INTER-INDUSTRY WAGE DIFFERENCES AND
THEORIES OF WAGE DETERMINATION

William T. Dickens

Lawrence F. Katz

Inter-Industry Wage Differences and Theories of Wage Determination

ABSTRACT

Numerous studies have shown large differences in wages for apparently similar workers across industries. These findings pose a challenge to standard models of labor market behavior. A problem with past studies of industry wage differences is that they have failed to distinguish between union and nonunion workers. Many economists may expect union workers wages to be set in a noncompetitive fashion but would be surprised if nonunion wages were.

We examine the differences in wages across industries for both union and nonunion workers. We find that even after controlling for a wide range of personal characteristics and geographic location large wage differences persist for both union and nonunion workers. Furthermore the premiums of union and nonunion workers are highly correlated. We review past studies which demonstrate that industry wage premiums are also highly correlated across countries and have been very similar over many decades. We present new evidence that the wages of different occupations are highly correlated across industries -- that is if any occupation in an industry is highly paid all occupations are. We also review the evidence which suggests that people who move from low to high paying industries receive a large fraction of the industry wage premium and that those who move from high to low paying industries lose the premium. Finally, we review the evidence on the correlates of industry wage differences. Quit rates, human capital variables, capital labor ratios and market power measures are all positively correlated with industry wage differences individually though the data are not adequate to determine their independent contributions in multiple regression.

On the basis of all the evidence we conclude that standard labor market clearing models can not easily explain all the facts. Several alternative models are discussed including efficiency wage and collective action threat models. These are found to be more consistent with the facts though some troubling problems remain.

William T. Dickens
Department of Economics
University of California
Berkeley, CA 94720

Lawrence Katz
Department of Economics
Harvard University
Cambridge, MA 02138

I. INTRODUCTION

Large differences in wages across industries exist for seemingly similar work. Substantial industry wage differentials remain even when union status, standard individual characteristics, and observed working conditions variables are controlled. Area wage surveys invariably reveal large wage differences for the same type of work in the same locality. Differences in compensation across establishments and industries in a local labor market tend to be expanded when employee benefits are also considered (Dunlop, 1985). The inter-industry wage structure appears to be extremely stable over time and remarkably similar across industrialized economies.

In a recent paper (Dickens and Katz, 1987), we analyze the relative importance of individual characteristics (standard human capital controls and demographic characteristics), geographic location, occupation, and industry in explaining wage differences among private sector workers in the United States. We conclude from an analysis of covariance that industry affiliation accounts for between seven and thirty percent of all inter-personal earnings variation for a cross section of nonunion workers and for between ten and twenty-nine percent for a cross-section of union workers.[1] Industry and occupation combined appear to account for a greater proportion of earnings variation than do schooling, experience, and demographic controls. Saunders and Marsden (1981) report similar results for several Western European economies. The pattern of industry wage differences presents a challenge to traditional models of the labor market.

A standard competitive labor market model offers several potential explanations for industry wage differentials including differences in labor quality (skill) and/or the quality of employment. Inter-industry wage differences can

1

also reflect transitory differentials related to shifts in labor demand or supply across sectors and imperfect short-run labor mobility.

In recent years, a number of alternative theories of wage determination (such as the efficiency wage theories surveyed by Katz (1986), Stiglitz (1986), and Yellen (1984); the union threat model of Dickens (1986); and the insider-outsider models of Shaked and Sutton (1984), Solow (1985), Rotemberg and Saloner (1986), and Lindbeck and Snower(1986)) have been proposed as possible explanations for industry wage differentials, equilibrium involuntary unemployment, and a wide variety of other labor market phenomena. These alternative explanations focus on potential reasons why firms may find it profitable to pay above market clearing wages and why the importance of these factors may differ across industries. Determining the empirical relevance of these alternative models of wage determination is quite important since the non-competitive models generate positive and normative implications, with respect to issues such as trade and industrial policy and unemployment insurance, that can be quite different from textbook competitive labor market models or implicit contract models.[2]

Efficiency wage models postulate that the potential benefits to a firm of higher wages include increased effort and reduced shirking by employees, lower turnover costs, a higher quality workforce, improved worker morale and better group work norms. Alternative rationales for the payment of non-competitive wage premiums relate to the presence union or individual bargaining power, or the threat of collective action by workers. Firms may find it profitable to pay more than competitive wages to unionized workers to prevent strikes and maintain industrial peace. In some situations individuals may be able to bargain for themselves some share of the firms earnings beyond their reservation wages. Industrial relations specialists and institutional economists have long argued

that nonunion firms often pay higher wages than necessary (to attract a qualified labor force) for the purpose of avoiding unionization.[3]

In this paper, we review a wide range of evidence on the magnitude, intertemporal stability, and structure of industry wage differences. We present new evidence on the nature and importance of inter-industry wage differentials for nonunion workers, for different occupations, and on the similarity in the pattern of these wage differentials across different groups of workers. The predictions of alternative theories of wage determination for inter-industry wage differences are analyzed and evaluated against the evidence.

As in past studies, we find large industry wage differences that cannot be explained by observed human capital, demographic, or locational variables. These industry differentials persist even when a sample of only nonunion workers is analyzed. The patterns of industry wage premiums are extremely similar for union and nonunion workers. We also find that industry wage premiums are highly correlated across occupations. In other words, if any workers in any occupation in an industry are highly paid relative to their observed individual characteristics, then workers in all occupations in the industry are likely to be. Industry wage differentials appear to be strongly correlated over long time periods and remarkably similar across countries.

The paper is organized as follows. Section II offers a discussion of our data and presents some basic empirical results on the size and nature of industry wage differentials for individual occupational groups. Evidence on the relationships of industry wage premiums across occupational groups, time periods, and countries is presented in section III. The relationship among wages and a wide range of industry characteristics is reviewed in section IV.

In section V, we discuss standard explanations for industry wage differentials in a competitive labor market. The evidence on the pattern of industry wages is

difficult to reconcile with competitive explanations based on compensating dif-
ferentials and/or unmeasured labor quality without significant ad hoc tinkering.
The consistency of alternative models with the evidence on differentials is ana-
lyzed in section VI. No single model appears entirely consistent with all the
evidence on wage differences. Concluding remarks and suggestions for future re-
search are made in section VII.

II. DATA ON INTER-INDUSTRY WAGE DIFFERENCES

We are interested in assessing the relevance of different theories of how wages
are determined in the absence of collective bargaining. For this reason we want
to examine the inter-industry and occupational distribution of wages for nonunion
workers and we are aware of no study which has done this. Many studies have in-
cluded industry dummies in union and nonunion wage regressions, but none have
analyzed the properties of these dummy variable coefficients nor have they con-
sidered the pattern of industry effects across occupations.

All twelve monthly Current Population Surveys (CPSs) from 1983 were combined
to generate a sample of individuals large enough to accurately estimate the av-
erage wages for detailed industry and occupational categories. Our sample consists
of private sector, nonagricultural, nonunion employees, 16 years of age or older
with complete data on industry and occupation and on either hourly wages or normal
weekly earnings and normal hours of work per week. Average earnings per hour were
computed for each individual with complete earnings data. Observations with re-
ported wages of less than $1.00 per hour or more than $250 an hour were assumed

to be coding errors and deleted from the data set.[4] Although the CPS is partially a panel data set, only those individuals in outgoing rotation groups are asked about earnings and people exit the sample only once a year. Thus, we can be sure that all observations represent unique individuals. This procedure left us with a sample of 109,735 nonunion workers.

We begin our analysis of industry and occupation wage patterns by analyzing the differences in wages across three digit 1980 Census of Population code industries for twelve occupational groups. Table 1 presents basic summary information on the extent of industry wage variation by occupation. We utilize the standard deviation in industry wage differentials to summarize the overall variability in wages across industries.[5] In all twelve occupations, even restricting attention to nonunion workers, there is substantial variation in the average log wage across industries. Column 1 presents our estimate of the standard deviation of the average log wage among industries. It ranges from a high of .46 for sales workers to a low of .17 for clerical workers. These are large differences by any account. A one standard deviation difference in the average wage paid to clerical workers in different industries is about 17% of their average wage. The story is similar when we weight the industries by their employment in the sample when computing the standard deviation of the log wages. In this case, we find standard deviations as large as .37 and as low as .13. Again sales workers show the most variation and clericals the least.

These large differences would not be a puzzle if they were easily explained by observable differences in worker characteristics or geographical differences in labor markets across industries, but they are not. This conclusion follows from an analysis of industry wage differentials by occupation after controlling for observable individual characteristics and locational variables. We estimated industry wage differentials of this type for our 12 occupation and three digit

Census of Population industry breakdown in two manners. The effects of observed human capital variables, demographic characteristics, and location were constrained to be the same for all occupations in both approaches. The industry wage effects were allowed to vary by occupation.

The first approach involved the estimation of industry-occupation cell fixed effects. We postulated an earnings function of the following form:

(1) $$W_{ijk} = X_{ijk}\beta + \alpha_{jk} + \varepsilon_{ijk}$$

where i indexes individuals, j indexes industries, and k indexes occupations; W_{ijk} is log(hourly wage) of individual i; X_{ijk} is a vector of individual and locational variables for individual i, β is a vector of parameters, α_{jk} is a fixed effect (or differential) for industry-occupation cell jk, and ε_{ijk} is an error term. This equation is equivalent to a wage equation with industry dummies, occupation dummies, and a full set of interaction terms between the industry and occupation dummies. The large number of industry-occupational cells implies that the only feasible approach to estimating the industry differentials for each occupation is to first run a de-meaned regression in which the industry-occupation cell means are subtracted off for the dependent variable and all the independent variables:

(2) $$W_{ijk} - W_{jk} = (X_{ijk} - X_{jk})\beta + u_{ijk}$$

where W_{jk} is the mean of the log of hourly earnings for workers in cell jk, X_{jk} is the the vector of the means of the individual and locational variables for workers in cell jk, and u_{ijk} is a regression error. This regression, assuming that the ε_{ijk} in equation (1) are uncorrelated with the X_{ijk}, yields a consistent

estimate of β. The mean residual for each cell j is then a consistent estimate
of the industry-occupation jk fixed effect:

$$(3) \qquad \hat{\alpha}_{jk} = W_{jk} - X_{jk}\hat{\beta}.$$

The estimated fixed effects were then grouped by occupation to analyze the re-
lationships among industry impacts on wages in different occupations

The third column of table 1 presents the weighted standard deviations of
industry fixed effects for each occupation from a log wage regression in which
the most salient individual characteristics have been controlled for as has each
individual's geographic location. The wage differences are smaller than for the
average log wage comparisons, but they are still very large ranging from standard
deviations of .10 for clerical and semi-skilled workers to a standard deviation
of .24 for professionals.

A more conservative approach to assessing the magnitude of industry wage
differentials is to first regress log wages on individual and locational variables
but not on industry-occupation cell dummy variables (fixed effects):

$$(4) \qquad W_{ijk} = X_{ijk}\beta + e_{ijk}.$$

The average residual for each industry-occupation cell provides a measure of in-
dustry wage differentials by occupation. This approach attributes all common
impacts on wages of industry-occupation cell fixed effects and individual and
geographic variables to the individual characteristics and geographic variables.
The corrected standard deviations for the average residual measure of industry
wage differentials for each of our twelve occupations are presented in the fourth
column of Table 1. This approach leads to a further reduction in the standard

deviations, but the industry differences are still very large. These large wage differences across industries not accounted for by observed worker characteristics or labor market location appear to be something of a mystery. In the next section, we find that the mystery deepens.

III. INDUSTRY WAGE DIFFERENCES ACROSS OCCUPATIONS, TIME AND COUNTRIES

There are many reasons why some workers in one industry might be paid more than similar workers in another industry. Wage differences may be required because of differences in the nonpecuniary aspects of jobs or labor quality requirements across industries. For example, blue collar workers in dangerous industries might receive higher wages to compensate them for the risks they have to take. Technical workers in another industry may have to have a special skill for which they are paid a wage premium. Efficiency wage considerations may necessitate the payment of wage premiums to groups of workers for whom shirking and/or turnover may be difficult to limit through other mechanisms and costly to the firm. Working conditions, skill requirements, worker malfeasance and monitoring problems, and turnover costs are likely to differ among occupations in a firm or industry. One thing many explanations for industry wage differentials have in common is that while they would lead us to expect differences in wages across industries for individual occupational groups, they would not lead one to expect the pattern of differentials to be similar for diverse occupations.[6] These explanations provide little reason to expect that an industry which paid its blue

collar workers more would also pay its secretaries more. However, examining the correlation of the log of wages of different occupations across industries for nonunion workers this is exactly what we find.

Table 2 presents the correlations of the average log wages of twelve occupational groups across industries.[7] The results are striking. Of the 66 correlations only five take values less than .50 and only 18 are less than .70. The lowest correlation is .40 (between semi-skilled blue collar workers and sales workers). The median correlation is .78. Only one pattern is noticeable -- the wages of the more autonomous occupations of sales, technical workers and transportation equipment operators are somewhat less correlated with the wages of other workers. However, the wages of professionals, who might also be considered highly autonomous, are highly correlated with the wages of other workers.

One might think that these correlations were the result of workers in the same industry having similar observed human capital characteristics or to geographic differences in the labor markets faced by industries. Yet the results presented in Table 3 suggest this is not the case. Corrected correlations of industry wage differentials (based on industry-occupation cell fixed effects from a regression also including controls for individual and locational variables) are shown in Table 3. Fifty-four of the sixty-six correlations are greater than .7. The median of .79 is slightly higher than the median for the correlations of the means for the raw wages. Results are very similar when mean residuals from the wage equation are used instead of fixed effects. The results indicate that even after controlling for a wide variety of labor quality and geographic variables there are large correlations between average wages in any two occupations within an industry. If one occupational group in an industry is high paid relative to its observed characteristics, all categories of workers in that industry tend to be high paid.

Up to this point, we have been dealing only with nonunion workers. How similar are the patterns between the union and nonunion sectors? The answer is that they are very similar. Stacking all the occupations together and correlating across the two sectors, we find corrected correlation coefficients of .84 for the raw data, .83 for the fixed effects, and .79 for the residuals of the wage equations.[8] Thus measures of inter-industry wage differences which ignore the difference between union and nonunion wage setting are unlikely to yield results different from studies which focus only on nonunion wages. This is an interesting and surprising result. Evidently there is not that much difference in the processes determining union and nonunion wages. We turn now to evidence of the stability of industry wage patterns over time and in different countries where union and nonunion workers are treated together.

Two previous studies suggest that the pattern of high correlation of occupational wages within industries may go back many years. Slichter (1950) reports that for 20 manufacturing industries in 1939 the rank order correlation of average hourly earnings of male skilled and semiskilled workers and male unskilled workers was .71. Kumar (1972) finds the correlation of wages of unskilled and skilled workers across 23 Canadian manufacturing industries in 1966 to be .81.

Industry wage differences for similar workers may reflect transitory differentials facilitating the reallocation of labor in response to the shifts in the sectoral composition of labor demand. If workers are fairly immobile in the short run, shifts in the fortunes of industries could lead to wage differentials that are similar for different occupations in an industry. But, many studies have found a remarkable stability in the pattern of industry wage premiums. This seems to rule out these transitory differentials as a major component of the explanation for industry wage differentials.

Cullen (1956) presents data showing the stability of the wage structure across manufacturing industries in the U.S. from 1899 to 1950. He finds the rank correlation of average annual earnings for 76 manufacturing industries for the years 1899 and 1950 to be .66. Cullen finds for a group of 84 manufacturing industries that 14 of the 21 industries in the highest-wage quarter in 1899 were still in the highest-wage quarter in 1947. Also, 15 of the 21 lowest wage industries in 1899 still in the lowest-wage quarter in 1947. Data on average hourly earnings for 33 manufacturing industries presented by Kendrick (1961) leads to similar although not quite as strong conclusions concerning the stability of industry rankings. Reder (1962) computes the rank correlation for average hourly earnings in 1899-1909 and 1948-53 from Kendrick's data to be .46.

Furthermore, limited evidence suggests that these persistent differentials don't just reflect stability in skill mix differences since industry wage differences for particular grades of labor also appear to have been fairly stable. For example, Slichter (1950) finds the rank correlation of male unskilled average hourly earnings for 20 manufacturing industries between 1923 and 1946 to be .73.

Strong stability in inter-industry wage rankings is also evident for the postwar United States. Montgomery and Stockton (1985) report that the rank correlation of mean hourly wages for 20 2-digit manufacturing industries between 1951 and 1981 was .675. Bell and Freeman (1985) find strong stability in the rankings for a group of 53 industries (both manufacturing and non-manufacturing) from 1948 to 1982. Krueger and Summers (1987b) find the correlation of estimated industry wage premiums between 1974 and 1984 to be .970.

Stability in industry rankings of average wages is also apparent over similar time periods for Sweden, the United Kingdom, and Canada (OECD, 1965). Lebergott (1947) finds strong similarities in industry wage structure in the 1940's for Canada, Sweden, the United Kingdom, and the United States. Krueger and Summers

(1987b) find quite high correlations for industry average wages across advanced industrial economies in the early 1980's, and Pryor (1973) reports concordance coefficients of .80 within Eastern Block countries, .59 between Western industrial countries and .67 between the two groups.

IV. CORRELATES OF INDUSTRY WAGE DIFFERENCES

The evidence presented in the last section suggests that there is a pattern of wage differentials where all workers in some industries are highly paid relative to similar workers in other industries. The pattern of which industries pay high wages has been very stable over time and across countries with widely varying methods of determining labor compensation. What are the attributes of high paying industries? There exists a large literature relating workers' wages to industry characteristics. Dickens and Katz (1987) review this literature. Many characteristics have been found to be significantly correlated with wages. Table 4 presents the correlations of average industry wages, union and nonunion industry wage premiums with a variety of industry characteristics for three-digit Census of Population industries circa 1983. The two measures of industry wage differentials (purged of the influence of observable worker variables) are three-digit industry fixed effects from regressions of log wage on individual characteristics, 11 occupation dummy variables, and state dummy variables for union and nonunion workers.[9]

Even after controlling for the influence of observed human capital and geographic variables by using industry fixed effects rather than raw average wages,

we still find that both union and nonunion wages are strongly correlated with a wide range of industry characteristics including average workforce characteristics, firm and establishment size, the capital labor ratio, and several measures of industry profitability or potential profitability. The industry characteristics are also strongly related to each other. The industry wage premiums for both union and nonunion workers are strongly negatively related to quit rates and strongly positively related to average weekly hours.

It turns out to be problematic to generate more precise information on the industry factors associated with industry wage premiums than that which is contained in the simple bivariate correlations. The literature on the relation of industry characteristics and wages provides very mixed evidence on which variables have significant relations with wages when other variables are included in the specification. Dickens and Katz (1987) reports experiments with a large number of specifications, samples, and methods for dealing with missing variables. Our exploratory analysis and the results of previous studies indicate that the industry characteristics that are significantly related to wage premiums and the magnitude of their correlations are quite sensitive to the specification (e.g. other variables included in the equation) and to the particular sample analyzed (e.g time period and mix of industries). The implication is that the effects of industry characteristics are probably not uniform across industries and that multicollinearity among industry variables makes certain inferences difficult. A few variables performed nearly consistently in relation to the estimated industry fixed effects from the 1983 CPS. One workforce characteristic -- average education -- had a stable and significant relations to wage premiums. It was always positively related and nearly always significant. Besides education profits, when only one of the three measures tried was entered, was always positively and often significantly related to nonunion industry wage premiums.

Proportion of workers in large plants or average establishment or firm size have typically been found to be positively related to industry wage differences in the presence of detailed controls (Kwoka, 1983; Long and Link, 1983; and Pugel, 1980). But establishment size and firm size appear more important in explaining wage differentials within industries than across industries. Krueger and Summers (1987a) find in analyzing the May 1979 CPS that the inclusion of plant size and firm size controls barley affects the estimates of industry wage differentials. Oi and Raisian (1985) also find quite large industry wage differentials remaining after controlling for establishment and firm size with individual data. Brown and Medoff (1985) conclude a quite detailed study of the impact of plant and firm size on wages by noting that most of the employer size effect of wages occurs within detailed (three-digit) industries.

A further issue is whether the relation of industry characteristics to wage differentials was similar in earlier time periods. Micro data on individual wages and characteristics as well as much of the industry data used in the previous analysis are not available for earlier periods. Still, we have been able to construct a small cross-section data set for manufacturing industries for 1939. Dickens and Katz (1987) analyze these data which cover 31 manufacturing industries including most of those employing the largest numbers of workers.

Log average hourly earnings are correlated across industries for skilled and semiskilled workers and unskilled workers. This confirms Slichter's (1950) rank correlation results. The partial correlation -- controlling for percent female, unionization and average age -- between skilled and unskilled wages is .42.

Both skilled and unskilled wages are positively correlated with extent of unionization in an industry. Since Slichter's (1950) data indicate that the relative wage structure in 1929 in these industries was quite similar to that in 1939 (rank correlation of .89) and since Lewis's (1963) estimates of industry

unionization in 1929 indicate quite little unionization in almost all of these industries at that time, this correlation indicates that pre-union high wage industries tended to be the ones that were subsequently heavily unionized.

A significant positive correlation is apparent between average hourly earnings for both unskilled and skilled and semiskilled workers with net income after taxes as a percentage of sales. This indicates that more profitable industries tended to pay higher wages at this date. Finally, the common finding in post-war data of a negative relation between quit rates and wages is replicated here.

V. STANDARD EXPLANATIONS FOR INTER-INDUSTRY WAGE DIFFERENCES

Industry wage differences in a textbook competitive labor market can arise from differences in worker ability, compensating differentials for non-pecuniary aspects of work that directly affect worker utility, and/or transitory wage differentials arising in the process of adjustment to sectoral shifts.

Labor Quality   Differences in production technologies across industries mean that employers in certain industries may find it profitable to hire higher quality workers (and hence pay higher wages) than those in other industries or to hire workers with valuable skills This explanation implies that equally productive workers are paid the same in different industries, and that industry wage differences reflect differences in labor quality. Although observed labor quality measures are found to explain a part of industry wage differences, our results

and the findings of previous studies show that large, statistically significant wage effects remain after controlling for a wide variety of individual characteristics. Our results also show that the size of industry wage effects is not much altered if wage equations are first estimated without industry dummy variables and the residuals are used to compute industry differentials. This approach credits observed quality variables with all the impact of unobserved variables that are correlated with both the measured quality variables and with industry status. If unmeasured labor quality is correlated with measured worker characteristics, then it cannot provide an explanation for the large remaining industry effects.

The high correlation of industry wage differences across occupations is also problematic for this view. Technology may explain why one type of worker in an industry would have to have some special skill which we do not observe. However it is much more difficult to explain why all occupations in such industries must be highly paid.[10]

Longitudinal data provides a potential control for time invariant, unmeasured labor quality. If high wage industries simply have high quality workers and if workers of a given quality are paid equally in different industries, wage changes should not be systematically linked to changes in industry status. Longitudinal data allow one to examine the wages of a given individual as he or she switches industries. First difference (or fixed-effects) estimation allows one to eliminate the impacts of unchanging labor quality (that is rewarded equally in all industries) on the industry wage effects estimates.

Krueger and Summers (1987a) estimate large effects of industry switches (for broadly defined industries) on wages in first differenced regressions utilizing matched CPS data for 1974-75, 1977-78, and 1979-80. The estimated industry effects from the first difference regression are similar in direction and magnitude

to pooled regression estimates. However, Krueger and Summers use CPS data in which it is believed that a substantial fraction of workers misreport their industry (Mellow and Sider, 1983). They construct a correction factor to adjust for this problem utilizing data from Mellow and Sider on the chance of spurious classification of an individual between any given pair of one-digit industries. This approach relies on the questionable assumption that the probability of making an error is not correlated across years. Relaxing this assumption assumption would probably lead to lower estimated industry wage effects for industry switchers. On the other hand, Krueger and Summers base their correction on data on discrepancies between employer and employee reports of industry classification. To construct the correction factor they must make an assumption about how often each is wrong about the classification. Their prefered correction assumes that when workers and employers disagree about which industry the worker is in they are each wrong half the time. In fact we would expect that employers probably have a better idea of which industry workers are in than workers do. Since Krueger and Summers use workers' reports of industry affiliation there are probably more misclassifications in the data Krueger and Summers use than they are assuming there are so their correction may not be adaquate and their estimates may instead be downward biased. Without information on the size of these two effects it is impossible to say which is more important. Experiments with alternative measurement error corrections by Krueger and Summers suggest that longitudinal estimates of industry wage effects are fairly sensitive to changes in assumptions about the extent of measurement error.

Murphy and Topel (1987) analyze industry-occupation wage differences. They also use the CPS but have a different means of correcting for misreporting of industry and occupation. They find that industry-occupation wage differences estimated for changers are less than half the size of those estimated in the cross

section. Krueger and Summers' uncorrected estimates of the industry effects for job changers are about the same magnitude and are almost certainly biased downward by the errors in reporting. The disparity is probably a result of Murphy and Topel confounding the effects of occupation changes and industry changes. It seems reasonable that those being promoted to higher paying occupations move from relatively high paying jobs in the occupations that they are leaving to relatively low paying jobs in the occupation they are joining. Thus their wages would not be expected to go up by the full difference between the average wages of the two occupations.

Vroman (1978) analyzes the pattern of earnings changes for industry switchers in the 1964-71 period. He uses a large sample drawn from the social security continuous wage history data base.[11] This data set has relatively reliable industry classifications for all workers. Unfortunately Vroman only reports the earnings changes of those leaving or entering the durable goods manufacturing and retail trade sectors. He does not discriminate between where they are coming from or going to. Still he finds that those who enter the high wage durable goods industry or leave the low wage retail trade industry experience substantial earnings increases of 20-60% depending on the time period.

The longitudinal evidence does run counter to the view that workers of a given quality are paid equally in different industries. It thus casts doubt on the compound hypothesis that high wage industries are those that employ proportionately more unobservably high ability workers and that these workers receive the same wage wherever they work. Yet industry switchers are not a random sample of workers and these first differenced estimates are likely to suffer from important selectivity bias. There are, however, explanations of inter-industry wage differences based on time-invariant, unmeasured labor quality in which workers of a given ability are paid differently in different industries, and ability is

18

imperfectly observed by labor market participants. Gibbons and Katz (1987) de-
velop a model in which industry technologies differ in their ability sensitivity
and only a noisy ex-ante ability signal is available to labor market participants
at the time of initial hiring. Subsequent productivity observations provide more
information about worker ability. The noisy ex-ante signal and the ex-post pro-
ductivity observations result in imperfect matching of workers to industries ex-
ante and improved matching ex-post. High ability workers gravitate towards with
ability sensitive industries and low ability workers get weeded with increased
labor market experience. This sorting model explains inter-intdustry wage dif-
ferences as returns to ability, and interprets inter-industry mobility as im-
proving the allocation of workers to industries as new information becomes
available. Certain matching models, which are essentially unmeasured labor
quality models, in which worker attributes have different value in different
matches (industries) are also potentially consistent with the longitudinal
results.[12] But sorting and matching models require substantial ad hoc tinkering
to explain why all occupations appear to benefit from good matches in the same
industries and why ability-sensitivity and industry rents are positively corre-
lated.

Compensating Differentials   A second possible competitive explanation is that
the industry wage differentials reflect compensating differentials for nonwage
job attributes that directly affect the utility of workers.[13] This is often the
justification for including industry dummies in wage equations estimated with
individual cross-section data. The relationships among industry variables and
wage differentials presented in section IV and the findings of Rosen (1969) in-
dicate that differences in average weekly hours may provide a labor supply channel
to help explain industry wage differences. Yet Krueger and Summers (1987a) find

that the inclusion of 10 working conditions variables, including weekly hours, in a standard wage equation barely affects the estimated industry wage premiums.[14]

Freeman (1981) and Krueger and Summers (1987a) find that differences in fringe benefits enlarge rather than offset wage differentials. Many important nonpecuniary job attributes are unlikely to be captured by these control variables.

If industry wage premiums reflect equalizing differences, then they do not reflect rents that make jobs especially valuable to workers. The implication is that there is no reason to expect industry wage premiums to be systematically related to quit rates. Industry and individual level studies both indicate that wage premiums are strongly associated with lower quit rates (Ulman (1965), Pencavel (1970), Freeman (1980), Dickens and Katz (1987) and Krueger and Summers (1987a)). This suggests that industry wage premiums reflect rents to good jobs or good matches and are not merely compensating differences.[15]

Industry wage differences could potentially arise from differences in patterns of human capital accumulation across industries. This does not appear to be the case. Krueger and Summers (1987a) find that industry wage differentials are approximately equal in magnitude and highly correlated for young (20 to 35 years old) and older (50 to 65 years old) workers. Further, the 1979 Current Population Survey contains information on job tenure (years with current employer). We utilized this data to determine if industry wage differences vary with job tenure. Estimates of log wage equations for separate tenure groups for nonunion, private sector workers indicated that the industry differentials are quite similar in magnitude and have a strong positive correlation. For example, the correlation for nine one-digit-industry dummy variables between the equations for those with less than one year of tenure and those with ten or more years is .91. When we pool tenure groups and estimate both intercept and slope coeffi-

cients for all one digit industries we find a negative correlation between the slopes and the intercepts of.33. But, when the tenure profiles are plotted very few cross. For the most part, high paying industries are high paying for workers of all ages and lengths of service.

VI. ALTERNATIVE EXPLANATIONS FOR INTER-INDUSTRY WAGE DIFFERENTIALS

A. EFFICIENCY WAGE EXPLANATIONS

The basic efficiency wage hypothesis states that the productivity of workers is a function of the wage paid by the firm. In this case, firms may not cut wages in the presence of excess supply of labor, since reducing wages can potentially increase labor costs. Equilibrium can be consistent with non-market clearing wages, job rationing, and even involuntary unemployment in some models. If efficiency wage considerations are important in some sectors and not as relevant in others, segmented (dual) labor markets of the type describe by Doeringer and Piore (1971) can arise.[16]

A number of conceptually distinct, although possibly complimentary, efficiency wage models may provide rationales for the payment of above market clearing wages. We describe the mechanisms of the four most relevant models briefly here.

The variant of the efficiency wage model that has drawn the most attention recently is the shirking model. Employers typically have only imperfect information concerning the behavior of workers on the job. The supervision and monitoring of worker actions is costly. The punishments for substandard employee performance available to a firm are typically limited by legal constraints and social custom. Under these conditions, employers must find mechanisms to elicit adequate effort from their employees. Piece rates and other direct pay-for-performance compensation schemes are often impracticable. Firms may find it profitable in this situation to raise wages above the opportunity costs of workers. By increasing wages, firms raise the cost of job loss and encourage workers to put forth adequate effort. When workers are paid wages above their opportunity costs, they value their jobs, and the threat of termination for detected loafing creates an incentive for workers not to shirk.

A second model of efficiency wages postulates that they are paid in order to minimize turnover costs. If firms must bear part of the costs of turnover and if quit rates are a decreasing function of wages paid, firms have an incentive to pay high wages to reduce costly turnover.

Imperfect information by firms about the abilities of workers may provide a selection rationale for efficiency wage payments. If workers are heterogeneous in ability and if ability and reservation wages are positively correlated, firms which offer higher wages will attract higher quality job applicants. If firms cannot observe applicant quality and lack devices to induce workers to reveal their true abilities, random hiring from the applicant pool must be utilized. A higher wage increases the expected ability of a worker hired randomly from the applicant pool. A wage above the market clearing level may minimize costs per efficiency unit of labor under these circumstances (Weiss, 1980). Institutional, legal, or sociological constraints preventing firms from differentiating wages

across workers with different productive characteristics can lead to similar results.

A final group of efficiency wage models are based on sociological considerations. Workers' effort levels may depend on the extent to which they feel they are being treated fairly by their employers. The perceived justness of the wage may affect worker productivity if effort levels are linked to worker morale and feelings of loyalty to the firm. Solow (1979) and Akerlof (1982) develop such models. Wages in excess of market clearing may be the outcome when wages play a dual role of both allocating labor across firms and of satisfying interpersonal and intertemporal wage norms that may affect worker performance.

A basic implication of efficiency wage models is that if the conditions necessitating efficiency wage payments differ across industries, then the optimal wage will differ among industries. This means that workers with identical productive characteristics are paid differently depending on their industry affiliation. These wage differences for similar workers may reflect industry characteristics that do not directly affect the utility of workers and thus would not require compensating differentials in a standard competitive labor market.

Each variant of the efficiency wage hypothesis predicts that particular industry and firm characteristics should be associated with industry wage premiums. The shirking model leads to the prediction that wages should be high where monitoring is difficult and/or costly and where the cost of workers not performing up to performance standards is high. Oi (1983) suggests that higher wages are required in large establishments since monitoring is typically more difficult. The cost of foul ups is likely to be large in industries with expensive equipment (possibly proxied by high capital/labor ratios) and for workers in positions where poor performance may affect many other workers' performance (integrated production processes). The turnover model implies that wage premiums should arise

where turnover and training costs are large and that wage premiums should yield the benefit of lower quit rates. The adverse selection model predicts higher wages, after controlling for observables, where it is difficult to evaluate labor quality. The sociological models are less specific but suggest that the importance of teamwork and ability-to-pay may be relevant.

All the models are superficially consistent with the observed patterns of industry wage differences. In fact, their ability to explain industry wage differences is a major reason why they have generated so much interest. These theories are also consistent with the evidence presented by Dickens and Lang (1985a,b,1986&1987) that indicates that wage distributions are better characterized by a pair of wage equations consistent with the dual labor market model than by a single human capital wage function. Dickens and Lang also find that primary sector jobs appear to be rationed as efficiency wage theory would predict.

Efficiency wage models are based on the argument that firms pay above market clearing wages because of the productivity augmenting benefits of doing so. Little empirical evidence is available on the benefits to firms of the payment of wage premiums.[17] The evidence discussed previously indicates that positive wage differentials are associated with lower quit rates. High wages appear to help reduce turnover costs. Much more research is required analyzing the costs and benefits of wage differentials.

One potential inconsistency with the evidence of these models is that, with the exception of the sociological theories, none of the models would lead one to expect the large positive correlations we find between the wage premiums of different occupations in the same industry. For example, secretarial jobs are virtually identical in many industries, but secretaries are highly paid in highly paid industries and less well paid in others. There is little in the economic

efficiency wage models that would lead one to expect this although some explanations have been proposed.

One possibility (Weiss 1966) is that managers in more profitable industries may be constrained by fear of anti-trust from making too high a profit for stockholders. This may lead them to use their industry's market power to purchase amenities for themselves. Heywood (1985) shows that a positive relation between wages and product market power arises from a simple model of expense-preference behavior by managers in a labor market where efficiency wages are paid. By paying their workers more they can spend less time monitoring them and still maintain the same level of productivity.

Alternatively, if workers are heterogeneous with respect to their propensity to shirk, the efficiency wage premium will depend on the cost to the company of worker shirking and not just the value to the worker and the probability of detection. Then if individual workers do not substitute completely for each other in the production of the firms product or in the use of some capital equipment, the efficiency wage premium will be proportional to the lost output or the cost of the under utilized capital.[18] If all occupations receive efficiency wages then this can lead to the cross occupation correlations. Thus it is conceivable but not probable that the shirking efficiency wage model can explain this phenomena since it seems unlikely that it would be necessary to pay all workers efficiency wages or that the substitutability condition would be met for all occupations. More theoretical work and empirical evidence is necessary to clarify this point.

The one class of efficiency wage models which seems to be most consistent with the existence of industry differences, the correlation of these differences between occupations, and the correlation of the industry differences with profits and concentration ratios is the class of sociological or normative models of efficiency wages. Workers may feel that an employer who is earning greater profits

should pay workers more. Such norms would affect the wages of all workers in an industry.

The normative model is also consistent with the evidence on the inter-temporal stability of industry wage premiums to the extent that industry profitability is stable over time. The little evidence we have suggests that it is at least on average over long periods of time. Furthermore, sociological models suggest that once wage differentials are established they may become customary with workers attaching normative significance to their maintenance (Piore, 1973). This is an additional argument why these considerations may lead to stable differentials which are only altered in periods of great economic distress. The analysis of events surrounding major changes in industry wage patterns is also an important avenue for future research.

The downside to the normative models is the cross-national evidence, particularly the finding of such a great degree of similarity between wage setting in Eastern block and Western developed countries. Presumably ability to pay should not be similar to that in Western nations nor should it matter for wage setting in centrally planned economies. The international evidence would seem to suggest a technological foundation for the wage patterns. The evidence on the correlation of wages within industries argues against such an interpretation. One possible reconciliation is to suggest that both economic and sociological efficiency wage models are relevant. Blue collar wages may be influenced by a desire to prevent shirking or reduce turnover. Norms may require that managers are paid more than supervisors and supervisors more than skilled workers. Finally, administrative support staff may feel that fairness requires that they be paid in relation to the earnings of those they work for. Economics may explain the differences between industries and normative considerations the patterns within industries.

This is not an elegant explanation for the patterns we observe. It begs the question why workers would adopt such norms and withhold effort if they were not satisfied. However, an inelegant explanation is not necessarily an incorrect one.

B. COLLECTIVE ACTION THREAT AND BARGAINING MODELS

Workers may be able to raise their wages above competitive levels through collective action and the threat of a strike or work slowdown. Much research effort has gone into documenting the non-competitive wage premiums earned by union workers. Freeman and Medoff (1984) summarize much of the empirical research in this area.

The model of Dickens (1986) shows that nonunion workers, even those employed in competitive industries, may benefit from the threat of collective action. Such premiums are most likely to arise where the costs of collective action to workers are low, where workers are most favorably disposed toward collective action, and where the firm has rents derived from market power or has large fixed capital investments. When collective action manifests itself in the formation of unions, union/nonunion wage differences will be largest where costs to forming unions are high and workers are least favorable to unionization. Also changes over time in these factors should be correlated with changes in the union/nonunion wage difference. Differences in industry wage premiums across occupations with important union threats (blue collar occupations) and those with smaller threats or no possibility of unionization (managers and professional workers) may provide fur-

ther information on the importance of union-based models. The international evidence on industry wage patterns can also be brought to bear.

The evidence presented on the correlates of industry wage premiums is certainly consistent with the union threat explanation as is the correlation between union and nonunion wage patterns. The across industry correlation of nonunion wages with union density may also be evidence of a union threat effect. As noted earlier the pattern of which industries pay high wages predates the large increase in unionism in the 1930s, but the pattern could have reflected the presence of a threat even in the absence of an established union movement. Mathewson in his 1931 book Restriction of Output among Unorganized Workers, and Roy in his introduction to the 1969 edition of Mathewson, report on numerous examples of workers acting in concert to obtain concessions from employers in the absence of unions. Even the international evidence may be compatible with this explanation. At first blush it may seem unreasonable to talk about a union threat in the Soviet Union. But, if we think in the more general terms of worker collective action the explanation seems more plausible. There are labor disputes even in the Soviet Union. Goldman (1983, p108-112) reports on a number of major work stoppages and even the formation of unauthorized trade unions. Given the political climate in the Soviet Union such actions are undoubtedly only the tip of the iceberg. Less visible small scale work actions and sabotage are probably more common. Still, it is unclear why the amount of rent workers could extract from different industries would have so similar a pattern in the East and the West even if there is a threat of collective action in the East unless it is related only to the technology and not to product market conditions. This objection also applies to the class of implicit bargaining or "indsider-outsider" models (Shaked and Sutton 1984, Lindbeck and Snower 1984, Solow 1985 and Rotemberg and Saloner 1986) To the

extent they can explain the cross occupational correlations they have difficulty explaining the cross national correlations.

Krueger and Summers (1987a) argue against the union threat explanation for industry wage patterns on the basis of their finding of a high correlation between industry wage patterns in the North and South. While union density is lower in the South, employers there cannot ignore the possibility of unions forming. Nothing in the threat model would lead us to expect that wages in the North and South would not be correlated. What the model would lead us to anticipate is that, if union density is lower in the South or Right-to-Work states because workers are less interested in unions or because it is more costly to form unions, the union/nonunion wage differential should be larger there. This is what Farber (1984) finds for Right-to-Work states and Freeman and Medoff (1984) find for southern states.

The changes in the union/nonunion wage gap in the 1930s and the 1970s are also consistent with the union threat model. It is often argued that the passage of the NLRA reduced the costs to workers of organizing unions. If that is so then we would expect to see a reduction in the union wage premium in the period following the NLRA. In the 1970s union density has been declining rapidly and many have attributed this to increased employer resistance to unions or a growing dissatisfaction with unions on the part of workers. Either of these trends could be expected to widen the union/nonunion wage gap if at least some nonunion wages are set to prevent unionization. The empirical evidence from both periods is consistent with this hypothesis (see Johnson (1981)). Of course this evidence would also be consistent with a competitive model of wage determination for the nonunion sector if high costs or more difficult organizing made unions more selective so that they only attempted to organize workplaces where larger wage gains were possible.

A final problem fitting the union threat explanation to the data is that such an explanation for industry wage patterns would not lead us to expect that the wages of managerial workers would be correlated with those of other workers since collective action by managers is not protected by U.S. labor law and is rarely if ever observed. It could be that managers in high wage industries must be higher paid to allow firms to promote from within. Alternatively the threat of collective action may be determining the wages of blue collar workers while wage norms mandate a relation between those wages and the wages paid managers.

VII. CONCLUSION.

Our study of the nature of industry wage patterns suggests several conclusions. The most compelling is that there appear to be large, persistent wage differentials that cannot be adequately explained by standard competitive labor market models. It seems unlikely that the large differences in wages between industries largely reflect differences in labor quality or compensating differentials for unseen job characteristics. Still sorting models where information about ability is revealed gradually with work experience may play some role in explaining wage differences and the pattern of inter-industry mobility. The correlation of wages and quit rates makes it unlikely that wage differences reflect differences in job quality. These explanations are also hard to reconcile with the observed correlations of industry wage differentials across occupations, the similarity of union and nonunion wages and with the positive relationship

between wages and ability to pay. The evidence taken together suggests to us that it will be productive to pursue other explanations.

While some of the other explanations we consider can explain observed patterns of wage differentials, none are entirely consistent with all aspects of the data. Economic efficiency wage models can explain the existence of industry differences but are difficult to reconcile with the finding of wage correlations across occupations within industries. Normative or Sociological efficiency wage models are consistent with the intra-industry correlations but are difficult to reconcile with the cross-national evidence. A combination of the two models provides a consistent though inelegant account of the facts.

The threat of collective action by workers is also consistent with most of the facts with two notable exceptions. The collective action threat model cannot explain why managers' wages should be correlated with those of other workers and is hard to reconcile with the high correlation of industry wage patterns between the East and the West. But the fact that it can account for so much of what we know about changes in union/nonunion wage differences as well as the anecdotal evidence on the importance of such considerations in wage setting in large non-union firms suggests that it is probably an important determinant of wages in the U.S. even if it is not the most important.

The consistency of industry wage patterns over time is one of the most interesting puzzles and provides one of the best opportunities for future research. One way of testing alternative theories is to see if they can help explain why those industries which changed relative position did so. Such research is of great importance given the differences in the policy implications of alternative theories.

FOOTNOTES

1. These wide ranges arise from the substantial collinearity between industry status and individual characteristics.

2. Bulow and Summers (1986), Dickens (1986), and Stiglitz (1986) provide detailed discussions of the policy implications of alternative wage determination models.

3. Foulkes (1980) presents numerous examples of large nonunion firms which maintain high wages at least partially to avoid unionization. Freeman and Medoff (1984, chapter 10) discuss the impacts of unions on nonorganized labor in the United States.

4. Most of the specifications presented have also been estimated with these outliers left in the data. The removal of these observations does not affect the qualitative nature of the results in any of the cases examined.

5. These estimates have been corrected to take into account the measurement (sampling) error in the means of the industry-occupation average log wages. Appendix 1 describes the correction for both the weighted and unweighted estimates.

6. A detailed discussion of the implications of alternative theories for the relationships among occupations in the pattern of industry wage differentials is deferred to sections V and VI. Transitory wage differentials arising from shifts in labor demand across sectors are likely to be common across occupations in an industry.

7. These correlations have been corrected for sampling error in the means of the industry-occupation cell average log wages. See appendix 1 for a description of the method used. Mellow and Sider (1983) show that as many as twenty percent of workers' one-digit occupations may not be correctly classified. This may lead to an upward bias in the estimated correlations across occupations. However, the extremely high correlations of even very distinct occupations leads us to believe that the effect is probably unimportant.

8. These correlations involve a mixture of industry and occupation wage differentials. We also estimated separate regressions for the union and nonunion samples with our usual set of control variables as well as 11 occupation dummies and three digit Census of Population industry dummies. The corrected correlation of these industry fixed effects for union and nonunion workers is .83. Our combined 1983 CPS private sector, union sample contains 25193 observations.

9. See Dickens and Katz (1987) for a more complete description of the data and procedures utilized in estimating the correlations in Table 4.

10. Oi (1983) develops a model with heterogeneous entrepreneurs in which the more talented entrepreneurs conserve on monitoring costs by hiring higher quality workers at all levels in the hierarchy. This model is a combination of an effi-

ciency wage and a labor quality story for wage differentials. Still, Oi's model implies that better entrepreneurs also operate larger firms. The small impact of the inclusion of controls for establishment and firm size on industry wage differentials (Krueger and Summers, 1987a) suggests that unobserved labor quality arising through this channel is not a primary factor in explaining industry wage differences for observationally equivalent workers.

11. Since Vroman's results refer to changes in annual earnings rather than in wage rates. It is possible that systematic changes in hours worked across industries rather than hourly earnings changes contribute to his findings.

12. The longitudinal results (industry switch effects) of Krueger and Summers (1987a) and Vroman (1978) are potentially consistent with models in which worker quality is heterogeneous (multidimensional) and match quality varies. Gibbons and Katz (1987) discuss in detail the large number of seemingly "unverifiable" assumptions about unobservables and information necessary to make a model, in which industry wage differences reflect ability, consistent with the basic stylized facts.

13. Rosen (1986) provides a comprehensive treatment of the theory of equalizing differences in the labor market and a survey of empirical studies of compensating differentials.

14. The working conditions variables included as controls by Krueger and Summers are weekly hours, commute time, workshift dummies, variables indicating dangerous or unhealthy conditions on the job, dummies indicating extent of choice of overtime, and variables indicating whether working conditions are pleasant. Krueger and Summers perform this analysis on a sample derived from the 1977 Quality of Employment Survey.

15. This interpretation is clean if workers have homogenous tastes concerning nonpecuniary aspects of work. If workers have heterogeneous preferences, then it is possible to imagine distributions of worker preferences with respect to nonwage aspects of work in which wage differentials that reflect compensating wage differentials for marginal workers may be negatively correlated with average quit rates in an industry. This means that quit rates do not depend on wage differences for marginal workers but do for infra-marginal workers. A particular contrived example is the case of one disamenity that some workers mind and others do not mind. If enough workers care about the disamenity, a compensating differential may arise to compensate the marginal worker for this disamenity. Workers who don't care about the disamenity take jobs at the high wage firms with the disamenity and earn rents. These workers have lower quit rates and reduce the average quit rate in high wage firms. Low wage firms without the disamenity have no workers earning rents. In this example, more infra-marginal workers are at the high wage firm and average quit rates are negatively correlated with wages. One could also construct examples going in the other direction. Thus, if workers have heterogeneous preferences, the relationship among quit rate and wage differentials may be difficult to relate to the importance of equalizing differences in the labor market.

16. Bulow and Summers (1986) develop a formal model in which dual labor markets arise from efficiency wage considerations.

Footnotes

17. Recent papers by Krueger (1986), Leonard (1987), and Levine (1987) attempt to directly analyze the wage-productivity relationship postulated by efficiency wage theories.

18. To see what is meant by this consider two alternative production processes. In one each worker is provided with his or her own machine. If any worker shirks the firm's loss is proportional to the value of the machine the worker is using. With unobservable heterogeneity of workers the wage the firm pays will depend on the value of the machine. If instead, a large number of workers use a common machine and workers who shirk do not get in the way of those who don't then the firm will simply hire enough workers so that it can count on having as many as it needs to accomplish the work. The firm can trade off between higher wages or more workers, but the value of the capital and/or the output being produced will not be a consideration. The occupational correlations can be explained if individual workers in one occupation are imperfect substitutes for the individual workers of another occupation, or if they work with common capital equipment (for example an assembly line). Note from the above examples that it is not sufficient for the groups to be imperfect substitutes (as in a standard production function) if the groups are sufficiently large since again the firm could simply hire enough workers to guarantee that the desired amount of work got done.

REFERENCES

Akerlof, G.A. "Labor Contracts as Partial Gift Exchange," Quarterly Journal of Economics 87 (November 1982): 543-69.

Bell, L. and R.B. Freeman. "Does a Flexible Industry Wage Structure Increase Employment? The U.S. Experience," NBER Working Paper #1604, April 1985.

Brown, C. and J. Medoff. "The Employer Size Wage Effect," Mimeo, November 1985.

Bulow, J. I. and Summers, L. H. "A Theory of Dual Labor Markets with Application to Industrial Policy, Discrimination and Keynesian Unemployment." Journal of Labor Economics 4 (July 1986): 376- 414.

Cullen, D. "The Interindustry Wage Structure, 1899-1950," AER 46 (June 1956): 353-69.

Dickens, W.T. "Wages, Employment and the Threat of Collective Action by Workers," NBER working paper #1856 (March 1986).

Dickens, W.T. and L.F. Katz. "Interindustry Wage Differences and Industry Characteristics," in K. Lang and J. Leonard eds., Unemployment and the Structure of Labor Markets, Basil-Blackwell, 1987.

Dickens, W.T. and K. Lang. "A Test of Dual Labor Market Theory," American Economic Review 75 (September 1985a):

------------------------. "Testing Dual Labor Market Theory: A Reconsideration of the Evidence," NBER Working Paper #1670, 1985b.

------------------------, "Labor Market Segmentation and the Union Wage Premium," NBER working paper #1883 (April 1986).

------------------------, "A Test of Dual Labor Market Theory: Further Results," Berkeley mimeo, 1987.

Doeringer P. B. and M. J. Piore, Internal Labor Markets and Manpower Analysis, Lexington, Mass.: D.C. Heath, 1971.

Dunlop, J. "Industrial Relations and Economics: The Common Frontier of Wage Determination," IRRA Proceedings 1984, 1985.

Farber, H.S. "Right-to-Work Laws and the Extent of Unionization," Journal of Labor Economics 2 (July 1984): 319-52.

Foulkes, F. Personnel Policies in Large Nonunion Companies Englewood Cliffs, N.J.: Prentice-Hall, 1980.

Freeman, R.B. "The Exit-Voice Tradeoff in the Labor Market, Unionism, Job Tenure, Quits, and Separations," Quarterly Journal of Economics 94 (June 1980): 643-73.

------------. "The Effect of Trade Unionism on Fringe Benefits," Industrial and Labor Relations Review 34 (July 1981): 489-509.

Freeman, R.B. and J. Medoff. What Do Unions Do? New York: Basic Books, 1984.

Gibbons, R.S. and L.F. Katz. "Sorting and Inter-Industry Wage Differences," Mimeo, May 1987.

Goldman, M.I. U.S.S.R. in Crisis W.W. Norton, New York, 1983.

Hammermesh, D. "Economic Aspects of Job Satisfaction," in O. Ashenfelter and W. Oates, eds., Essays in Labor Market Analysis. New York: Halstead Press, 1977.

Heywood, J.S. "Market Structure and Wages: The Role of Imports," Mimeo, University of Michigan, February 1985.

Heywood, J.S. "Labor Quality and the Concentration-Earnings Hypothesis," Review of Economics and Statistics, forthcoming 1986.

Johnson, G. "Changes Over Time in the Union/Nonunion Wage Differential," Mimeo, University of Michigan, February 1981.

Jovanov, N. "Strikes and Self-Management," in J. Obradovic' and W.N. Dunn, Workers' Self-Management and Organizational Power in Yugoslavia Univ. Center for International Studies, Pittsburgh, 1978.

Katz, L.F. "Efficiency Wage Theories: A Partial Evaluation," in S. Fischer, ed., NBER Macroeconomics Annual 1986. Cambridge, Ma.: MIT Press, 1986.

Kendrick, J. Productivity Trends in the United States. Princeton, N.J.: NBER, Princeton U. Press, 1961.

Krueger, A.B. "Ownership, Agency and Wages: An Empirical Analysis," Harvard University, unpublished paper, November 1986.

Krueger, A.B. and L.H. Summmers. "Efficiency Wages and the Inter-Industry Wage Structure." Econometrica forthcoming 1987a.

------------------------------. "Reflections on the Inter-Industry Wage Structure," in K. Lang and J. Leonard, eds., Unemployment and the Structure of Labor Markets. London: Basil Blackwell, 1987b.

Kumar, P. "Differentials in Wage Rates of Unskilled Labor in Canadian Manufacturing Industries," Industrial and Labor Relations Review 26 (October 1972): 631-45.

Kwoka, J. "Monopoly, Plant, and Union Effects on Worker Wages," Industrial and Labor Relations Review 36 (January 1983): 251-57.

Lawrence, C. and R. Lawrence. "Relative Wages in U.S. Manufacturing: An Endgame Interpretation," Brookings Papers on Economic Activity (1985:1): 47-106.

Lebergott, S. "Wage Structure," RESTAT (November 1947).

References

Leonard, J.S. "Carrots and Sticks: Pay, Supervision and Turnover," Journal of Labor Economics forthcoming 1987.

Levine, D. "Tests of Efficiency Wage and Rent-Sharing Theories: The Pay-Productivity Relation," Harvard, unpublished paper, January 1987.

Lewis, H.G. Unionism and Relative Wages in the United States. Chicago: University of Chicago Press, 1963.

----------. "Union Relative Wage Effects: A Survey of Macro Estimates," Journal of Labor Economics 1 (January 1983).

Lindbeck, A. and Snower, D. "Wage Setting, Unemployment, and Insider-Outsider Relations. American Economic Review Proceedings 76 (May 1986): 235-9.

Long, J.E. and Link, A.N. "The Impact of Market Structure on Wages, Fringe Benefits, and Turnover," Industrial and Labor Relations Review 36 (January 1983): 239-50.

Mathewson, Stanley B. Restriction of Output Among Unorganized Workers Southern Illinois University Press, Carbondale, 1969.

Mellow, W. and H. Sider, "Accuracy of Response in Labor Market Surveys: Evidence and Implications," Journal of Labor Economics, October 1983.

Montgomery, E. and D. Stockton. "Evidence on Causes of the Rising Dispersion of Relative Wages," Mimeo, April 1985.

Murphy, K. and R. Topel. "Unemployment, Risk, and Earnings," in Kevin Lang and Jonathan Leonard eds., Unemployment and the Structure of Labor Markets. London: Basil Blackwell, 1987.

Oi, W. "Heterogeneous Firms and the Organization of Production," Economic Inquiry 21 (April 1983): 147-71.

Oi, W. and J. Raisian. "Impact of Firm Size on Wages and Salaries," Mimeo, August 1985.

OECD. Wages and Labor Mobility. Paris: OECD, 1965.

Pencavel J. An Analysis of the Quit Rate in American Manufacturing Industry. Princeton, N.J.: IR Section Princeton, 1970.

Piore, M.J. "Fragments of a 'Sociological' Theory of Wages," American Economic Review Proceedings 63 (May 1973): 337-44.

Pryor, F. Property and Industrial Organization in Communist and Capitalist Nations. Bloomington, Ind.: Indiana University Press, 1973.

Pugel, T. "Profitability, Concentration and the Interindustry Variation in Wages," RESTAT 62 (May 1980): 248-53.

Reder, M. "Wage Differentials: Theory and Measurement," in Aspects of Labor Economics. Princeton: Universities-NBER, Princeton U. Press, 1962.

Rosen, S. "On the Interindustry Wage and Hours Structure," Journal of Political Economy 77 (March/April 1969): 249-73.

--------. "The Theory of Equalizing Differences," in O. Ashenfelter and R. Layard, eds., Handbook of Labor Economics, volume 1. New York: North-Holland, 1986.

Rotemberg, J.J. and Saloner, G. "A Theory of Inter-Industry Wage Differentials," M.I.T. mimeo 1986.

Saunders, C. and D. Marsden. Pay Inequalities in the European Communities . London: Buttersworth, 1981.

Shaked A. and Sutton J., "Involuntary Unemployment as a Perfect Equilibrium in a Bargaining Model," Econometrica 52, No.6 (November, 1984) p1351-64.

Slichter, S. "Notes on the Structure of Wages," RESTAT 32 (February 1950): 80-91.

Solow, R. "Another Possible Source of Wage Stickiness," Journal of Macro Economics 1, 1979, p79-82.

----------- "Insiders and Outsiders in Wage Determination," Scandinavian Journal of Economics 87 (2), (1985) 411-28.

Stiglitz, J.E. "Theories of Wage Rigidity," in J. Butkiewicz, et al, eds. Keynes' Economic Legacy: Contemporary Economic Theories. New York: Praeger Publishers, 1986.

Topel, R. "Equilibrium Earnings, Turnover, and Unemployment," Journal of Labor Economics 2 (October 1984): 500-522.

Ulman, L. "Labor Mobility and Industrial Wage Structure in the Postwar United States," Quarterly Journal of Economics 89 (February 1965): 73-97.

Vroman, W. "Cyclical Earnings Changes of Low Wage Workers," in R. Ehrenberg, ed., Research in Labor Economics, vol. 2. Greenwich, Ct.: JAI Press, 1978.

Weiss, Andrew, "Job Queues and Layoffs in Labor Markets with Flexible Wages," Journal of Political Economy 88 (June 1980): 526-38.

Weiss, Leonard, "Concentration and Labor Earnings," American Economic Review 56 (March 1966) p 96-117.

Yellen, J. "Efficiency Wage Models of Unemployment," American Economic Review Proceedings 74 (May 1984): 200-205.

References

TABLE 1

STANDARD DEVIATION OF AVERAGE LOG WAGE ACROSS INDUSTRIES

| Occupations[1] | Raw Data | | Wage Equation | Wage Equation |
	Unweighted	Weighted	Fixed-Effects[2]	Residuals[3]
Managers	.23	.24	.17	.13
Professionals	.27	.30	.20	.22
Technicians	.21	.19	.13	.09
Supervisors	.24	.26	.18	.16
Sales	.46	.37	.29	.14
Clerical	.17	.13	.14	.09
Service	.29	.19	.18	.11
Crafts	.20	.15	.16	.10
Operatives	.22	.21	.17	.11
Semi-Skilled	.20	.15	.14	.08
Trans. Equip. Oper.	.17	.16	.15	.13
Laborers	.22	.15	.15	.09

1. Definitions of occupational categories can be found in
Appendix 2.

2. These are unweighted standard deviations. The wage regressions
contained dummy variables for state, smsa, marital status, sex, race,
and part-time work. Education (years of schooling), education squared,
experience (age-education-5) and experience squared were included
as continuous variables. Experience and experience squared were
also interacted with all the other variables except for the
state and smsa dummies and education squared.

3. These are weighted standard deviations. The wage regressions
contained dummy variables for state, marital status, sex, race,

part-time work and whether or not the individual lives in an SMSA. Education (years of schooling), education squared, experience (age-education-5) and experience squared were included as continuous variables. Experience and experience squared were also interacted with all the other variables except for the state dummies and education squared.

CORRELATIONS OF AVERAGE INDUSTRY LOG WAGES ACROSS OCCUPATIONAL GROUPS
1983 CPS PRIVATE SECTOR NONUNION WORKERS

	Manage	Prof.	Tech.	Super.	Sales	Cleric	Service	Crafts	Operate	Semi-Skilled	Trans Oper.	Labor
Managers	1.00	.94	.68	.70	.81	.94	.85	.77	.73	.48	.80	.77
Professionals		1.00	.78	.86	.77	.89	.74	.81	.85	.63	.77	.78
Technicians			1.00	.70	.60	.78	.57	.74	.65	.45	.47	.57
Supervisors				1.00	.78	.83	.83	.90	.81	.89	.79	.80
Sales					1.00	.73	.76	.70	.43	.40	.56	.67
Clerical						1.00	.82	.82	.77	.57	.78	.85
Service							1.00	.90	.90	.70	.69	.83
Crafts								1.00	.91	.90	.73	.72
Operatives									1.00	.91	.68	.94
Semi-Skilled										1.00	1.00*	.78
Trans. Equip. Oper.											1.00	.94
Laborers												1.00

*The correction for sampling error in industry-occupation cell means causes some correlations to be greater than 1.00.

TABLE 3.

CORRELATIONS OF INDUSTRY WAGE DIFFERENTIALS ACROSS OCCUPATIONAL GROUPS
FIXED EFFECTS
1983 CPS PRIVATE SECTOR NONUNION WORKERS

	Manage	Prof.	Tech.	Super.	Sales	Cleric	Service	Crafts	Operate	Semi-Skilled	Trans Oper.	Labor
Managers	1.00	.98	.60	.84	.84	.99	.84	.89	.71	.68	.81	.83
Professionals		1.00	.71	.93	.74	.90	.74	.86	.82	.77	.75	.78
Technicians			1.00	.76	.61	.75	.68	.79	.62	.39	.46	.57
Supervisors				1.00	.88	.92	.96	1.00*	.79	.95	.81	.79
Sales					1.00	.79	.74	.78	.41	.46	.55	.70
Clerical						1.00	.86	.89	.76	.71	.79	.89
Service							1.00	1.00*	.97	.76	.73	.89
Crafts								1.00	.79	.96	.79	.79
Operatives									1.00	1.00*	.77	1.00*
Semi-Skilled										1.00	.97	.90
Trans. Equip. Oper.											1.00	.93
Laborers												1.00

*The correction for sampling error in industry-occupation cell means causes some correlations to be greater than 1.00.

The regression from which the fixed effects were calculated contained education (years of schooling) and its square; experience (age-education-5) and its square; 50 state dummy variables; 44 SMSA dummy variables; dummy variables for marital status, race, sex, and part-time work; and interaction terms for both experience and experience squared with all the other variables except the state dummies, the SMSA dummies and education squared.

TABLE 4

CORRELATIONS OF INDUSTRY ATTRIBUTES, 1980S

Each cell shows the correlation coefficient with the number of industries (n) in parentheses below it in the original. Column headers labeled in the original run from "FE Non Union" through "Injury Rate"; the remaining variables (Hours of Work onward) continue the lower‑triangular matrix.

Variable*	FE Non Union	FE Union	Avg. Wage	Avg. Inc.	Quit Rate	Labor Prdct	Educa‑tion	Tenure	Exper‑ience	%Fem	%Black	Layoff Rate	Injury Rate	Hrs Work	Hrs OT	Comp Ratio	Unemp	Union Cov	Emp/Estab	Emp/Firm	Sales/Firm	4‑Firm
Industry Fixed Effect for Nonunion Workers	1.000 (216)																					
Industry Fixed Effect for Union Workers	0.647 (209)	1.000 (209)																				
Average Wage	0.834 (160)	0.790 (159)	1.000 (160)																			
Average Weekly Income	0.860 (160)	0.781 (159)	0.982 (160)	1.000 (160)																		
Quit Rate	-0.595 (80)	-0.568 (80)	-0.641 (80)	-0.640 (80)	1.000 (80)																	
Labor Productivity	0.619 (77)	0.551 (77)	0.573 (77)	0.631 (77)	-0.427 (77)	1.000 (77)																
Years of Education	0.146 (216)	0.166 (209)	0.262 (160)	0.229 (160)	-0.482 (80)	0.730 (77)	1.000 (223)															
Years of Job Tenure	0.404 (194)	0.244 (190)	0.541 (152)	0.593 (152)	-0.320 (76)	0.431 (73)	-0.166 (200)	1.000 (200)														
Years of Experience	0.391 (216)	0.204 (209)	0.404 (160)	0.465 (160)	-0.362 (80)	-0.238 (73)	-0.198 (200)	0.322 (200)	1.000 (223)													
Percent Female	-0.451 (173)	-0.548 (172)	-0.671 (157)	-0.708 (157)	0.324 (78)	-0.204 (76)	0.172 (173)	-0.388 (164)	-0.338 (173)	1.000 (173)												
Percent Black	-0.025 (175)	-0.048 (172)	0.008 (154)	-0.005 (154)	0.128 (76)	-0.054 (73)	-0.181 (180)	0.156 (172)	0.201 (180)	0.101 (163)	1.000 (180)											
Layoff Rate	-0.352 (80)	-0.286 (80)	-0.286 (80)	-0.294 (80)	0.381 (80)	-0.389 (75)	-0.507 (80)	-0.012 (76)	0.248 (80)	0.049 (78)	0.034 (76)	1.000 (80)										
Injury Rate	0.104 (147)	0.136 (146)	0.176 (141)	0.189 (141)	0.362 (80)	-0.366 (77)	-0.555 (153)	0.204 (147)	0.246 (153)	-0.473 (145)	0.140 (146)	0.453 (80)	1.000 (153)									
Hours of Work per Week	0.737 (160)	0.579 (159)	0.684 (160)	0.797 (160)	-0.397 (80)	0.563 (77)	0.044 (160)	0.574 (152)	0.572 (160)	-0.680 (157)	-0.033 (154)	-0.170 (80)	0.259 (141)	1.000 (160)								
Hours of Overtime per Week	0.222 (77)	0.388 (77)	0.292 (77)	0.403 (77)	-0.092 (75)	0.303 (77)	0.189 (77)	0.258 (73)	-0.071 (77)	-0.398 (76)	-0.039 (73)	0.078 (75)	0.171 (77)	0.722 (77)	1.000 (77)							
Ratio of Total Comp to Wage and Salary	0.591 (72)	0.607 (72)	0.726 (72)	0.743 (72)	-0.630 (72)	0.439 (72)	0.544 (77)	0.678 (73)	0.205 (77)	-0.479 (76)	-0.152 (73)	-0.084 (75)	-0.109 (77)	0.557 (77)	0.557 (72)	1.000 (72)						
Average Unemployment Rate, 79 82 84	-0.075 (200)	0.009 (196)	-0.084 (157)	-0.093 (157)	0.351 (77)	-0.375 (77)	-0.606 (204)	0.062 (194)	0.097 (204)	-0.236 (170)	0.027 (175)	0.423 (77)	0.399 (148)				1.000 (204)					
Union Coverage	0.548 (216)	0.491 (209)	0.637 (160)	0.653 (160)	-0.457 (80)	-0.067 (77)	-0.248 (223)	0.480 (200)	0.569 (223)	-0.512 (173)	0.174 (180)	0.250 (80)	0.174 (153)	0.420 (157)	0.250 (173)			1.000 (223)				
Employees per Establishment	0.516 (216)	0.255 (209)	0.437 (160)	0.463 (160)	-0.388 (78)	0.113 (76)	-0.060 (140)	0.529 (134)	0.532 (140)	-0.217 (138)	0.338 (136)	0.029 (78)	0.029 (153)						1.000 (140)			
Employees per Firm	0.234 (140)	0.153 (139)	0.248 (136)	0.264 (136)	-0.296 (78)	0.629 (76)	0.127 (140)	0.301 (134)	0.125 (140)	-0.037 (138)	0.134 (136)	-0.225 (78)	-0.087 (124)							1.000 (140)		
Sales per Firm	0.278 (185)	0.226 (183)	0.324 (159)	0.349 (159)	-0.172 (79)	0.657 (76)	0.103 (191)	0.272 (182)	0.110 (191)	-0.125 (172)	0.054 (174)	-0.178 (79)	-0.122 (152)								1.000 (191)	
Four Firm Concen‑tration Ratio	0.265 (73)	0.268 (73)	0.310 (73)	0.306 (73)	-0.385 (71)	0.172 (73)	0.239 (73)	0.128 (73)	0.302 (73)	-0.056 (72)	0.066 (69)	0.083 (71)	-0.203 (73)									1.000 (73)

The number below the correlation coefficient is the number of industries with data on both variables.

*Variable definitions and sources can be found in Dickens and Katz (1987).

TABLE 4 (CONTINUED)

CORRELATIONS OF INDUSTRY ATTRIBUTES, 1980S

Each cell shows the correlation coefficient with the number of industries below it.

Variables*	FE Non Union	FE Union	Avg. Wage	Avg. Inc.	Quit Rate	Labor Prdct	Education	Tenure	Experience	%Fem	%Black	Layoff Rate	Injury Rate	Hours
R&D Expenditures/Sales	0.394 / 77	0.156 / 77	0.173 / 77	0.207 / 77	-0.330 / 75	0.262 / 77	0.678 / 77	-0.006 / 73	-0.069 / 77	0.078 / 76	-0.410 / 73	-0.330 / 75	-0.459 / 77	0.297 / 77
Capital/Labor Ratio	0.382 / 158	0.198 / 155	0.373 / 135	0.423 / 135	-0.224 / 72	0.434 / 68	-0.073 / 159	0.385 / 150	0.359 / 159	-0.339 / 140	0.241 / 143	-0.031 / 72	0.138 / 127	0.438 / 135
Percent Production Workers	-0.551 / 159	-0.399 / 158	-0.514 / 159	-0.562 / 159	0.291 / 72	-0.639 / 77	-0.268 / 159	-0.389 / 151	-0.306 / 159	0.358 / 157	0.089 / 153	0.468 / 72	0.033 / 141	-0.574 / 159
Net-Income/Sales	0.366 / 185	0.138 / 183	0.273 / 159	0.309 / 159	-0.118 / 80	0.423 / 77	0.190 / 159	0.116 / 182	0.136 / 191	-0.101 / 172	0.055 / 174	-0.373 / 79	-0.150 / 152	0.337 / 159
Avg. Rate of Return on Capital	0.178 / 185	-0.002 / 183	0.080 / 159	0.101 / 159	0.131 / 79	0.354 / 76	0.136 / 191	-0.019 / 182	0.067 / 191	-0.014 / 172	-0.086 / 174	-0.292 / 79	-0.116 / 152	0.160 / 159
Net-Income per worker	0.174 / 139	0.121 / 138	0.161 / 135	0.180 / 135	0.193 / 77	0.538 / 75	0.150 / 139	0.103 / 133	-0.091 / 139	-0.042 / 137	-0.021 / 135	-0.182 / 77	0.033 / 123	0.127 / 135

Variables*	Over-time	Comp.	Avg. Unemp.	Union Covrg	Emply/ Est.	Emply/ Firm	Sales/ Firm	Conc. Ratio	R&D/ Sales	K/L	%Prod. Worker/Sales	NetInc /Sales	Return on K	NetInc per E
Hours of Overtime per Week	1.000 / 77													
Ratio of Total Comp to Wage and Salary	0.280 / 72	1.000 / 72												
Average Unemployment Rate, 79 82 84	-0.041 / 77	-0.198 / 72	1.000 / 204											
Union Coverage	0.250 / 77	0.531 / 72	0.151 / 204	1.000 / 223										
Employees per Establishment	-0.078 / 76	0.324 / 71	0.043 / 137	0.580 / 140	1.000 / 140									
Employees per Firm	0.255 / 76	0.293 / 71	-0.002 / 137	0.201 / 140	0.377 / 140	1.000 / 140								
Sales per Firm	0.137 / 76	0.231 / 71	0.018 / 186	0.187 / 191	0.096 / 139	0.650 / 139	1.000 / 139							
Four Firm Concentration Ratio	-0.035 / 73	0.340 / 68	-0.099 / 73	0.342 / 73	0.594 / 72	0.134 / 72	0.041 / 72	1.000 / 73						
R&D Expenditures/Sales	-0.067 / 77	0.275 / 72	-0.416 / 77	-0.201 / 76	0.491 / 76	0.162 / 76	-0.014 / 76	0.328 / 73	1.000 / 77					
Capital/Labor Ratio	0.562 / 68	0.518 / 63	0.070 / 152	0.399 / 159	0.481 / 124	0.186 / 124	0.173 / 144	0.083 / 65	0.064 / 68	1.000 / 159				
Percent Production Workers	-0.076 / 77	-0.338 / 72	0.095 / 156	-0.292 / 159	-0.500 / 136	-0.171 / 136	-0.184 / 158	-0.122 / 73	-0.642 / 77	-0.515 / 134	1.000 / 159			
Net-Income/Sales	-0.071 / 77	0.141 / 71	-0.205 / 186	0.084 / 159	0.313 / 136	0.151 / 136	0.126 / 158	0.091 / 72	0.417 / 76	0.357 / 144	-0.553 / 158	1.000 / 159		
Avg. Rate of Return on Capital	-0.059 / 76	-0.029 / 71	-0.065 / 186	-0.083 / 191	0.031 / 139	0.028 / 139	0.078 / 191	-0.070 / 72	0.111 / 76	0.191 / 144	-0.312 / 158	0.628 / 191	1.000 / 191	
Net-Income per worker	0.183 / 75	0.145 / 70	-0.135 / 136	-0.123 / 139	-0.108 / 139	0.017 / 139	0.067 / 75	0.076 / 71	0.067 / 75	0.008 / 123	-0.170 / 135	0.436 / 139	0.449 / 139	1.000 / 139

The number below the correlation coefficient is the number of industries with data on both variables.

*Variable definitions and sources can be found in Dickens and Katz (1987)

APPENDIX 1

SAMPLING ERROR CORRECTION FOR STANDARD DEVIATIONS AND CORRELATIONS

We encounter a problem in estimating both the standard deviations of the industry-occupation wage effects and the correlations of the industry wage effects across occupations. The problem is that whether we are using cell means or dummy variable estimates we only have a sample of all people in the cell and our estimates are subject to sampling error. This biases estimated standard deviations up and correlations down. Since the magnitude of the bias can be estimated we are able to construct correction factors which yield consistent estimates of the across industry standard deviations and correlation coefficients.

The industry-occupation cell mean or estimated fixed effect for industry i and occupation j (m_{ij}) can be written

$$\text{(A1)} \quad m_{ij} = m'_{ij} + e_{ij}$$

where m'_{ij} is the true cell mean or fixed effect and e_{ij} is the sampling error of the estimate. Thus the variance of the estimated means across all industries for occupation i is

$$\text{(A2)} \quad \text{Var}(m_j) = \text{Var}(m'_j) + \text{Var}(e_j).$$

To obtain an unbiased estimate of the across industry variance of the true industry means or fixed effects we construct

(A3) $\widehat{Var}(m'_j) = \widehat{Var}(m_j) - \widehat{Var}(e_j).$

For cell means

(A4) $\widehat{Var}(m_j) = (\sum_i n_{ij}(m_{ij}-M_j)^2)/N_j$

and

(A5) $\widehat{Var}(e_j) = (\sum_i \sum_k (lw_{ijk}-m_{ij})^2/(n_{ij}-1))/N_j$

where M_j is the average wage for everyone in occupation j, n_{ij} is the number of observations in industry-occupation cell ij, N_j is the number of people in all industries in occupation j, and lw_{ijk} is the log of the hourly wage for person k in industry i and occupation j.

Computing the correlations of the m_js yields a biased estimate of the correlations of the m'_js. This is because $cov(m_j,m_k)=cov(m'_j,m'_k)$, but as noted above, the variances in the denominator of the correlation coefficient of the m_js are biased upward so the estimated correlation is biased downward. This problem is solved by using the consistent variance estimates from A3 in constructing the correlations.

The problem becomes more involved when we wish to correct the variances and the correlations of the industry-occupacion fixed effects. This can be easily done using the variance-covariance matrix of the regression from which the fixed ef-

fects were derived, but since the fixed effects estimates are obtained using a two-step procedure we must construct the estimated variance-covariance matrix as

$$(A6) \quad \widehat{Var}(m) = \hat{\sigma}^2 \ [(X'X)^{-1} + (X'X)^{-1}X'Z(Z'PZ)^{-1}Z'X(X'X)^{-1}]$$

where m is the vector of industry and occupation fixed effects, σ is the estimated standard error of the regression with the fixed effects, X is the matrix of fixed effect dummy variables, Z is the matrix of covariates, and $P=X(X'X)^{-1}X'$. $\hat{\sigma}(Z'PZ)^{-1}$ is the variance-covariance matrix from the demeaned regression. The entire expression is easily computed using proc reg and proc matrix in SAS. Since we suspected that error variances were different in different industry-occupation cells we first estimated the regression to obtain estimates of the error variance for each cell and then reestimated it using data where each observation is divided by the square-root of the estimated cell error variance. The estimate of the variance-covariance matrix for the m s can also be constructed using weighted data.

The variance of the m'_js may then be constructed as in A3 above where $\widehat{Var}(m_j)$ is constructed as before and

$$(A7) \quad \widehat{Var}(e_j) = (\sum_i n_{ij} vm_{ij})/N_j - (\sum_{ik}\sum n_{ij} n_{kj} vm_{ij,kj})/(\sum_{ik}\sum n_{ij} n_{ik})$$

where vm_{ij} is the diagonal element of $\widehat{Var}(m)$ corresponding to the fixed effect for industry i and occupation j, and $vm_{ij,kj}$ is the covariance term for the fixed effects for occupation j for industries i and k.

When estimating the correlations of the industry fixed effects it is no longer true that the estimated covariance of two occupation's fixed effects across industries is an unbiased, or even consistent, estimate of the covariances of the true fixed effects since the regression procedure induces a correlation in the measrement errors (e). A consistent estimate can be constructed as

$$(A8) \quad \widehat{cov}(m'_j, m'_k) = \widehat{cov}(m_j, m_k) - \widehat{cov}(e_j, e_k)$$

where

$$(A9) \quad \widehat{cov}(e_j, e_k) = (\sum_i vm_{ij,ik})/I - (\sum_i \sum_l vm_{ij,lk})/I^2$$

$vm_{ij,lk}$ is the estimated covariance of the jth and kth occupation fixed effect for industries i and l from A6 and I is the number of industries. A consistent estimate of the correlation of the true fixed effects can be obtained by dividing the estimated covariance from A8 by the square root of the consistent estimates of the variances.

OCCUPATION   1980 CENSUS OCCUPATION CODES

Occupation	1980 Census Occupation Codes
Managers	1-34,37,475-476
Professionals	43-199,258
Technicians	203-235
Sales	253-257,259-285
Clerical	307-389
Service	403-407,416-427,434-447,449-455,457-469
Laborers	484,486-487,498-499
Operatives	488,598,614,614-617,686,703-706,708-709,714,723, 725-733,738-779,829
Semi-Skilled	683,783-786,789-795,797,799
Crafts	504-549,563-597,599,634-679,684-685,687-688,694-699, 707,713,724,734-737,787
Supervisors	35-36,243,303-306,413-415,433,448,456,485,489,494, 497,503,553-558,613,633,689-693,796,803,843
Trans. Equip. Oper.	804-828,833-834,844-859,876
Laborers	863-875,877-883,885,887-889