Speed of Technical Progress and Length of the Average Interjob Period

by

William J. Baumol*
Edward N. Wolff**

Working Paper No. 237

May 1998

* Director, C.V. Starr Center for Applied Economics, New York University; Senior Research Economist and Professor Emeritus, Princeton University

** Professor of Economics, New York University

The authors are deeply grateful to The Jerome Levy Economics Institute of Bard College and the C.V. Starr Center for their generous support of this work, to Graeme Hunter for his excellent research assistance, to Alan Blinder for his very helpful comments, and to Sue Anne Batey Blackman for her invaluable assistance.

Abstract. The mean duration of unemployment has approximately doubled in the U.S. between the early 1950s and the mid-1990s, with most of the increase occurring since the early 1970s. We first construct a simple model linking the average duration of unemployment with the speed of technical change. Using aggregate time-series data for the U.S., we find strong evidence that both the rate of TFP growth and investment in office, computing, and accounting equipment (OCA) per employee have a significant positive effect on mean unemployment duration. Moreover, literally all of the two-thirds rise in mean unemployment duration between 1971 and 1994 (two similar points in the business cycle) can be attributed to increases in OCA investment.

JEL Codes J64, O33, J11

Keywords: Unemployment duration, technical change, computerization

> "[In] Rotterdam....of the 50,000 jobless, 32,000 have been unemployed for more than a year, and many for more than three years....More than 40% of the 17m unemployed in the European Union have been out of work for at least a year; a third have never worked at all. In the United States...only 11% of the unemployed have been looking for work for more than a year" (The Economist, July 30-August 5, 1994, pp. 19-20.

We will argue here that when technical progress is continuous a speedup of change can have two profound employment effects. It can increase the "natural rate of unemployment" and it can increase the average duration of unemployment. It does the latter by cutting more severely the jobs available to those whom it is particularly unremunerative to retrain, notably the ill-educated and the older workers.

We provide a rather elementary theoretical discussion, showing the role of the sunk-costs of effective retraining. We will review the data for the industrial countries. Finally, we will provide an econometric investigation of the relation between technological change and duration of unemployment.

In saying that both the level and duration of unemployment can be increased by more-rapid technical change we are emphatically not asserting that this is the only source of such developments. Clearly, these are affected by many other influences -- the structure of the unemployment insurance system, other elements of public policy, union power and behavior, international trade

developments, and a profusion of others. Our econometric study takes account of such variables, as well as measures of the speed of technical change. Its results shed light on the role of these other variables and provide support for our hypothesis.

1. SPEED OF TECHNICAL CHANGE AND NATURAL RATE OF UNEMPLOYMENT

First, let us consider briefly how increased technical change can lead to long-term elevation of the natural rate of unemployment, focussing upon its frictional and structural unemployment components. These include the period of joblessness after technical obsolescence closes plants permanently or for reconstruction or retooling. Increased speed of technical change raises the share of the labor force that is unemployed in any period, because the plant in which they were employed is closed more often.

An illustration can make more concrete the logic of the effects of continuous innovation on level of unemployment. Assume that, initially, the continuing rate of technical progress is such that an average plant can be expected to need closing for redesign and retooling once every 25 years. If the typical employee of the plant is laid off during this period and is then rehired after six months or, on average, takes the same time to find a new job, technical progress will have contributed 2 percent to the prevailing structural unemployment figure, with a half year in 25 or 2 years in 100 spent between jobs on that account. Next, consider a speed up in the rate of technical change, so that plant must, on average, be

modernized every 12.5 years instead of every 25. If everything else remains as before, the contribution of technical change to unemployment must obviously have doubled, to 4 percent of the labor force. The argument is, clearly, independent of our illustrative numbers.[FN 1]

It follows that the constant creation and loss of jobs resulting from technical change do not simply balance out, even if the two occur at identical rates. The process stirs up job change and that takes time, contributing a net increase in the natural rate of unemployment, and one that is certainly not transitory so long as the pace of technical progress continues.

2. TRENDS IN THE DURATION OF UNEMPLOYMENT

However, the focus of our story is not the level of unemployment but its duration. The distinction is clear and has important implications about the social consequences of unemployment. With a given unemployment rate, duration of joblessness can vary substantially. The unemployment rate will be the same if four million workers are unemployed for three months on average, as when one million workers loose their jobs for a full year. Yet the consequences for the mental state of the people without jobs, for their behavior and for the functioning of society can differ considerably.[FN 2]

Before turning to the relationship between the rate of technical progress and the duration of unemployment it is

appropriate to review the evidence on trends in the length of joblessness, though the information is well known to specialists. In the industrial countries, the length of time a typical jobless person spends "between jobs" has increased substantially and fairly steadily since the Second World War. Figure 1 summarizes data provided by the Bureau of Labor Statistics (see Table 1 for data sources and methods). It indicates that over the 45 year period from 1948 through 1993 the average duration of the period of unemployment has more than doubled, and that the share of the unemployed composed of persons unemployed more than half a year (the longest period covered in the BLS data) has almost exactly quadrupled. This trajectory is characterized by fluctuations of considerable magnitude. A regression of the natural logs of the data yields a growth rate of nearly 1 percent compounded for average duration of unemployment, and an annual growth rate of 1.7 percent in the proportion of the unemployed who were jobless half a year or more. By 1993, the share of the unemployed who were jobless for more than six months had exceeded 20 percent of the total.

The problem of protracted joblessness is international, as illustrated by the 1994 OECD data for 10 industrial countries reported in Figure 2a. These show, for each country, the percent of unemployed workers who had been jobless for a year or more. We see that the U.S., with its 12 percent figure, had the lowest incidence of long-term unemployment. Italy, Belgium and the Netherlands had the unenviable position of being at the top, with more than half of

their jobless having been out of work for a year or more. These countries also have overall unemployment rates significantly higher than the U.S.

Figure 2b compares the percentage growth in long-term unemployment for the same 10 countries between 1975 and 1994. (While this graph is primarily concerned with growth, we have put in the levels for 1975 and 1994 for reference.) Once again, the U.S., with its 130 percent increase over the 19-year period, is near the bottom of the group. It is outstripped by Germany, with its 320 percent rise, and by Canada, France, the United Kingdom and Sweden, where long-term unemployment as a share of total unemployment rose by approximately 250, 245, 210, and 145 percent, respectively. Clearly, this is no minor phenomenon, and the U.S. is not its most badly damaged victim.

3. DURATION OF JOBLESSNESS AND RATE OF TECHNICAL PROGRESS

Next we provide a theoretical link between the speed of innovation and the length of time an average jobless person is unemployed. The components of the scenario are quite familiar. It will be argued that the rate of technical progress has two pertinent effects. First, it increases the relative cost of employing a person whom it is relatively expensive to retrain, or who is less likely to provide an incremental revenue product sufficient to repay the cost of retraining. The enhanced relative price of hiring such workers will lead to substitution for their services, by replacement with higher

paid workers whose retraining cost is not so high. Second, with both absolutely and relatively fewer jobs available to these workers it will take longer for them to find new employment. With a higher proportion of the unemployed having high retraining costs, and with an increase in the average duration of joblessness of such workers, the average duration of unemployment in the economy will tend to rise. That, in essence, is our story.

The pertinent relationships are illustrated by two vastly oversimplified models. Once again, we deal with an increase in the frequency with which workers need retraining to keep up with major plant retoolings. First, we show the nearly obvious result

PROPOSITION 1. A rise in the speed of technical change that increases the frequency of plant redesign and retooling will increase the relative price to the employer of a less educated worker whose wage is relatively low, but whose retraining cost is high.

For simplicity, we assume that all workers fall into one of two classes, less educated and better educated, and use the following notation:

w = the annual wage of an uneducated worker

h = the frequency of plant retooling

kh = the annualized cost of retraining of an unskilled worker

w^* = the annual wage of a skilled worker

k^*h = the annualized cost of retraining of a skilled worker

$c = (w+kh)/(w^*+k^*h)$ = the relative annual cost of employment of an

unskilled worker, where

(1) $(w+kh) < (w^*+k^*h)$, but $k > k^*$.

We use h as our measure of speed of technical progress. Then, to determine the effect of a speed up of technical progress on the relative cost of the two types of worker to their employer we calculate directly

(2) $dc/dh = [k(w^*+k^*h) - k^*(w+kh)]/(w^*+k^*h)^2 > 0$ (by (1)).

Thus, increased rapidity of technical change must raise the relative price of unskilled labor, as was to be shown. As we know (see, e.g., Hicks [1949]), at least in the competitive model, a rise in the price of one input relative to that of another leads unambiguously to <u>some</u> substitution of the latter for the former.[FN 3] The clear implication is that a speedup of the rate of technical change leads to a reduction in the relative demand for unskilled labor. Note that this result was obtained considering only changes in relative retraining cost. It is likely to be strengthened by such supplementary influences as the likelihood that more rapid technical change will increase the level of skill and education needed by workers, thereby reducing the relative marginal product of the unskilled.

Our story requires only one more observation. This is the lengthening as a result of more rapid technical progress of the period before an average unskilled and unemployed worker can find a new job. We take it as obvious that with relatively fewer jobs available to them, it will on average, take such workers more time

than before to land new jobs. It will, for example, take longer to arrange an interview, and it will require more interviews before they find employers willing to hire them.

We can now assemble the components of our scenario. With the unskilled constituting a greater proportion of the unemployed, and with their interjob lag increased, the average for the economy is likely to rise, though, as we will see, there is a possible exception. Thus, we show next,

PROPOSITION 2. If the less educated and older workers' average interjob duration is no smaller than that of other workers, then a speedup of technical progress of the sort in question will increase the average duration of unemployment for the labor force as a whole.

Here, we use the notation

$u = n_u/(n_u+n_s)$ = share of the unskilled among the unemployed [where n_u (n_s) = number of unskilled (skilled) and jobless persons]

t_u and t_s = their respective average lengths of time between jobs

r = the rate of technical change (frequency of plant closings).

Then we have

(3) u' (= du/dr) > 0, by proposition (1) and

(4) $t_u' > 0$, by assumption.

The average duration of unemployment is, then,

(5) $A = ut_u + (1-u)t_s$, so that

(6) $dA/dr = A' = u'(t_u-t_s) + ut_u' + (1-u)t_s'$.

If t_s' is nonnegative, or at least not negative and large, then A'

must be positive unless t_s is (considerably) larger than t_u. This gives us Proposition 2.

The calculation indicates as an exception the case in which the unskilled are able to find jobs far faster than the skilled. The explanation of this exceptional case is straightforward. If the unskilled had a very much shorter interjob period than the skilled, then a rise in their share of the unemployed would simply increase the weight (in the weighted average) of their less protracted joblessness. It can be argued that such a difference is unlikely to be of the required magnitude.[FN 4]

The same story, with one minor difference, can be repeated for older workers. Like the unskilled, they too may be harder to retrain than young educated workers, because the elderly may have become set in their ways, and because their education from far in the past may be less helpful in adaptation to the latest technical developments. In addition, because older workers are closer to retirement age, they will offer the employer a briefer stream of incremental revenues with which to recoup the sunk costs of their retraining (cf. Becker, 1975). As a result, the prospects for recoupment of those training costs will be dimmer for older employees, once again leading to their replacement by younger educated workers and, through the same chain of relationships as in the case of the unskilled, making for lengthening of the average duration of unemployment for the economy as a whole.

We end this discussion by reemphasizing that the mechanism

just described is not the only influence that can lead to lengthening of the period of joblessness. For example, increased complexity of new products and processes can be at least as disadvantageous to unskilled or older workers as sheer speed up of technical change. This must be kept in mind in any casual evaluation of the model by direct comparison with the data. Such other variables can help to reconcile the growth in the duration of employment, as documented here, with the fact that in much of the industrial world the growth of total factor productivity has declined materially since the decades immediately following the Second World War, apparently implying that technical change has slowed.[FN 5] For a more careful test of the argument it is, however necessary to turn to systematic econometric analysis.

4. EMPIRICAL INVESTIGATION: DATA AND SIMPLE CORRELATIONS

A. Technological Variables. Since the pace of technical change is itself almost impossible to observe directly, we use five alternative indices to measure technological activity. The first is the standard rate of total factor productivity (TFP) growth, TFPGRTH, defined as:

$$(7) \qquad TFPGRTH = Y^\circ - \alpha L^\circ - (1 - \alpha)K^\circ,$$

where Y° is the annual rate of output growth, L° is the annual growth in labor input, K° is the annual growth in capital input, and α is the average wage share over the period. The second and third

are indices of R&D activity -- the ratio of R&D expenditures to GDP and the number of full-time equivalent (FTEE) scientists and engineers engaged in R&D per 1,000 employees.

The fourth measure is investment in new equipment and machinery as a ratio to full-time equivalent employees (FTEE). This index is included to allow for the possibility that some portion of new technology may be embodied in capital investment. Standard measures of TFP growth do not adequately capture this effect. Because computers may play a particularly important role as transmitters of new technology, we use as our fifth index investment in computers (or, more specifically, office, computing, and accounting equipment, or OCA) per FTEE.

Panel A of Table 2 provides descriptive statistics on these variables, as well as average unemployment duration. These variables are all based on economy-wide data, unless otherwise indicated. We have selected five periods, which roughly correspond to peaks in the business cycle (low points in the unemployment rate), since unemployment duration is closely correlated with the unemployment rate (that is, both are counter-cyclical). The mean duration of unemployment remained largely unchanged over the 1950s, 1960s, and 1970s, at about 11.5 weeks, then jumped to 14.6 weeks in the 1980s and to 15.6 weeks in the first half of the 1990s.

All five technology indicators are positively correlated with unemployment duration. The most highly correlated one is OCA investment per FTEE (a correlation coefficient of 0.54). It

increased gradually from $6 (in 1987 dollars) per FTEE in the 1950s to $21 per FTEE in the 1970s, and then jumped to $185 per FTEE in the 1980s and $522 per FTEE in the 1990s. Equipment investment per FTEE rose more gradually over the postwar period, though more than doubling over this time span, and has the second highest correlation coefficient with mean unemployment duration (0.49).

Third in line is FTEE scientists and engineers engaged in R&D per 1,000 employees, which increased at a rather constant rate from the 1950s to the mid-1990s, rising by more than 50 percent. Next in line is the ratio of R&D expenditures to GDP, which rose sharply between the 1950s and 1960s, fell off in the 1970s, increased in the 1980s and then rose slightly in the 1990s. Of this group, TFP growth has the lowest correlation coefficient with mean duration of unemployment. TFP growth was at its highest point in the 1950s and 1960s, at 1.6 and 1.8 percent per year, respectively, when unemployment duration was low. Annual TFP growth then fell to 0.7 percent during the 1970s, 0.5 percent during the 1980s, and 0.3 percent during the early 1990s.

B. Institutional Variables. The structure of the unemployment insurance (UI) itself may also have an important effect on the duration of unemployment. In particular, by reducing the cost to an individual of being jobless, the UI system will generally prolong the duration of unemployment for many workers (see, for example, Feldstein, 1974). The original architects of the UI system explicitly recognized this and argued, in fact, that the added

security individuals had while unemployed would enable them to select a job more compatible with their skills and interests.

The type of unemployment occasioned by the job search process is search unemployment. The UI system reduces the costs of remaining unemployed, so the reservation wage for those searching for a new job will be higher on average than without UI benefits. As a result, we can expect an increase in their average duration of unemployment. The higher the UI benefits, the longer will be the average unemployment spell. Most empirical studies have confirmed a positive relation between the UI replacement rate (the ratio between the UI benefit and the previous wage) and the average duration of unemployment. Typically, an increase in the replacement rate of 0.1 is associated with a half week to week increase in the average duration of unemployment. All told, the UI system may cause covered workers to remain unemployed 16 to 31 percent longer than those not covered.[FN 6]

In Panel B of Table 2, we have selected three features of unemployment insurance (UI) programs. The first is the UI coverage rate, the percent of all employees covered by the UI system, which rose substantially over the postwar period, from 65 to 94 percent of employment, and has a simple correlation coefficient of 0.49 with average unemployment duration. The second is the replacement rate, the ratio between mean UI benefits and the average previous wage, which has shown a slight upward trend over the postwar period. Its simple correlation with unemployment duration is only 0.35. The

third is the insured coverage rate, the percent of unemployed workers receiving benefits. Lack of benefits may be due to any of three factors: (1) no coverage from the UI system; (2) failure to meet the eligibility criteria (either insufficient wages or time worked); or (3) exhaustion of benefits (normally after 26 weeks). The insured coverage rate has been dropping over time, from 53 percent in the 1950s to 35 percent in the 1990s, at the same time that unemployment duration has been rising. As a result, rather paradoxically, the two series are negatively correlated.[FN 7]

Two other institutional factors that may affect the duration of unemployment are the presence of unions and the minimum wage. We would expect that a high rate of unionization will raise entry wages and therefore, ceteris paribus, increase the probability of an unemployed worker finding a wage offer equal to or exceeding his or her reservation wage. This will tend to lower the duration of joblessness. A change in the minimum wage may be expected to have the same effect. As the minimum wage falls in real terms, entry wages for new jobs will also generally fall. Workers with a given reservation wage will thus have an increasingly difficult time finding jobs with wage offers above their reservation wage.

Both results are confirmed in Panel B of Table 2, which show negative correlations between mean unemployment duration and both the unionization rate and the minimum wage. In fact, the unionization rate has been falling rather steadily since the 1950s, from 24 percent to 16 percent in the early 1990s. Likewise, the

minimum wage in 1987 dollars, after increasing between the 1950s and 1970s, from $3.60 per hour to $4.52, fell to an average of $3.33 during the 1990s.

C. Demographic Influences. One of the most notable changes in the postwar period has occurred in the demographic composition of the labor force. In the U.S. (and other OECD countries) there has been a rising rate of labor force participation of females and a decline in the labor force participation rate of older men. As a result, the gender composition of the labor force has been shifting over time toward females and away from males, particularly older men. Because the incidence of unemployment and labor force attachment differs among different demographic groups (unemployment rates have historically been higher for women than men and for younger workers than older ones), it is likely that these demographic changes may partly account for the rise in unemployment duration.

Table 3 provides a breakdown of employment by gender and age group for the same five periods. Between 1950 and 1995, females as a percent of employed workers increased from 29 to 46, while men declined as a share from 71 to 54 percent. However, the changes were not uniform over the various age groups. Young men (under age 25) fell from 8.8 percent of total employment in the 1950s to 8.1 percent in the 1990s. The share of men of prime working ages (25 to 54) in total employment declined from 46 to 39 percent. The biggest change was the decline in the share of older men (55 and over) in total employment, from 13.3 to 7.1 percent. Among female workers,

the only very substantial change is the share of females of prime working age in total employment, which surged from 20 percent in the 1950s to 33 percent in the 1990s. Moreover, this share shows a very sharp increase between the 1970s and 1980s, coincident with the big increase in mean unemployment duration. The correlation coefficients confirm the strong negative relation between average unemployment duration and the share of both teen-age men and men 55 or over in total employment and the strong positive relation between unemployment duration and the share of prime working age women in the labor force.

Table 4 provides another side of the issue by showing the mean duration of unemployment by demographic group. We have used all the demographic details on unemployment duration published by the Bureau of Labor Statistics.[FN 8] The results show that the rise in unemployment duration between the 1970s and 1980s was almost universal among demographic groups, with the average number of weeks of unemployment rising in the order of 3 to 4 weeks. However, more recently, between the periods 1980-89 and 1990-95, the picture is much more mixed, with the average duration of unemployment rising for some groups but not for others.

Another striking result is that the average duration of unemployment is considerably greater for older workers than younger ones. Among both men and women, the average weeks of unemployment rose almost monotonically with age. Moreover, between 1980-89 and 1990-95, unemployment duration increased for older workers (45 and

over for men and 35 and older for women), whereas it declined for younger age groups. Partly as a result of this, the spread in unemployment duration widened between older and younger workers from the 1970s to the early 1990s. The difference in average time of unemployment between men aged 16 to 19 and men aged 55 to 64 increased from 10.8 to 17.1 weeks; the corresponding change for women was from 9.0 to 12.6 weeks.

There are also differences in unemployment duration among gender and racial groups, though they are not as pronounced as among age groups. Unemployment duration has been higher for men than for women and this has widened over time, from 2.6 weeks (13.1 less 10.5) in the 1970s to 3.9 weeks in the early 1990s. The mean duration of unemployment has also been somewhat higher for black workers than white ones and has also increased modestly over time. The difference in average duration between black and white men rose from 1.4 weeks in 1970-79 to 1.7 weeks in 1990-93 and from 1.2 to 1.5 weeks between black and white women.

Differences by marital status appear to be less important. Single (never married) persons have experienced lower average unemployment duration than married or previously married (widowed, divorced, or separated) persons, though this may to a large extent reflect the fact that singles are, on average, younger than the latter group. Mean unemployment duration has been very similar for currently married and previously married men though it has tended to be lower for currently married women than previously married ones.

This latter result, however, may simply reflect the greater likelihood that a married woman will drop out of the labor force after an extended period of unemployment than one who is widowed, divorced, or separated.

5. MULTIVARIATE REGRESSION ANALYSIS

We turn next to multivariate regression analysis to sort out the effects of technological, institutional and demographic variables on changes in unemployment duration. The analysis is based on aggregate time-series data for the U.S., covering the period 1950-1995.

Our primary dependent variable is the (natural) logarithm of the average duration of unemployment. There are statistical problems associated with the use of mean unemployment duration as a dependent variable in a regression. The most serious is that the variable is based on a truncated distribution, since we can observe individuals only while they are in the midst of an unemployment spell. In the Current Population Survey (the source of these data), information on the length of unemployment is collected only from individuals who are unemployed at that time. As a result, these individuals have not completed their unemployment spells, so that the survey essentially interrupts spells that are still in progress (see Kiefer, 1988, for an extended discussion of statistical problems associated with unemployment duration data). To avoid some of the pitfalls that beset duration data, most researchers have used the logarithm of duration as the dependent variable (see Devine and Kiefer, 1991,

Chapter 5). Alternative dependent variables are the percentage of unemployed workers out of work 15 or more weeks and the percentage out of work 27 or more weeks.

The first set of results, based on aggregate data, with the natural logarithm of the mean duration of unemployment as the dependent variable, confirm the predictions of our model (see Table 5). The coefficient of TFPGRTH5, a five-year running average of annual TFP growth, is positive and significant at the one percent level in all specifications. We use a five-year running average of TFP growth to eliminate most of the cyclical sensitivity of TFP growth. In particular, TFP growth is procyclical, falling during a recession and rising during a recovery. A one percentage point increase in annual TFP growth is associated with a 12 percent increase in the mean duration of unemployment. This result is particularly striking since the simple correlation between TFP growth and unemployment duration is small and since the two move cyclically in opposite directions.

The coefficient of OCAFTEE, investment in office, computing, and accounting equipment in constant dollars per full-time equivalent employee, is also positive and statistically significant in all specifications (at the one percent level in three out of the four equations shown in Table 5 and at the five percent level in the other). The effect is quite strong. An increase of $1,000 (in 1987 dollars) of OCA investment per employee is associated with a 53 percent increase in the mean duration of unemployment. However, the

three other technology variables -- R&D intensity, scientists and engineers engaged in R&D, and investment in equipment and machinery per employee, all have positive coefficients but are not statistically significant.

We also control for the UNEMPRATE, the overall unemployment rate, in these regressions. As shown in Figure 1, the duration of unemployment is quite cyclical and is strongly correlated with the overall unemployment rate, since the higher the unemployment rate, the lower the probability of a jobless worker obtaining a job and, ceteris paribus, the longer the spell of unemployment. The coefficient of UNEMPRATE is positive and significant at the one percent level in all specifications.

Three parameters of the UI system were also included in the regression analysis: (1) LNUIREPL, the natural logarithm of the UI replacement rate; (2) UICOVER, the percent of workers covered by the UI system; and (3) UIINSCOV, the percent of unemployed workers receiving benefits. Each has the predicted positive coefficient but is generally not statistically significant. These results may seem surprising, particularly for the UI replacement rate, in light of previous studies. However, these studies are all based on cross-sectional or panel data, where the variation of the UI replacement rate is across individuals, not over time. Moreover, the change in the UI replacement rate between 1950 and 1995 has been quite small (from 33.9 to 36.5 percent).

The natural logarithm of the minimum wage in constant dollars,

LNMINWAGE, has the predicted negative coefficient which is significant at the ten percent level when this variable is included with only a constant term and UNEMPRATE (see specification 2). However, when TFPGRTH5 and OCAFTEE are also included, the coefficient of LNMINWAGE becomes insignificant. Similarly, the unionization rate, UNIONRATE, has a negative coefficient, which is also significant at the ten percent level when only a constant term and UNEMPRATE are included (see specification 4). However, when TFPGRTH5 and OCAFTEE are added to the specification, the coefficient of UNIONRATE becomes insignificant.

Some of the demographic variables also have a significant effect on unemployment duration. After some experimentation, we found that the best fit is provided by the inclusion of the following three demographic variables: (1) percent of total employees in age group 16-19; (2) percent of total employees in age group 20-24; and (3) men in age group 25-54 as a percentage of total employment (see specification 6). These three variables are all significant at the five percent level. The percentage of teenagers in total employment has a negative coefficient, most likely reflecting the transitory nature of teenage employment. If they become unemployed, they are very likely to drop out of the labor force. On the other hand, the other two variables each has a positive coefficient. A plausible reason is that workers aged 20 to 24 and male workers aged 25 to 54 will tend to remain in the labor force when they become unemployed and continue to search for a new

job.[FN 9] Specification 6 has the highest adjusted-R^2 (0.91) and the smallest standard error.

The same regressions were repeated with two other dependent variables: (1) the percent of unemployed workers who are unemployed for 15 or more weeks; and (2) the percent of unemployed workers who are unemployed for 27 or more weeks. The results, shown in Table 6, are very similar to those reported in Table 5.

Table 7 shows the results of the last set of regressions, in which we employ as the dependent variable the mean duration of unemployment for individual age groups. The results support one of our major hypotheses, that older age groups are more adversely affected by technological change than younger ones in terms of length of unemployment spells. Among men, the coefficient of TFP growth (TFPGRTH5) rises almost monotonically with age group, from zero for the youngest to 0.22 for the oldest, though it is only marginally significant in two cases. The coefficient on OCAFTEE does rise monotonically with age group, from -0.06 for the youngest to 0.76 for the oldest, and it is significant at the one or five percent level for the four oldest groups.

The results for females are very similar. The coefficient of TFPGRTH5 rises monotonically with age group, from -0.02 for the youngest to 0.13 for the oldest, and it is significant at the five or ten percent level for the oldest four groups. The coefficient on OCAFTEE increases almost monotonically by age group, from -0.15 to 0.59, and is statistically significant at the one percent level for

the oldest four groups and at the ten percent level for the youngest. It is also striking that the coefficients on TFPGRTH5 and OCAFTEE are negative for the youngest age group.[FN 10]

6. SUMMARY REMARKS

The duration of unemployment has risen rather dramatically over the last half century. The mean duration of unemployment has approximately doubled between the early 1950s and the mid-1990s, with most of the increase occurring since the early 1970s. The percentage of unemployed workers out of work 15 or more weeks more than doubled over the same period, while the percentage of the unemployed out of work 27 or more weeks tripled. We also found that the rise in unemployment duration between the 1970s and the early 1990s was almost universal among demographic groups, with the average duration of unemployment generally rising about 3 to 4 weeks.

Another striking finding is that average weeks of unemployment rise almost monotonically with age. Moreover, between the 1970s and early 1990s, the spread in unemployment duration widened sharply between older and younger male workers -- from 10.8 to 17.1 weeks between teenagers and ages 55-64.

Our econometric results provide strong support to the central thesis of our paper, that the duration of unemployment increases when the rate of technological change rises. This result is confirmed by the positive and significant coefficients of both TFP

growth and investment in OCA per employee. Moreover, the results support our second hypothesis that technological change will more adversely affect older than younger workers in terms of duration of unemployment. TFP growth bore a much stronger positive relation to length of unemployment among older men than younger and among older than younger women. These results are consistent with the argument that firms are reluctant to invest in the new training associated with new technology for older workers because of the shorter pay-off period or, perhaps, because of the greater difficulty of retraining older workers ("you can't teach an old dog new tricks").

Demographic variables also have a strong influence on the duration of unemployment. In particular, the proportion of total employment in age group 16-19 is negatively related to unemployment duration, while the proportion in age group 20-24 and that of men in age group 25-54 have a positive bearing.

A straightforward decomposition, shown in Table 8, can allow us to understand the sources of the sharp increase in unemployment duration observed over the last 25 years or so. We have selected two years, 1971 and 1994, at about the same stage of the business cycle. Over this period, mean unemployment duration increased by 66 percent (from 11.3 to 18.8 weeks). By far the greatest effect is contributed by the increase in investment in OCA per employee over this period, from virtually zero to $860 (in 1987 dollars). It accounted for 103 percent of the increase in the log mean duration of unemployment (LNMEANDUR).

The slowdown in TFP growth was minimal over this period, from 0.31 to 0.0 percent per year, and accounted for -6.9 percent of the change in LNMEANDUR. Demographic changes in the composition of the labor force were on net offsetting: the three percentage point decline in the share of teenagers in the labor force (which has a negative effect on LNMEANDUR) was counterbalanced by a three percentage point drop in the share of workers aged 20 to 24 (which has a positive effect on LNMEANDUR). There was no change in the share of males aged 25 to 54 in the labor force. The independent variables collectively explained 93.5 percent of the change in LNMEANDUR (and the residual the other 6.5 percent).

On a final note, the results reported here do provide indirect support to the skill-biased technical change hypothesis that has been put forward to explain rising earnings inequality in the U.S. economy (see Bound and Johnson, 1992, for example). The widespread diffusion of computers in the economy that occurred over the last quarter century has led employers increasingly to favor younger workers, who are presumably better educated and easier to train, than older ones.

REFERENCES

Barling, P. and P. Handal, "Incidence of Utilization of Public Mental Health Facilities as a Function of Short Term Economic Decline," **American Journal of Community Psychology**, 8, 1980, pp. 31-39.

Becker, Gary S., **Human Capital: A Theoretical and Empirical Analysis**, (New York: Columbia University Press and National Bureau of Economic Research), 2nd edition, 1975.

Barron, John M. and Wesley Mellow, "Unemployment Insurance: The Recipients and Its Impact," **Southern Economic Journal**, 47, 3, January 1981, pp. 606-616.

Bean, Charles R., "European Unemployment: A Survey, "**Journal of Economic Literature**, Vol. XXXII, No. 2, June 1994, pp. 573-619.

Brenner, M.H., **Mental Illness and the Economy**, Cambridge, Mass.: Harvard University Press, 1973.

Britt, Chester L., "Crime and Unemployment Among Youths in the United States, 1958-1990: A Time Series Analysis," **American Journal of Economics and Sociology**, 53, 1, 1994, pp. 99 and 102.

Bound, J., and G. Johnson, "Changes in the Structure of Wages in the 1980s: An Evaluation of Alternative Explanations," **American Economic Review**, 82, 1992, pp. 371-392.

Classen, Kathleen P., "Unemployment Insurance and Job Search," in Steven A. Lippman and John J. McCall, eds., **Studies in the Economics of Search**, Amsterdam: North-Holland, 1979, pp. 191-219.

Cohn, R.M., "The Effect of Employment Status Change on Self Attitudes," **Social Psychology**, 41, 1978, pp. 81-93.

Devine, Theresa J. and Nicholas M. Kiefer, **Empirical Labor Economics: The Search Approach**, New York: Oxford University Press, 1991.

Dooley, D. and R. Catalano, "Economic Change as a Cause of Behavioral Disorder," **Psychological Bulletin** 87, 1980, pp. 450-468.

Ehrenberg, Ronald G. and Ronald Oaxaca, "Unemployment Insurance, Duration of Unemployment, and Subsequent Wage Gains," **American**

Economic Review, 66, December 1976, pp. 754-766.

Feather, N.T. and P.R. Davenport, "Unemployment and Depressive Affect: A Motivational and Attributional Analysis," **Journal of Personality and Social Psychology**, 41, 1981, pp. 422-436.

Feldstein, Martin, "Unemployment Compensation: Adverse Incentives and Distributional Anomalies," **National Tax Journal**, 27, June 1974, pp. 231-244.

——, and James Poterba, "Unemployment Insurance and Reservation Wages," **Journal of Public Economics**, 23, 1984, pp. 141-167.

Frank, J.A., "Economic Change and Mental Health in an Uncontaminated Setting," **American Journal of Community Psychology**, 9, 1981, pp. 395-410.

Gibbs, Jack, "Crime, Unemployment, and Status Integration," **British Journal of Criminology**, 6, 1966, pp. 49-58.

Gordus, J.P., P. Jarley, and L.A. Ferman, **Plant Closings and Economic Dislocation**, Kalamazoo, Mich.: Upjohn Institute, 1981.

Hammermesh, A.S. and N.M. Soss, "An Economic Theory of Suicide," **Journal of Political Economy**, 82, 1974, pp. 83-98.

Juhn, Chinhui, Kevin M. Murphy and Robert H. Topel, "Why Has the Natural Rate of Unemployment Increased Over Time?," **Brookings Papers on Economic Activity, 2**, 1991, pp. 75-126.

Katz, Lawrence F. and Bruce D. Meyer, "Unemployment Insurance, Recall Expectations, and Unemployment Outcomes," **Quarterly Journal of Economics**, 19, 1984, pp. 118-126.

Kiefer, Nicholas M., "Economic Duration Data and Hazard Functions," **Journal of Economic Literature**, 26, 2, June 1988, pp. 646-679.

Landau, S.G., D.L. Neal, M. Meisner, and J. Prudic, "Depressive Symptomatology Among Laid-Off Workers," **Journal of Psychiatric Treatment and Evaluation**, 2, 1980, pp. 5-12.

Mallinckrodt, Brent and Bruce R. Fretz, "Social Support and the Impact of Job Loss on Older Professionals," **Journal of Counseling Psychology**, Vol. 35, No. 3, 1988, pp. 281-286.

Meyer, Bruce D., "Unemployment Insurance and Unemployment Spells," **Econometrica**, 58, 4, July 1990, pp. 757-782.

Moffitt, Robert and Walter Nicholson, "The Effects of Unemployment Insurance on Unemployment: The Case of Federal Supplemental Benefits," **Review of Economics and Statistics**, 1982, pp. 1-11.

Organization for Economic Cooperation and Development (OECD), **Employment Outlook**, Paris: OECD, July 1995 and July 1994.

——, **The OECD Jobs Study: Facts, Analysis, Strategies**, Paris: OECD, 1994.

——, **The OECD Jobs Study: Evidence and Explanations, Part I: Labour Market Trends and Underlying Forces of Change**, Paris: OECD, 1994.

——, **Quarterly Labour Force Statistics**, No. 2, Paris: OECD, 1994.

——, **Labour Force Statistics 1971-1991**, Paris: OECD, 1993.

——, **Measures to Assist the Long-Term Unemployed: Recent Experience in Some OECD Countries**, Paris: OECD, 1988.

Parnes, H.S. and R. King, "Middle-Aged Job Losers," **Industrial Gerontology**, 4, 1977, pp. 77-95.

Pearlin, L.I. and C.W. Radabaugh, "Economic Strains and the Coping Functions of Alcohol," **American Journal of Sociology**, 82, 1976, pp. 652-663.

Perfetti, L.J. and W.C. Bingham, "Unemployment and Self-Esteem in Metal Refinery Workers," **Vocational Guidance Quarterly**, 31, 1983, pp. 195-202.

Pierce, A., "The Economic Cycle and the Social Suicide Rate," **American Sociological Review**, 32, 1967, pp. 457-462.

Phillips, Llad, Harold L. Votey, Jr., and Donald Maxwell, "Crime, Youth and the Labor Market," **Journal of Political Economy**, 80, 1972, pp. 491-504.

Smart, R.G., "Drinking Problems Among Employed, Unemployed and Shift Workers," **Journal of Occupational Medicine**, 21, 1979, pp. 731-736.

Solon, Gary, "Labor Supply Effects of Extended Unemployment Benefits," **Journal of Human Resources**, 14, 2, Spring 1979, pp. 247-255.

NOTES

1. The trivial relationship, of course, is $u(r) = s/n(r)$, where s is the average length of plant "down time" during modernization, n is the number of time periods before a plant requires modernization, on average, r is the rate of technical progress and u is the resulting contribution to the unemployment rate. Since $n'(r) < 0$ it follows that $u'(r) > 0$.

2. There is a rich and well-documented body of materials in the literature of sociology and social psychology that studies effects of unemployment not widely mentioned in economic discussions. They indicate that joblessness has consequences such as increased suicide, divorce, psychosomatic illness and, perhaps, increased criminal activity, among other effects whose social cost must surely be added to the foregone output that results from unemployment. Though much of this literature does not distinguish clearly between lengthy and brief unemployment it is surely plausible that a short spell of unemployment causes little lasting psychic or social damage. It is only when the unemployment goes on and on, and the worker begins even to suspect that he or she will never hold a job again, that the various forms of socially damaging behavior become substantial.

A few references as well as a summary of the evidence are provided in the following passage (Mallinckrodt and Fretz [1988 p. 281]):

> The devastating impact of job loss on physical and mental health has been summarized in several reviews of empirical investigations (Dooley and Catalano, 1980; Gordus, Jarley, and Ferman, 1981). Job loss has been linked to increased rates of suicide (Hammermesh and Soss, 1974; Pierce, 1967); diagnosed cases of mental illnesses; or increases in both inpatient and outpatient use of mental health services (Barling and Handal, 1980; Brenner, 1973; Frank, 1981), increased alcohol abuse (Pearlin and Radabaugh, 1976; Smart, 1979), more external locus of control (Parnes and King, 1977), lowered self-esteem (Perfetti and Bingham, 1983), and severe depression (Landau, Neal, Meisner, and Prudic, 1980). Some unemployed workers, depending on their attributional style, respond to the uncontrollable aversive event of job loss with learned helplessness behaviors, namely, depression and a lowered self-concept, that can immobilize job seeking efforts (Cohn, 1978; Feather and Davenport, 1981).

The more-ambiguous evidence on the relationship between unemployment and crime is discussed in Britt [1994].

3. The model obviously assumes some stickiness in relative wages. Otherwise, the wages of the unskilled may fall sufficiently to offset the decline in the demand for those workers, though the usual supply-demand model leads us to expect a wage fall to moderate the rise in unemployment of the unskilled but not to offset it altogether.

4. It may reasonably be conjectured that for very unskilled labor with very low wages hiring practices are rather casual, sometimes not even requiring job interviews (as in the hiring of longshoremen). Then for them the average interjob period may well have been relatively brief, initially. However, our discussion focuses on older workers as well as those who are unskilled. For workers over 44(!) years old unemployment duration has been between 30 and 45 percent greater than that of the average member of the labor force (table 4). Consequently, it seems plausible that for this combined group the average length of interjob period will not be much different than that for the remainder of the labor force. Add to that the rise in near permanent unemployment in both of these groups in the wake of accelerated technical change and it seems safe to assume that t_s is not materially larger than t_u.

5. Our own judgment is that the rapid TFP growth of the 1950s and 1960s is ascribable to a considerable degree to the recovery of economies ruined by depression and war. Such an economy, working with skills, knowledge and experience already available, can achieve a spectacular rate of growth of productivity with little technical change. Predictably, such a process will end once the ruined economies have been resuscitated, and productivity growth after that has occurred is bound to slow materially. If this is indeed a major part of the explanation of the slowdown, the leveling off of TFP need not imply that there has been any slowdown in technical change. Add to that the lag in reaping the benefits of at least some major innovations, as some observers believe is true of the contribution of computers to TFP growth, then one can conclude that the slowdown in TFP growth may not imply a slowdown in the rate of technical change.

6. See Marsten (1975), Ehrenberg and Oaxaca (1976), Hammermesh (1977), Welch (1977), Classen (1979), Solon (1979), Barron and Mellow (1981), Moffitt and Nicholson (1982), Feldstein and Poterba (1984), Meyer (1990), Katz and Meyer (1990), and Devine and Kiefer, 1991, Chapter 5, for a fairly complete review of the literature.

7. A fourth parameter of the system, the maximum number of weeks of UI benefits, varies too little over the postwar period (39 weeks in some deep recession years and 26 weeks in all others) to be of much interest here.

8. Unfortunately, for the purposes of this analysis, unemployment duration by educational group is not available.

9. In contrast, the coefficients of the percentage of workers aged 55 and over and the percent of workers who are women in age group 25 to 54 are both negative but statistically insignificant. The results do suggest that these groups tend to drop out of the labor force when they lose their job.

10. Regressions run by gender and race group do not show very sizable differences in results. The coefficient of TFP growth, for example, varies from 3.7 for black females to 3.9 for black males, 4.0 for white females, and 4.3 for white males. Differences in results among marital groups are also not very substantial.

Table 1
Variable Definitions and Data Sources and Methods

1. Mean duration of unemployment and the percent of unemployed workers who are unemployed for 27 weeks or more or 15 weeks or more. Source: Council of Economic Advisers, **Economic Report of the President, 1996**, (United States Government Printing Office, Washington, DC: 1996). The data were originally tabulated by the Bureau of Labor Statistics.

Mean duration of unemployment by demographic group is computed from: Bureau of Labor Statistics, **Employment and Earnings**, (Washington, DC: United States Government Printing Office), various years.

2. The civilian unemployment rate. Source: Council of Economic Advisers, **Economic Report of the President, 1996**, op. cit. The data were originally tabulated by the Bureau of Labor Statistics.

3. R&D expenditures include company, federal, and other sources. Source: National Science Foundation, **Research and Development in Industry**, (Arlington, VA: National Science Foundation), various years.

4. Full-time equivalent (FTEE) scientists and engineers engaged in R&D. Source: National Science Foundation, **Research and Development in Industry**, (Arlington, VA: National Science Foundation), various years.

5. Gross non-residential fixed capital. Sources: John C. Musgrave, "Fixed Reproducible Tangible Wealth in the United States: Revised Estimates," **Survey of Current Business**, Vol. 71, No. 1, January, 1992; "Fixed Reproducible Tangible Wealth in the United States," **Survey of Current Business**, Vol. 74, No. 8, August, 1994.

6. Full-time equivalent employees (FTEE). Sources: U.S. Bureau of Economic Analysis, National Income and Product diskettes, 1959-88; U.S. Bureau of Economic Analysis, **National Income and Product Accounts of the United States: Vol. 2, 1959-88**, (Washington, DC: U.S. Government Printing Office), September 1992; **Survey of Current Business**, Vol. 71, No. 4, January, 1992; and **Survey of Current Business**, Vol. 76, No. 1/2, January/February 1995.

7. Gross Domestic Product (current and 1992 dollars). Source: Council of Economic Advisers, **Economic Report of the President, 1997.**

8. Investment in office, computing, and accounting equipment [1987 dollars] and investment in total equipment and machinery. Source: U.S. Bureau of Economic Analysis, Diskette of Detailed Investment by Industry. (Received January 1996).

9. Employees covered by Unemployment Insurance. Sources: Council of Economic Advisers, **Economic Report of the President, 1996** and **Economic Report of the President, 1984.** Employment is for age 16 and over.

11. UI replacement rate: Committee on Ways and Means, U.S. House of Representatives, **1994 Green Book,** (Washington, DC: U.S. Government Printing Office). Data supplemented by: Council of Economic Advisers, **Economic Report of the President, 1996;** and **Economic Report of the President, 1984.**

12. UI insured coverage rate: Committee on Ways and Means, U.S. House of Representatives, **1994 Green Book.**

13. Minimum wage. Source: U.S. Bureau of the Census, **Statistical Abstract of the United: 1997** (117th edition), Washington, DC, 1997.

14. Consumer Price Index. Source: Council of Economic Advisers, **Economic Report of the President, 1997.**

15. Percent of labor force covered by unions. Source: Bureau of Labor Statistics worksheets. Estimates for 1983-1995 are annual averages from the Current Population Survey. Estimates for 1950-83 are the annual average number of dues paying members reported by labor unions. Data exclude numbers of professional and public employee associations.

16. Employment by gender and age. Sources: 1950-1974. U.S. Bureau of Labor Statistics, **Handbook of Labor Statistics,** (United States Government Printing Office, Washington, DC: 1985), Bulletin 2217, Table 15. 1975-1993. US Bureau of Labor Statistics, **Employment and Earnings,** (United States Government Printing Office, Washington, DC: 1977-94). January issues, various years. Figures are based on annual averages for household data.

Table 2
Mean Unemployment Duration and Mean Values of Technological And Institutional Variables by Period[a]

A. Technological Variables

Period	Mean Duration of Unemployment (Weeks)	Ratio of R&D Expenditures to GDP [%]	FTEE Sci. & Eng. Engaged in R&D per 1000 Employees	OCA Investment per FTEE[b]	Equipment Investment per FTEE[b]	Annual Rate of TFP Growth [%][c]
1950-59	11.4	1.50	4.01	0.006	1.96	1.56
1960-69	11.7	1.97	4.81	0.007	2.54	1.75
1969-79	11.5	1.56	4.32	0.021	3.46	0.65
1979-89	14.6	1.83	5.47	0.185	3.80	0.47
1990-95	15.6	1.89	6.30	0.522	4.35	0.29
Correlation with Mean Unemployment Duration[f]		0.30	0.40	0.54	0.49	0.23

B. Institutional Variables

Period	Mean Duration of Unemployment (Weeks)	Percent of Employees Covered by UI	UI Replacement Rate[d] [%]	UI Insured Coverage Rate[%][e]	Union Members as Percent of Labor Force	Minimum Wage in 1987 Dollars
1950-59	11.4	64.9	33.4	53.3	24.4	3.59
1960-69	11.7	73.2	34.9	47.1	22.6	4.46
1969-79	11.5	82.6	36.5	47.8	21.1	4.52
1979-89	14.6	92.6	36.2	36.8	18.0	3.73
1990-95	15.6	93.9	36.7	35.2	16.0	3.33
Correlation with Mean Unemployment Duration[f]		0.49	0.35	-0.39	-0.56	-0.34

a. See Table 1 for variable definitions and sources and methods.
b. In thousands of 1987 dollars per employee. Private sector only.
c. Uses FTEE and gross non-residential capital stock, the private sector only.
d. Ratio of mean UI weekly benefit to mean weekly wage.
e. Ratio of insured unemployment to total unemployment.
f. The correlation coefficient is computed on the basis of 36 observations (annual data from 1950 to 1995), except for the ratio of R&D expenditures to GDP (1953-1994), scientists and engineers engaged in R&D (1957-1994), and UI insured coverage rate (1967-1993).

Table 3

Mean Unemployment Duration and the Percentage Distribution of Total Employment by Gender and Age and by Period[a]

	Mean Duration of Unemployment (Weeks)	Percentage Distribution of Total Employment								
		Male				Female				
		16-19	20-24	25-54	55+	16-19	20-24	25-54	55+	Total
1950-60	11.4	3.4	5.4	46.4	13.3	2.6	3.8	20.3	4.8	100.0
1960-69	11.7	3.9	6.2	42.7	12.2	3.0	4.4	21.4	6.1	100.0
1969-79	11.5	4.5	7.4	38.6	10.3	3.7	6.1	23.3	6.0	100.0
1979-89	14.6	3.4	6.9	37.8	8.1	3.1	6.1	28.9	5.6	100.0
1989-95	15.6	2.6	5.5	39.2	7.1	2.4	5.0	32.7	5.4	100.0
Simple Correlation with Mean Unemployment Duration[b]		-0.51	0.07	-0.31	-0.52	-0.26	0.19	0.56	0.01	

a. See Table 1 for variable definitions and sources and methods.
b. The correlation coefficient is computed on the basis of 36 observations (annual data from 1950 to 1995).

Table 4

Mean Duration of Unemployment by Demographic Group[a]
(Period Averages)

	1970-79	1980-89	1990-93
Men			
All Men	13.1	17.1	17.2
16 to 19 years	8.3	9.3	8.5
20 to 24 years	11.6	14.5	12.6
25 to 34 years	14.0	18.3	17.0
35 to 44 years	16.8	21.1	20.3
45 to 54 years	18.0	22.7	24.1
55 to 64 years	19.1	23.8	25.6
65 years and over	21.0	19.3	24.5
Women			
All Women	10.5	12.4	13.3
16 to 19 years	7.5	7.8	7.5
20 to 24 years	9.5	10.8	9.5
25 to 34 years	10.8	12.9	13.2
35 to 44 years	12.1	14.7	16.0
45 to 54 years	13.9	16.1	18.1
55 to 64 years	16.5	17.8	20.1
65 years and over	18.2	15.6	19.6
White, 16 years and over	11.7	14.4	15.2
Men	12.8	16.6	16.9
Women	10.2	11.6	12.9
Black, 16 years and over	12.8	17.0	16.6
Men	14.2	19.3	18.6
Women	11.4	14.6	14.4
Men, 16 years and over:			
Married, spouse present	14.8	19.4	19.6
Widowed, divorced, or separated	14.4	20.9	20.3
Single (never married)	11.2	14.3	14.3
Women, 16 years and over:			
Married, spouse present	10.6	12.2	14.0
Widowed, divorced, or separated	10.9	15.4	15.7
Single (never married)	9.4	10.9	11.2

a. See Table 1 for variable definitions and sources and methods.

Table 5
Regressions of the Mean Duration of Unemployment
On Institutional, Technological, and Demographic Variables[a]

Independent Variables	Specification (1)	(2)	(3)	(4)	(5)	(6)
Constant	1.56☼☼	2.59☼☼	1.74☼☼	2.55☼☼	1.41☼☼	-1.80
	(13.4)	(8.15)	(4.57)	(7.62)	(4.04)	(1.24)
TFPGRTH5	0.127☼☼		0.127☼☼		0.127☼☼	0.114☼☼
	(8.79)		(3.93)		(3.81)	(4.46)
OCAFTEE	0.531☼☼		0.458☼		0.582☼☼	0.621☼☼
	(4.13)		(2.63)		(2.96)	(2.78)
UNEMPRATE	0.133☼☼	0.089☼☼	0.133☼☼	0.085☼☼	0.138☼☼	0.130☼☼
	(8.79)	(5.58)	(8.38)	(4.94)	(8.73)	(8.81)
LNMINWAGE		-0.411#	-0.123			
		(2.00)	(0.54)			
UNIONRATE				-0.024#	0.005	
				(1.73)	(0.38)	
%EMP1619						-8.15☼
						(2.42)
%EMP2024						11.34☼
						(2.58)
%MAL2554						6.45☼
						(2.55)
R^2	0.90	0.84	0.90	0.84	0.90	0.93
Adj. R^2	0.89	0.82	0.88	0.82	0.88	0.91
Std. Err.	0.076	0.101	0.077	0.101	0.077	0.067
DW stat.	1.97	1.94	2.02	1.87	1.96	1.98
No of Obs	38	43	38	43	38	38
Est. Tech.	AR(2)	AR(2)	AR(2)	AR(2)	AR(2)	AR(2)

a. Dependent variable is LNMEANDUR: the natural logarithm of the mean duration of unemployment. t-ratios (absolute values) are shown in parentheses below the coefficient. The sample is based on aggregate data for the U.S. economy.

Key:

TFPGRTH5: Five-year running average of the annual percentage rate of total factor productivity growth [see equation 3].

OCAFTEE: Investment in office, computing, and accounting equipment (in 1987 dollars) per full-time equivalent employee.

Table 5 (continued)

UNEMPRATE: Annual overall unemployment rate

LNMINWAGE: The natural logarithm of the minimum wage in 1987 dollars.

UNIONRATE: Percentage of labor force covered by unions.

%EMP1619: Percentage of total employees in age group 16-19.

%EMP2024: Percentage of total employees in age group 20-24.

%MAL2554: Percentage of total employees who are men in age group 25-54.

AR: Autoregressive process. (1) First-order: $u_t = \ddot{e}_t + \varphi_1 \cdot u_{t-1}$
(2) Second-order: $u_t = \ddot{e}_t + \varphi_1 \cdot u_{t-1} + \varphi_2 \cdot u_{t-2}$, where u_t is the error term of the original equation and $\ddot{e}_t$ is a stochastic term assumed to be identically and independently distributed.

See Table 1 for data sources and methods.

Significant at the ten percent level (2-tail test).
☼ Significant at the five percent level (2-tail test).
☼☼ Significant at the one percent level (2-tail test).

Table 6
Regressions of the Percent of Unemployed Workers Who are Unemployed for 15 or More Weeks or 27 or More Weeks On Institutional, Technological, and Demographic Variables[a]

Independent Variables	Dependent Variable %UNEMPL15	%UNEMPL27	%UNEMPL15	%UNEMPL27
Constant	-6.85☼	-9.21☼☼	-83.6☼	-83.9☼
	(2.43)	(3.63)	(2.64)	(2.57)
TFPGRTH5	2.97☼☼	2.62☼☼	1.88☼☼	1.78☼☼
	(3.77)	(3.96)	(3.46)	(3.16)
OCAFTEE	11.33☼☼	8.88☼☼	18.33☼☼	15.22☼☼
	(2.79)	(3.54)	(3.73)	(3.01)
UNEMPRATE	4.60☼☼	3.01☼☼	4.66☼☼	2.94☼☼
	(12.5)	(8.94)	(13.8)	(8.46)
%EMP1619			53.4	-49.7
			(0.70)	(0.63)
%EMP2024			96.8	180.9#
			(1.00)	(1.81)
%MAL2554			153.0☼☼	142.1☼
			(2.78)	(2.50)
R^2	0.92	0.86	0.94	0.89
Adj. R^2	0.90	0.84	0.93	0.86
Std. Err.	1.93	1.82	1.66	1.67
DW stat.	1.93	2.02	1.84	1.90
No of Obs	38	38	39	39
Est. Tech.	AR(2)	AR(2)	AR(1)	AR(1)

a. t-ratios (absolute values) are shown in parentheses below the coefficient. The sample is based on aggregate data for the U.S. economy. Key (also see footnotes to Table 5):

%UNEMPL15: Percent of unemployed workers who are unemployed for 15 or more weeks.

%UNEMPL27: Percent of unemployed workers who are unemployed for 27 or more weeks.

\# Significant at the ten percent level (2-tail test).
☼ Significant at the five percent level (2-tail test).
☼☼ Significant at the one percent level (2-tail test).

Table 7
Regressions of the Mean Duration of Unemployment by Gender and Age Group On Technological Variables[a]

Demographic Group	Independent Variables: Constant	TFPGRTH5	OCAFTEE	UNEMPRATE	R^2	Adj. R^2	Std. Err.	DW Stat	No of Obs
Men by age group:									
16-19 years	1.44☼☼	-0.001	-0.059	0.108☼☼	0.89	0.86	.057	2.15	22
	(14.7)	(0.02)	(1.07)	(8.80)					
20-24 years	1.34☼☼	0.092	0.163	0.168☼☼	0.85	0.80	.092	2.00	22
	(7.69)	(1.61)	(1.67)	(7.70)					
25-34 years	1.69☼☼	0.096	0.409☼☼	0.143☼☼	0.82	0.76	.098	2.01	22
	(8.24)	(1.41)	(3.12)	(5.54)					
35-44 years	2.09☼☼	0.125#	0.542☼	0.101☼☼	0.72	0.65	.115	1.72	22
	(8.67)	(1.79)	(2.47)	(3.38)					
45-54 years	2.33☼☼	0.089	0.653☼☼	0.081☼☼	0.79	0.72	.099	2.12	22
	(11.1)	(1.33)	(4.26)	(3.15)					
55-64 years	1.85☼☼	0.216#	0.763☼	0.144☼	0.58	0.48	.187	1.81	22
	(4.27)	(1.79)	(2.65)	(2.61)					
Women by age group:									
16-19 years	1.57☼☼	-0.024	-0.145#	0.073☼☼	0.82	0.76	.063	2.07	22
	(13.1)	(0.60)	(2.00)	(4.80)					
20-24 years	1.54☼☼	0.044	0.018	0.109☼☼	0.82	0.76	.082	2.01	22
	(9.06)	(0.81)	(0.14)	(5.05)					
25-34 years	1.37☼☼	0.116☼	0.422☼☼	0.144☼☼	0.84	0.81	.083	1.71	22
	(7.77)	(2.26)	(3.38)	(6.45)					
35-44 years	1.35☼☼	0.109☼	0.697☼☼	0.156☼☼	0.89	0.86	.079	1.82	22
	(8.11)	(4.81)	(6.87)	(7.55)					
45-54 years	1.77☼☼	0.116#	0.504☼☼	0.119☼☼	0.84	0.79	.093	2.21	22
	(9.49)	(1.84)	(3.75)	(5.04)					
55-64 years	1.78☼☼	0.131#	0.586☼☼	0.130☼☼	0.70	0.63	.120	1.94	22
	(7.42)	(1.74)	(3.42)	(4.34)					

a. The dependent variable is the natural logarithm of the mean duration of unemployment by demographic group. t-ratios (absolute values) are shown in parentheses below the coefficient. The sample is based on aggregate data for the U.S. economy covering years 1972 to 1995. Equations are estimated using a second-order autoregressive process. See footnotes to Table 5 for the key.

\# Significant at the ten percent level (2-tail test).
☼ Significant at the five percent level (2-tail test).
☼☼ Significant at the one percent level (2-tail test).

Table 8
Decomposition of Change in the Mean Duration of Unemployment Between 1971 and 1994 Into Technological, and Demographic Effects[a]

	Value of Each Variable		Contribution of Each Variable[c]		Change in Contribution	Percentof Change in LNMEANDUR
Year	1971	1994	1971	1994	1971 - 1994	Explained
LNMEANDUR	2.42	2.93	2.42	2.93	0.51	
Constant	1.00	1.00	-1.80	-1.80	0.00	
TFPGRTH5[b]	0.31	0.00	0.04	0.00	-0.04	-6.9
OCAFTEE	0.01	0.86	0.01	0.53	0.53	103.4
UNEMPRATE	5.90	6.10	0.77	0.79	0.03	5.1
%EMP1619	0.08	0.05	-0.64	-0.38	0.26	51.0
%EMP2024	0.13	0.10	1.46	1.15	-0.30	-59.7
%MAL2554	0.40	0.40	2.55	2.56	0.00	0.6
Residual			0.05	0.08	0.03	6.5
Sum			2.42	2.93		100.0

a. Dependent variable is LNMEANDUR: the natural logarithm of the mean duration of unemployment. The decomposition is based on the coefficients from specification 6 of Table 5. See footnotes to Table 5 for variable definitions.

b. Percentage points.

c. Defined as the coefficient value multiplied by the value of the variable in each year.