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TECHNOLOGICAL CHANGE AND THE EXTENT OF FRICTIONAL AND STRUCTURAL UNEMPLOYMENT

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I. Introduction

Structural and frictional unemployment are usually considered among the unpleasant and exogenous facts of economic life about which little can be done. As technology advances and the composition of demand changes, employment must also shift. In the process of adjusting to a new equilibrium, some people will endure spells of unemployment. Usually, this is considered part of a healthy re-equilibration process, and the resulting unemployment is seen as part of the underlying "natural" rate of unemployment. Recent oil and trade shocks that have reduced manufacturing employment focus attention on how the economy adjusts to structural changes. This paper analyzes the nature of this adjustment process and shows the magnitude of gross flows of employment across industries and establishments. It dissects the flow of job creation and destruction, and develops a clearer empirical view of the dynamics of establishment size in relation to employment and unemployment. Only when the ongoing rate of job turnover in the economy is established, can we begin to judge how flexible the economy is and how great technological change would have to be to strain the economy's ability to adapt.

At least since the Luddites forcefully expressed their opinions, many people have believed that technological change contributes to unemployment. With the advent of the computer age, fears have increased either that there will be little productive work left for people to do, or that as the pace of technological change quickens, the volatility of employment will increase as industries go in and out of technological style. The latter hypothesis depends on change generating unemployment. In a flexible economy, this need not necessarily be the outcome. With good information and low adjustment costs, workers may shift across industries without experiencing frequent or long unemployment. The goal of this paper is to show the normal level of turnover of jobs in the U.S. economy. I will show that in a normal year a substantial fraction of all jobs are destroyed and created. Most of this flux is within, not across, industry lines.

If technological change were a driving force in employment growth and decline, and if the degree of technological change or the impact of technological change on employment varied substantially across industries, then we would expect to see sharp differences in employment patterns among establishments in different industries. In fact, there is greater employment variation within industries than across industries. Part of the employment variation within industries may be due to temporary cost advantages reaped from technological advances, but this is not the sort of technological change that has a pervasive effect across an entire industry. The cross-industry shifts, which have attracted the most attention, and where one might expect technological effects to dominate, ignore the source of most job flux.

In a sense, the technological unemployment cup is both half empty and half full. If all the employment variation observed here is fundamentally caused by technological change, then technological change, as measured here, may account for roughly 2.2 percentage points of unemployment in an average year between 1977 and 1982. At the same time, an economy that loses one in nine jobs and creates one in eight jobs in an average year already has experience with great job volatility, which suggests considerable flexibility to respond to additional technological change.

The population of establishments analyzed here is described in the next section. Section III provides an overview of the economy of the state studied here, and of the growth and decline of employment. New evidence on the instability of jobs is presented in Section IV. The transient nature of demand shocks at the establishment level is demonstrated in Section V. Section VI tests for the existence of industry, area, or year effects on establishment growth rates. Section VII presents the conclusions.

II. Population Characteristics

The sample studied here is drawn from a complete survey of establishments in the state of Wisconsin. While the industrial composition of the Wisconsin economy is not exactly representative of the U.S. economy, it is not a bad approximation. For example, manufacturing employment accounts for 34.5 percent of private non-agricultural wage and salary employment in Wisconsin in 1980, compared to 27.4 percent of employment in the nation. There is not much reason to expect Wisconsin employers to be any more insulated from or exposed to technological change. The underlying data are collected as part of the administration of the unemployment insurance (U.I.) program. This is not a sample. It is (in theory and by law) the population of establishments in the state. The state Department of Industry, Labor and Human Relations prepares annual files from the March Unemployment Compensation Contribution Reports. These reports must by law be filed by all establishments paying at least one employee $1,500 in any quarter of the year.[1] This data is the primary source of Federal employment statistics. In the majority of cases, these establishments are the sole operating asset of a firm, so there is not much distinction between establishments and firms. Where possible, company-wide reports for multi-establishment companies and for companies which acquired other companies between 1977 and 1982 have been eliminated from the sample studied here. Transfers of ownership are treated not as a continuation of a single business, but rather as a death and a birth. This obviously is not appropriate for some applications. In particular, job gain and loss rates and the variance of growth rates may be overstated.

Births and deaths have relatively little impact on job creation and destruction because they are concentrated in the smallest establishments. It is, however, possible that plant closings have a disproportionately large effect on unemployment. In a 1978-79 version of this data set that counts transfers as a continuation of business rather than as a birth and death, 11 percent of all job losses and 18 percent of all job gains were accounted for by deaths and births, respectively. (The Job Generation Process in Wisconsin, Table 2-2, p. 145) The greater part of the gross job flows, 89 percent of losses and 82 percent of gains, occurred through the contraction or expansion of going concerns.[2]

The population studied here has 124,711 establishments with 1,198,638 employees in 1978. That averages 9.6 employees per establishment, not a great surprise to those familiar with County Business Patterns data. The distribution is, of course, highly skewed. More than 80 percent of employment is in establishments with ten or more employees, but at the same time, more than 80 percent of the establishments employ fewer than ten employees. Most of the institutional analysis of business deals with big business. Fewer than

2 percent of the establishments studied here have more than 100 employees. The large establishment is not the typical establishment, but surprisingly little is known about the small establishments that predominate.[3]

III. Growth and Decline: Ratio of Cell Means

What happens when the unemployment rate in a state doubles in three years? Perhaps one pictures a cataclysmic event -- war, natural disaster, the invention of the steam engine, or at least an oil shock -- some major disturbance causing the rapid extinction of a large proportion of all jobs. In Wisconsin, the state unemployment rate doubled in three years from 5.0 percent in 1979 to 10.0 percent in 1982, which indeed is the period following the second oil shock (see Table 1). The number of unemployed people also nearly doubled to 235,630 over these years. What does it take to double the unemployment rate and put an extra 120,000 people out on the street?

It only takes an average annual decline in employment of less than 1.2 percent between 1979 and 1982 (line 7). This is a loss of 79,000 jobs. The remaining third of the additional unemployed in these years is accounted for by the 40,000 person increase in the labor force. During the earlier period, 1977 and 1980, total employment grew. Despite this, the unemployment rate also rose during these years, because the growth rate of employment fell more than the growth rate of the labor force. Under such conditions, it does not take great declines in the employment growth rate to produce an increase in the unemployment rate.

Between 1977 and 1980, sample employment increased by 15.6 percent. In the next year it fell by 3.5 percent. Table 2 shows that the annual average growth rate of total employment (equivalent to an employment weighted establishment average) is 1.10 (1978), 1.04 (1979), 1.02 (1980), 0.97 (1981) and 1.02 (1982). This is a 13 percentage point drop in the rate of employment growth between 1978 and 1981.

The net employment growth rate is usually all that can be observed. Here it averages 2.8 percent annually among all establishments. But this turns out to be the sum of two large numbers.[4] Growing establishments average 30 percent growth in each year of growth. Shrinking establishments average 21 percent shrinkage. The employment weighted average of these two (and of the stable) yields the observed 2.8 percent net growth.

Distributing establishments by growth rates shows that mean growth does not decline because the entire distribution of growth rates shifts down. The employment growth rate declines not because all establishments are growing slower (they are not) but rather because shrinking establishments shrink faster and because about the middle of the distribution, establishments that were growing start to shrink. It is primarily this shift of only 5 percent of the establishments that lowers aggregate employment growth. The observed aggregate fluctuations occur not because of a widely shared response by establishments to changing incentives, but rather because of a more concentrated change by a small proportion of establishments.

The large changes in the share of all employment in growing or shrinking establishments are apparent[5] in Table 3. As the growth rate of total employment declined from 9.1 percent (1978) to -3.7 percent (1981), the share of employment in growing plants declined from .59 to .31. Meanwhile, the share of employment in shrinking plants nearly doubled from .34 (1970) to .61 (1981). These shifts can account for most of the decline in the growth rate of employment between 1977 and 1981.

Mean of Ratios

Carrying the process of disaggregation one step further, take as the growth rate the mean of establishments' growth rates rather than the growth rate of mean employment. Table 4 weights each establishment equally, whereas Table 2 weighted each establishment's growth by its initial employment.

Comparing Table 4 to Table 2, we observe that the average establishment grows faster than does total (or average) employment. This occurs because the small grow faster. Note the large standard variation (in parentheses) of growth rates across establishments. This is particularly true in manufacturing, where coefficients of variation greater than one are common. While the average growth rate changes over the years by less than 10 percentage points, the standard deviation of growth in the cross-section can exceed 180 percentage points. This reveals considerable heterogeneity in growth rates across establishments.

Comparing the six-year average annual growth rates with the growth rate over six years in Table 4, we see again evidence of regression to the mean; growth is concentrated among the small. In an average year, the average growth rate is 6 percent. But this does not take place in the same establishments year after year. It does not compound. Each year a new set of small establishments accounts for much of this growth, for after six years the average establishment has grown by only 15 percent, which is less than one would expect from the compounding of the average 6 percent annual growth rate. Growth and decline tend to be transient rather than chronic conditions -- a point we shall later develop further. Over these same six years, the average growing establishment has doubled in size, the average shrinking establishment has been reduced to a third its original size, and only one-third of all establishments have maintained their original employment level.

IV. Job Turnover

Short durations of employment and high frequencies of disemployment are typically thought of in terms of the characteristics of people. The statistics in Table 5 (lines 7 and 10) reveal tremendous turnover of jobs themselves. New jobs equal to 13.8 percent of the previous year's base are created each year, while 11.0 percent are destroyed. The difference between these two flows, 2.8 percent net employment growth, is all that is usually observed. Of course, the gross flows analyzed here are themselves only the tip of the iceberg. They include only job destruction and creation that changes the net size of an establishment between one March and the next, and ignore all other.[6] But even the tip of the iceberg looks surprisingly large. About one in every nine jobs disappear each year. More than one in every eight jobs is created every year. This is not during a great depression, nor a great boom. These are the magnitudes of gross job flows experienced in the average year between 1977 and 1982.

We can now re-examine the state economy in light of gross rather than net employment flows. Between 1977 and 1978, two and one-third jobs were created for every one destroyed (Table 5, line 12). Three years later, between 1980 and 1981, only seven-tenths of a job was created for every one destroyed. Both the decline in jobs created and the increase in jobs destroyed contribute to the increase in the unemployment rate observed over these years.

It would be of great interest to know whether similarly large gross flows existed in earlier years and how they affected the "natural" rate of unemployment. Apparently, in the past either gross flows were smaller or they were accommodated with less unemployment and less inflation. The short time period observed here cannot answer such questions. The gross turnover rate is the sum of the job creation and the destruction rates and is used as a measure of labor market turbulence. This rate ranges from .22 to .34 (Table 5, line 13) but shows no obvious pattern. On the basis of these statistics, one could not say that greater churning in the labor market was associated either with greater or less employment growth.

These statistics from establishments can, under certain assumptions, be used to make inferences about the distribution of job durations -- the lifetime of the job itself. These may then be compared to data reported by workers on job tenure -- the lifetime of a worker-job match. Assuming stationarity and stable distributions, the average duration of a job is the inverse of the death rate. Under these assumptions, the average job in this sample lasts 9.1 years (completed spell). Hall (1982, p. 720) reports that the expected median tenure of a worker in 1978 was 7.7 years (completed spell).[7] A job that dies must cause either a quit or a fire, and so truncate job tenure. It seems likely that short job durations contribute to short job tenure and so add to unemployment, although nothing more precise than this can be said on the basis of the mean durations and tenures at hand.

Stronger evidence of the relationship between job turnover and unemployment comes from a more direct comparison of the job destruction rate reported here with the transitions from employment to non-employment reported by individuals in the CPS. Poterba and Summers (1985) correct this series for reporting errors and find that between 1977 and 1982 the average monthly probability of moving from employment to non-employment is .019. (Poterba and Summers, 1985, Table V, Total Adjusted and Raked). I find here that .11 of all jobs disappear in an average year over the same period. This is a monthly rate of about .009. If few of the incumbants in disappearing jobs manage to find new employment without an intervening spell of non-employment, then this comparison suggests that, depending upon the magnitude of measurement error, roughly half of the transitions from employment to non-employment reported by individuals could be accounted for by the disappearance of their jobs.

This may have important implications for the "natural" rate of unemployment. To illustrate, suppose that the year to year employment changes measured here capture only half of all job turnover during a year, and that only half of this turnover is associated with any unemployment. (Both of these assumptions are guesses.) Then in an average year, we expect about 11 percent of all jobs to be destroyed and result in unemployment. Dynarski and Sheffrin (1986) report that an average completed spell of unemployment lasts 10.3 weeks, or one-fifth of a year. Using this duration in a rough calculation, job loss could account for about 2.2 percentage points, or more than a quarter of Wisconsin's 7.6 percent average unemployment during 1978-1982. The companion paper by Podgursky analyzes further the subsequent experience of displaced workers. Neither standard analyses (in terms of personal characteristics) nor standard policies are likely to be of much use in understanding or preventing the problem of workers who are caught in the wrong place at the wrong time. Neither manpower nor aggregate demand policies address this fundamental instability of jobs.

Non-manufacturing jobs are sometimes thought of as more stable than those in manufacturing. Two dimensions of stability should be distinguished: stability in a steady-state, and stability over the cycle. The first four columns of Table 6 show the proportions of jobs created and destroyed each year in the non-manufacturing and manufacturing sectors of the Wisconsin sample. In nearly all years, both the job creation and the job destruction rates are higher outside of manufacturing. By this measure, manufacturing jobs are more stable. They are also more cyclically sensitive. The rates of job gain and loss change more over the cycle in manufacturing than outside.

The last two columns of Table 6 present new hire and layoff rates in Wisconsin manufacturing derived from Employment and Earnings. These are the sum of the reported monthly rates. The new hire and layoff rates were selected from among other components of accessions and separations because they were presumed to be more closely tied to job gain and loss. The rates of job creation and destruction calculated here range between one-third and three-quarters of the new hire and layoff rates. This suggests that a substantial portion of new hires and layoffs are accounted for by job creation and destruction.[8]

Technological change is typically thought of as affecting different industries to different degrees. For example, the rate of technological change in the furniture industry is not generally thought to be as great as that in the electronic machinery industry. If technological changes plays a substantial role in explaining the rates of job loss and gain observed here, then we would expect to see different rates in different industries. Tables 7 and 8 present annual job loss and gain rates by industry. Employment in industries typically characterized as undergoing great technological change (such as electrical machinery or chemicals) is not obviously more volatile than in industries usually thought of as embodying more mature, unchanging technologies (such as furniture, lumber, or stone, clay and glass).

V. The Dynamics of Establishment Size

This section examines the nature of the time path of changes in establishment size. The correlation of the logarithm of establishment size for establishment i in year t (S_{it}) and of the first difference of this, $D_{it} = S_{it} - S_{it-1}$, are analyzed here.

Establishment size can be modelled as the sum of transient and cumulative innovations.

(1) $$S_{it} = w_{it} + \mu_{it}$$

and

(2) $$w_{it} = w_{i,t-1} + \epsilon_{it}$$

where

S_{it} = logarithm of establishment i size in year t

μ_{it} = white noise, $E(\mu_{it} \cdot \epsilon_{it}) = 0$

w_{it} = random walk component.

The first difference ($S_{it} - S_{it-1}$) of the logarithm of size may now be expressed as:

(3) $$D_{it} = \epsilon_{it} + \mu_{it} - \mu_{t-1}$$

where ϵ_{it} is the innovation in the random walk component of size, and ($\mu_t - \mu_{t-1}$) is a moving average component. Positive autocorrelation of the ϵ_1 indicates the persistence of shocks or lags in adjustments. If the ϵ_i are serially uncorrelated, then this model predicts that growth rates ($D_{it} = \Delta S_{it}$) more than two years apart are uncorrelated and follow a random walk. It also predicts that growth rates in adjoining years will be negatively correlated:

(4) $$COR(D_{it}, D_{1,t-1}) = \frac{-\sigma_u^2}{\sigma_\epsilon^2 + 2\sigma_\mu^2}$$

(5) $$= \frac{-1}{\frac{\sigma_\epsilon^2}{\sigma_\mu^2} + 2}$$

In this model the ratio of lasting to transient errors is identified from the correlation of the logarithm of growth rates two years apart. A test of the fit of this model is provided by its prediction of negatively correlated growth rates in neighboring years, and uncorrelated growth rates in years further apart.

Table 9 presents a correlation matrix for the logarithm of size and its first difference, the logarithm of growth rate. Unlike the rest of the analysis in this paper, these correlation matrices are calculated only for the subsample of establishments with positive employment in all years. The growth rates are smaller than in the full sample. Note also that the cross-section standard-deviation of size hardly changes over time, and that the lowest growth rate (in 1982) is associated with the highest cross-section standard-deviation of growth rates.

Table 9 shows a number of pieces of evidence pointing to a regression to the mean in size. The elements of the upper right corner of the table are all negative. In every case larger size is associated with slower growth in each subsequent year. By the same token, larger size is associated with faster growth in each previous year. Large establishments have recently grown and will soon shrink, on average. Small establishments have recently shrunk and will soon grow, on average. The latter statistical artifact is the foundation for the belief that small establishments are the fountainheads of employment growth. (See Leonard, 1985, for further development.)

The lower right hand quadrant of Table 8 shows the correlations of growth rates with themselves over time. All but one of the correlations are negative, and all of the significant correlations are negative. The strongest pattern is for growth rates one year apart. These average a correlation of .24. Above average growth in one year is likely to be followed (and proceeded) by significantly below average growth in the next year. If the establishment grows, it likely shrank in the recent past and will grow in the near future. There is certainly not complete persistence of shocks to growth rates. But neither is there complete adjustment from a shock after one year. What adjustment occurs is primarily in the first year. An employment growth rate 100 percent above average one year is likely to be followed by one 25 percent below average next year, which is then followed by a random walk. This also explains why the average changes we previously observed between 1977 and 1982 were much less than the compounding of the annual average changes.

This correlation of first differences in size can now be interpreted in terms of equation (3). As predicted by this process, growth rates one year apart are negatively correlated; those more than one year apart are close to uncorrelated. That $E(\epsilon_{it}, \epsilon_{i,t+k}) \cong 0$ for $k \geqslant 2$, suggests that establishments quickly adjust and that shocks are not persistent. The one year apart correlation is roughly .25, which corresponds to $\sigma_\epsilon^2 = 2\sigma_\mu^2$. Half of the variance in growth rates then represents real shocks, and at most half represents a moving average (MA(1)) process of transient errors. Since a pure measurement error process is MA(1) in growth rates and implies $COR(D_{it}, D_{1,t-1}) = -0.5$, this provides a bound on the role of measurement error in the results reported here.

There are other possible explanations besides transient real shocks for the half of growth rate variance that follows an MA(1). This component of variance could all be measurement error. An alternative explanation is that target employment follows a random walk. Actual employment may differ from the target by an error which persists less than one year. Both explanations are consistent with an MA(1) process.

VI. The Non-Existence of Industry Shocks

Among the most basic economic models of establishment growth is one that posits that the growth rates of establishments should depend on which industry or region they are in. Structural change implies non-transient shifts of employment across industry and/or regional lines. Technological change is usually assumed to have pervasive effects within any one industry, but different effects in different industries. It has become commonplace to speak of the industry or region shocks suffered by the economy since at least 1973, and to attribute to them problems of both the level and the variation of unemployment. Certain industries or regions are widely recognized as being in growth or decline, and it is usually assumed that such trends are widely shared by establishments within the particular industry or region. This last assumption is challenged by the evidence to be presented here.

While there certainly are industries or regions that have experienced a trend of growth or decline, it is mistaken to infer from this aggregate experience that such growth or decline is widely shared by establishments within these groups. For two digit S.I.C. industries, and for counties in Wisconsin, industry or region trends are largely irrelevant for the average establishment in an industry or region.

The purely idiosyncratic components of variation in establishment growth rates can be reduced by grouping and taking averages of growth rates within industry, by county, by year cells. Table 10 shows two pooled time-series cross-section regressions for the mean and variance of growth rates within cells on a set of twenty-five industry dummies, seventy-one county dummies, and four year dummies. The dependent variable in the first regression is the average growth rate of employment for establishments in an industry-county-year cell. In the second regression it is the within-cell variance of the establishment growth rates. Cyclical effects common to all industries will be captured by the year dummies, but otherwise the growth rate regression is not meant to indicate differing cyclical sensitivities across industries. Rather, its purpose is to indicate whether establishments in different industries have, on average, different mean growth rates between 1977 and 1982. This is taken here as a measure of structural change.

Judging from the R^2 (.02) the complete set of industry and county variables capture little of the variance of establishment growth rates. Although the F-statistic of the first equation is marginally significant of the 5 percent level and that of the second equation is significant at the 1 percent level, individually, most of the coefficients are not significantly different from zero. The exceptions run contrary to expectations. The four industries with significantly different growth rates are apparel (.28), rubber and plastic (.21), primary metal (.15) and electrical equipment (.17). All of these industries show higher than average growth rates, yet with the exception of the last, total employment fell in all these industries in Wisconsin between 1977 and 1982. (BLS, Employment and Earnings, 1977 to 1982)

The variance of growth rates within nearly all industries and counties is greater than the variance across industries and counties. Knowing the industry or county a establishment is in does not contribute significantly to knowledge about its growth rate.[9] For the average establishment (not the average worker), there is neither an industry nor a county effect. The risk (i.e., layoff risk) a worker faces is firstly establishment specific, and secondly (i.e., reemployment probability) industry or region specific. In most applications, information on the average worker (or the employment weighted average establishment -- aggregate employment) will be more appropriate than information on the average establishment. The first method of reconciling the nonexistence of industry or county effects observed here with their existence taken for granted everywhere else, is to note the difference between weighted and unweighted averages. This in turn suggests that what are typically labeled as industry effects really tend to affect only the largest establishments within an industry. For many purposes, this suffices. Moreover, whatever cross-industry shifts there are, are likely to cause more unemployment than the cross-establishment shifts within an industry that dominate here. A related explanation is that there is, for unknown reasons, large variation in growth rates across establishments. What show up as changes in aggregate industry growth rates come about because a relatively small proportion of establishments shift from growing to shrinking, or vice versa.

Competition provides a second explanation for the non-existence of industry effects. Suppose product demand is fixed, markets are competitive, and establishments gain small randomly arriving cost savings through technological progress. This yields an expected negative correlation of growth rates within an industry, because one establishment's gain must be another's loss.

If technological change is driving these growth rates, it must be affecting different establishments within the same industry very differently.

There is only one significant calendar year effect in Table 10. The average establishment may not be much influenced by its industry or region, but it is influenced by the year. However, given the degrees of freedom here, this is not a very powerful result. The business cycle surely exists, but it does not greatly and similarly affect most establishments. In particular, the declines in total employment growth rate from 9.9 (1978) to 3.6 (1979), and to 1.5 (1980) are not accompanied by significant reductions in the mean growth rate of establishments. The exception is 1981, when mean growth rates fall significantly by 11 percentage points. Otherwise, one would not have significant evidence that a recession or boom had occurred by observing the unweighted average establishment in Table 10.

Table 10 pools across years and so averages out changes over the cycle, but the main result can also be observed in unpooled regressions on single years (not shown). Out of 25 industry dummies, from 1 to 4 are significantly different from zero in a single year between 1977 and 1982. Similar results are found for counties. While the different cyclical sensitivities of total employment in different industries is well known, this does not generally carry over to the average growth rates of establishments.

The second equation in Table 8 is a regression of the variance of establishment growth rates within industry, area, year cells on a set of dichotomous variables, indicating industry, area and year. Again, with few exceptions, there is no general evidence of significant industry, area, or year effects on the variance of establishment growth rates. The exceptions may well be caused by reporting errors in the raw data. It is interesting to note that years of high unemployment rates or of employment decline are not associated with significantly greater variance of growth rates across establishments within cells.

David Lilien (1982) has advanced the argument that cyclical increases in the unemployment rate are caused by structural change, measured by the employment share weighted variance of the logarithm of industry growth rate across one- or two-digit SIC industries. For example, he reports this variance of log growth rates at .00081 in 1981. The logical argument made by Lilien to tie this variation causally to unemployment carries through with at least as great force to further disaggregated measures. What happens when we expand his measure to include frictional unemployment by calculating the variance of the logarithm of employment growth across individual establishments?

This measure takes on the following values: .118 (1977-78), .113 (1978-79), .115 (1979-80), .114 (1980-81), .127 (1981-82). These are unweighted. Evidently, the cross-industry measure includes only a small part of the variation in growth rates across establishments. Here we observe a total variance 140 times the cross-industry variance measured by Lilien. Obviously, the within industry variance accounts for all but a negligible part of this. By this measure, then, frictional sources are of far greater importance than structural sources of unemployment. The total variance shows an upward trend between 1978 and 1981. More often than not, it moves in the same direction as the unemployment rate, although the unemployment rate increases most in a year (1980-81) that this variance actually declines. With only five time-series observations, the concordance of these data with Lilien's hypothesis cannot be precisely judged.

A distinct hypothesis is that, because of different cyclical sensitivities, faster mean employment growth is associated with greater variance in establishment growth rates. This would imply that the predicted values and residuals from the variance regression are positively correlated with those from the mean growth regression in Table 7. The observed values are actually strongly positively correlated (r ≅ .9). Cells with high (or higher than expected) mean employment growth rates also have a high variance of growth rates across establishments within the cell. As the mean of the distribution of growth rates shifts up, the variance tends to increase.

VII. Conclusion

This paper has attempted to provide some new empirical evidence on the nature and magnitude of structural and frictional shifts in employment across industries and establishments. The findings from this analysis of the private employers of Wisconsin over one business cycle hopefully provides some perspective from which to judge the impact of technological change.

About one-ninth of all jobs are destroyed and more than one-eighth created each year on average between 1977 and 1982. Huge gross flows are hidden beneath the usual net flow data. Gross employment flows range from 3 to 17 times greater than net employment flows. Jobs themselves are more unstable than previous aggregate statistics have revealed. As much as half of the transitions of workers from employment to non-employment may be accounted for by the destruction of jobs. Such job loss may account for roughly 2.2 percentage points, or more than a quarter of Wisconsin's average unemployment during 1978-1982.

There are few strong industry effects on employment growth at the establishment level. Rather there is substantial diversity among establishments within an industry. The across-sector variation in the logarithm of employment growth rates, used by Lilien (1982) to measure structural change, is just the tip of the iceberg. One hundred forty times greater is the total variation across establishments, nearly all of which is within industry -- not across. By this measure, employment shifts across establishments within an industry are of far greater magnitude than shifts across industry lines. Increases in this growth rate variance are at best weakly associated with increases in the unemployment rate.

Establishments appear to adjust their employment quickly. Whatever adjustment occurs is largely completed within the first year. This is followed by a movement in the other direction that suggests both measurement error and overshooting the employment target. Employment growth rates one year apart are negatively correlated, and thereafter nearly follow a random walk.

This paper has shown surprisingly large gross employment flows based on the population of establishments in one state. Between 1977 and 1982, 11.0 percent of the previous year's employment is destroyed and 13.8 percent is created each year. Gross job turnover ranging from one-in-three to one-in-five jobs occurs in these years. The level of employment at establishments is characterized by substantial volatility that shows some positive cyclical variation but little industry effect. Roughly one quarter of the "natural" rate of unemployment may be accounted for by these largely idiosyncratic fluctuations in labor demand within establishments. An economy that loses one in nine jobs and creates one in eight jobs yearly would appear to be one with considerable flexibility to absorb technological change.

Footnotes

1. Establishments using only self-employment or unpaid family labor are not required to file reports and are exempt from U.I. taxes. Therefore, one worker establishments are likely to be underrepresented here. However, one person establishments with an office address and a phone number are likely to be included. Through 1977, agricultural establishments, railroads, and non-profit organizations were exempt from U.I. coverage. Beginning in 1978, only railroads, non-profit establishments with one to three employees, and agricultural establishments with less than ten employees were excluded. Of these changes, only the non-profits are of substance. To maintain a consistent series, non-profit and government employment were excluded from the data used here in all years. These exclusions include 25 percent of state employment. Foreign (out of state) employment is also excluded.

2. Where possible, large establishments reporting the greatest percentage change in employment where checked against published County Business Patterns data. If the published data ruled out such large changes, the observations were dropped from the sample. This occurred in fewer than 70 cases, but other reporting errors cannot be precluded. In particular, establishments that may have incorrectly reported stable employment were not checked.

3. If the results to be analyzed here are thought of as coming from a population, there is no need nor scope for statistical inference. The results presented here are in this case the true population parameters calculated without sampling. In a broader sense, the establishments analyzed here may be thought of as a sample from a larger population across states or time, or each

establishment's employment may be thought of as including a deviation from target. In both these latter cases, the usual rules of statistical inference apply.

4. Since vacancies average only 1.7 to 3.7 percent of the workforce (Abraham (1983)) and are typically filled within a few months, such turnover is assumed to have no effect on the establishment side measures of job gain or loss. In other words, I assume workers who quit or are fired are all quickly replaced and so do not affect the measures of job gain or loss calculated here.

5. Because of a regression to the mean phenomena, the shrinking establishments tend to start larger than the growing establishments. Table 3 shows the share of the previous year's employment accounted for by establishments that grew since the previous year. While growing establishment account for 23 percent of all establishments, they account for an average of 4 percent of all employment in the year prior to their growth. Similarly, shrinking establishments account for 21 percent of all establishments, but 47 percent of all employment in the year prior to their decline. In part because of an integer constraint in the way employment is counted here, the stable establishments are primarily one and two person establishments. Stable establishments then account for about two-thirds of the establishments, but on 8 percent of the jobs each year.

6. Overcounts of job loss and gain when ownership of an establishment changes hands appears to be a relatively minor problem with the data used here. A version of this data which made great efforts to correct for this still shows an average 10% yearly job gain and 11% yearly job loss between

1978 and 1981. See The Job Generation Process in Wisconsin: 1969-1981, p. 133.

7. This lends itself to a competing risks formulation. If a worker quits or is fired before the job is done, we know only that job duration (life of the job, not the job-employee match) exceeded job tenure (life of the employee-job match).

8. It is reasonable to expect greater variations in the level of employment where wages are more rigid. Leonard (1986) shows that annual variation in employment is not greater in unionized plants than in their non-union counterparts. If wage rigidity is to contribute to the explanation of establishment level employment volatility, then it is probably a pervasive institution not isolated to the union sector.

9. This heterogeneity across establishments within an industry and region may also help explain the difficulties encountered by compensating differentials studies that utilize industry level data to measure, for example, a worker's risk of becoming unemployed. See Murphy and Topel (1986). Moreover, this substantial idiosyncratic part of unemployment risk should be diversifiable. In this sample, the correlation of growth rates across establishments is too low to be a barrier to insurance against layoff.

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Table 1: Overview of the Wisconsin Economy, 1977-1982

	1977	1978	1979	1980	1981	1982
1. Unemployment Rate	6.3	5.9	5.0	7.1	9.5	10.3
2. # Unemployed (000)	136.76	132.28	115.83	169.14	223.97	235.63
3. Growth Rate of # Unemployed	--	-.033	-.124	.460	.324	.052
4. Labor Force (000)	2170.8	2242.0	2316.6	2382.2	2357.0	2356.3
5. Growth Rate of Labor Force	--	.033	.033	.028	-.011	-.0
6. Employment (000)	2033.7	2109.5	2199.7	2214.2	2134.0	2120.9
7. Growth Rate of Employment	--	.037	.043	.007	-.036	-.006
8. Inflation Rate of CPI Index, Milwaukee	--	.055	.133	.169	.112	.072
9. U.S. Unemployment Rate	6.9	6.0	5.8	7.0	7.5	9.5

Source: Lines 1-8: Wisconsin State Department of Industry, Labor and Human Relations, Employment and Economic Indicators, 1977-1982, May, June, July publications. Line 9: Economic Report of the President, 1985, Table B-33, p. 271.

Table 2: Growth Rates of Employment, 1977-1982
Ratio of Means

	Industry		
	All	Non-Manufacturing	Manufacturing
Mean 6-Year Employment Per Establishment	9.70	6.54	42.76
Growth Rates:			
78/77	1.10	1.11	1.08
79/78	1.04	1.03	1.04
80/79	1.02	1.02	1.01
81/80	0.97	0.98	0.94
82/81	1.02	1.01	1.04
Mean	1.03	1.03	1.03
82/81	1.14	1.14	1.14

Table 3: Proportion of Employment in Growing, Shrinking and Stable Establishments

	Proportion of Employment in Establishments That Are		
	Growing	Shrinking	Stable
1977-78	.585	.338	.077
1978-79	.557	.369	.074
1979-80	.462	.462	.076
1980-81	.314	.606	.080
1981-82	.333	.579	.088
Average	.450	.471	.079

Table 4: Growth Rates of Employment, 1977-1982

Mean of Establishment Ratios

	Industry		
	All	Non-Manufacturing	Manufacturing
Mean 6-Year Employment Per Establishment	9.70	6.54	42.76
Growth Rates:			
78/77	1.11 (.70)	1.11 (.66)	1.13 (.99)
79/78	1.07 (.75)	1.06 (.63)	1.11 (1.51)
80/79	1.05 (.75)	1.05 (.58)	1.10 (1.68)
81/80	1.03 (.69)	1.03 (.58)	1.02 (1.35)
82/81	1.03 (.85)	1.03 (.66)	1.07 (1.89)
Mean	1.06	1.06	1.09
82/81	1.15 (1.80)	1.14 (1.04)	1.26 (5.10)

Note: Cross-section standard deviation in parentheses.

Table 5: The Wisconsin Economy Revisited: Gross Flows

	1978	1979	1980	1981	1982
1. Unemployment Rate	5.9	5.0	7.1	9.5	10.3
2. # Unemployed	132,280	115,830	169,140	223,970	235,630
3. Growth Rate of # Unemployed	-.033	-.124	.460	.324	.052
4. Employment (sample)	1,198,638	1,242,423	1,260,652	1,216,805	1,245,694
5. Growth Rate of Employment	.099	.036	.015	-.035	.024
6. Jobs Created	187,186	150,931	148,269	115,072	221,583
7. Share of Jobs Created	.172	.126	.119	.091	.182
8. Growth Rate of Jobs Created	--	-.19	-.02	-.22	.93
9. Jobs Destroyed	79,439	107,146	130,040	158,919	192,694
10. Share of Jobs Destroyed	.073	.089	.105	.126	.158
11. Growth Rate of Job Destruction	--	.35	.21	.22	.21
12. Ratio of Job Birth to Death	2.36	1.41	1.14	.72	1.15
13. Gross Turnover Rate	.245	.215	.224	.217	.340

Table 6: Job Turnover in Wisconsin by Sector, 1978 - 1982

Sector	Proportion of Jobs					
	Non-Manufacturing		Manufacturing		Manufacturing, BLS*	
	Gained	Lost	Gained	Lost	New Hires	Layoffs
1978	.19	.084	.14	.054	.26	.11
1979	.14	.11	.11	.057	.31	.11
1980	.13	.12	.10	.082	.26	.14
1981	.11	.14	.055	.11	.16	.26
1982	.17	.16	.20	.15	.16	.20

*These are twelve times the average of the April through March monthly rates published in the BLS, Employment and Earnings, vols. 24-29, 1977-1982, Table D-4, for the Wisconsin manufacturing sector. Because the federal government discontinued the series, the 1982 figures are for the eight months through November, 1981.

Table 7: Proportion of Jobs Lost

Industry	Year 1978	1979	1980	1981	1982
Mining and Construction	.14	.18	.22	.25	.30
Food and Kindred Products	.09	.08	.09	.06	.17
Textiles	.03	.11	.13	.17	.13
Apparel	.07	.15	.13	.12	.18
Lumber	.08	.15	.15	.18	.25
Furniture	.07	.08	.11	.15	.13
Paper	.03	.04	.03	.06	.12
Printing and Publishing	.04	.04	.06	.07	.09
Chemicals	.05	.06	.04	.06	.11
Petroleum and Coal	.03	.08	.07	.13	.04
Rubber and Plastics	.05	.04	.18	.11	.17
Leather	.04	.08	.14	.08	.11
Stone, Clay and Glass	.05	.07	.08	.17	.21
Primary Metals	.06	.02	.08	.15	.14
Fabricated Metal	.05	.04	.06	.13	.15
Machinery, except Electrical	.06	.02	.07	.14	.13
Electrical Equipment	.04	.09	.10	.11	.15
Transportation Equipment	.04	.02	.11	.09	.27
Instruments	.03	.13	.06	.09	.28
Miscellaneous Manufacturing	.06	.09	.11	.13	.10
Transportation and Utilities	.05	.07	.08	.10	.13
Wholesale and Retail Trade	.09	.11	.12	.14	.16
Finance, Insurance and Banking	.06	.07	.06	.08	.10
Services	.09	.11	.11	.13	.15

Table 8: Proportion of Jobs Gained

Industry	Year 1978	1979	1980	1981	1982
Mining and Construction	.29	.20	.15	.13	.14
Food and Kindred Products	.11	.10	.14	.11	.32
Textiles	.19	.06	.08	.01	.05
Apparel	.26	.10	.08	.07	.18
Lumber	.32	.10	.11	.06	.09
Furniture	.13	.08	.08	.05	.15
Paper	.10	.12	.03	.03	.10
Printing and Publishing	.12	.09	.08	.06	.12
Chemicals	.12	.05	.08	.06	.10
Petroleum and Coal	.05	.14	.09	.05	.10
Rubber and Plastics	.18	.13	.12	.07	.16
Leather	.09	.04	.02	.08	.12
Stone, Clay and Glass	.13	.10	.12	.06	.12
Primary Metals	.16	.13	.06	.04	.08
Fabricated Metal	.12	.10	.10	.05	.25
Machinery, except Electrical	.15	.14	.10	.03	.34
Electrical Equipment	.13	.11	.22	.06	.11
Transportation Equipment	.10	.06	.04	.07	.18
Instruments	.13	.10	.24	.04	.08
Miscellaneous Manufacturing	.13	.11	.10	.06	.10
Transportation and Utilities	.13	.11	.10	.08	.12
Wholesale and Retail Trade	.19	.13	.13	.12	.19
Finance, Insurance and Banking	.16	.10	.10	.10	.11
Services	.21	.15	.14	.13	.19

Table 9: Correlation Matrices of the Logarithm of Firm Size (S_t) and of the First Difference ($D_t=S_t-S_{t-1}$) of the Logarithm of Firm Size, 1977-1982

N = 49,508 Firms with Positive Employment in All Years

	Mean	σ	S_{78}	S_{79}	S_{80}	S_{81}	S_{82}	D_{78}	D_{79}	D_{80}	D_{81}	D_{82}
S_{77}	1.93	1.34	.966	.949	.932	.918	.898	-.118	-.046	-.051	-.069	-.076
S_{78}	1.99	1.35		.967	.950	.935	.914	.142	-.104	-.055	-.073	-.078
S_{79}	2.02	1.35			.966	.951	.930	.084	.150	-.115	-.076	-.079
S_{80}	2.02	1.36				.967	.947	.079	.089	.143	-.142	-.077
S_{81}	2.01	1.35					.963	.075	.085	.077	.114	-.138
S_{82}	1.97	1.35						.073	.085	.079	.049	.132
D_{78}	.058	.349							-.225	-.017	-.018	-.008
D_{79}	.033	.344								-.237	-.015	-.003
D_{80}	.001	.350									-.258	.006
D_{81}	-.017	.347										-.239
D_{82}	-.035	.366										

Note: All of these correlations are significant well beyond conventional levels, with the following exceptions: (D_{82},D_{78}) at .06, (D_{82},D_{79}) at .53, and (D_{82},D_{80}) at .16.

Table 10: Regressions of Within Cell Mean and Variance of Growth Rates

N = 6920

	Mean of Cell Growth Rate	Within Cell Variance of Growth Rate
Intercept	1.099	-1.733
	(.11)	(11.21)
Year 1979	-.021	1.138
	(.03)	(3.14)
Year 1980	-.029	3.529
	(.03)	(3.14)
Year 1981	-.110	-.102
	(.03)	(3.14)
Year 1982	-.033	4.345
	(.03)	(3.14)
SIC20 Food	.045	3.541
	(.06)	(6.13)
SIC21 Tobacco	-.001	1.143
	(.28)	(26.97)
SIC22 Textiles	-.025	-1.488
	(.09)	(9.23)
SIC23 Apparel	.279	15.489
	(.07)	(6.90)
SIC24 Lumber	.028	-0.056
	(.06)	(6.10)
SIC25 Furniture	.029	0.100
	(.07)	(6.86)
SIC26 Paper	.035	.544
	(.07)	(7.10)
SIC27 Printing and Publishing	.037	-.309
	(.06)	(6.10)
SIC28 Chemicals	.027	-.082
	(.07)	(7.21)

Table 10, Continued

	Mean of Cell Growth Rate	Within Cell Variance of Growth Rate
SIC29 Petroleum	.061 (.11)	1.789 (10.91)
SIC30 Rubber and Plastic	.206 (.07)	19.485 (6.65)
SIC31 Leather	-.009 (.08)	1.364 (7.54)
SIC32 Stone, Clay and Glass	-.007 (.06)	-.418 (6.28)
SIC33 Primary Metal	.152 (.07)	10.543 (6.95)
SIC34 Fabricated Metal	.050 (.06)	-.125 (6.31)
SIC35 Machinery	.073 (.06)	-.247 (6.15)
SIC36 Electrical Equipment	.170 (.07)	2.704 (7.00)
SIC37 Transportation Equipment	.005 (.07)	1.11 (6.85)
SIC38 Instruments	.070 (.07)	.945 (7.28)
SIC39 Miscellaneous Manufacturing	.023 (.07)	.367 (6.47)
SIC4- Transportation and Public Utilities	.033 (.06)	-.176 (6.10)
SIC5- Wholesale and Retail Trade	.018 (.06)	-.077 (6.08)
SIC6- Finance, Insurance, and Real Estate	.020 (.06)	-.198 (6.08)
SIC7- Personal, Business, Repair, and Entertainment Services	.029 (.06)	-.069 (6.10)

Table 10, Continued

	Mean of Cell Growth Rate	Within Cell Variance of Growth Rate
SIC8- Health, Education, and Legal Services	.056 (.06)	.104 (6.08)
R^2	.02	.01
F-Statistic	1.33	1.01
Mean of Dependent Variable	1.08	2.16
S.E.E.	.85	82.58

Standard error in parentheses.

Correlation of residuals from two equations: 0.9140.

Note: Based on 124,737 underlying plant observations. Omitted industry is construction and mining (SIC = 1). Both equations include dichotomous variables for 71 counties, of which only two were systematically different from zero in each regression.