question. The second is the age group composite variable that "tracks the history" of the age group in question.

The Age Group Composite Variable

In the theoretical section, the age group composite variable was identified as a weighted average of the unemployment rate at entry, for each age group, where the weights correspond to the labour force distribution by age group. Labour Force Survey data do not contain this kind of detail. Nevertheless, we have developed a technique which proxies the concept. The procedure employed is as follows.

In the larger age groups (25-44 and 45-64) there were enough data points prior to 1973 to use a 20-year horizon. For the age groups 25-44 and 45-64, we averaged the labour market experience for the age group one down at the beginning of the first 10-year period and at the close of the first 10-year period (over a decade) before applying weights and a uniform lag of 1 year, 5 years, and 10 years.

For those age groups that span only 10 years, a 10-year horizon is all that is necessary, since those in the previous age group – say 45-54 – 10 years ago are the same group that are 55-64 years old today. Here we focus directly on three lags (1 year, 5 years, and 10 years) without prior averaging. The key here is to construct a variable where the group membership (at a younger age) in the constructed variable is similar to the group membership for the dependent variable now (in that part of the stack), enabling one to determine if a *group's history* has had an impact on its current unemployment rate.

In the theoretical section, the age group composite variable not only had a lag structure associated with it, but also had a specific set of weights. Our procedure begins by imposing a weighting system on the lag structure of the composite age group variable. In the stepwise estimation technique used, however, we eventually relax the imposed distribution (but not the focus on 1, 5, and 10) to obtain a statistical estimate of the weights. The exact computational procedure is found in the appendix for each age group composite variable found on the right-hand side.

Preliminary Investigation of Lagged Dependent Variable and the Age Group Composite Effect

Scatter diagrams 2 through 6 provide insight into the relationship between the dependent variable, the three components of the age group composite variable, and the lagged dependent variable. The scatter between the dependent variable and the lagged dependent variable is interesting (Figure 2). But, the fact that the scatter between the first component of the age group composite variable lagged 1 year and the third component of the age group composite variable lagged 10 years proves to be just as interesting (Figures 3 and 4). Perhaps the most striking result is that the third component of the age group composite variable is more highly correlated with the dependent variable than the first component. Weighting the three components of the age group composite variable with trial weights (males 0.5, 0.25, 0.25; females 0.4, 0.10, 0.60) and combining the result with the lagged dependent variable weighted by the speed of adjustment obtained from the trial results reported in the next section provides an even more interesting result. The scatter tightens up (Figure 5). As we iterated to the final result, this scatter tightens further (Figure 6).

Trial Regressions

Table 2 reports four trial regressions which relate the stacked time series of unemployment rates by age group (10 groups in all) to: (1) the age group composite variable; (2) the lagged dependent variable; and (3) a variety of cyclical and structural indicators (see Table 1 for definitions and sources). We have computed regressions for both an unweighted and a weighted version of these equations. It is clear that *weighting* the unemployment rates, gives a better result. The most revealing computation is contained in the columns that report the weighted results. In the static version of the equation, with no lagged dependent variable, the age group composite variable appears with an elasticity of one and is highly significant. When the lagged dependent variable is added, as a regressor, the two do compete, but both successfully contribute to a reduction in the residual variance of the equation. In addition, the long-run elasticity comes in again at about 1. Furthermore, the structural and cyclical variables all take reasonable signs.[12] Thus the trial results which do not permit male and female differences in the speed of adjustment or elasticities with respect to the age group composite variable, nor male/female differences in structural or cyclical effects, strongly suggest that the age group composite variable makes an independent contribution to explaining the variance of the stacked time series of unemployment rates by age group. What is key in this result is that the lags on the age group composite variable, in most cases, are 10 years, and in two age groups are as long as 20 years. In addition, the long-run elasticity with respect to this variable seems to be about 1, since the two coefficients (speed of adjustment and history) add to 1.

Final Estimates

In Table 2 we did not permit males and females to differ, as we were interested more in the problems that related to weighting and the relationship between the lagged dependent variable, the age group composite variable and the dependent variable. In Table 3, we (1) relax many of the restrictions on males and females and (2) set out to determine statistically the nature of the lags related to the age group composite variable. The procedure followed five steps.

As before, the dependent variable is a weighted stacked time series of unemployment rates by age group, containing 210 observations. The independent variables include: an age group composite variable for males and for females separately; a lagged dependent variable for males and females separately; cyclical variables including capacity utilization, the employment dispersion variable of Lilien,[13] and a U.S. gap variable; structural variables included minimum wage, percentage of union memberships, business taxes, energy prices and the school enrolment rate (for males), and a dummy variable for the age group 45-64.

Step 1 relaxed the male/female restrictions on the age group composite variable, the lagged dependent variable, and the structural and cyclical variables. Nevertheless, it maintains the initial weighting system for males and females used in the trial computations reported in Table 2. For males, the weights were maintained at 0.5, 0.25, 0.25; for females, they were maintained at 0.4, 0.10 and 0.60. The results were interesting. With the weighting system maintained, the composite variable effect for females strengthened, while the lagged dependent variable effect weakened. For males, the opposite occurred. The age group composite effect was reduced and the lagged dependent variable effect increased. Nevertheless, all four variables remained significant even in the face of structural and cyclical variables. In Step 2, we fixed the lag structure for the lagged dependent variables and the age group composite variables to that determined in Step 1 and proceeded to investigate additional structural variables excluded in Step 1. In Step 3, we fixed the structural and cyclical variables to the impacts suggested in Step 2 and again reassessed the impact of the lagged dependent variable and the age group composite variable, this time freeing the weighting system (on the components 1, 5, and 10), so that it could be statistically determined. Under these circumstances, a total weight of 0.20 for the male age group composite variable was obtained, as opposed to a weight of 0.18 in Step 1. For females, a total weight of 0.51 was obtained, as opposed to 0.47 in Step 1. For males, the components of these weights were on the border line of significance. For females, only two components remained statistically significant, the component at t–5 dropped out. For both males and females, the weight on t–10 remained large. In Step 4, we *fixed the distribution* of the weights for t–1, t–5, and t–10 to conform to the pattern obtained in Step 3. It is not surprising that this step produces a total impact similar to Step 1, where information on energy and school enrolment were ignored (0.17 for males and 0.55 for females). Step 5 fixed the dynamics related to the lagged dependent variable and the age group composite variable to the weighting system and coefficients obtained in Step 4, permitting energy shocks and the school enrolment rate once again to have an impact. Equation 5 represents the final set of estimated coefficients used in the development of the dynamic recursive natural rate model simulated in the next section.[14, 15]

The Age Group 15-24

The youngest age group for both males and females does not have the same structural equation as those of older age groups and thus was not included in the stack. There is no previous age group from which they emerge. The influential variables here are the cycle, the adjustment mechanism to equilibrium, and the structural variables. The equation for males is:

Table 2

Pooled cross-section/time series results for the unemployment rate

Dependent Variable	Stacked time series of unemployment rates by cohort			
Weighting[1]	Unweighted		Weighted	
	Static	Dynamic	Static	Dynamic
Independent variables				
Cohort composite[2]	1.04634	0.37796	0.99317	0.33338
	(20.0)	(6.8)	(72.2)	(7.3)
Lagged dependent	–	0.70310	–	0.67792
		(15.7)		(14.8)
Capacity utilization	−1.73346	−1.52470	−1.85233	−1.49860
	(3.0)	(3.9)	(3.3)	(3.9)
Employment dispersion variable	0.00657	0.14555	0.00612	0.14038
	(0.1)	(3.2)	(0.1)	(3.1)
U.S. employment rate minus U.S. natural rate[3, 4]	−0.85982	−0.96627	0.73421	−0.99477
	(0.3)	(0.5)	(0.3)	(0.6)
Minimum wage divided by average industrial wage	1.29062	0.76639	1.27911	0.69545
	(4.7)	(4.1)	(5.2)	(4.0)
Percentage of labour force in unions[5]	0.36224	0.21146	0.45900	0.22580
	(5.1)	(4.3)	(7.1)	(4.8)
Federal direct taxes on business divided by GDP	0.43193	0.29784	0.42570	0.25833
	(2.7)	(2.8)	(2.9)	(2.5)
Dummy for age group 45-64	0.67740	0.24871	0.64121	0.22209
	(13.1)	(5.6)	(15.2)	(5.5)
Constant	8.61950	8.05121	9.21685	7.93925
	(3.3)	(4.5)	(3.6)	(4.5)

R^2	0.7340	0.8805	0.9690	0.9852
$\bar{R}^2$	0.7234	0.8751	0.9677	0.9845
DW	1.0044	2.2922	1.0807	2.2680

1 The dependent variable, the cohort composite variable, and the lagged dependent variable when weighted are weighted by the percentage of those in a given cohort compared to the total labour force.
2 For the details on the construction of this variable, see Appendix B.
3 Females only.
4 Note that this variable was entered 1–(U.S. employment rate minus U.S. natural rate).
5 Females only.

Table 3

Estimation of the natural rate model

Dependent Variable[1]	Weighted stacked time series of unemployment rates by cohort[2]				
Independent variables	(1)	(2)	(3)	(4)	(5)
Cohort composite – males[3, 4]	0.18273 (2.4)	(1)	0.20026	0.17014 (2.3)	(4)
Weight t–1 (*WM*1)	0.50		0.07189 (1.0)	0.35898	
t–5 (*WM*2)	0.25		0.03312 (0.5)	0.16538	
t–10 (*WM*3)	0.25		0.09525 (1.4)	0.47563	
Lagged dependent – males	0.83820 (11.4)	(1)	0.82076 (22.0)	0.85159 (11.9)	(4)
Cohort composite – females[3, 4]	0.46711 (8.0)	(1)	0.50796	0.50622 (8.1)	(4)
Weight t–1 (*WF*1)	0.40		0.19137 (3.9)	0.37674	
t–5 (*WF*2)	0.10		–	–	
t–10 (*WF*3)	0.60		0.31659 (8.2)	0.62326	
Lagged dependent – females	0.54454 (9.3)	(1)	0.54816 (13.0)	0.55108 (9.7)	(4)
Capacity utilization	–	–			–
Males	–1.55704 (4.0)	–1.66732 (3.7)	(2)	–1.58027 (4.1)	–1.64462 (3.6)
Females	–0.97907 (1.7)	–1.35847 (3.0)		–0.96215 (1.6)	–1.33477 (3.0)
Employment dispersion	0.13615 (3.1)	0.14121 (3.3)	(2)	0.13089 (2.9)	0.13674 (3.2)
1 – (U.S. rate – U.S. natural rate)	–	–	(2)	–	–
Males	–	–		–	–
Females	–4.35640 (1.6)	–4.56341 (2.1)		–4.85303 (1.8)	–5.06801 (2.3)
Minimum wage divided by average industrial wage	–	–	(2)	–	–
Males	–	–		–	–
Females	0.85985 (4.7)	0.91567 (4.4)		0.86264 (4.8)	0.91439 (4.4)
Percentage of labour force in unions	–	–0.55499 (1.6)	(2)	–	–0.57719 (1.7)
Males	–0.23404 (0.7)	–		–0.19658 (0.6)	–
Females	–0.71427 (1.4)	–		–0.72850 (1.5)	–

Federal direct taxes on business divided by GDP	0.15190 (1.4)	–	(2)	0.13609 (1.3)	–
Males	–	0.19441 (1.3)		–	0.18157 (1.2)
Females	–	0.23306 (1.3)		–	0.21968 (1.1)
Dummy for age 45-64	–		(2)	–	–
Males	0.12595 (1.9)	0.12562 (3.2)		0.11428 (1.8)	0.11407 (2.9)
Females	0.27493 (5.4)	0.27382 (7.0)		0.27540 (5.5)	0.27425 (7.0)
Relative price of energy	–	–	(2)	–	–
Males	–	0.24705 (1.2)		–	0.29068 (1.4)
Females	–	–		–	–
Energy shock	–	−0.01050 (3.0)	(2)	–	−0.01040 (3.0)
Males	–	–		–	–
Females	–	–		–	–
School enrolment rate	–	–	(2)	–	–
Males	–	−0.42643 (1.4)		–	−0.45312 (1.5)
Females	–	–		–	–
Constant	8.72495 (4.4)	10.2195 (5.4)	(2)	8.63026 (4.4)	10.1315 (5.4)
R^2	0.9862	0.5394	0.9876	0.9863	0.5367
$\bar{R}^2$	0.9852	0.5088	0.9872	0.9853	0.5059
SEE	0.2027	0.1972	0.1933	0.2024	0.1968
DW	2.2940	2.3747	2.3669	2.3069	2.3850

1 For a definition of variables, see Table 1.
2 For a description of the cohort weighting scheme, see Appendix B.
3 For a description of the method used to construct this variable, see Appendix B.
4 The model was estimated in a stepwise fashion to gain insight into the statistical significance of the weights on the cohort composite variable.

$$
\begin{aligned}
\text{Log}(URM15-24c) = {} & \underset{(9.3)}{0.531}\,\text{Log}(URM15-24c)_{-1} - \underset{(12.9)}{2.88}\,\text{Log}(CUR) \\
& - \underset{(2.9)}{0.786}\,\Delta\,\text{Log}(CUR)_{-1} - \underset{(3.2)}{0.681}\,\Delta\,\text{Log}(CUR)_{-2} \\
& - \underset{(3.3)}{0.716}\,\Delta\,\text{Log}(CUR)_{-3} - \underset{(3.2)}{0.893}\,\Delta\,\text{Log}(CUR)_{-4} \\
& + \underset{(2.3)}{0.583}\,[\text{Log}(CUR)_{-1} - \text{Log}(CUR)_{-6}] \\
& + \underset{(4.0)}{1.199}\,\text{Log}(UNION) + \underset{(6.6)}{9.680}
\end{aligned}
\qquad (13)
$$

$\overline{R}^2 = 0.9774$
$SEE = 0.0387$
$DW = 2.3103.$

The female equation is:

$$
\begin{aligned}
\text{Log}(URF15-24c) = {} & \underset{(4.2)}{0.557}\,\text{Log}(URF15-24c)_{-1} - \underset{(2.6)}{1.446}\,\text{Log}(CUR) \\
& - \underset{(1.2)}{0.278}\,\Delta\,\text{Log}(CUR)_{-1} - \underset{(1.4)}{0.232}\,\Delta\,\text{Log}(CUR)_{-2} \\
& - \underset{(1.3)}{0.231}\,\Delta\,\text{Log}(CUR)_{-3} - \underset{(1.2)}{0.275}\,\Delta\,\text{Log}(CUR)_{-4} \\
& + \underset{(1.3)}{0.044}\,\text{Log}(SIG-c) + \underset{(2.8)}{1.371}\,\text{Log}(UNION) \\
& - \underset{(0.7)}{1.638}\,\text{Log}(1-(USGAP/100)) \\
& + \underset{(1.4)}{0.158}\,\text{Log}(1/WMR) + \underset{(1.1)}{2.870}
\end{aligned}
\qquad (14)
$$

$\overline{R}^2 = 0.9691$
$SEE = 0.0456$
$DW = 2.0702.$

Because we cannot take into account the history of, say, 15-20-year-olds in the equation for 15-24-year-olds, the coefficient on the lagged dependent variable is no doubt larger than it should be. And the approach to equilibrium is slower (it takes more time) than might be the case if we could account for the "history" of 15-24-year-olds. This is because the model "misjudges" the position of equilibrium.[16]

Sample Period Static and Dynamic Simulation Performance

Using the estimated coefficients from the 10 age groups that form the basis of the estimation stack and the associated identities, the model can be written down in recursive dynamic form and solved over the simple period in both static and dynamic mode (for a complete description of the model in dynamic recursive form see Appendix C). The results of these simulations are found in Figures 7 to 10. Because of the length of the lags, these simulations can only be carried out for the period 1975 through 1990.[17]

The sample period performance of the model for the aggregate unemployment rate and the rate associated with the 25-and-up age group tracks the historical data closely. The largest error (both dynamic and static) is made in 1983. The detail for males and females in Figures 9 and 10 reveals that all age groups (but more so for females) have some difficulty in the period 1982-83. Nevertheless, the dynamic prediction of the rise and fall of the unemployment rate during the period 1980-90 is quite accurate.

The Dynamic Natural Rate Model

From the dynamic recursive equation system that tracks the actual rate of unemployment, we can derive the dynamic natural rate model by age group and then aggregate using labour force weight to obtain the aggregate natural rate. The natural rate model is dynamic because the age group composite variable remains in each age group equation even after the equilibrium condition of $u = u_{-1} = u^*$ is imposed on the system within an age group. We could impose this condition between age groups also; in doing so, this would represent a higher order of equilibrium.

Both models (the dynamic recursive model for the actual rate and the dynamic recursive natural rate model) must be solved at the same time so as to ensure that a link is maintained between the natural rate model and *history as it is generated* by the dynamic recursive model for the actual rate. If both models are taken to the limit, with no cycles or structural shocks imposed, they both should settle down to the same long-run equilibrium. This, in fact, is the case.

Sample Period Performance – The Natural Rate

Not only can the actual rate be tracked with the model, but the natural rate can be tracked as well. By putting the cyclical variables to their peak (cycle = peak), letting the structural variables take on their historical values and imposing the condition that $u = u_{-1}$ on each age group equation, a dynamic sample period simulation (for the natural rate) is possible. The results of this dynamic simulation are recorded in Figure 11.

A large gap remains open in the mid-1980s, but closes during the late 1980s. It was at this point (1986-89) that inflation began to move upward. The gap opens again as the 1990s are approached. In the dynamic natural rate model, the gap opens partly because of the increase in the actual unemployment rate and partly because of the impact of history and of the structural variables on the natural rate, particularly the reduction in youth unemployment. The reasonableness of the gap between the natural and the actual rate is a strong test of the model. What results at the tail end of the sample period, where the natural rate continues to fall, could be a false signal. Nevertheless, these results may also be indicative of how slippery the natural rate is as a policy anchor. In short, the gap may have been opened much wider than necessary to achieve the desired reduction in inflation. The fact that the inflation targets have already been achieved is indicative of this fact.[18]

The Models' Response to Shocks

Subsequent to 1991, we have abstracted from the current cyclical downturn and set all structure values to their 1990 values and cyclical variable to values representative of their peaks. By 2015, the model(s) have approached their long-run resting point. At that point, we impose a variety of shocks. Figures 12a to 19b record eight types of shocks.

Shock 1 is an impulse to capacity utilization. Capacity utilization rates move below their peak in a cyclical fashion, which produces a characteristic business cycle effect on unemployment rates. Figure 12a records the impulse and Figure 12b records the effect of this impulse. What results, is a long tail on the unemployment rate for the age group 25 and up. What is important is the ripple effect that the original impulse has on the natural rate, in addition to the fact that it lifts the natural rate above its long-run equilibrium for a 20-year period.

The second shock merely duplicates the force of the first shock two additional times (Figures 13a and 13b). What is important in this experiment is the manner in which peaks and troughs of the cycles in unemployment successively move higher and higher away from equilibrium, for the natural rate and for the actual rate. What is also important is the intertwining of the natural and actual rate once the shocks die out.

Figures 14a and 14b report an impulse to the youth unemployment rate, characterized by a shift in the constant term in the equations.[19] The message here is clear and simple. If such a shift lasts for a decade, the impact is to raise both the actual and the natural rate above long-run equilibrium for a period of no less than 25 years. Note the impact on the rate for those 25 and over for the period subsequent to the removal of the shock.

Figures 15a and 15b extend this impulse to youth unemployment to three uniform shocks. Again one sees the result already observed; peaks in the 25-and-up unemployment rate that are successively higher and an intertwining of the natural and actual rate over time.

Figures 16a and 16b show the impact of a permanent shock or permanent increase to the youth unemployment rate. This leads to a permanent increase in the unemployment rate for those 25 and over. The increase is slow and insidious, but a new higher equilibrium is eventually reached in the system. This is pure hysteresis, with respect to unemployment rates 25 and over, coming about as a result of a permanent shift in the constants of the youth unemployment rate equation(s).

Figures 17a and 17b show the impact of a single shock to utilization, to the structural variables and to the youth unemployment rate. It is much like what the 1980s have been all about. The net result is to lift both the actual and the natural rate away from their equilibrium. The startling result is that, once things settle back to normal (the stock is removed), it takes almost a generation for the natural rate to return to its previous equilibrium and, during this time, the natural and observed unemployment rates are intertwined.

Figures 18a and 18b impose three cycles of equal force, stemming from changes in utilization, movements in structural factors, and shifts in the constants on the youth unemployment equation. What results is an appalling picture of ever higher peaks and troughs in both the natural and the actual unemployment rate.

The last case, as in the previous case, imposes three structural and cyclical shocks, but turns the impulse to youth unemployment rates into a permanent shock (Figures 19a and 19b). In this case, we see the successive rise in peaks, but when the shocks are removed the system will equilibrate, if given enough time, at a new higher natural and actual rate.

Summary of the Results

In summary, these shocks characterize a system with the following properties. Shocks of equal force, when successively applied, produce a divergence from equilibrium of both the natural and actual rates with successive peaks climbing to higher and higher levels, even though the second and third shocks are identical (in force) to the first. In addition, when the shocks are removed, the two rates in their return to equilibrium become intertwined and indistinguishable. Finally, if a permanent shift in youth unemployment occurs, the system eventually acquires this characteristic, with all unemployment rates shifting upwards, as this reverberates through age groups. In most cases, the return to equilibrium takes nearly a generation. It is easy to specify shocks of a plausible magnitude that hold the natural rate away from its long-run equilibrium for a 20-year period.

These results are generated from a structure that has no non-linearities of the type typically needed in other models to produce regime changes in equilibrium.[20] The key is found in a structure which admits two types of unemployment rates into the structural equation, the lag dependent variable and the age group composite variable. Thus, history coexists with the natural rate (or vice versa), but in doing so it destroys the natural rate as a policy anchor, since at any point during the cycle, the natural rate itself is never close to its long-run equilibrium. One implication is – you must open the gap wider than originally anticipated to bring about a reduction of inflation by a given amount. In addition, by systematically opening and closing the gap to control inflation, one erodes the power of the exercise, since the natural rate rises above equilibrium and hangs there for perhaps as long as a decade or two.

Conclusions

The results contained in this paper are at variance with the idea that the natural rate is impervious to the cycle. A structure has been derived from a model disaggregated by age and sex that clearly indicates the lagged dependent variable should be accompanied by a variable that accounts for history. When the natural rate equations are derived, the age group composite variable does not drop out, but remains. A dynamic model of the natural rate results. When the full system is subjected to shocks, the actual rate and the natural rate are both disturbed from long-run equilibrium, producing a characteristic long tail. The length of this tail is nearly a generation. Under the circumstances, one would have to call this hysteresis.

This result has profound implications for public policy. One implication of this result concerns youth unemployment. If youth unemployment drifts upward for some autonomous reason, prime age unemployment will drift upward also as it absorbs the "characteristic of its youth," regardless of the cycle. Opening the output gap to fight inflation under these circumstances can do long-run damage. As a result, it would appear that other methods to wring inflation from the system are required. Of course, this point of view does not deny that monetary policy should play the lead role in the *prevention of inflation*, but the cure offered up by monetary policy, given the structure of this model, would appear to be intolerably high. Structural policies, including consensus building, seem much more the order of the day.

Figure 1
The impact of cohort scarring on the unemployment rate

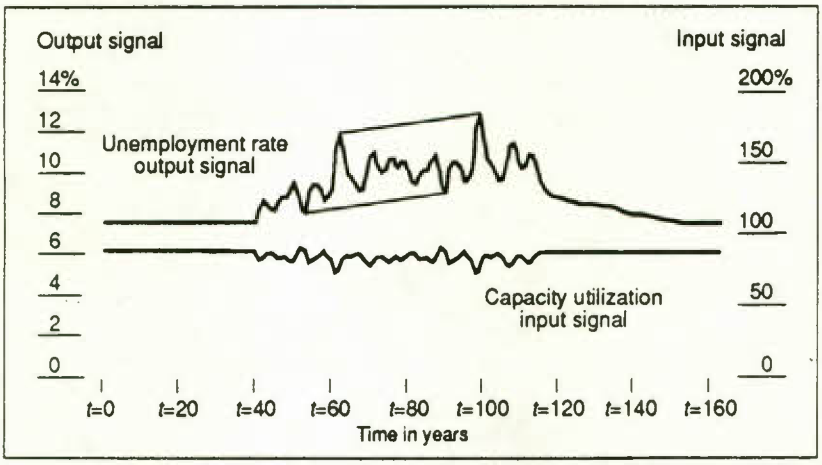


Figure 2
Scatter diagram, log(u) versus lagged dependent variable

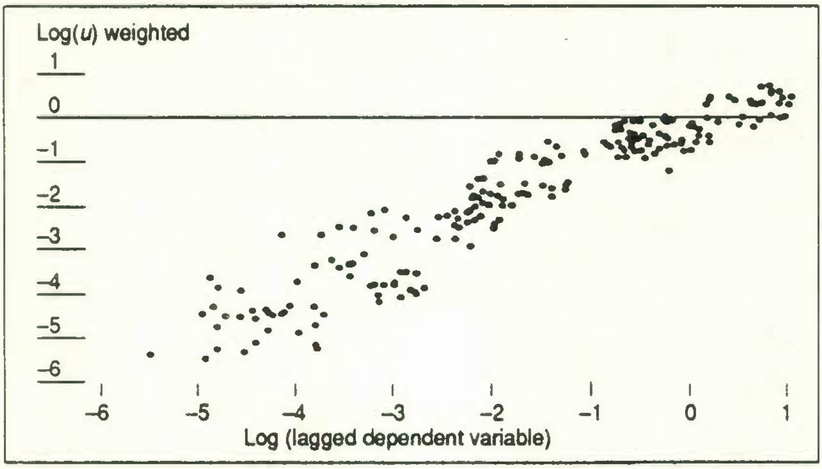


Figure 3
Scatter diagram, log(*u*) versus first component of cohort composite

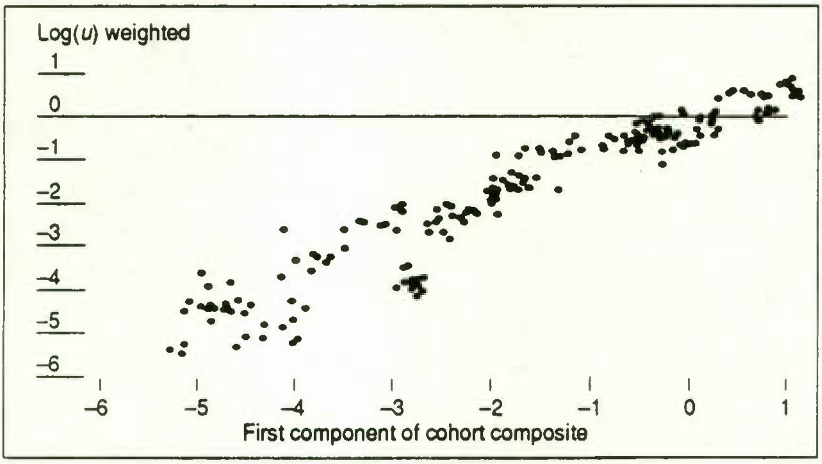


Figure 4
Scatter diagram, log(*u*) versus third component of cohort composite

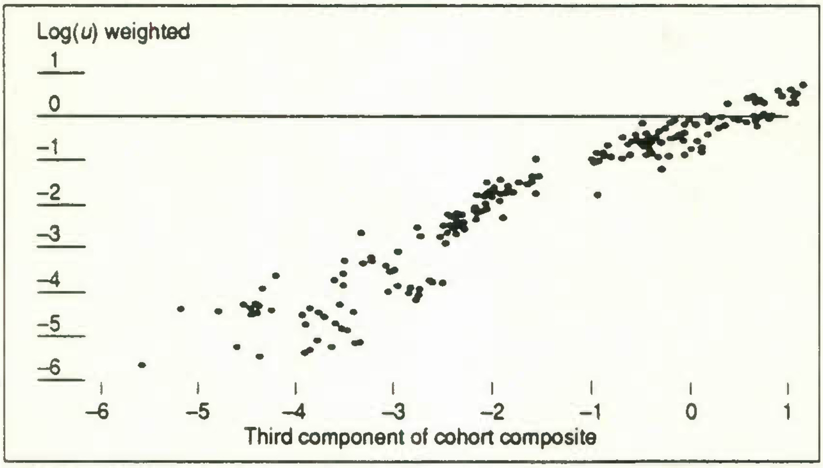


Figure 5
Scatter diagram, log(*u*) versus initial weights

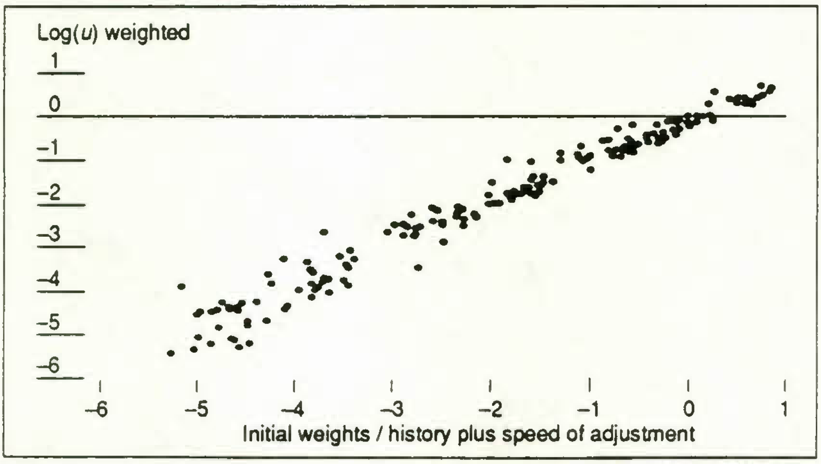


Figure 6
Scatter diagram, log(*u*) versus final weights

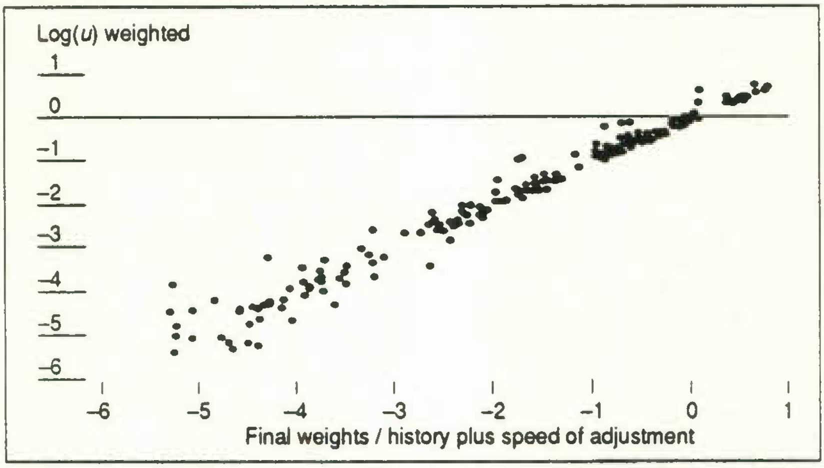


Figure 7
Unemployment rate, 1975-90

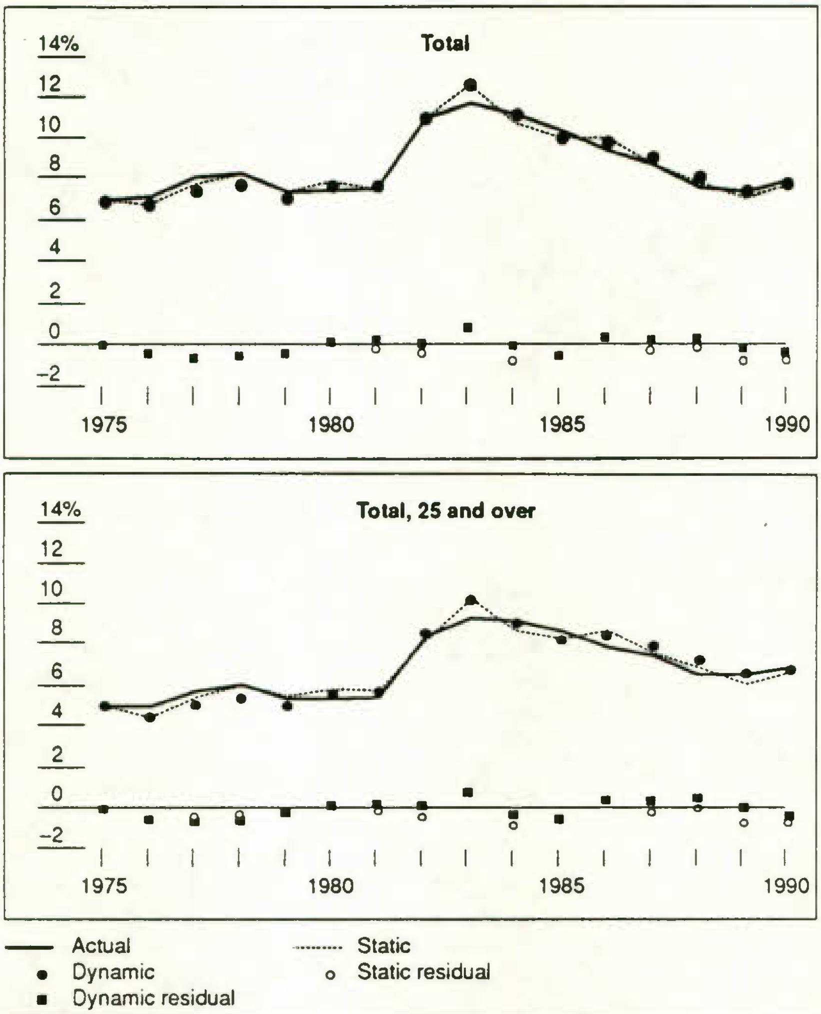


Figure 8
Unemployment rate – Males and females, 15-24, 1974-90

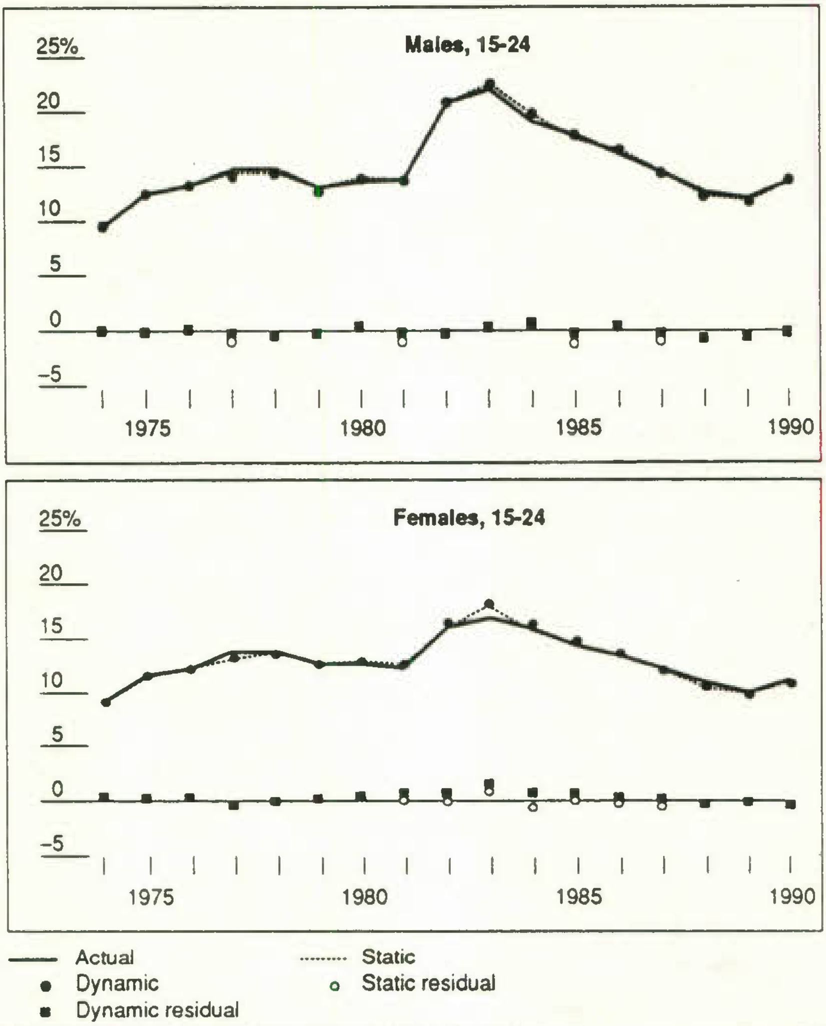


Figure 9
Unemployment rate – Males and females, major categories, 1974-90

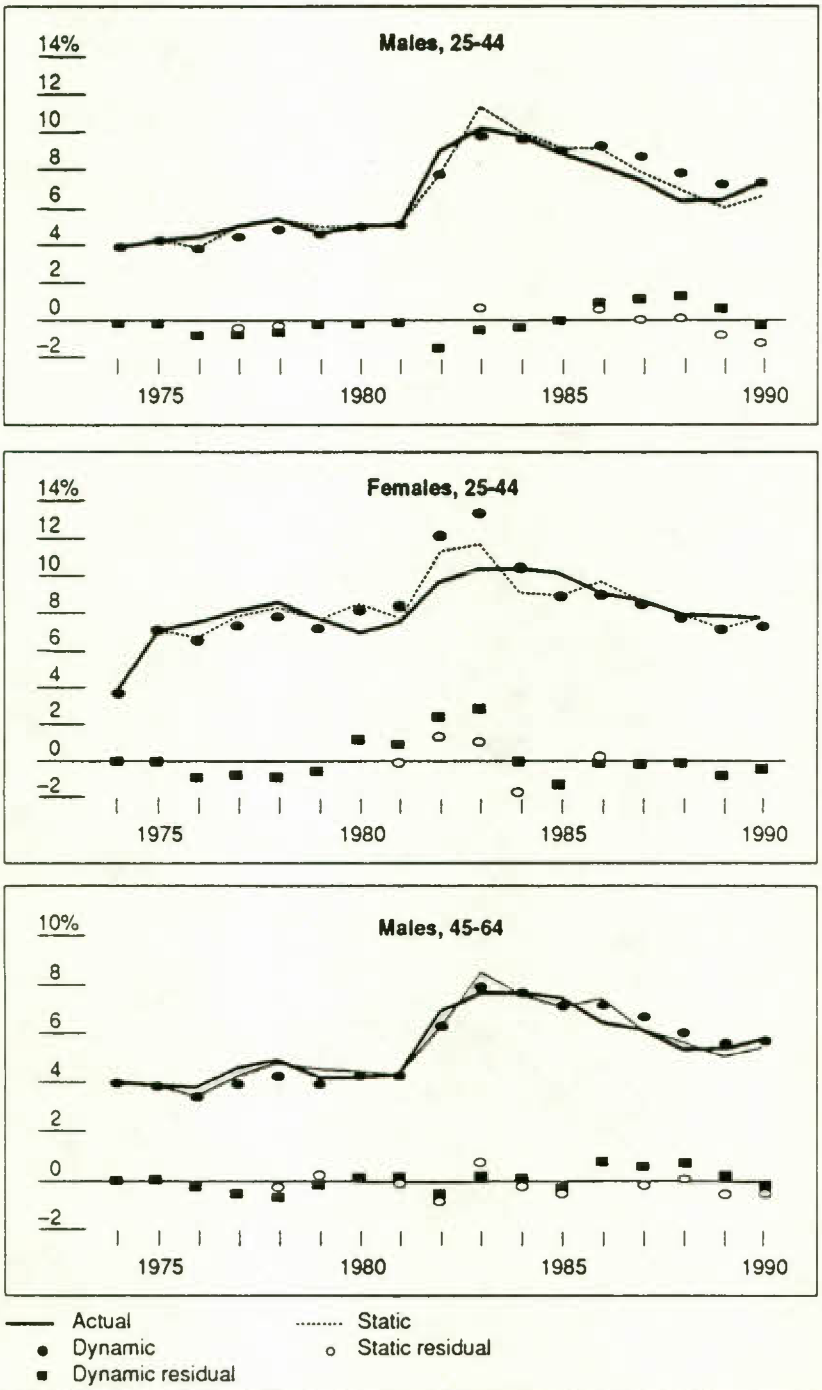


Figure 9 (cont' d.)

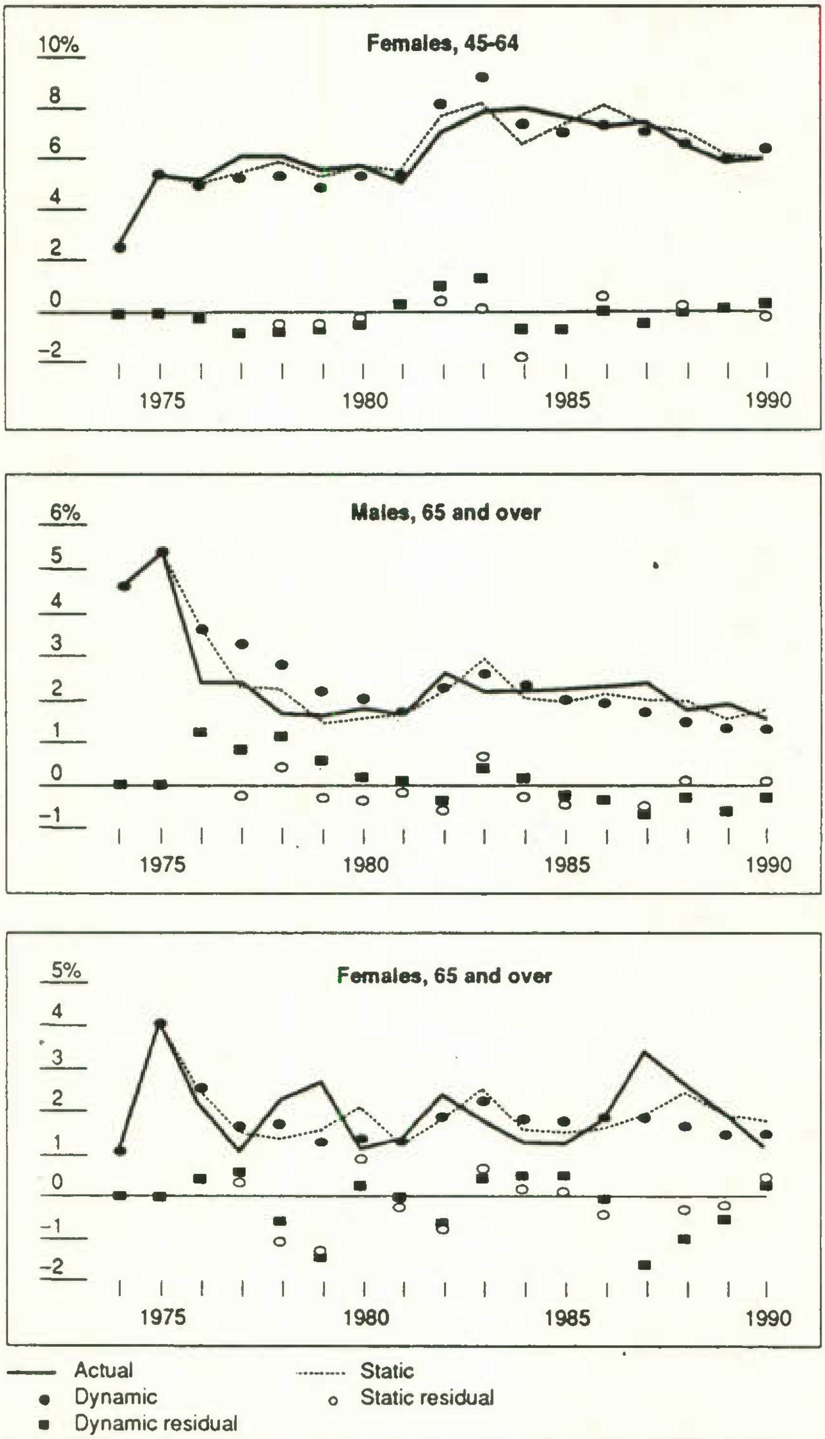


Figure 10
Unemployment rate – Males and females, detailed categories, 1974-90

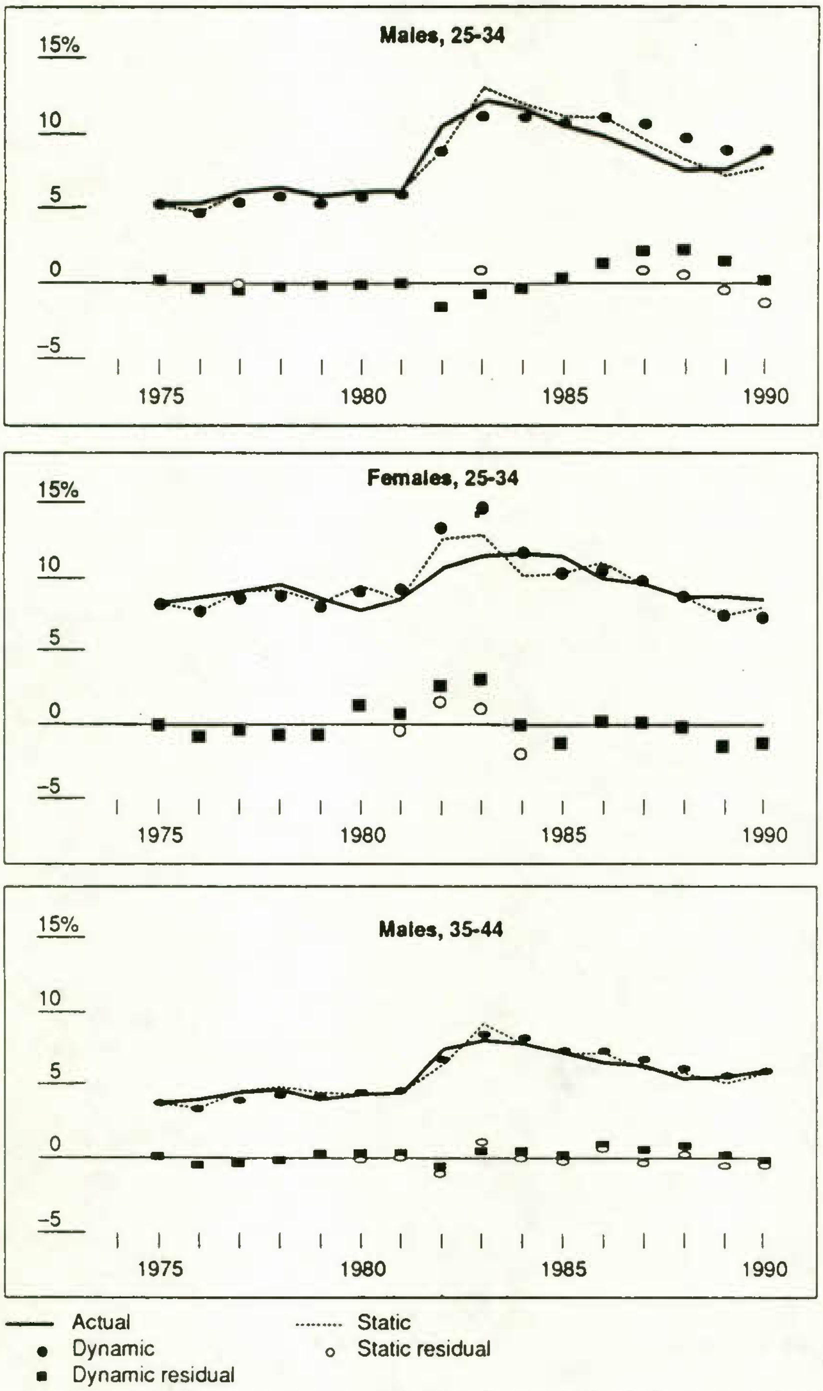


Figure 10 (cont'd.)

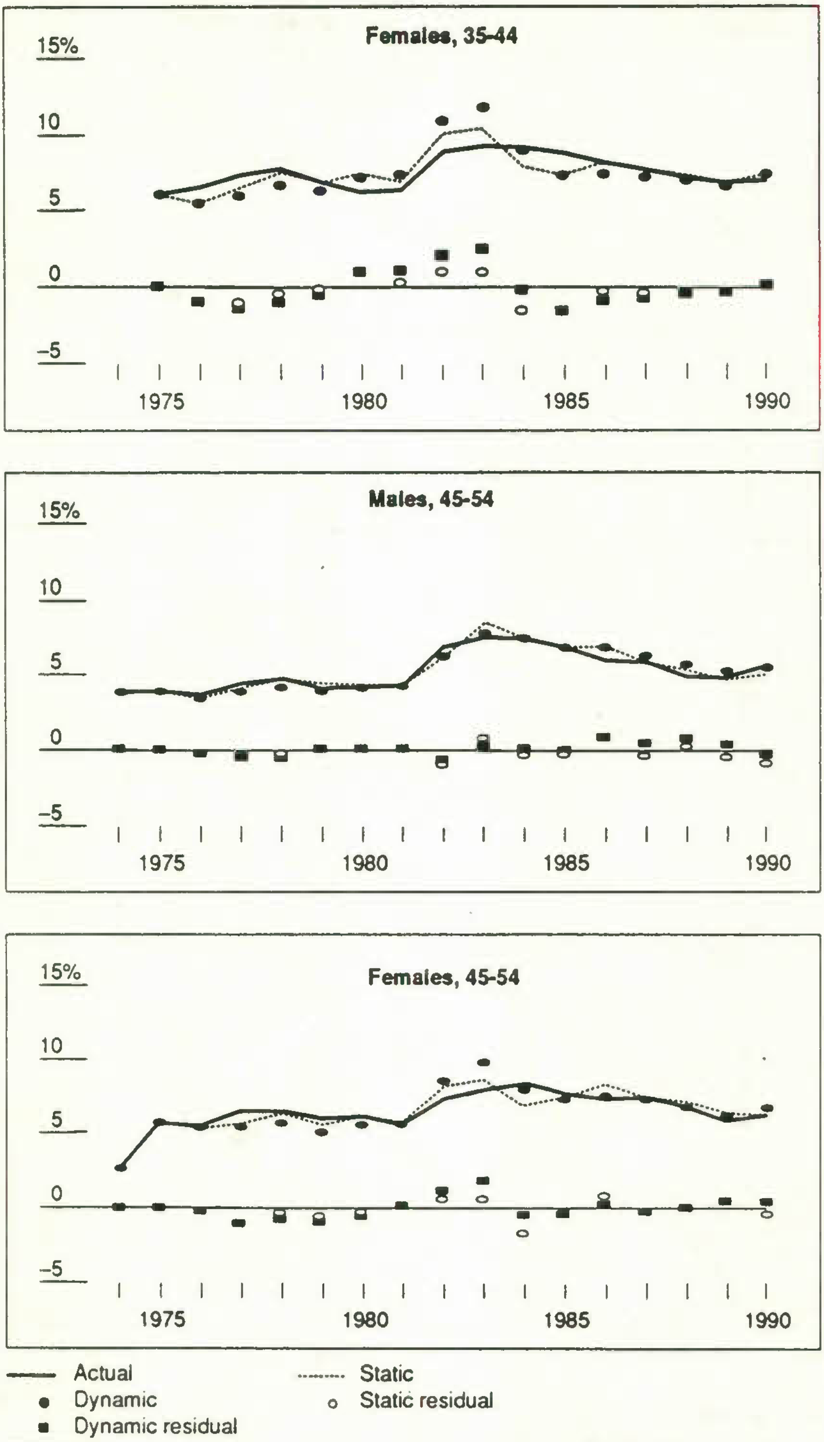
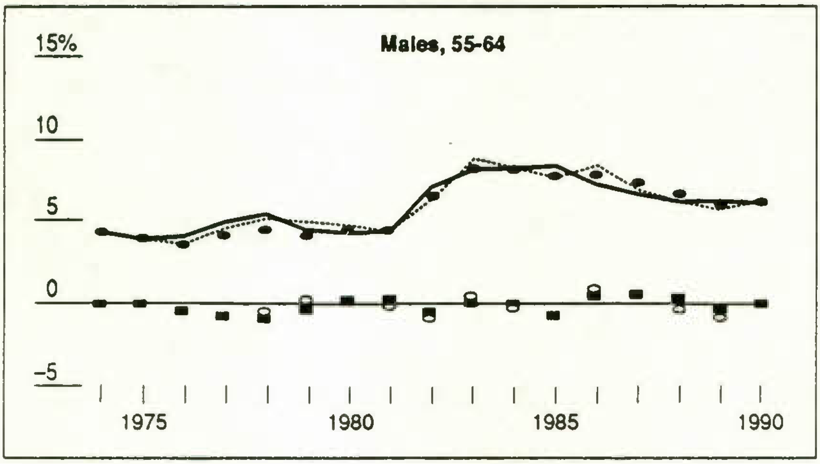
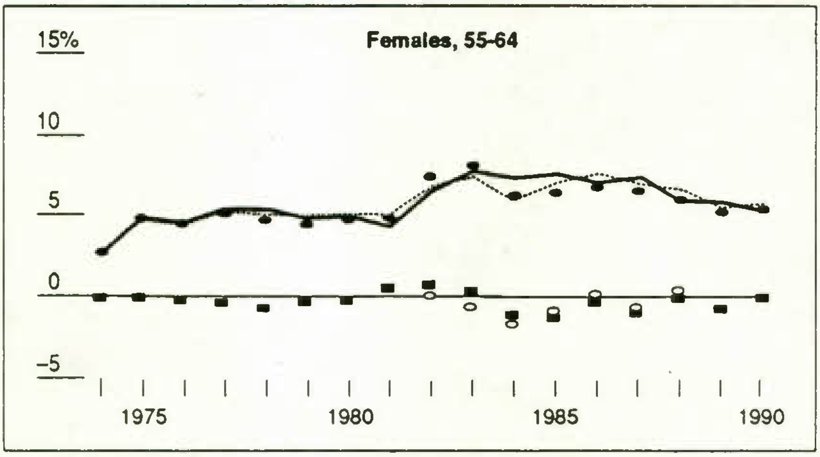


Figure 10 (concl' d.)





— Actual
.... Static
● Dynamic
○ Static residual
■ Dynamic residual

Figure 11
Sample period comparison of natural with actual rate, 1976-90

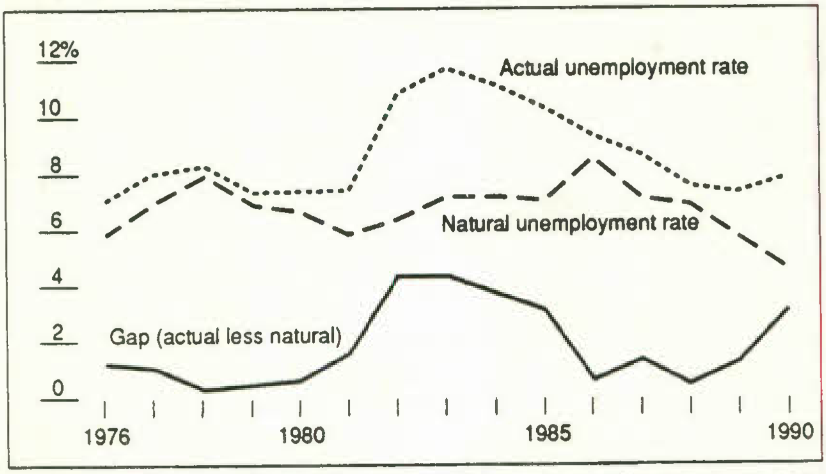


Figure 12a
Shock to capacity utilization (one cycle)

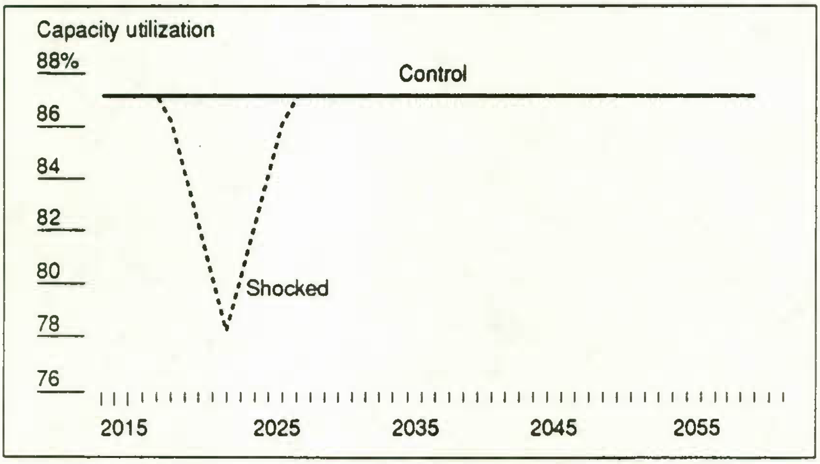


Figure 12b
Hysteresis scarring – Shock to utilization rate (one cycle)

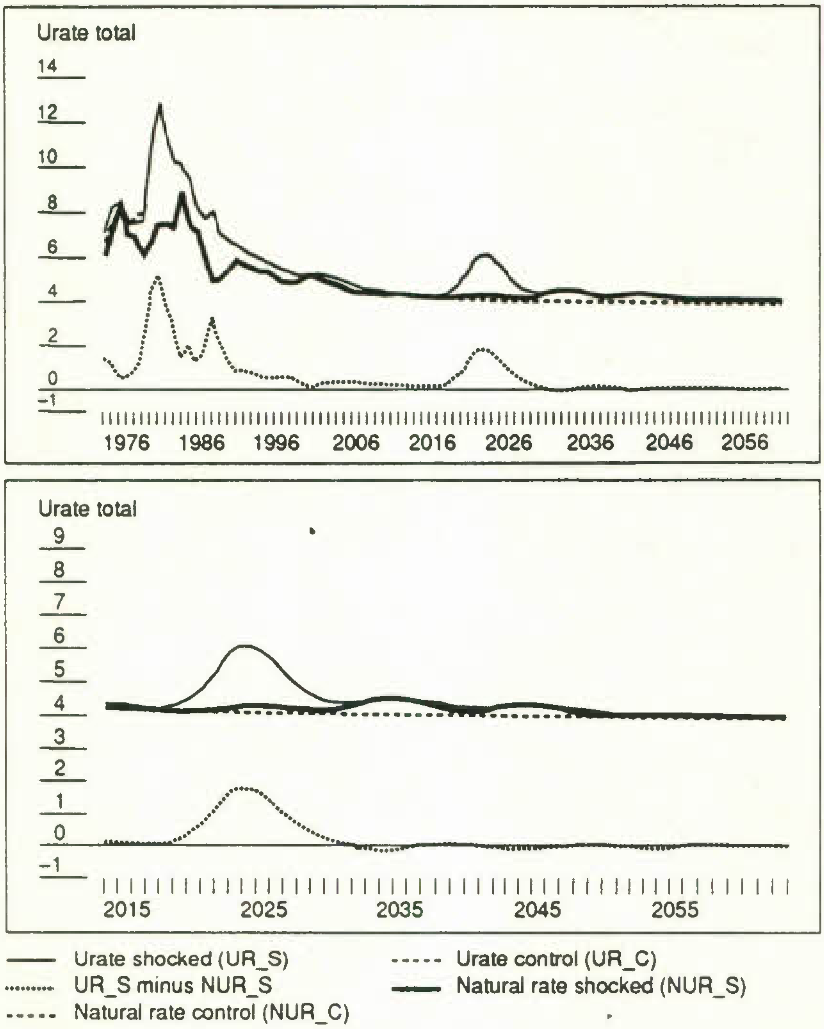
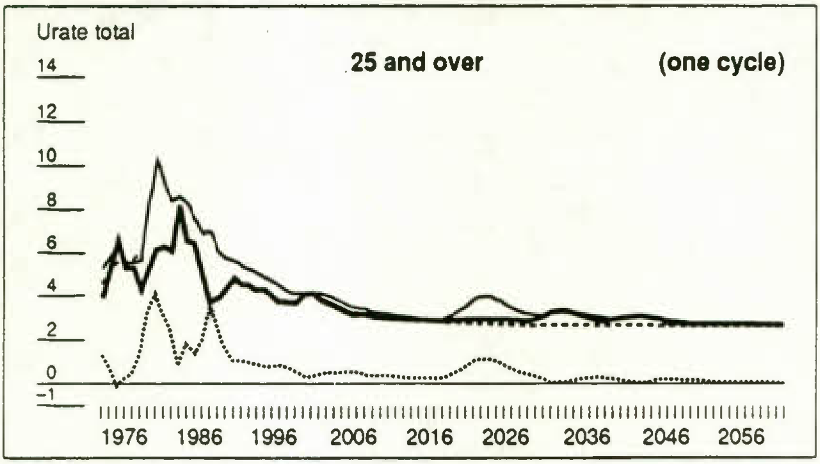
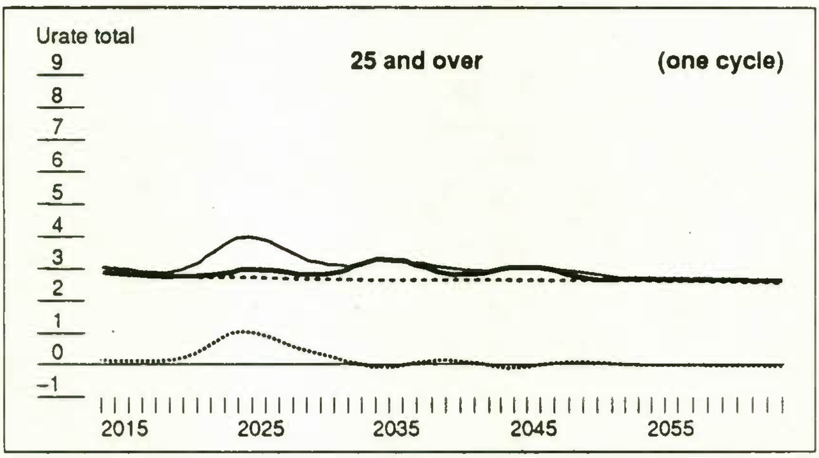


Figure 12b (cont' d.)





—— Urate shocked (UR_S)
········ UR_S minus NUR_S
- - - - Natural rate control (NUR_C)
----- Urate control (UR_C)
▬▬ Natural rate shocked (NUR_S)

Figure 13a
Shock to capacity utilization (three cycles)

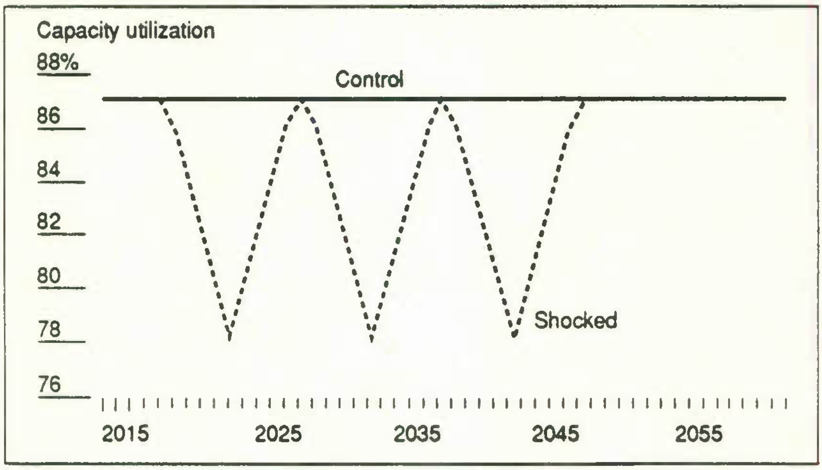


Figure 13b
Hysteresis scarring – Shock to utilization rate (three cycles)

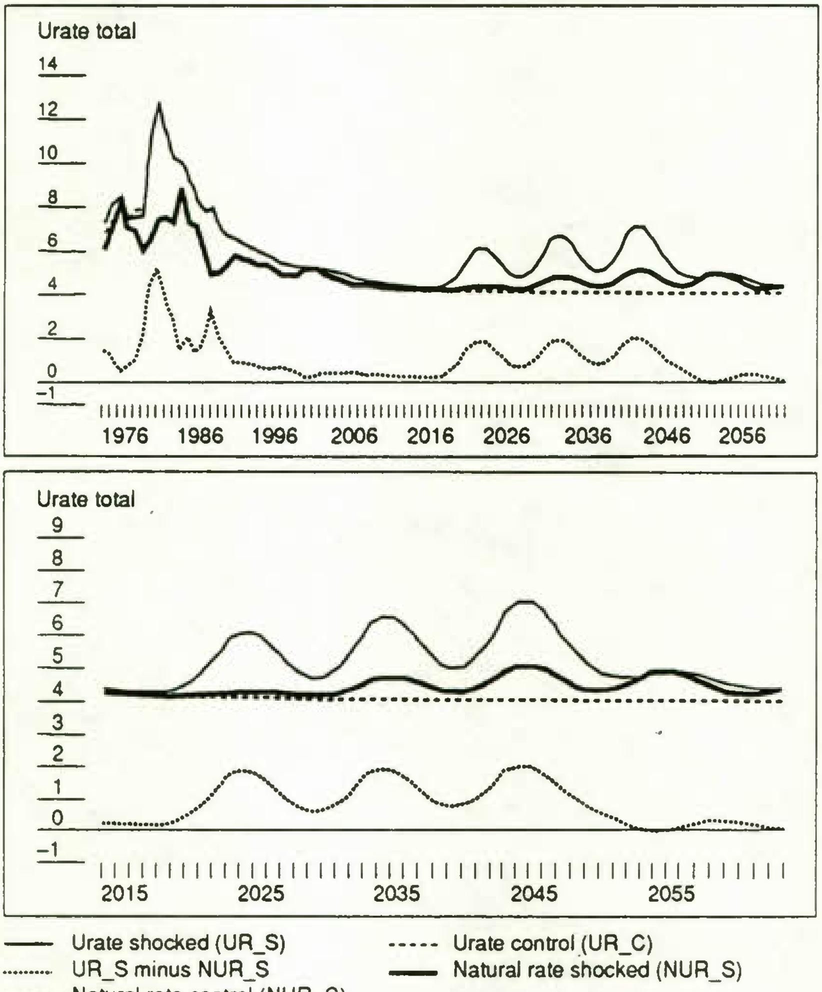
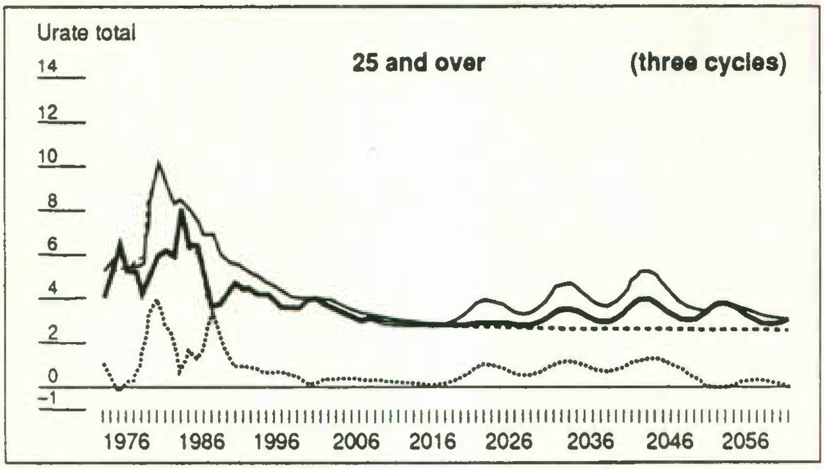
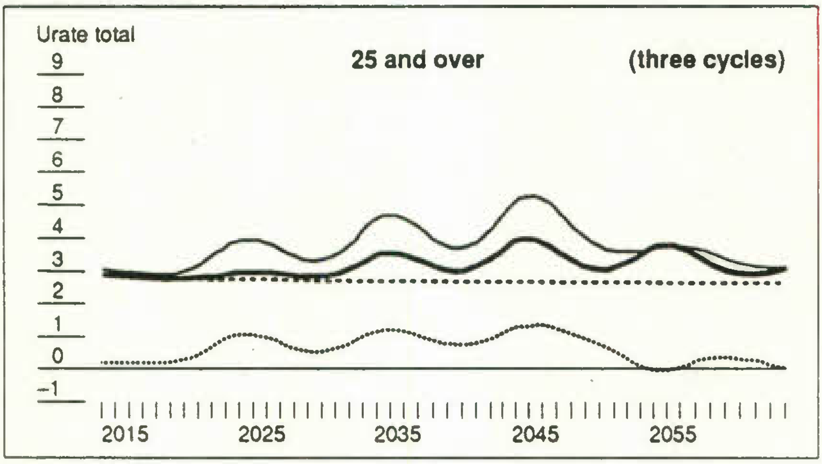


Figure 13b (cont' d.)





Urate shocked (UR_S)
UR_S minus NUR_S
Natural rate control (NUR_C)
Urate control (UR_C)
Natural rate shocked (NUR_S)

Figure 14a
Shock to youth unemployment, males and females 15 to 24 (one cycle)

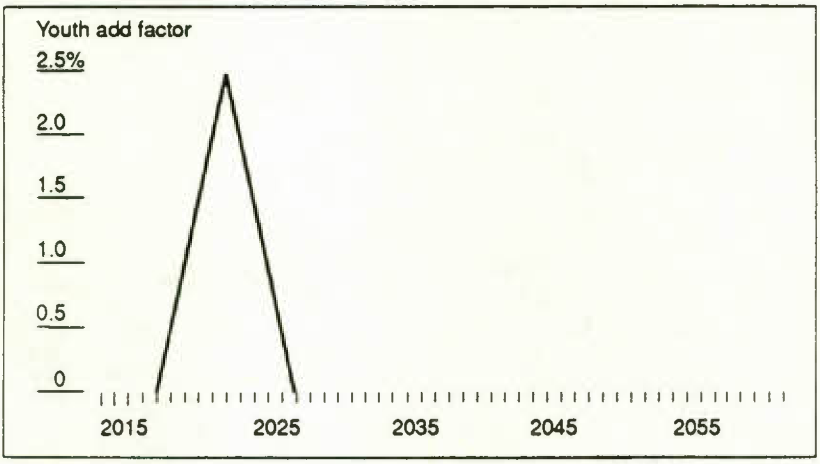


Figure 14b
Hysteresis scarring – Shock to youth unemployment (one cycle)

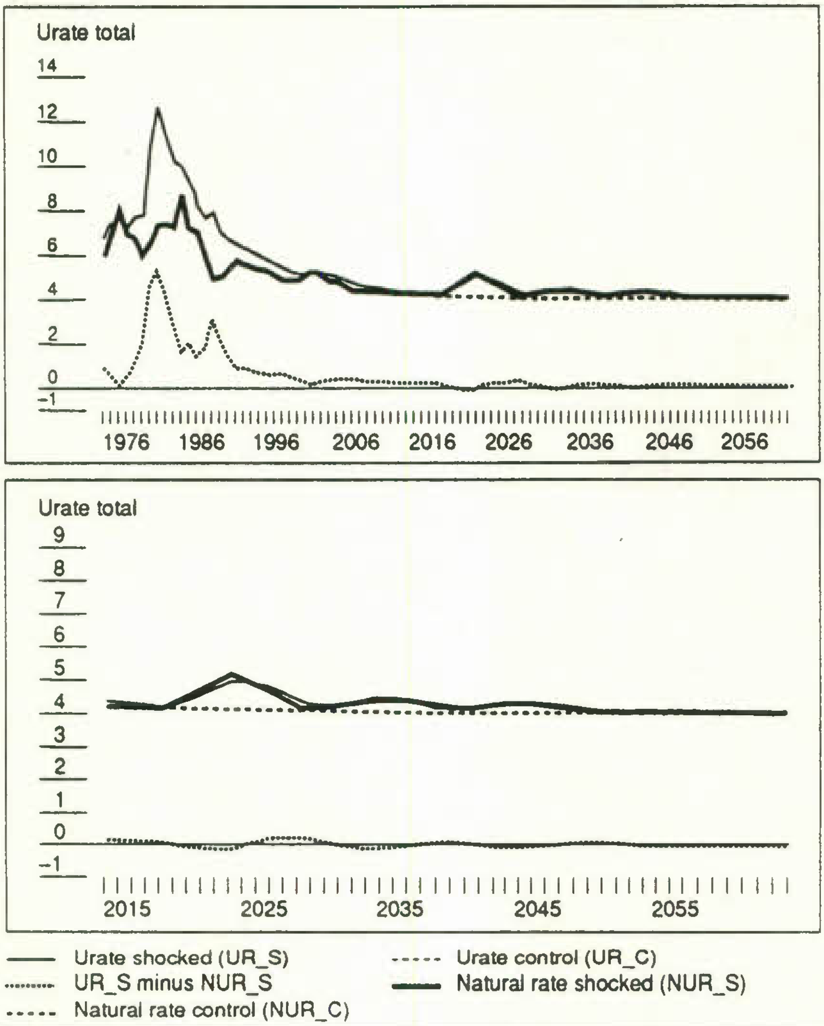
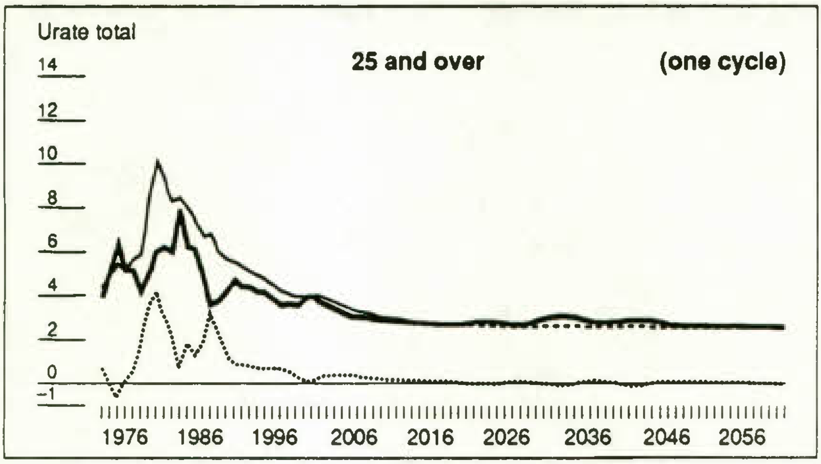
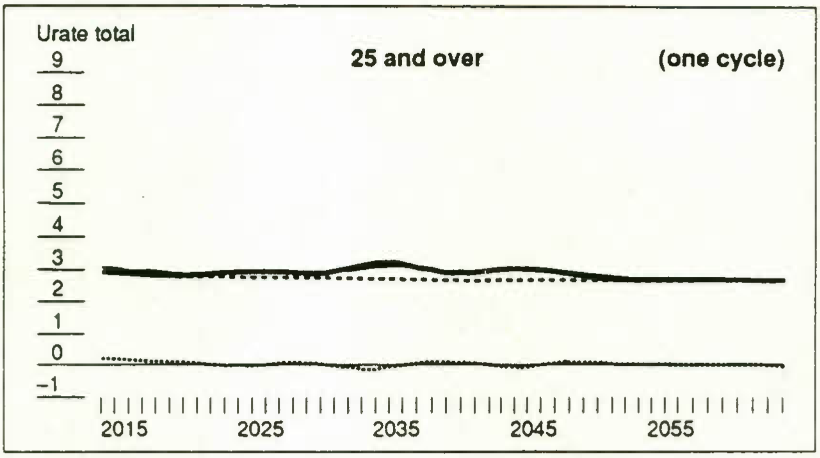


Figure 14b (cont' d.)





—— Urate shocked (UR_S)
----- Urate control (UR_C)
.... UR_S minus NUR_S
▬▬ Natural rate shocked (NUR_S)
----- Natural rate control (NUR_C)

Figure 15a
Shock to youth unemployment, males and females 15 to 24 (three cycles)

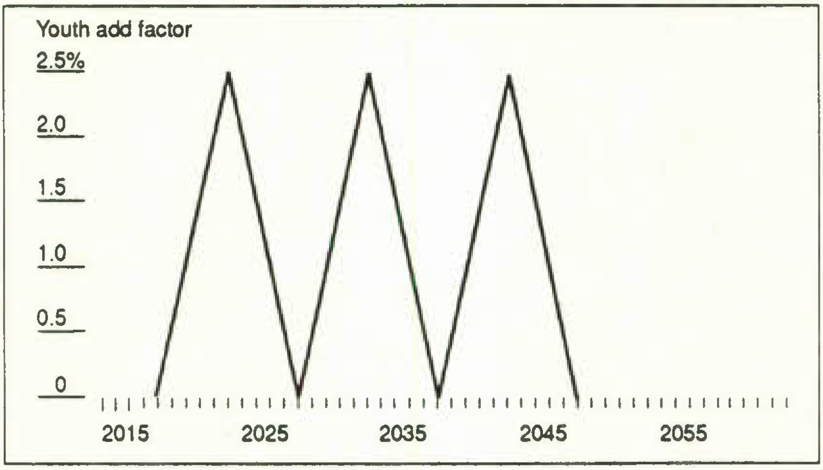


Figure 15b

Hysteresis scarring – Shock to youth unemployment (three cycles)

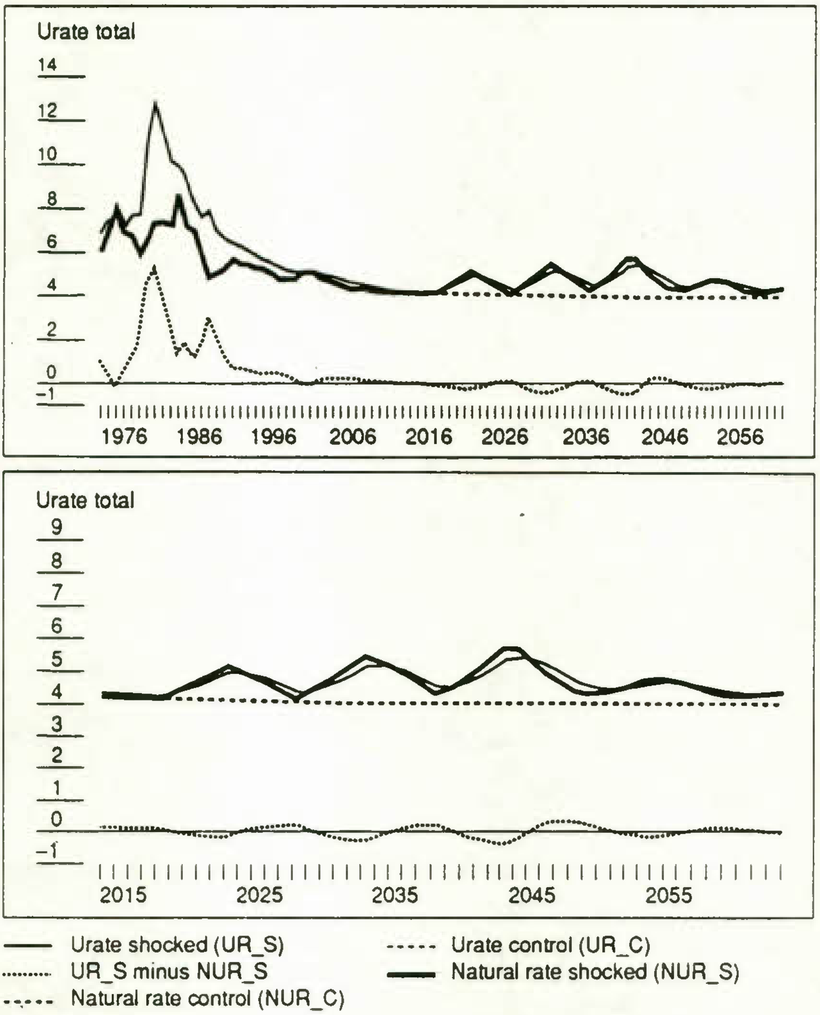
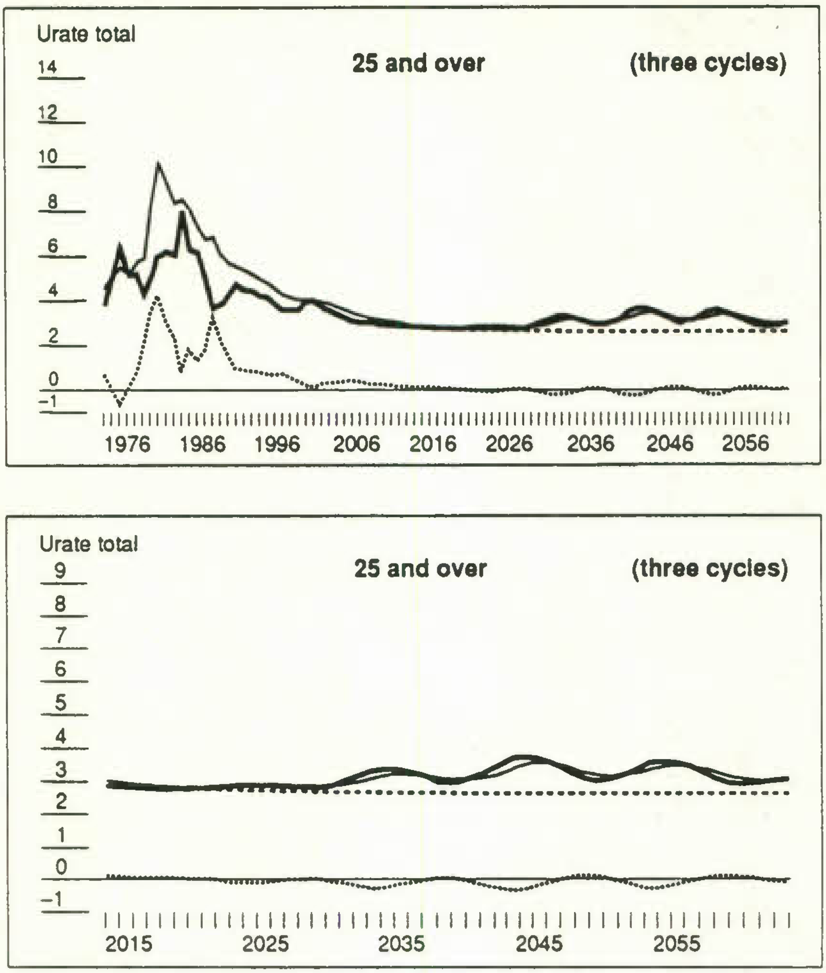


Figure 15b (cont' d.)



Urate shocked (UR_S) ----- Urate control (UR_C)
UR_S minus NUR_S — Natural rate shocked (NUR_S)
----- Natural rate control (NUR_C)

Figure 16a
Shock to youth unemployment (permanent)

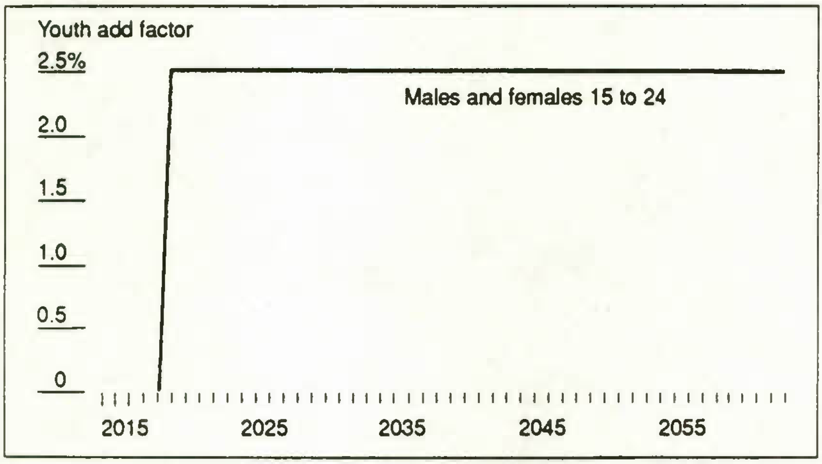


Figure 16b
Hysteresis scarring – Shock to youth unemployment (permanent)

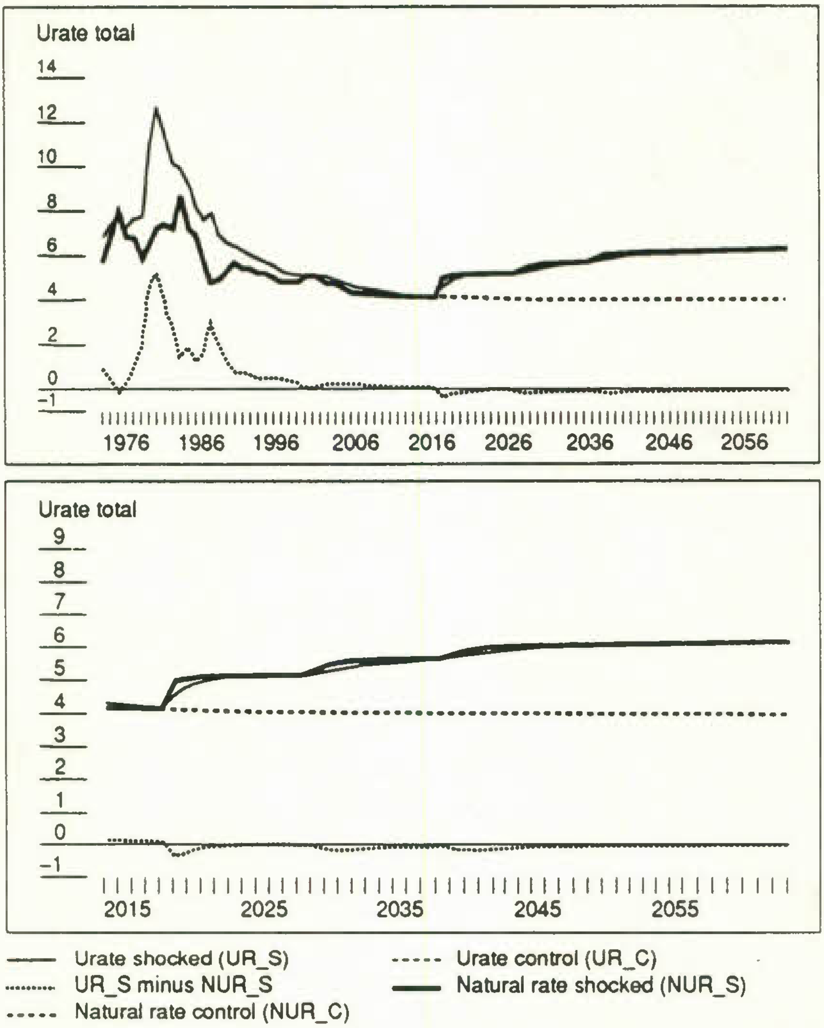
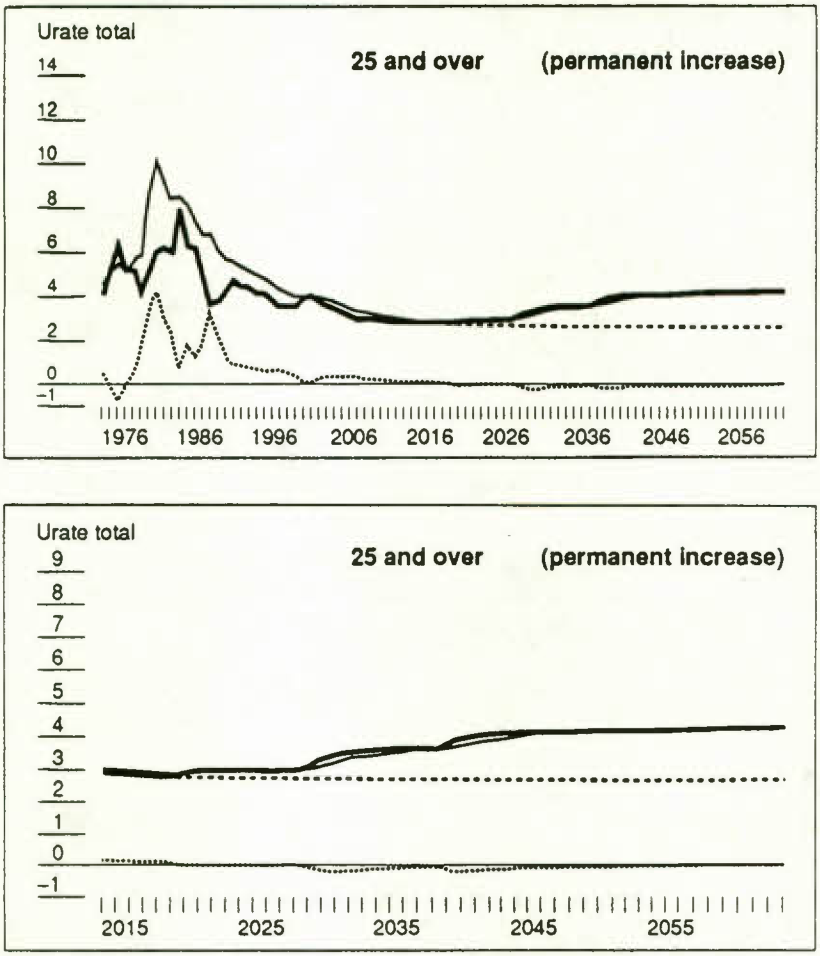


Figure 16b (cont' d.)



—— Urate shocked (UR_S) ----- Urate control (UR_C)
.... UR_S minus NUR_S ▬▬ Natural rate shocked (NUR_S)
- - - - Natural rate control (NUR_C)

Figure 17a
Shock to utilization, structural and youth (one cycle)

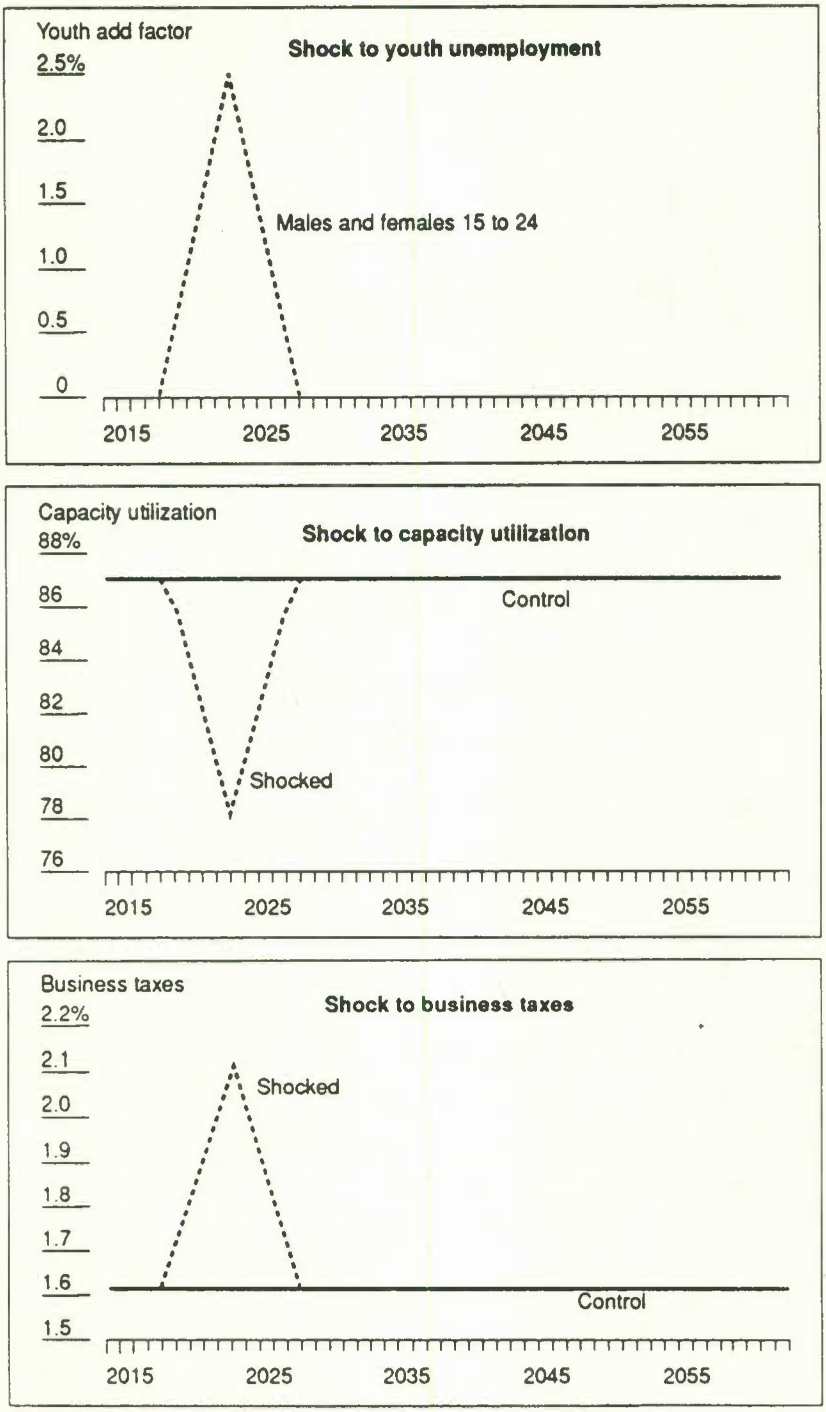
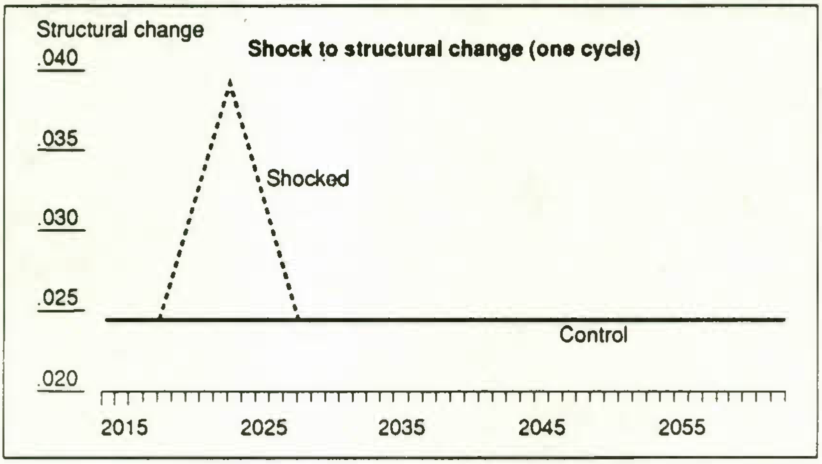
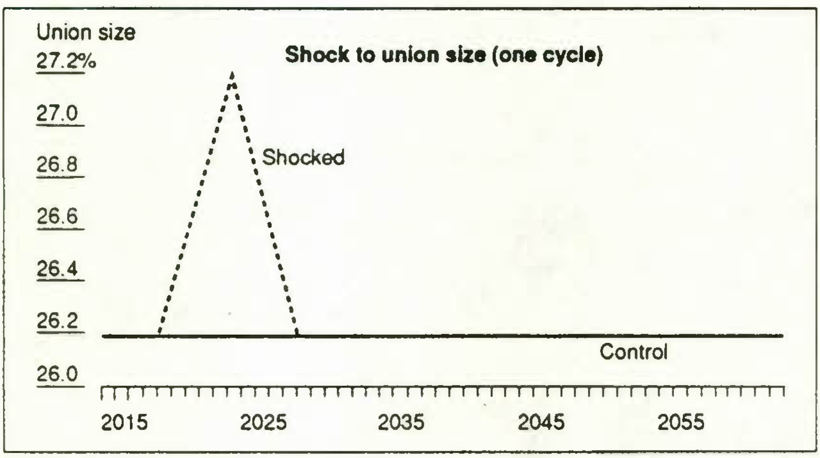


Figure 17a (cont'd.)





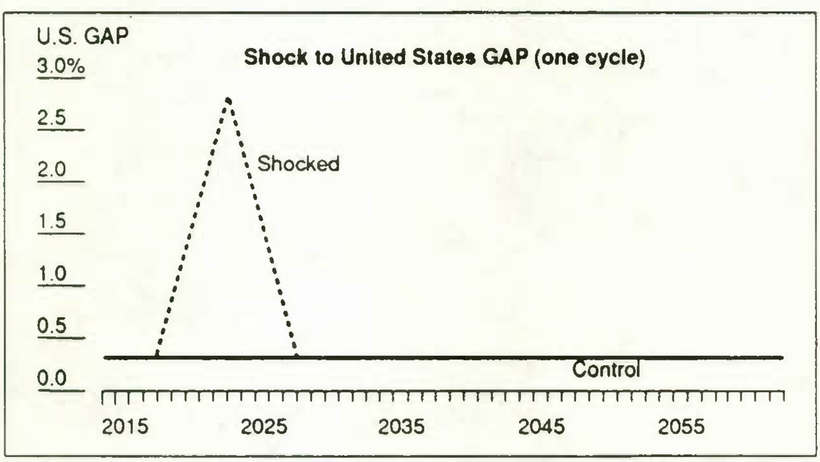


Figure 17a (cont'd.)

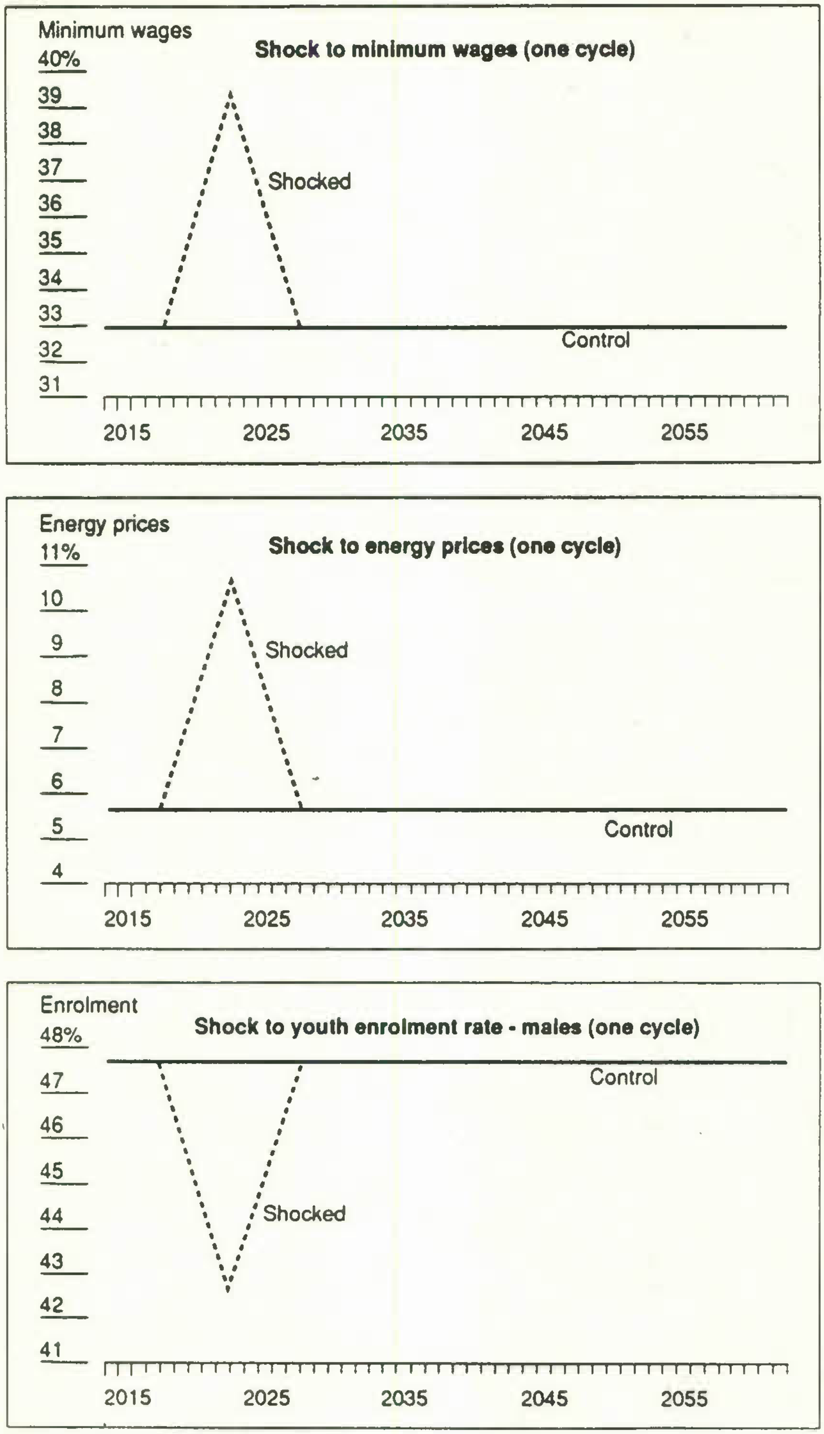


Figure 17a (concl'd.)

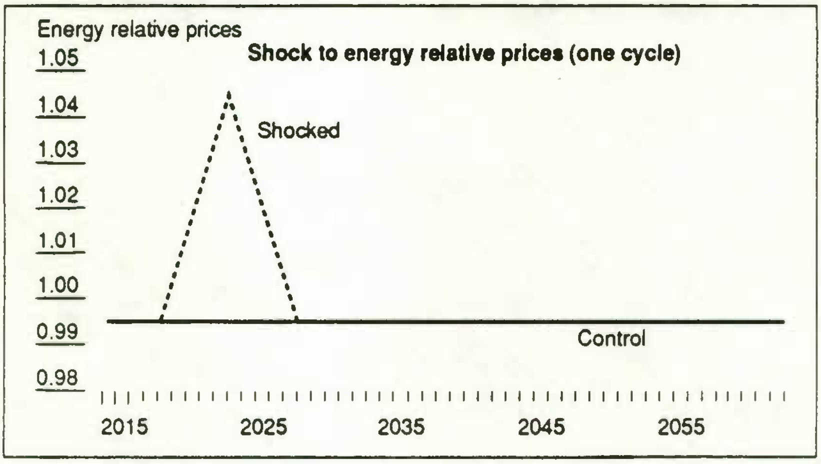
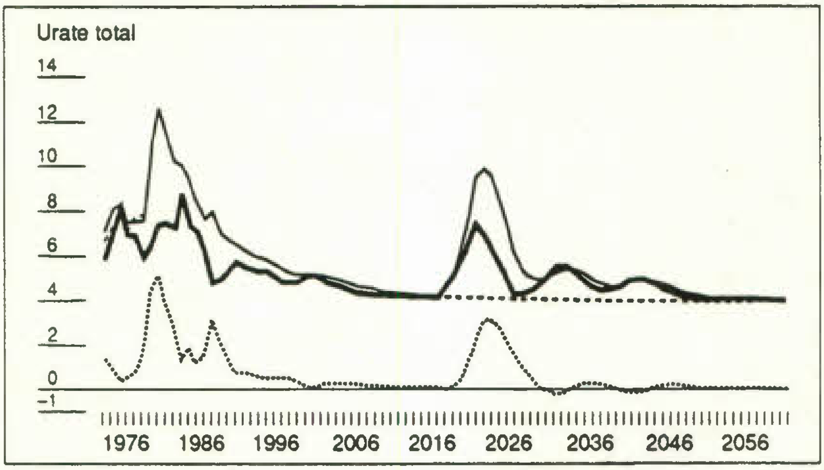
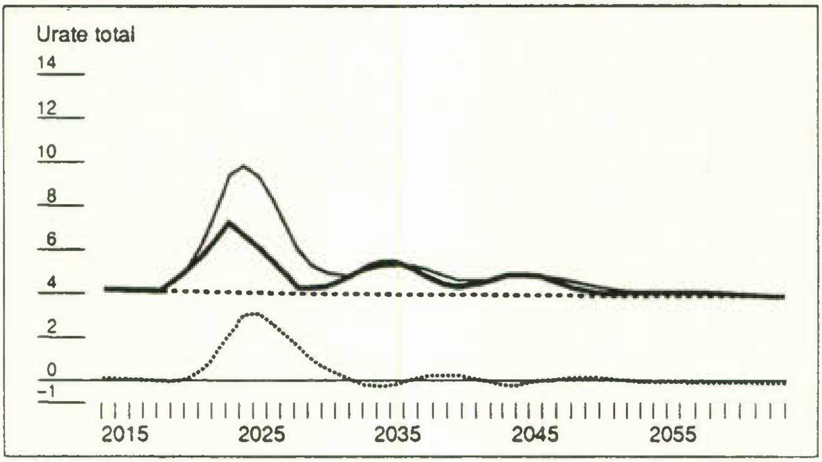


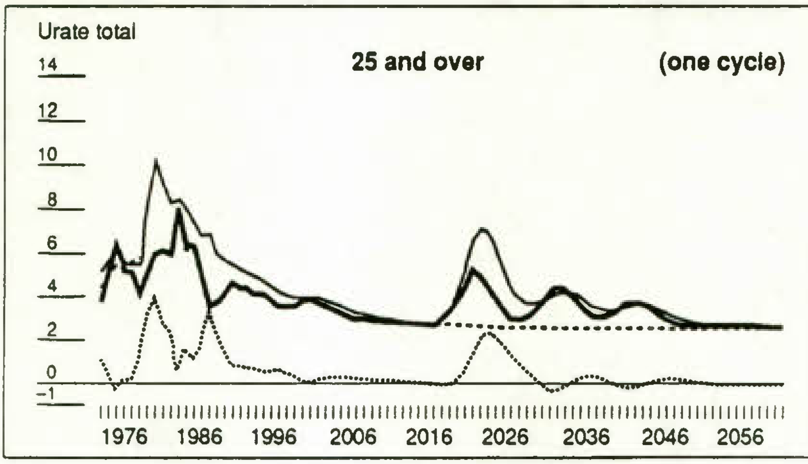
Figure 17b
Hysteresis scarring – Shock to utilization, structural and youth (one cycle)

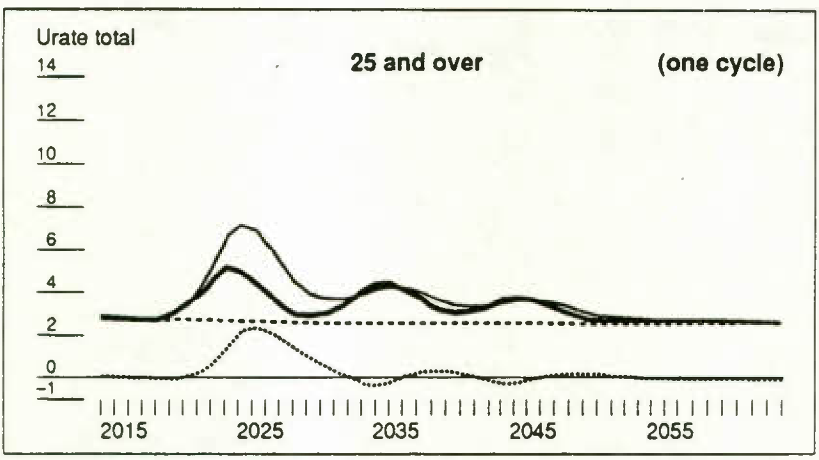




Urate shocked (UR_S)
UR_S minus NUR_S
Natural rate control (NUR_C)
Urate control (UR_C)
Natural rate shocked (NUR_S)

Figure 17b (cont' d.)





—— Urate shocked (UR_S)
.... UR_S minus NUR_S
----- Natural rate control (NUR_C)
----- Urate control (UR_C)
▬▬ Natural rate shocked (NUR_S)

Figure 18a
Shock to utilization, structural and youth (three cycles)

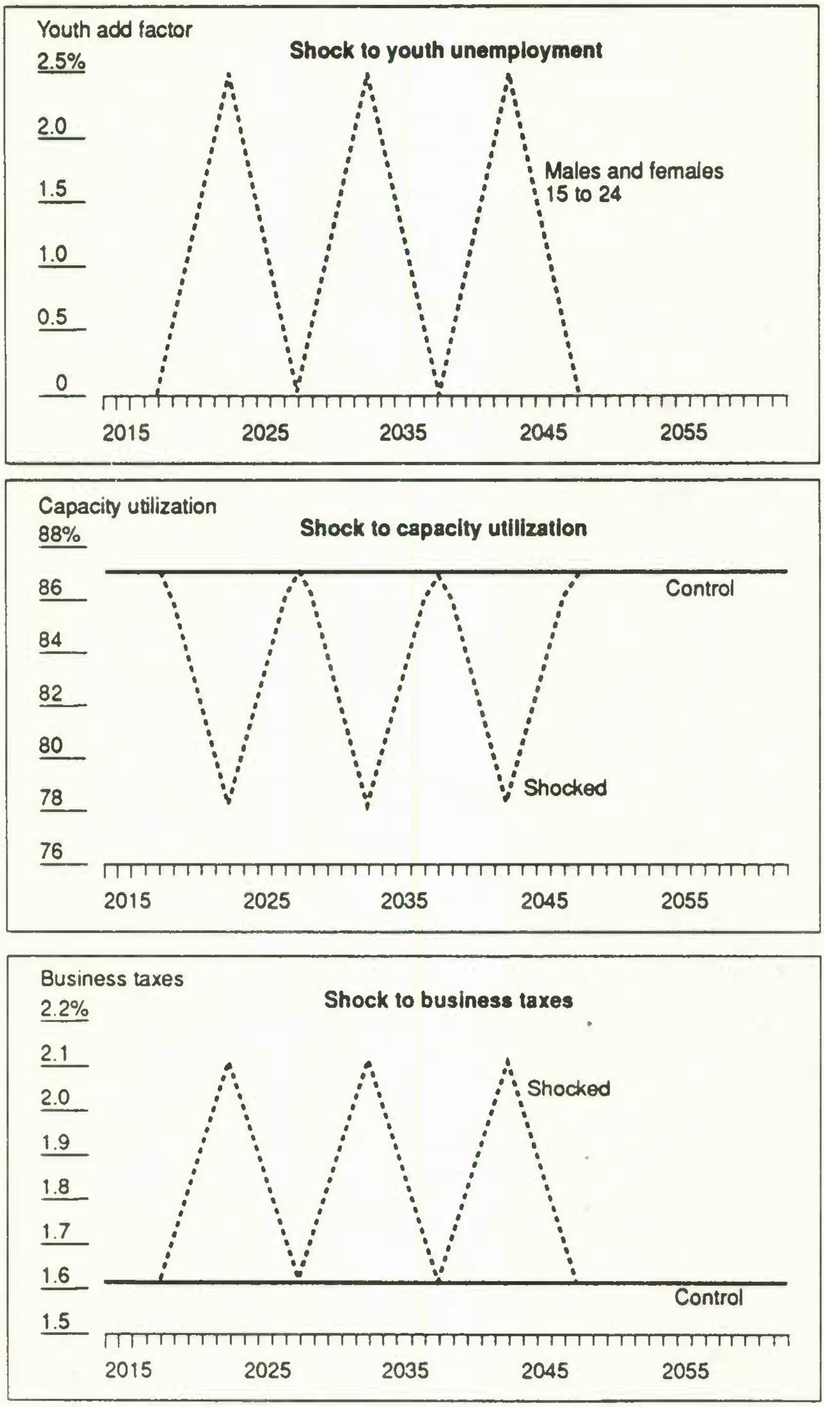
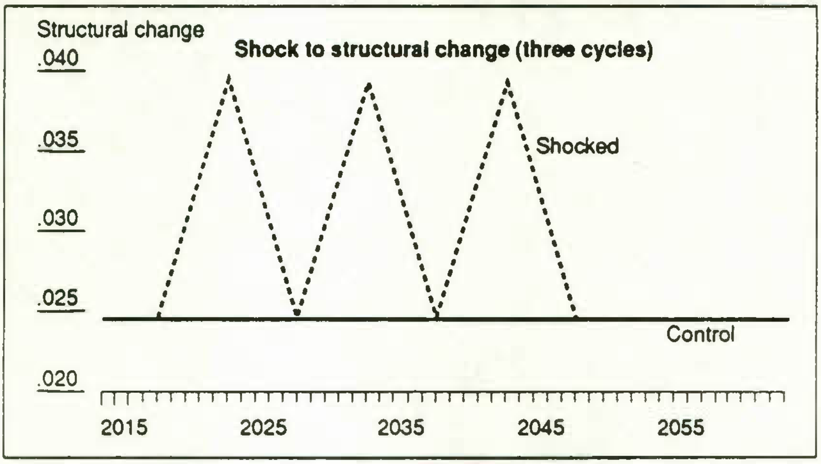
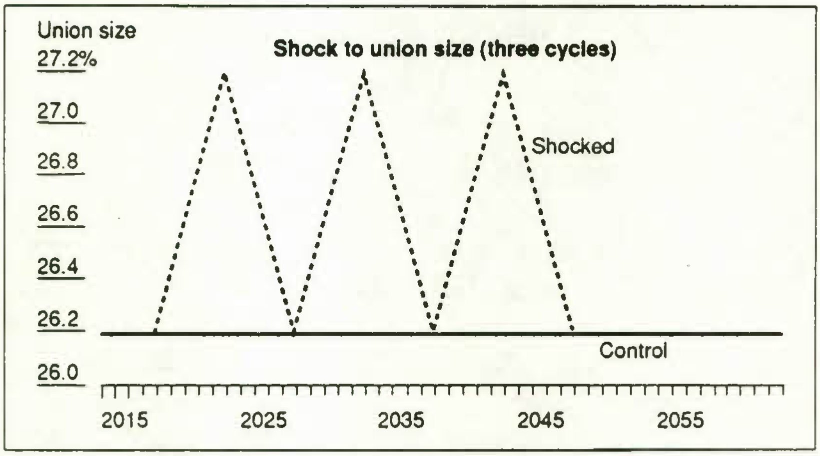


Figure 18a (cont'd.)





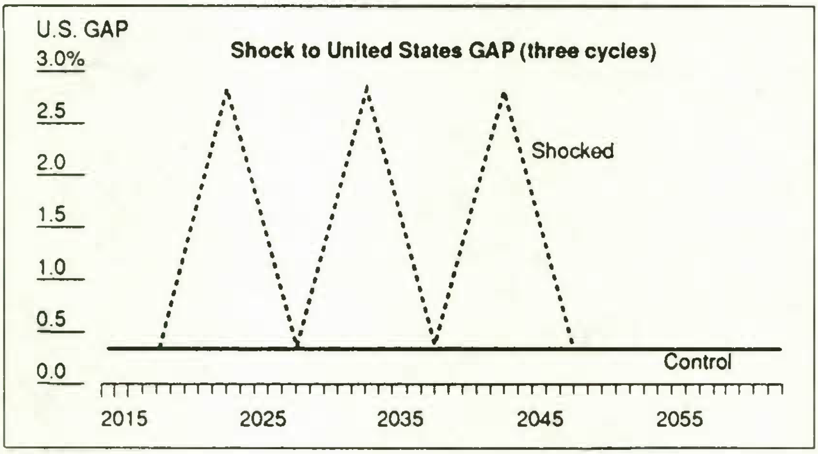


Figure 18a (cont'd.)

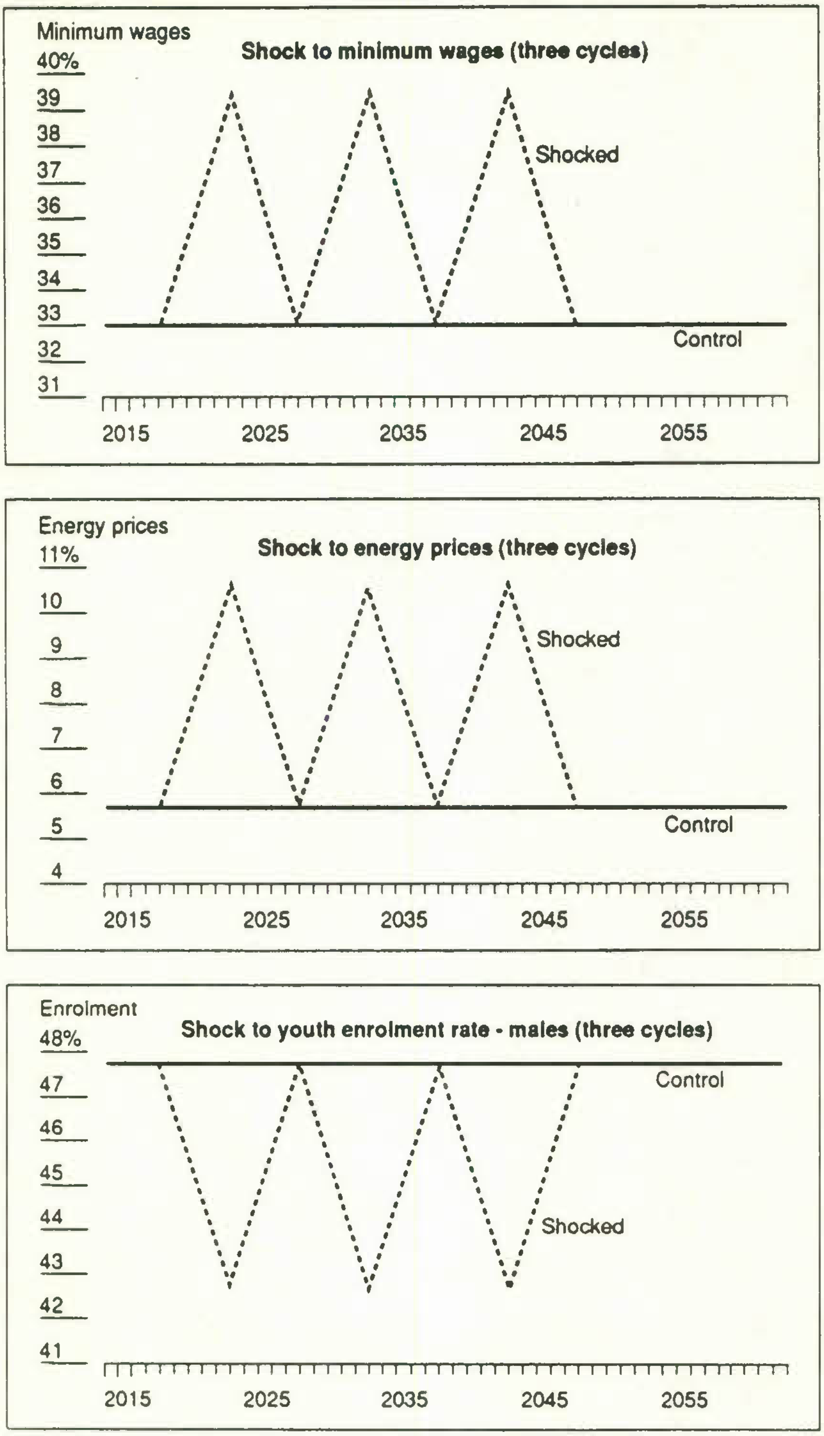


Figure 18a (concl'd.)

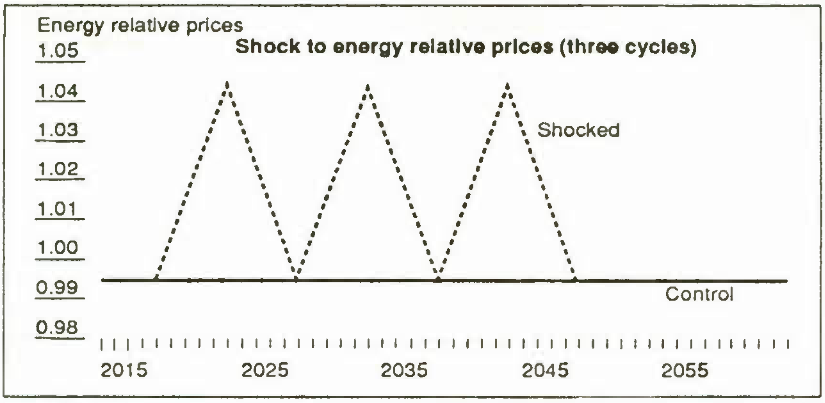
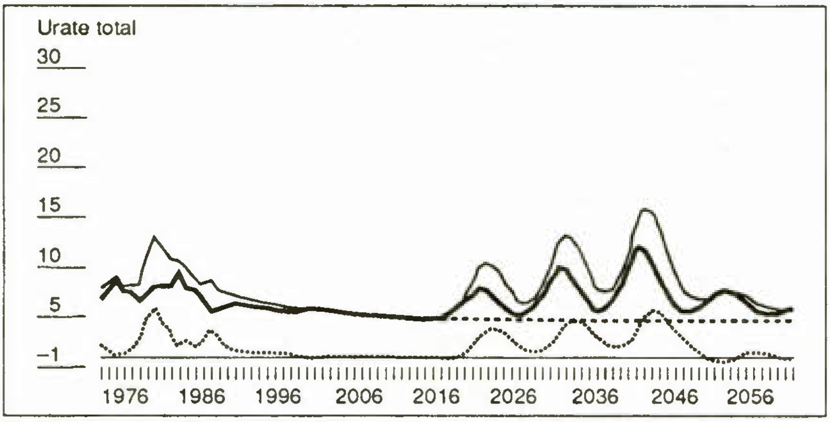
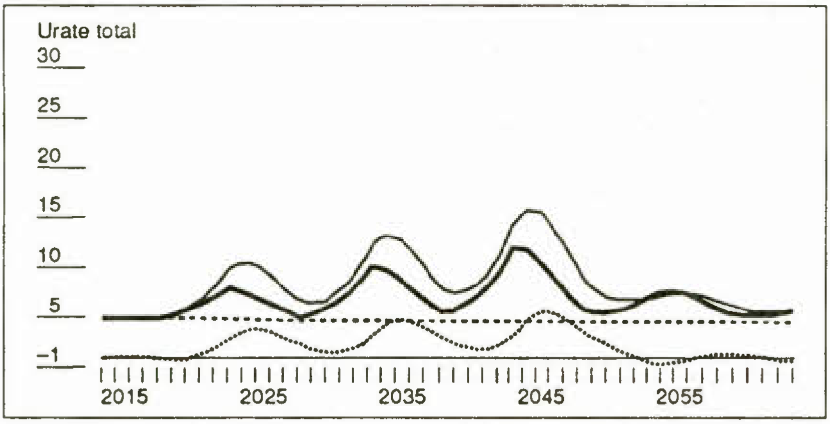


Figure 18b

Hysteresis scarring – Shock to utilization, structural and youth (three cycles)





Urate shocked (UR_S) ----- Urate control (UR_C)

UR_S minus NUR_S Natural rate shocked (NUR_S)

Natural rate control (NUR_C)

Figure 18b (cont'd.)

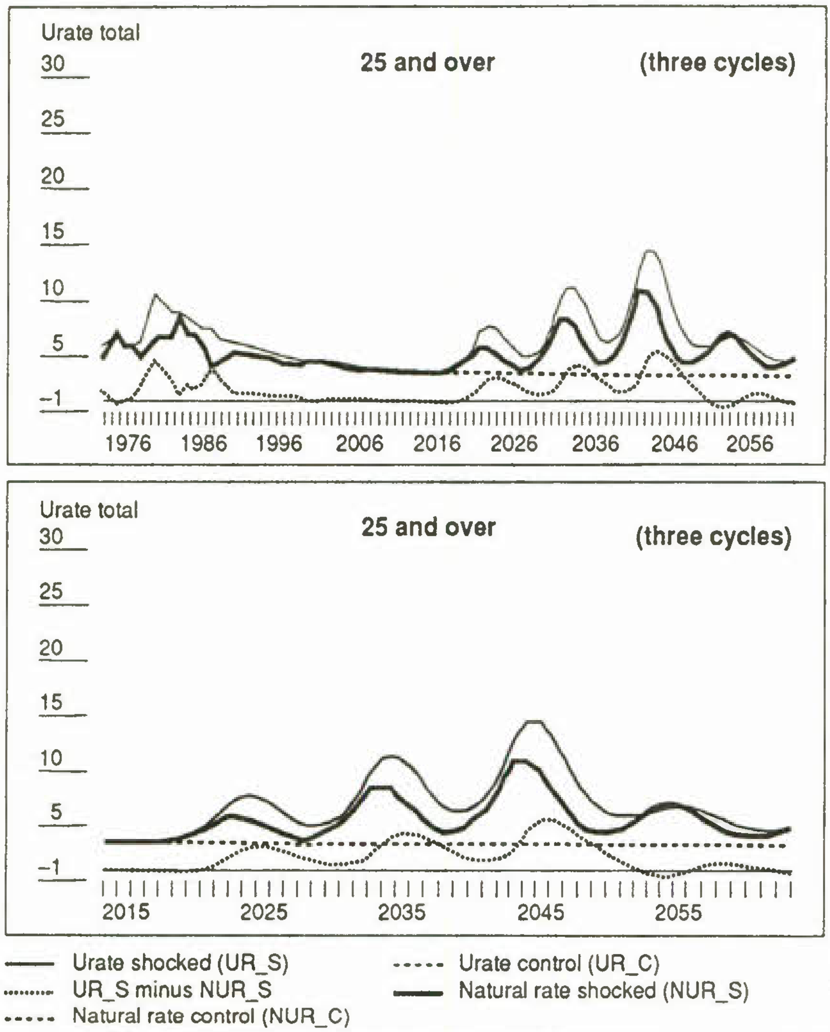


Figure 19a
Shock to utilization, structural (three cycles) and youth (permanent)

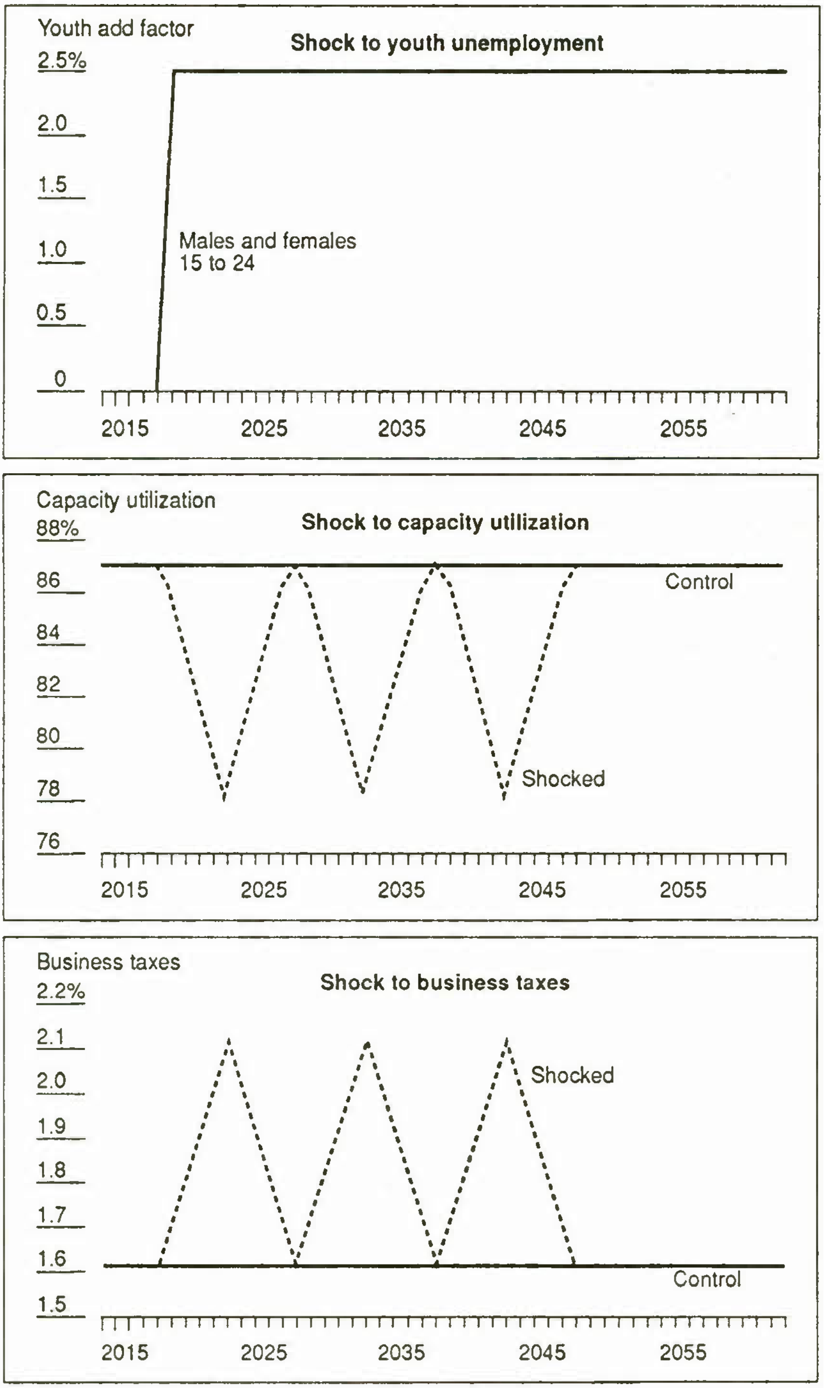


Figure 19a (cont'd.)

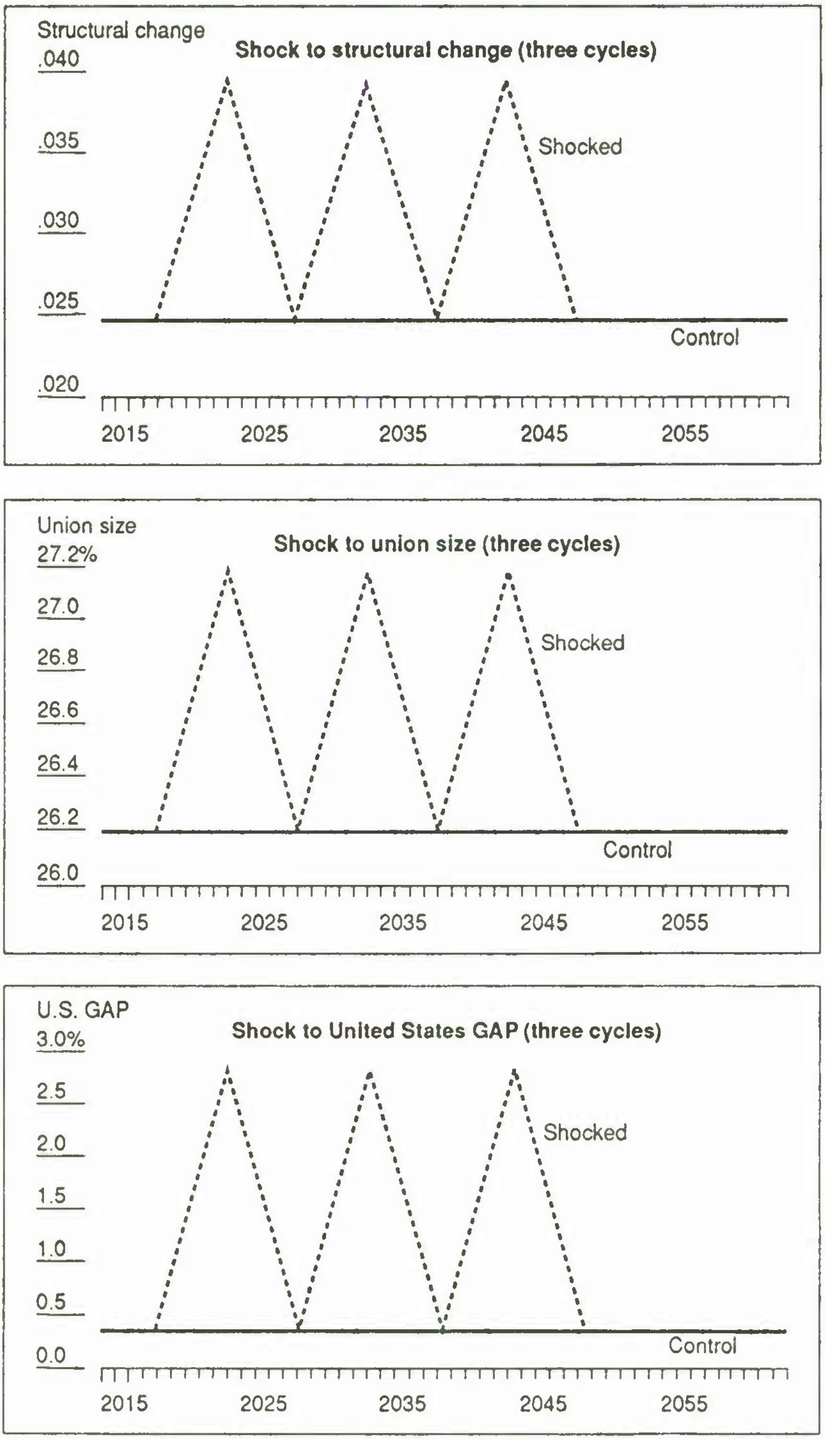


Figure 19A (cont'd.)

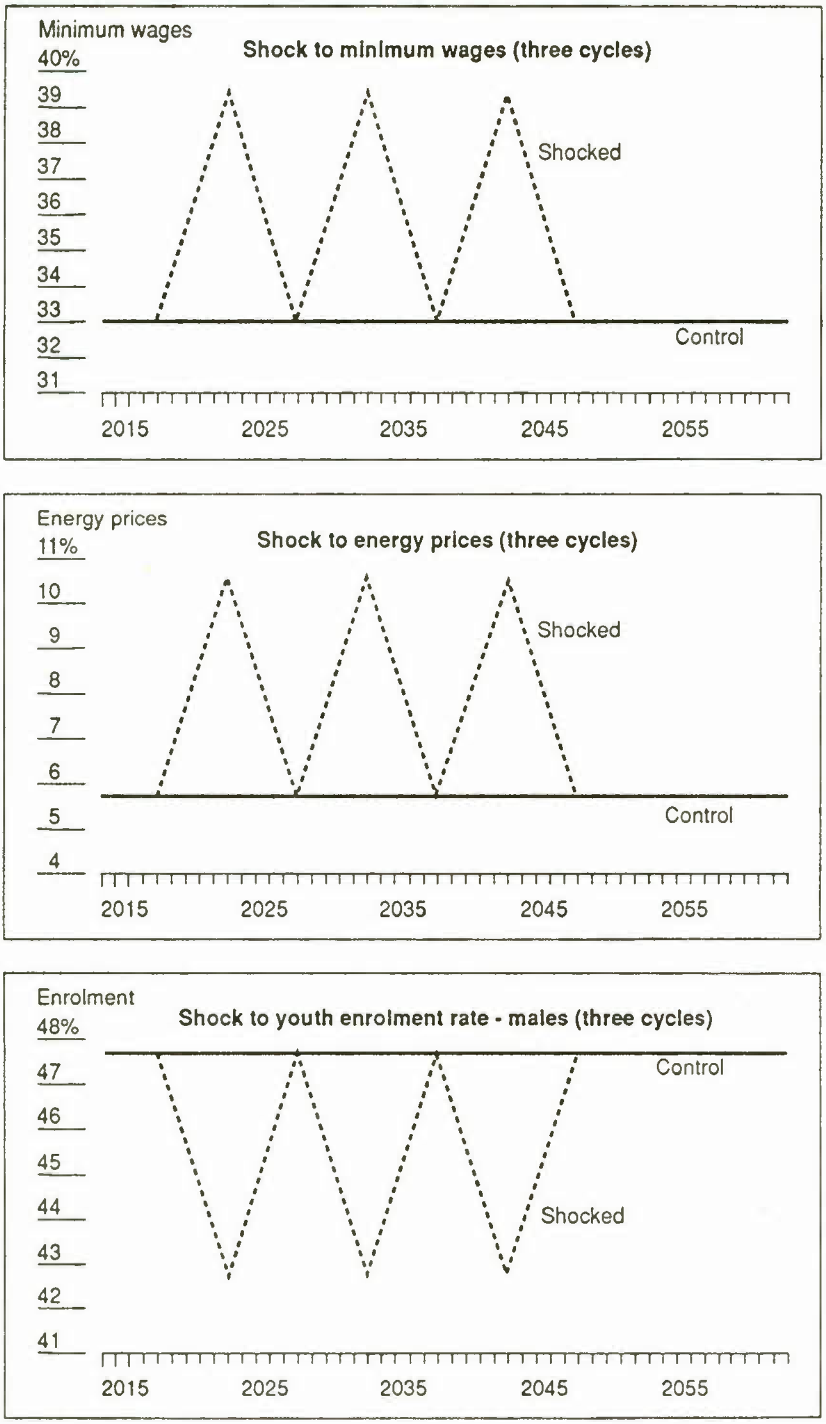


Figure 19a (concl'd.)

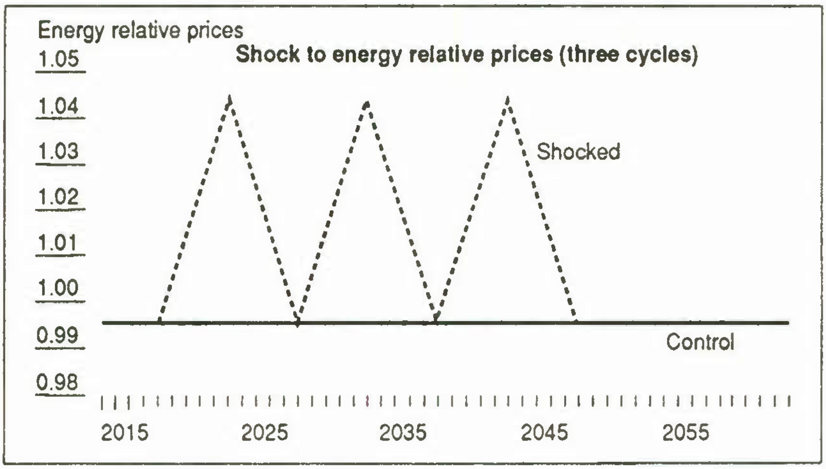


Figure 19b

Hysteresis scarring – Shock to utilization, structural (three cycles) and youth (permanent)

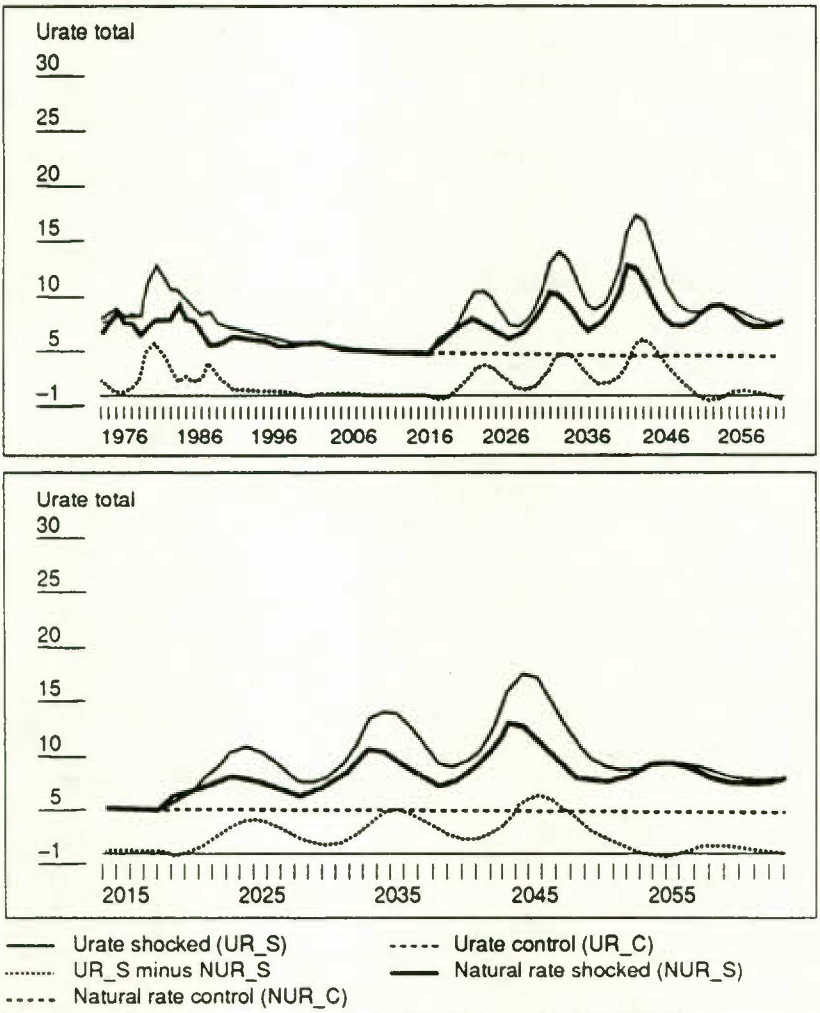
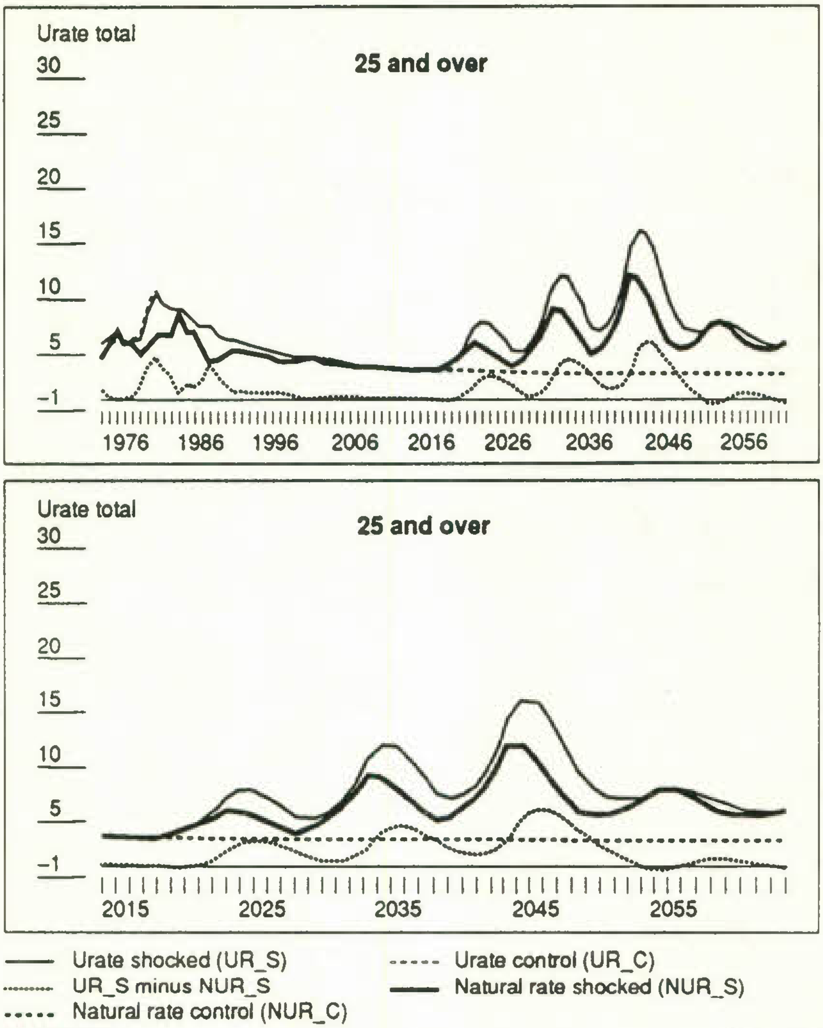


Figure 19b (cont'd.)



Appendices

A Aggregate Natural Rate Model

The aggregate natural rate model can be derived as follows. Let

$u(i)$ = unemployment rate for the ith cohort,
CUR = cyclical variable,
$c(i)$ = constant for the ith cohort,
α = coefficient on CUR,
β = coefficient on $u(i-1)_{-1}$,
ε = coefficient on $u(1)_{-i+1}$,
λ = coefficient on $u(i)_{-1}$ or speed on adjustment.

By aggregating (6) in the text across cohorts we obtain,

$$\sum_{i=1}^{41} u(i) = c(1) + \alpha\, CUR + \lambda \left[\sum_{i=2}^{41} c(i) + \beta \sum_{i=2}^{41} u(i-1)_{-1} \right.$$
$$\left. + \ \varepsilon \sum_{i=2}^{41} u(1)_{-i+1} + \alpha \sum_{i=2}^{41} CUR \right] + (1-\lambda) \left[\sum_{i=2}^{41} u(i)_{-1} \right]. \tag{A.1}$$

$$\sum_{i=1}^{41} u(i) = c(1) + \lambda \sum_{i=2}^{41} c(i) + \alpha\, CUR + \lambda\, \alpha \sum_{i=2}^{41} CUR$$
$$+ \lambda \left[\beta \sum_{i=2}^{41} u(i-1)_{-1} + \varepsilon \sum_{i=2}^{41} u(1)_{-1+1} \right] \tag{A.2}$$
$$+ (1-\lambda) \sum_{i=2}^{41} u(i)_{-1}.$$

$$\sum_{i=1}^{41} u(i) = \left[c(1) - \lambda\, c(1) + \lambda \sum_{i=1}^{41} c(i) \right] + \alpha\, CUR + 40\, \lambda\, \alpha\, CUR$$
$$+ \lambda\, \beta \sum_{i=2}^{41} u(i-1)_{-1} + (1-\lambda) \sum_{i=2}^{41} u(i)_{-1} + \varepsilon\, \lambda \sum_{i=2}^{41} u(1)_{-i+1}. \tag{A.3}$$

$$\sum_{i=1}^{41} u(i) = c^* + (\alpha + 40\,\alpha\,\lambda)\,CUR + \lambda\,\beta\,u(41)_{-1}$$

$$-\ \lambda\,\beta\,u(41)_{-1} + \lambda\,\beta \sum_{i=1}^{40} u(i)_{-1} + (1-\lambda) \sum_{i=2}^{41} u(i)_{-1} \qquad \text{(A.4)}$$

$$+ (1-\lambda)\,u(1)_{-1} - (1-\lambda)\,u(1)_{-1} + \varepsilon\,\lambda \sum_{i=2}^{41} u(1)_{-i+1}.$$

$$\sum_{i=1}^{41} = c^* + a^*\,CUR + \lambda\,\beta \sum_{i=1}^{41} u(i)_{-1} + (1-\lambda) \sum_{i=1}^{41} u(i)_{-1}$$

$$+ \varepsilon\,\lambda \sum_{i=2}^{41} u(1)_{-i+1} - \lambda\,\beta\,u(41)_{-1} - (1-\lambda)\,u(1)_{-1}. \qquad \text{(A.5)}$$

$$\sum_{i=1}^{41} u(i) = c^* + a^*\,CUR + b^* \sum_{i=1}^{41} u(i)_{-1}$$

$$+ \varepsilon\,\lambda \sum_{i=2}^{41} u(1)_{-i+1} - \lambda\,\beta\,u(41)_{-1} - (1-\lambda)\,u(1)_{-1}. \qquad \text{(A.6)}$$

$$\frac{1}{41} \sum_{i=1}^{41} u(i) = \frac{c^*}{41} + \frac{a^*}{41}\,CUR + \frac{b^*}{41} \sum_{i=1}^{41} u(i)_{-1}$$

$$+ \frac{\varepsilon\lambda}{41} \sum_{i=2}^{41} u(1)_{-i+1} - \frac{\lambda\beta}{41}\,u(41)_{-1} - \frac{(1-\lambda)}{41}\,u(1)_{-1} \qquad \text{(A.7)}$$

where $a^* = (\alpha + 40\,\alpha\,\lambda)$

$$b^* = \lambda\,\beta + 1 - \lambda$$

$$c^* = \left[(c(1) - \lambda\,c(1)) + \lambda \sum_{i=1}^{41} c(i) \right].$$

This equation can be simply written as:

$$u = constant + [(\alpha + 40\,\alpha\,\lambda)/41]\,CUR$$

$$+ [(\lambda\,\beta + 1 - \lambda)/41]\,u_{-1} + [\varepsilon\,\lambda/41]\sum_{i=2}^{n} u(1)_{-i+1} \quad \text{(A.8)}$$

$$- [\lambda\,\beta/41]\,u(41)_{-1} - [(1-\lambda)/41]\,u(1)_{-1}.$$

For $u = u_{-1} = u^{*}$, we have

$$u^{*} = constant^{*} + [(\alpha + 40\,\alpha\,\lambda)]\,[(\lambda\,\beta + 1 - \lambda)]^{-1}\,CUR$$

$$+ [\varepsilon\,\lambda]\,[(\lambda\,\beta + 1 - \lambda)]^{-1}\sum_{i=2}^{n} u(1)_{-i+1}$$

$$- [\lambda\,\beta]\,[(\lambda\,\beta + 1 - \lambda)]^{-1}\,u(41)_{-1} \quad \text{(A.9)}$$

$$- [(1-\lambda)]\,[(\lambda\,\beta + 1 - \lambda)]^{-1}\,u(1)_{-1}.$$

Now the coefficient on $\sum_{i=2}^{u} (u(1))_{-i+1}$ is equal to $[\varepsilon\,\lambda]\,[\lambda\,\beta + 1 - \lambda]^{-1}$.

For $\lambda = 0.7$ and $\beta = 0.35$, we have

$(\varepsilon \times 0.7)/(0.7 \times 0.35 + 1 - 0.7)$

$(\varepsilon \times 0.7)/(0.54)$

$\varepsilon \times 1.296$.

In the example in the text for $\varepsilon = 1$ the elasticity of the natural rate with respect to $u(1)_{-i+1}$ for any i is 1.296. Now if $\beta = 0.15$, $\varepsilon = 0.50$, $\lambda = 0.5$, this elasticity falls to $0.50 \times 0.50/(0.5 \times 0.15 + 1 - 0.5) = 0.434$.

Thus, a reasonably high elasticity of u^{*} with respect to $u(1)_{-i+1}$ can result from plausible values for λ, β, and ε. What is important is that to ensure hysteresis all that is needed is $\varepsilon > 0$. Under these circumstances, u^{*} will increase permanently in the sense that the *effect dies only when the cohort dies* (or retires).

B Age Group Composite Variable

The age group composite variable is a key right-hand-side variable in the aggregate natural rate model set out in Appendix A. The theory indicates that a weighted average of entry group unemployment rates, where the average spans the working life of the members of the labour force and weights are the percentage distribution of the labour force across age groups, is the correct way to compute this variable. Thus,

$$(cohort\ composite)_t = \sum_{i=2}^{n} w(i)_t \ u(1)_{-i+1}$$

where n is the number of age groups, $w(i)_t$ are the weights, and $u(1)_{-i+1}$ is the entry cohort unemployment rate in period $-i + 1$. Given the breakdown available from the Labour Force Survey, it is impossible to make such a computation. Nevertheless, we can develop a proxy by partitioning the procedure as follows.

The Labour Force Survey contains the breakdown set out in Table 1. Consider the 25-to-34 year olds. The entry age group for this group are the 15-to-24 year olds. In fact, the later lagged 10 years contains those who are 25 to 34 today, lagged five years it contains some of them, and lagged one year it contains a few – those who were 24 years old last year. Thus, for cohorts that span 10 years in the Labour Force Survey, the 25-to-34 year olds, we define the age group composite variable as:

$$\text{age group composite (25 to 34)} = w_1\, u\,(15 \text{ to } 24)_{-1} + w_2\, u\,(15 \text{ to } 24)_{-5} + w_3\, u\,(15 \text{ to } 24)_{-10}$$

where $w_1 + w_2 + w_3 = 1$.

This definition is used for both males and females in the following cohorts:

(1) 25 to 34 focus on 15 to 24 (lag 1, 5, 10)

(2) 55 to 64 focus on 45 to 54 (lag 1, 5, 10)

(3) 65 and up focus on 55 to 64 (lag 1, 5, 10).

The choice of w_1, w_2, and w_3 is explained in the text in the section dealing with the estimation of the model. The least appropriate cohort for this method of partitioning is that of 65 and up, as there may be some 76-year-olds still working and thus the possibility does exist that they might experience unemployment. Nevertheless, this possibility is small.

The two larger groups, those 25 to 44 and 45 to 64 require an additional step. For these two cases, a moving average of labour market conditions is formed for the previous age group. In the case of 25-to-44 year olds this moving average is:

$$LMC(15-24)_t = \frac{\mathit{number\ of\ unemployed}\,(15-24)_{t-1} + \mathit{number\ of\ unemployed}\,(15-24)_{t-10}}{\mathit{labour\ force}\,(15-24)_{t-1} + \mathit{labour\ force}\,(15-24)_{t-10}}.$$

The age group composite (25 to 44) then becomes

$$w_1\, LMC\,(15\text{-}24)_{t-1}$$

$$+\, w_2\, LMC\,(15\text{-}24)_{t-5}$$

$$+\, w_3\, LMC\,(15\text{-}24)_{t-10}.$$

This same procedure is used for the 45-to-64-year age group. Proceeding in this way we use all information from 1953 to 1990 in the construction of the age group composite variables for the 10 groups that make up the stacked regression under consideration.

C Equations: Dynamic Natural Rate Model

This appendix, which contains the equations of the model, is available from the author who is now with Investment Canada [(613) 995-0465].

Notes

1 Arthur M. Okun, "Upward mobility in a high-pressure economy," *Brookings Papers on Economic Activity* (1), 1973.

2 Henry C. Wallich, "Conservative economic policy," *Yale Review*, Vol. 46 (Autumn 1956), p. 68.

3 M. Freedman, "The role of monetary policy," *American Economic Review*, pp. 1-17, March 1968.

4 It may appear inconsistent to suggest that equilibrium itself can be displaced, but at some future date be restored as a result of the natural workings of the system. But as we intend to demonstrate, there are "orders" of equilibrium that depend on both the time scale and structure. In this sense, in response to a shock, the unemployment rate may seem to "hang in the air" for no obvious reason, returning to a previous equilibrium only after a lengthy period of time. If the horizon is short, it appears as if something fundamental has occurred to "equilibrium"; if it is long, this is not the case. If the horizon spans a generation and at the same time it takes a generation to re-establish a previous equilibrium position, it is hard to deny that something fundamental (akin to hysteresis) has occurred.

5 The most comprehensive work dealing with hysteresis in economics is *Unemployment, Hysteresis and the Natural Rate Hypothesis*, editor Rod Cross (New York: Basil Blackwell, 1988), which contains the papers presented at a conference that took place at the University of Saint Andrews in Scotland in July 1986. Chapter 3 of this compendium contains a paper on the history of hysteresis by Cross and Andrew Allen. They use a number of examples from the physical sciences to illustrate the meaning of hysteresis. They make reference to the famous visual representation of the effect of hysteresis in ferromagnetic fields. Within this context the hysteresis loop describes how the electro-magnetic characteristics of Ferro metals change during a complete cycle of magnetisation and demagnetisation. In fact, field characteristics never returned to the original state, once a magnetising force has been applied and removed. The implication is that the equilibrium properties of the metal have changed in some fundamental way. This idea has been carried over to economics. Most models in economics assume unique equilibria. Hysteresis admits to the possibility of multiple equilibria. The importance of hysteresis can be traced to its policy implications, given the existence of numerous equilibria. Under a regime of hysteresis, traditional policy anchors, such as the natural rate of unemployment, are themselves dependent upon the means of implementing a policy goal, such as opening the output gap to control inflation. Under these circumstances, there are important implications for

demand-management policy. If hysteresis is a factor, permanent damage could result from a policy that forces the economy away from equilibrium, as a means of achieving a particular goal. This is very different from the paradigm which counts on the independence of policy from any effect on equilibrium. Concepts related to hysteresis, such as persistence, are much less of a problem to policy formulation. For example, the slow return to equilibrium as characterized by the long tail on the Canadian unemployment rate or by changes in the composition of the duration and incidence component of the national and provincial unemployment rates. Persistence does not point in the direction of permanent damage, but only to long-lasting effects that diminish over time. Nevertheless, if the horizon is a generation, or if the effect is uniquely related to a particular group as it ages within the context of the labour force, the question as to whether or not some "order" of hysteresis is present in the data remains open.

6 This is easily demonstrated by exponentiating (1) to obtain $u_t^{ws} = (u_{t-1}^{ws})^{\alpha} e^{n_t}$. For $\alpha = 1$, we have $u_t^{ws} = u_{t-1}^{ws}\ e^{n_t}$. The mean of u_t^{ws} is $E\{u_t^{ws}\} = E\{u_{t-1}^{ws}\}\ E\{e^{n_t}\}$ since u_{t-1}^{ws} and n_t are independent. The second term on the right-hand side is the moment generating function of n_t, and assuming n_t to be *nid* with zero mean and variance σ^2 results in $E\{e^{n_t}\} = e^{\frac{1}{2}\sigma 2}$. Thus $E\{u_t^{ws}\} = E\{u_{t-1}^{ws}\}\ e^{\frac{1}{2}\sigma 2}$ and the unemployment rate generated by (1) is trended, if σ^2 is non zero. Thus, while the log unemployment rate may follow a random walk, given a stochastic process, the unemployment rate will be positively trended.

7 We have yet to subject the coefficient on u_{t-1}^{ws} to a unit root test.

8 In this case, we use the Bank of Canada industrial rate of capacity utilization.

9 We have picked two historical periods, entry, and the experience of a group one year ago. But this model can easily be modified to focus on the experience of a group at any two points in time. What is important is that we account for the group's experience at selected points in time. In this illustration, we use entry and last year as the points where historical observations are taken.

10 The dependent variable in each of the 100 trials was $u + [(0.7\ x\ 0.35)/41]u55up_{-1} + [0.3/41]u15_{-1}$.

11 Andrew Burns, "Unemployment in Canada, frictional, structural and cyclical aspects," Working Paper No. 1, Economic Council of Canada (Ottawa, 1990).

12 The signs are consistent with those obtained by Burns.

13 D. M. Lilien, "Sectoral shifts and cyclical unemployment," *Journal of Political Economy*, Vol. 90, No. 4, pp. 777-93, 1982.

14 Subsequent to the estimates reported in this section, we have been able to estimate the complete system simultaneously, avoiding stepwise restrictions. In doing this, for males the coefficient on the lagged dependent variable comes in at 0.73 with *t* test of 7.9. The lags for 1, 5, and 10 on the components of the age group composite variable come in at 0.39, 0.1, and 0.09, with *t* tests of 1.7, 1.3, and 1.0. Thus the age group composite impact for males has a coefficient of 0.58, considerably larger than that obtained in the stepwise regressions. The normalized weights for males are 0.67, 0.17, and 0.16. For females, the coefficient on the lagged dependent variable is 0.54, not much different than that obtained in Step 5. The coefficient on the lags of the variables making up the cohort composite variable are 0.21, 0.11, and 0.3 with *t* tests of 3.0, 1.2, and 4.2. The distribution of the weighting is identical to that of Step 1 and similar to that of Step 5, with most of the weight occurring on the first and last lags, with the last lag weighted heavier than the first. These results confirm the basic structure, as we have reported it in Table 3.

15 There is the possibility that the age composite variable has captured structural factors such as the greater relative size of one age group over another and the impact of this on competition for jobs as opposed to employment experience. Nevertheless, this makes it all the more important to understand "history" when making policy at any one point in time.

16 This is important. The larger the coefficient is on the lagged dependent variable, the longer it takes for the decay process to equilibrium to occur. What a positive coefficient on the age group composite variable indicates is that "equilibrium" is closer than you think, thus the decay process must be shorter (in periods) and the lagged dependent variable effect must be weaker.

17 When the estimate of $\log(u_t^{ws})$ is converted to an estimate of u_t^{ws} by simple exponentiation, what results is a biased estimate of u_t^{ws} (see note 6). Goldberger has recognized this problem when dealing with Cobb-Douglas production functions ("The interpretation and estimation of Cobb-Douglas functions," *Econometrica*, Vol. 35, No. 3-4, pp. 464-72). Cloutier, and Cloutier and Wesa (Economic Council of Canada, Discussion Papers No. 305 and 352) following Goldberger have accounted for this bias in their use of translog cost functions as applied to agriculture in three Prairie provinces and to labour supply functions for married women in Canada. In the current case (a natural rate equation broken down by age and gender), this correction has not been made. From a practical point of view, since the biased estimate of u_t^{ws} underestimates

the positive trend, any inferences and conclusions drawn stand both before and after such a correction.

18 The Bank of Canada and the Department of Finance set targets for inflation in the February 1991 Federal Budget. By mid-winter 1992, the first of these targets had been more than achieved.

19 We implement this shock such that the constant terms of the youth unemployment equations are adjusted for both the actual rate and the natural rate. For the case of the actual rate, the adjustment is equal to *adj*, in the case of the natural rate equation the adjustment is equal to $adj \ x \ (1-\lambda)^{-1}$.

20 For example, see L. R. Klein and R. S. Preston, "Stochastic nonlinear models," *Econometrica* (January 1969).

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