NBER WORKING PAPER SERIES

THE EFFECTS OF THE MINIMUM WAGE ON THE EMPLOYMENT AND EARNINGS OF YOUTH

Robert H. Meyer

David A. Wise

Working Paper No. 849

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

January 1982

The research reported here is part of the NBER's research program in Labor Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #849
January 1982

The Effects of the Minimum Wage on The Employment and Earnings of Youth

ABSTRACT

The employment and earnings effects of the minimum wage are estimated by parameterizing an hypothesized relationship between underlying market employment and wage relationships versus observed wage and employment distributions in the presence of a legislated minimum. If there had been no minimum during the 1973-78 period, we estimate that employment among out-of-school men 16 to 24 would have been approximately 4 percent higher than it in fact was. Among young men 16 to 19 employment would have been about 7 percent higher and among those 20 to 24, 2 percent higher. Employment among black youth 16 to 24 would have been almost 6 percent higher than it was, as compared with somewhat less than 4 percent for white youth. Although it is sometimes argued that the adverse employment effects of the minimum are offset by increased earnings, we find virtually no earnings effect. Had the minimum not been raised over the 1973-78 period, inflation would have greatly moderated the adverse employment effects of the minimum, with approximately two-thirds of the potential employment gains from elimination of the minimum attained. The weight of our evidence is inconsistent with a general increase in youth wage rates with increases in the real minimum. Our findings support the hypothesis that the effects of the minimum are concentrated on youth with sub-minimum market wage rates.

Robert H. Meyer
The Urban Institute
2100 M Street, N.W.
Washington, D.C. 20037

(202) 223-1950

David A. Wise
J.F.K. School of Government
Harvard University
Cambridge, MA 02138

(617) 495-1178

THE EFFECTS OF THE MINIMUM WAGE ON THE EMPLOYMENT AND EARNINGS OF YOUTH

by

Robert H. Meyer and David A. Wise*

It is often presumed that the minimum wage reduces the employment of youth. It is also often presumed that the adverse employment effect is moderated by a positive earnings effect. These two theoretical presumptions are reflected in two empirical questions: how large is the employment effect and how large is the earnings effect? The employment effect has been the subject of considerable research, but much less attention has been directed to the earnings effect, even though the two impacts are integrally related. Previous analysis of employment effects have been based largely on aggregate time series or cross section data.[1] The earnings effects have been neglected at least in part because traditional methods of analysis have not allowed direct inferences about the distribution of wage rates in the absence of a minimum. Although studies based on aggregate data have recognized that its impact should depend on the level of the minimum relative to the average level of wage rates, they ignore

---

* This research was supported by grant SES-8007165 from the National Science Foundation. Part of the work was formulated under contract number J-9-M-0-0046 from the U. S. Department of Labor. We received helpful comments from Charlie Brown and Steven Venti and from participants in the labor seminars at Columbia University and at Harvard University.

1. Most have been based on aggregate time series data (e.g. Gramlich [1976], Mincer [1976], and Hamermesh [1980]) and to a lesser extent on aggregate cross-section (e.g. Welch and Cunningham [1978], Ehrenberg and Marcus [1979], and Cunningham [1980] data.

the heterogeneity among individual market wage rates and thus also that some individuals are much more likely than others to be affected by the minimum. To take advantage of heterogeneity across individuals, it is natural to consider individual market wage rates. Motivated by this observation, we use individual employment and wage data to estimate the effects of the minimum on the labor market experiences of youth. A natural outcome of our procedure is joint estimation of the impacts of the minimum on employment and on wage rates and earnings, reflecting the close relationship that indeed exists between them. Our analysis relies on individual data for several years in the 1970s. Thus it takes advantage of the differential impacts that the minimum has on different individuals at a point in time, as well as shifts in the minimum over time.

Our estimation procedure is based on explicit parameterization of the effect of the minimum wage on the joint distribution of wage rate and employment outcomes that would exist in the absence of the minimum. Thus it emphasizes explicitly the relationship between the level of the minimum wage and the distribution of market wage rates that individuals would receive in the absence of the minimum. The procedure provides estimates of a market wage function that enables us to compare expected earnings of persons who would have been employed without a minimum with the expected earnings of these same persons in the face of minimum wage legislation. Both of these may be compared with the expected earnings of those who are employed when the minimum is in effect. The procedure also allows us to estimate the incidence of non-employment by market wage rate, with and without a minimum. We set forth this procedure in an earlier paper (Meyer and Wise [1981]) but based estimates only on data for one year.

In this paper, we provide estimates based on several years in the 1970s. There are at least two advantages to pooling individual data for several years. First, it provides greater variation in the level of the minimum relative to the market distribution. A good deal of variation is provided by shifts in this distribution due to individual and regional differences in wage rates, given a single national minimum. Such variation is increased by shifts over time in the real minimum. This is important because much of the power in the estimation technique derives from differences among individuals in their market wage rates versus the level of the minimum. Second, and possibly most important, shifts over time in the national minimum wage allow us to estimate possible upward shifts in the whole youth wage distribution, with increases in the minimum.[1]

We have proposed a basic model that we believe captures the primary effects of the minimum as described by most researchers. In particular, we begin by presuming that the major effect of the minimum is concentrated on persons who would otherwise be paid below the minimum. Some youth who in the absence of the minimum would be paid below the minimum are presumed to receive the legal minimum; others because of non-coverage or non-compliance are presumed to be paid below the legal minimum. We explicitly parameterize these possibilities and estimate the likelihood that each will occur. Specification to allow for these outcomes is

---

1. Because many macroeconomic and demographic factors affect differences over time in youth employment, however, it is possible that the best estimates of the effects in a given year are based on data for that year only. It is arguable that individual year estimates are more accurate than estimates of the effects of shifts in the minimum.

motivated in large part by the empirical wage distributions presented in Section I. In addition to these possibilities, it is sometimes argued that the minimum wage induces a bumping up effect that results in an upward shift in the whole youth wage distribution; even persons with market wage rates above the minimum are affected. Sometimes the argument is put in the context of substitution of higher quality for lower quality workers. With pooled time series cross-section data we are able to estimate possible shifts in the overall wage distribution with shifts in the minimum.

We estimate that if there were no minimum wage, employment among out-of-school male youth 16 to 24 would be about 4 percent higher and employment of those 20 to 24 about 2 percent higher. Among black youth, employment increases would be greater, about 6 percent for those 16 to 24, and 10 percent for those 16 to 17. We find little effect of the minimum on the expected earnings of youth; the higher wage rates of some youth are about offset by the non-employment of others.

Without increases in the minimum during the 1970s, inflation would have eliminated a large part of the non-employment of the minimum. If the 1973 minimum of $1.60 had been maintained through 1978, about two-thirds of potential employment gains with no minimum would have been achieved.

We find that the market wage rates of both white and black youth fell relative to adult wages between 1973 and 1978. These results are in contrast to raw data that suggest that only white youth wage rates fell. Apparently because more low wage black than white youth are without work because of the minimum, mean wage rates of those working suggest that black wages did not fall, while in fact low-wage black youth were increasingly without work.

Graphs of wage distributions that motivate our specification are presented in Section I. In Section II we describe our procedure. We begin with a two-equation model that yields joint estimates of market wage and employment equations. Under a simplifying assumption that is not contradicted by empirical evidence, most of the estimates from the two-equation model can also be obtained from a single-equation model based only on the wage rates of employed persons. To understand the approach, some readers may want to proceed directly to a description of this simple model, without being encumbered by the more complicated two-equation version that uses all available information on wage rates and employment status.

Parameter estimates are shown in Section III. The estimates are based on May Current Population Survey data for 1973, 1976, 1977, and 1978. These years included the two highest and two lowest minimum wage levels between 1973 and 1978. Most of the results are presented in Section IV in the form of simulations based on the estimates in Section III. Concluding comments are in Section V.

I. Empirical Distributions of Wage Rates

Casual reasoning suggests that the impact of the minimum should be greatest for persons who would otherwise have the lowest wages. Indeed this is one of the presumptions underlying our analytic approach. The graphs in Figures 1 through 6 help to demonstrate this assumption and thus to motivate our subsequent analysis.

The figures present histograms of empirical wage distributions by age group for 1973 and 1978. The real minimum was about 10 percent higher in 1978 than in 1973. (It was about 14 percent higher in 1976 and 4 percent higher in 1977, the other years used in our analysis.) The histograms are broken into 25 cent intervals. For convenience there is a break at the level of the minimum in each year. The 1973 data are in 1978 dollars. The minimum was \$2.65 in 1978 and the 1973 minimum of \$1.60 was about \$2.40 in 1978 dollars. To facilitate graphing, the wage interval .90 to 1.15 for 1978 includes all persons with wage rages below 1.15 and the 5.90 to 6.15 interval all persons with wage rates above 5.90. Thus the apparent concentration of wage rates in these intervals must be interpreted accordingly. A complete graph of the wage distribution would approach zero gradually in both tails. The highest interval for 1973 also includes all persons above this interval and the lowest interval all persons below. Figures 1, 3, and 5 pertain to 1978 and Figures 2, 4, and 6 to 1973.

It is apparent from the graphs not only that the impact is greater for younger than for older workers, but also that the impact was greater in 1978 than in 1973. Relative to the central tendency of wage rates, the minimum was higher in 1978 than in 1973. While among youth 16 to 17 the effect of the minimum is very apparent, although less so in 1973, it is much less apparent among those 20 to 24. Indeed, among youth 20 to 24 in 1973 the discontinuity at the minimum is barely perceptible.

In short, the graphs confirm that the minimum wage impinges more on youth who would otherwise have low wages than on those whose underlying wage rates are higher. Additional graphs presented in Meyer and Wise (1981), show that the impact is greater in low than in high wage areas and also is greater among the least educated than among those with higher levels of education. Furthermore the graphs exhibit two characteristics that are fundamental to our statistical specification. First, a substantial number of youth are employed at wage rates below the minimum. Second, there is a very substantial concentration of wage rates at the minimum, in addition to the discontinuity at the minimum. There is a spike at the minimum, the distributions are not simply truncated at this point.

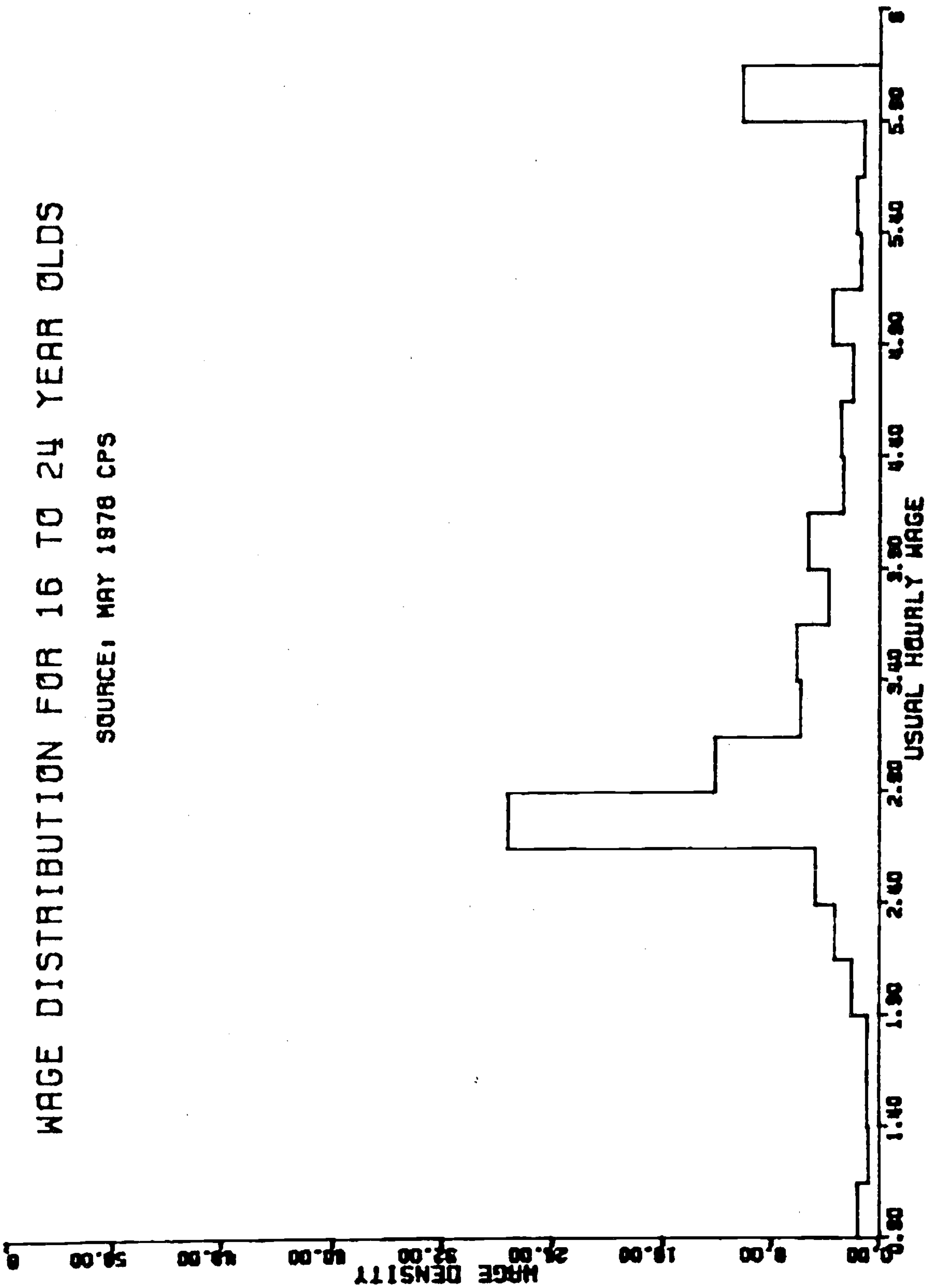
WAGE DISTRIBUTION FOR 16 TO 24 YEAR OLDS
SOURCE: MAY 1978 CPS
USUAL HOURLY WAGE
WAGE DENSITY

Figure 1

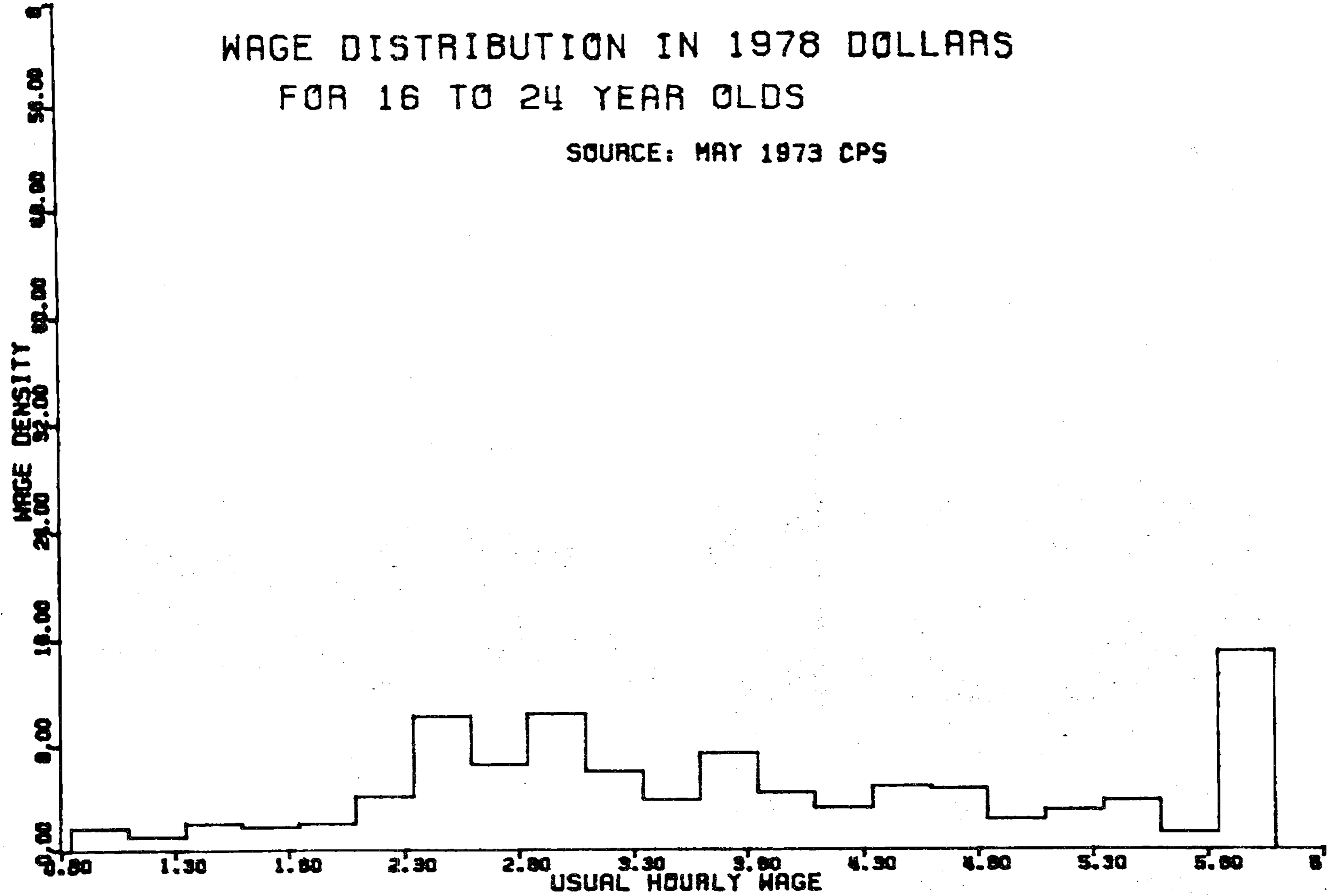
WAGE DISTRIBUTION IN 1978 DOLLARS
FOR 16 TO 24 YEAR OLDS
SOURCE: MAY 1973 CPS
WAGE DENSITY
USUAL HOURLY WAGE
0.80
1.30
1.80
2.30
2.80
3.30
3.80
4.30
4.80
5.30
5.80

Figure 2

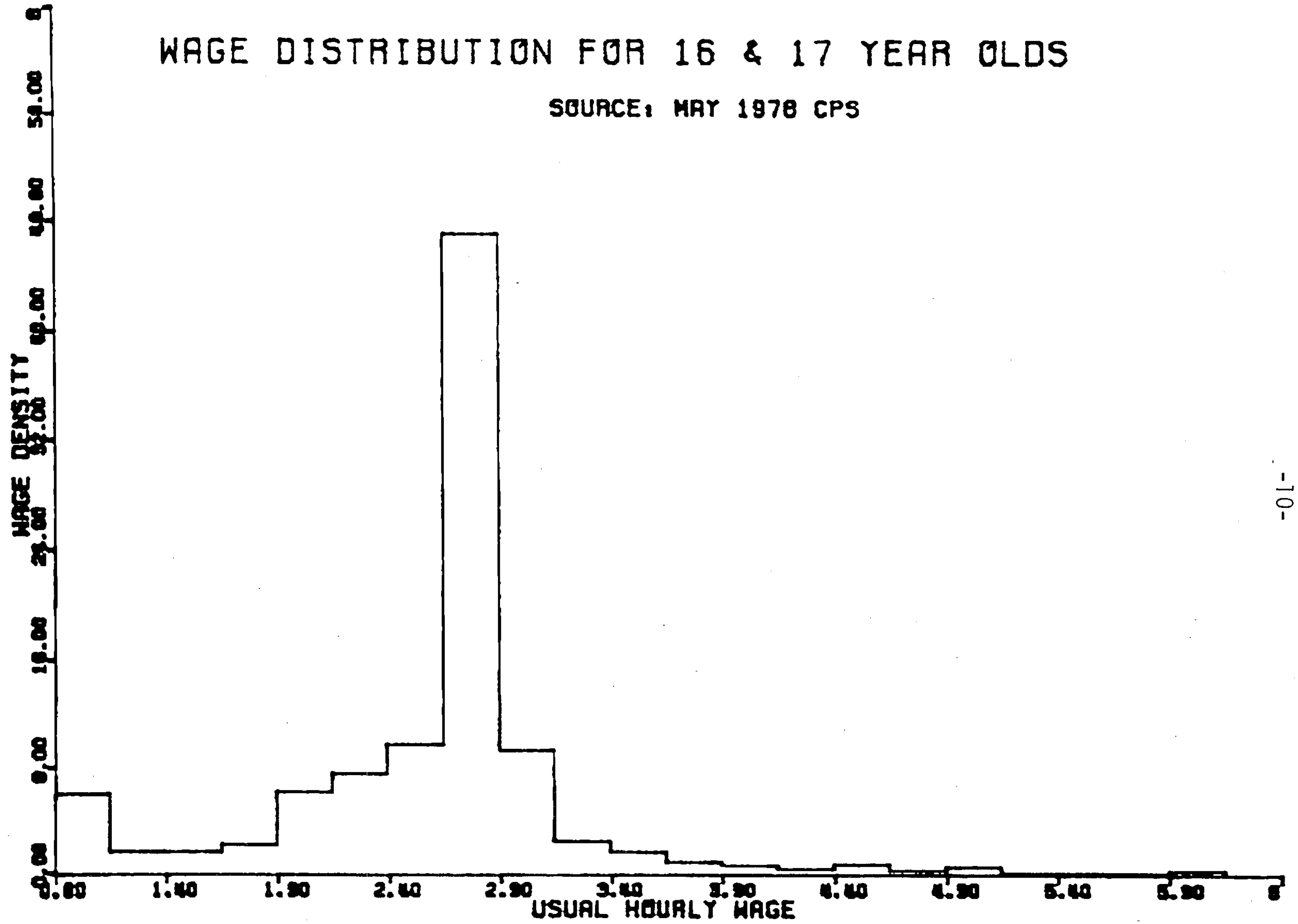
WAGE DISTRIBUTION FØR 16 & 17 YEAR ØLDS
SØURCE: MAY 1978 CPS
WAGE DENSITY
USUAL HØURLY WAGE
1.40
1.90
2.40
2.90
3.40
3.90
4.40
4.90
5.40
5.90

Figure 3

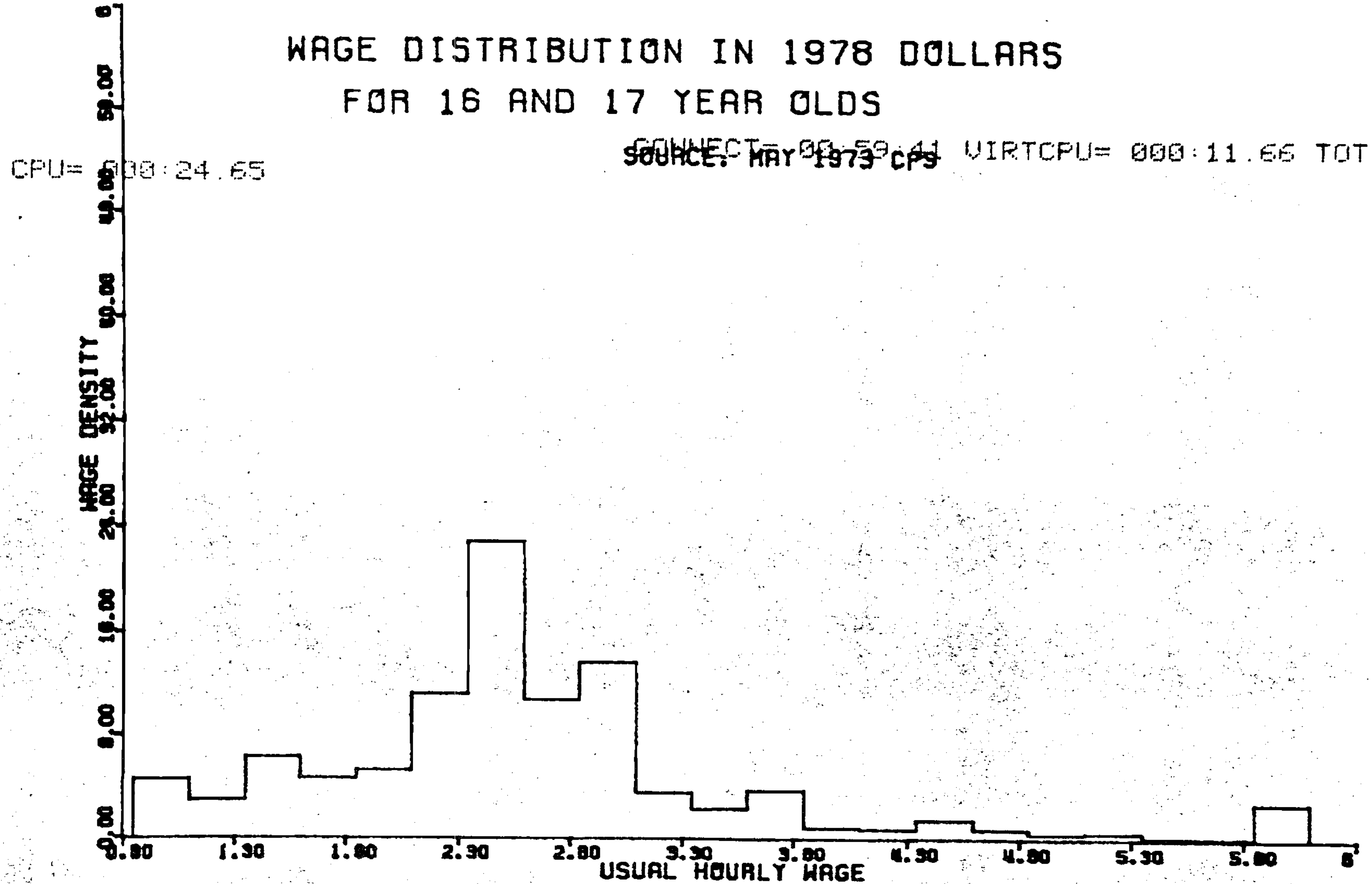
WAGE DISTRIBUTION IN 1978 DOLLARS
FOR 16 AND 17 YEAR OLDS
SOURCE: MAY 1973 CPS
CONNECT= 00:59:41 VIRTCPU= 000:11.66 TOT
CPU= 000:24.65
WAGE DENSITY
USUAL HOURLY WAGE
0.80
1.30
1.80
2.30
2.80
3.30
3.80
4.30
4.80
5.30
5.80

Figure 4

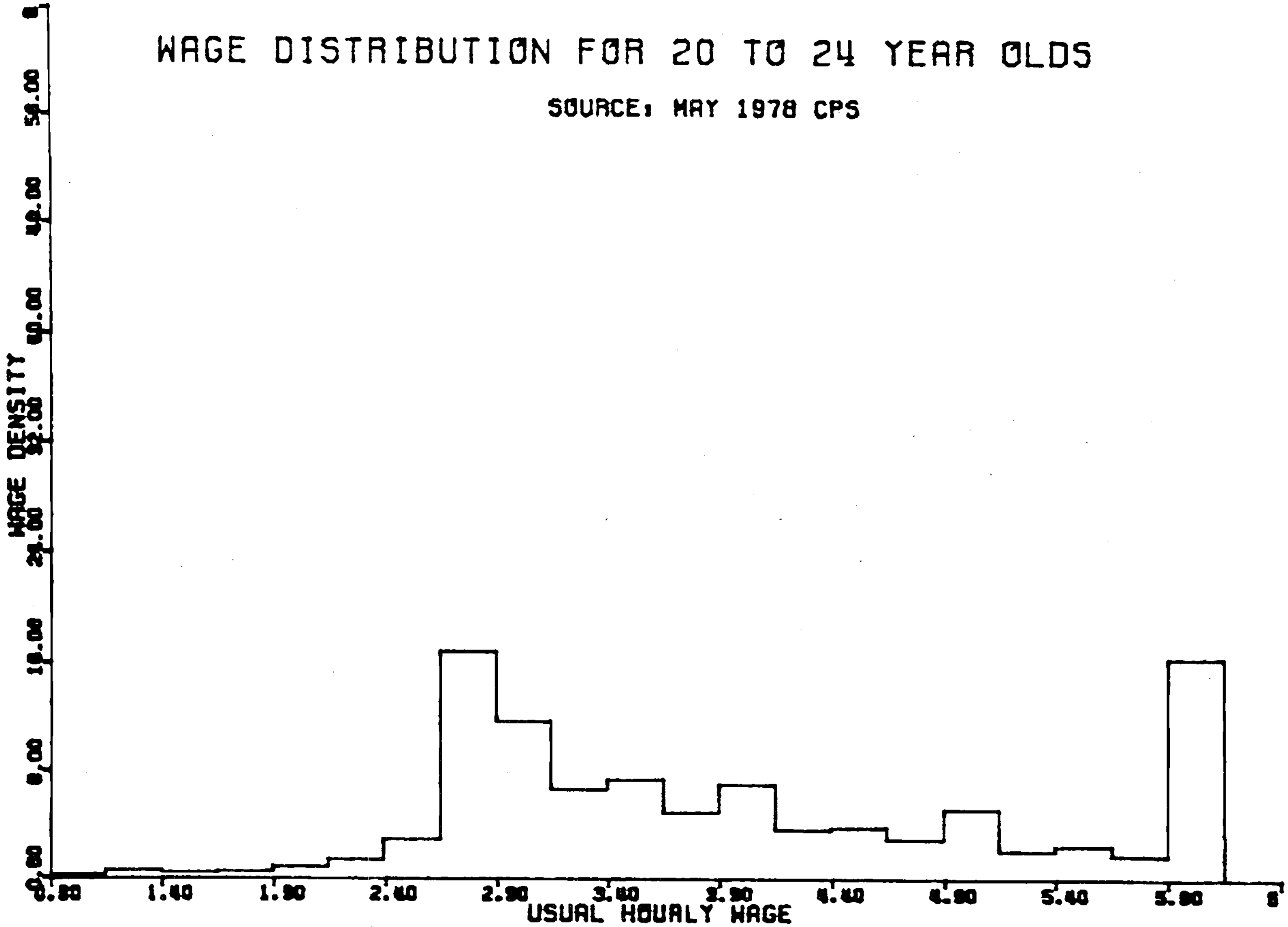
WAGE DISTRIBUTION FOR 20 TO 24 YEAR OLDS
SOURCE: MAY 1978 CPS
WAGE DENSITY
USUAL HOURLY WAGE

Figure 5

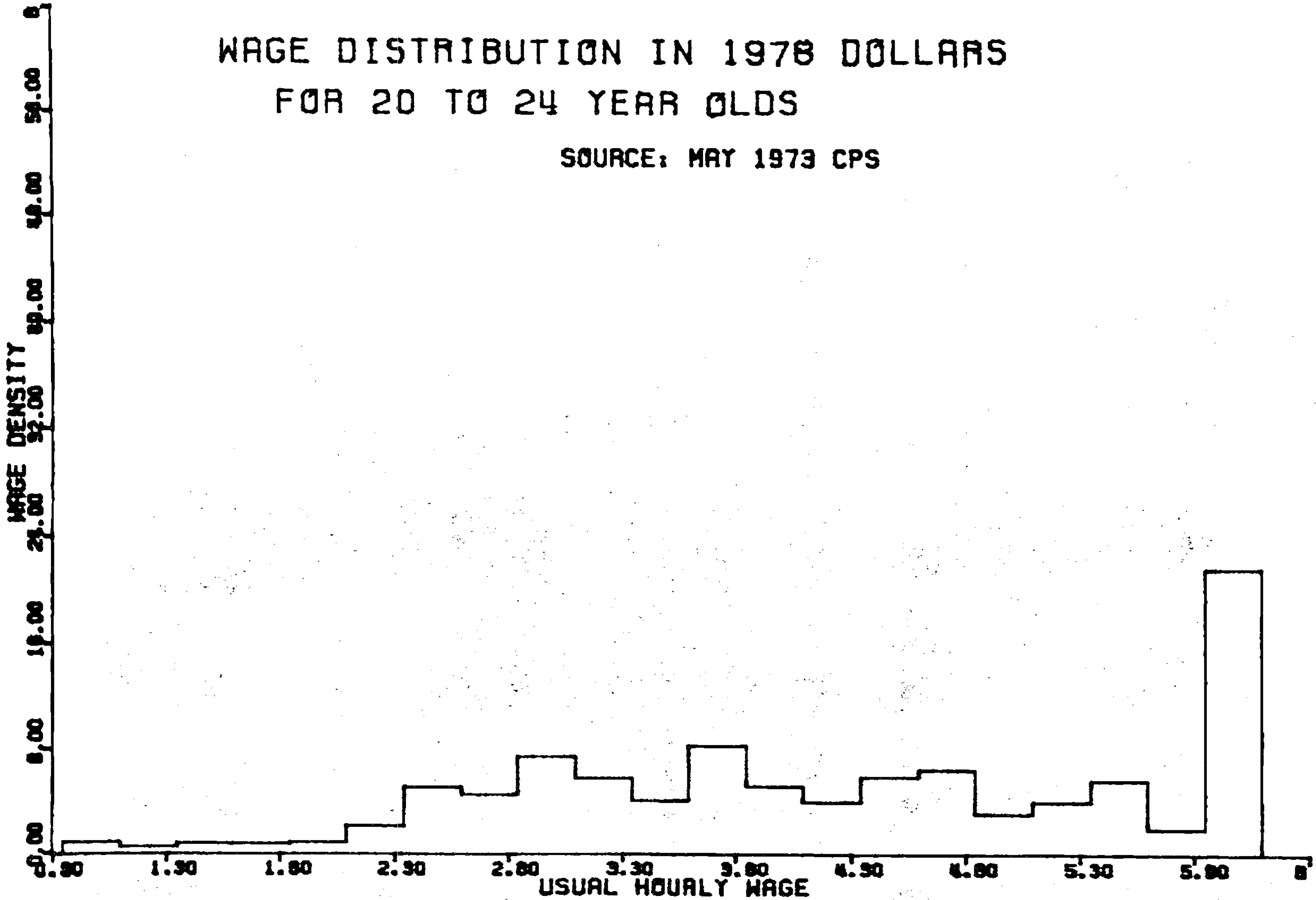
WAGE DISTRIBUTION IN 1978 DOLLARS
FOR 20 TO 24 YEAR OLDS
SOURCE: MAY 1973 CPS
WAGE DENSITY
USUAL HOURLY WAGE
0.80
1.30
1.80
2.30
2.80
3.30
3.80
4.30
4.80
5.30
5.80

Figure 6

II. The Model

We shall begin by setting forth the basic assumptions of our approach. Then we shall set forth the statistical details of a two-equation model including both wage and employment equations. We shall then show that if the disturbance terms in this model are uncorrelated--which is consistent with our empirical findings--most of our estimates can be obtained from a single-equation model based on observed wage rates only. The single equation model is motivated and set forth independently in the last part of this section. Because the single equation model is easier to visualize, some readers may wish to read sections A and C without giving much attention to the more complicated model described in Section B.

A. Basic Assumptions

Consider a group of youth characterized by a vector of measured attributes X. The elements of X include individual measures such as education and age, as well as area specific indicators of labor market conditions and calendar year indicators. Suppose that in the absence of the minimum wage, some of these youth would be employed. Those employed would receive a distribution of wage rates. We shall refer to these employment and wage rate outcomes as market outcomes.

Now suppose that the minimum wage is set at level M. Some persons will continue to be paid at a wage below the minimum because they work in non-covered sectors of the economy or on jobs that are not subject to the minimum. And indeed there may be some shifting of employment from covered to non-covered sectors and jobs. Others may be paid below the minimum because of non-compliance. For whatever reason, the net result is that some persons with an underlying wage below the minimum will continue to be hired at a wage below M. To allow for this possibility, we suppose that there is a probability P_1 that persons with an underlying wage below M will receive a wage below this level. (We have not allowed P_1 to depend on the precise value of the underlying wage.)

We also suppose that some persons with an underlying wage below the minimum would after its introduction be paid at the minimum.[1] Although a simple application of marginal productivity theory would imply that persons with an underlying wage below M, would not receive M, there are several possible explanations for such a possibility. One is that employers may pay the minimum to persons they would otherwise pay less than the minimum, but hire fewer or hire them for fewer hours. Whereas without the minimum, a young person may be hired on a permanent basis for eight hours each Saturday, if the youth must be paid the minimum, he may be hired for fewer Saturdays to do only those tasks at which he is most productive. Employers may, for example, be less prepared to pay for "slack time."[2]

A variant of this argument, but dependent upon different types of labor rather than different tasks, is the following: suppose that output is dependent on several qualities of labor, each with a marginal

---

1. Welch and Cunningham [1978] impose an extreme form of this assumption, that is, that all persons with market wage rates below the minimum are paid the minimum when it is in effect.

2. Hall [1979] develops a similar point within a framework based on the theory of employment contracts.

product conditional on the employment of the others. Suppose the minimum wage is set above the marginal product of some of the groups. Within each of these groups, employment could be reduced until the marginal product of those remaining is equal to the minimum and thus members of the group are paid at M. This would result in a pile-up of wage rates at the minimum, as exhibited in the empirical distributions of Section I.[1] This possibility could lead also to some upward shifting in the marginal products of higher quality workers and thus their wage rates as well, a possibility that is allowed for in our empirical specification.

Another possibility is that since the minimum wage applies only to compensation paid directly to an employee, employers can vary the level of non-wage compensation (e.g. on-the-job training or fringe benefits) to offset changes in direct compensation. Individuals with market wages below the minimum may be raised to the minimum in exchange for a comparable reduction in on-the-job training expenditures and fringe benefits. Individuals with market wages above the minimum will be unaffected.[2]

Another explanation is that employers hire at the minimum persons who would otherwise be hired at wage rates below the minimum, but offset this overpayment with slower wage increases--say, with age for example--than would be observed without the minimum.[3]

---

1. This version of a possible explanation was suggested to us by Roger Gordon.

2. See Mincer and Leighton [1980] for an analysis of the effects of the minimum wage on investment in on-the-job training. Wessels [1980] examines the the theoretical aspect of the minimum wage in a model that includes fringe benefits.

3. Lazear [1980] has investigated this possibility, but did not find much empirical support for it.

In addition, employers may find it difficult to identify differences in the quality of young workers, particularly in view of the high turnover in youth employment and the absence of an extensive employment history. If only because of this lack of precision, employers to comply with the legislation may raise to the minimum the wage rates of some employees who would otherwise receive an underlying wage below M.

In reality, the explanation of the observed pattern of wage rates is likely to reflect a combination of several plausible tendencies. Whatever the reason, we suppose that with probability P_2, a person with an underlying wage below the minimum will be employed and paid the minimum.

Finally, some persons who would otherwise be employed at market wage rates below the minimum are without work after its introduction. They are neither employed below M (which occurs with probability P_1) nor at M (which occurs with probability P_2). The probability of being without work because of the minimum is $1 - P_1 - P_2$.

We believe that the major effects of the minimum are concentrated on persons with sub-minimum market wage rates, and indeed this presumption is consistent with the primary postulated effects of the minimum.[1] Nonetheless, some of the explanations given above are consistent with some effect on the pay of youth with higher market wage rates. Other forms of labor

---

1. We have not allowed P_1 or P_2 to depend--for persons with market wage rates below M--on the difference between the market wage and the minimum, although in principle we think that they would. We believe, however, that our estimates of P_1 and P_2 are good estimates of the average values that would be obtained if somewhat more realistic assumptions were incorporated in our statistical analysis. Indeed, this conclusion is supported by estimates obtained by dividing the market distribution below the minimum into two intervals and estimating P_1 and P_2 values for each interval.

substitution arguments also could lead to an increase in wages of youth with market rates above the minimum. Sometimes it is argued that institutional hierarchical wage structures together with a minimum may lead to a general bumping up of the wage distribution. We allow calendar year shifts in the wage distribution to capture such shifts with changes in the level of the minimum.[1]

B. A General Two-Equation Model

We shall base our estimates on data from the May Current Population Surveys for 1973, 1976, 1977, and 1978. For our analysis, it is important to have accurate hourly wage rate data. In particular, we would like to observe a true picture of the distribution of wage rates around the minimum. Some respondents are not employed, however, and thus do not report a wage rate. In addition, a substantial fraction of those who are employed do not report hourly wage rates.[2] In a random sample of 5000 out-of-school young men 16 to 24, the distribution by employment status and reported versus not reported hourly wage is as follows:

1. A large proportion of these are salaried. About 90 percent of hourly employees report an hourly wage rate.

Category	Percent	
Total	100.0	
Not Employed	16.1	
Employed	83.9	100.0
Wage Rate Known		58.8
Wage Rate Unknown		41.2

We shall show below that estimates can be based only on employed youth with reported wage rates, and indeed many of our simulations derive from such estimates. It is clear, however, that the data contain considerable information on observed employment status that is not used if this approach is followed. But to use all the data, our statistical specification must reflect not only the presumed structural effect of the minimum wage, but must also reflect the unknown wage rates of some of those who are employed. We proceed as follows:

Consider again a group of individuals with measured attributes X. Suppose that in the absence of a minimum wage, employment and wage relationships in a given year would be of the form

(1)
$$E = X\alpha + \varepsilon_1 ,$$
$$W = X\beta + \varepsilon_2 ,$$
$$R \equiv \text{probability of a reported hourly wage.}$$

Employment is denoted by the unobserved index variable E with the property that an individual is employed if $E > 0$, W is the wage rate, α and β are parameters to be estimated, and ε_1 and ε_2 are disturbance terms with covariance matrix

$$(2) \qquad \Sigma = \begin{bmatrix} 1 & \rho\sigma \\ & \sigma^2 \end{bmatrix} .$$

Note that E and W are specified in reduced form. Given X, R is assumed to be uncorrelated with E and W, although R could in principle depend on X and need not be the same for each person with observed attributes X.[1]

In fact, we use several years of data so that E and W are specified as

$$E_t = X_t\alpha + \delta_t + \varepsilon_{1t} ,$$

$$W_t = X_t\beta + d_t + \varepsilon_{2t} ,$$

where δ_t and d_t are year-specific shifts in the underlying employment and wage relationships, and W_t is the real wage rate in year t. The δ_t and d_t are intended to capture shifts due to changes in the real minimum from one year to the next. For example, as discussed above, an upward shift in the minimum may result in an overall upward movement in the wage rates of all youth, in addition to the effect on those with sub-minimum market wages. In practice, we are not able to distinguish the effect of the minimum on the year specific shifts from the effect of other aggregate changes in the economy, like demographic trends. We shall argue below, however, that the estimated values are not consistent with a general upward shift in wage rates because of increases in the real minimum. To simplify exposition, we shall repress for now the subscript t, as well as the year-specific

---

1. The substantive assumption is that given X, the random component of R is not correlated with ε_1 or ε_2.

terms, proceeding with the implicit understanding that they are incorporated in the vector X.

For expository purposes we shall pause for a moment and consider a diagram that relates the values of E, W, and R to the possible outcomes in the presence of a minimum wage, as shown in Figure 7. The entries within the diagram pertain to outcomes with a minimum wage. The notation on the top and bottom outside margins of the diagram pertain to underlying values of the employment and wage variables. On the right outside margin is indicated whether, among persons who would be employed in the absence of a minimum, a wage would be reported. The single-lined area indicates the proportion of the group who would not be employed with a minimum wage. Those with $E < 0$ would not be employed without the minimum and added to this group are those with $W < M$ who are not employed with a minimum--the two areas indicated by $1 - P_1 - P_2$. Some of the latter group would have

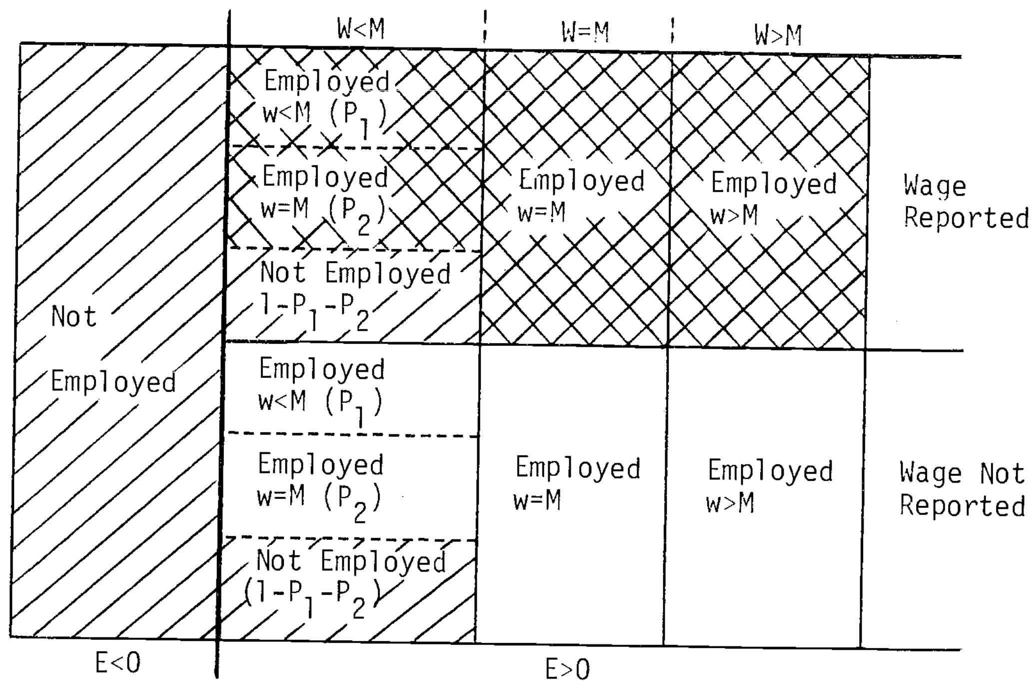

Figure 7

a reported wage and others would not. We observe hourly wage rates for persons schematically included in the crossed area. (This is the group used in the procedure to be described in Section C below. From this group we can also estimate P_1 and P_2.) The remaining group we observe to be employed but we don't observe their wage rates. Our goal then is to describe the probabilities of the possible outcomes.

To do this we assume that E and W (a transformation of the wage rate) are distributed bivariate normal. To facilitate computation--and we believe without appreciably altering the results--we suppose, as noted above, that the unmeasured determinants of the underlying employment and wage equations on the one hand and the unmeasured determinants of whether a wage is reported on the other, are not correlated. This allows us to proceed with a bivariate instead of a trivariate distribution.[1] For ease of exposition we have only specified two relationships in equation (5). We might more formally have added a third, say $S = X\delta + \varepsilon_3$ where an employed worker has an observed wage if $S > 0$. If ε_3 is uncorrelated with ε_1 and ε_2, however, expressions like $\Pr(E > 0, W = w, S > 0)$ can be written as $\Pr(E > 0, W = w)\cdot\Pr(S > 0)$. Our assumptions lead to expressions like these and rather than carry the third equation throughout the analysis, we have suppressed it, simply letting R indicate the probability of a reported hourly wage. (Extensions of this reasoning demonstrates also that if ε_1 and ε_2 are uncorrelated, then consistent estimates of P_1 and P_2 and the parameters of the market wage function

---

1. We shall not explain this in detail but without this assumption, the development would proceed much as we have laid it out except that we would have to evaluate trivariate integrals in some instances.

are obtained by the procedure to be described in Section C. We shall return to this.)

If we consider all persons in the CPS survey, there are five possible observed outcomes, corresponding to the schematic diagram in Figure 7:

(3)
- (i) Not employed,
- (ii) Employed with a wage w less than M,
- (iii) Employed with a wage w equal to M,
- (iv) Employed with a wage w greater than M,
- (v) Employed without a reported wage.

We shall specify the minimum wage as the interval from M_1 to M_2, where $M_2 - M_1$ is one cent.[1] Then if f represents the density of W, if ϕ is a standard normal density function, and if Φ and Φ_2 are standard normal univariate and bivariate distribution functions respectively, the probabilities of the possible outcomes are as follows:

(4)

(i) Pr[Not employed]

$$\begin{aligned} &= \Pr[E < 0] \\ &+ \Pr[E > 0 \text{ and } W < M]\cdot(1 - P_1 - P_2) \\ &= 1 - \Phi[X\alpha] \\ &+ \Phi_2\left[X\alpha, \frac{M - X\beta}{\sigma} ; -\rho\right]\cdot(1 - P_1 - P_2) \qquad = \Pr(1) \end{aligned}$$

(ii) Pr[Employed with a wage w less than M]

$$\begin{aligned} &= \Pr[E > 0, W = w]\cdot P_1 R \\ &= \Pr[E > 0 | W = w]\cdot f(W)\cdot P_1 R \\ &= \Phi\left[\frac{X\alpha + (\rho/\sigma)(w - X\beta)}{(1 - \rho^2)^{\frac{1}{2}}}\right]\cdot \frac{1}{\sigma}\phi\left(\frac{w - X\beta}{\sigma}\right)\cdot P_1 R \quad = \Pr(2)\cdot R \end{aligned}$$

---

1. In preliminary estimates we experimented with wider intervals to test the sensitivity of our model to this range. Within a moderate range around M, our results are not appreciably affected by the size of the interval.

(iii) Pr[Employed with a wage w equal to M]

$$= \Pr[E > 0,\ M_1 < W < M_2]\cdot R$$

$$+ \Pr[E > 0,\ W < M]\cdot P_2\cdot R$$

$$= \left(\Phi\left[X\alpha,\ \frac{M_2 - X\beta}{\sigma}\ ;\ -\rho\right] - \Phi\left[X\alpha,\ \frac{M_1 - X\beta}{\sigma}\ ;\ -\rho\right]\right)\cdot R$$

$$+ \Phi_2\left[X\alpha,\ \frac{N_2 - X\beta}{\sigma}\ ;\ -\rho\right]\cdot P_2\cdot R = \Pr(3)\cdot R$$

(4) (iv) Pr[Employed with a wage w greater than M]

$$= \Pr[E > 0,\ W = w]\cdot R$$

$$= \Pr[E > 0 | W = w]\cdot f(W)\cdot R$$

$$= \Phi\left[\frac{X\alpha + (\rho/\sigma)(w - X\beta)}{(1 - \rho^2)^{\frac{1}{2}}}\right]\frac{1}{\sigma}\phi\left(\frac{w - X\beta}{\sigma}\right)\cdot R \qquad = \Pr(4)\cdot R$$

(v) Pr[Employed without a wage]

$$= \Pr[E > 0,\ W < M]\cdot(P_1 + P_2)\cdot(1 - R)$$

$$+ \Pr[E > 0,\ W \geq M]\cdot(1 - R)$$

$$= \Phi_2\left[X\alpha,\ \frac{M - X\beta}{\sigma}\ ;\ -\rho\right]\cdot(P_1 + P_2)\cdot(1 - R)$$

$$+ \Phi_2\left[X\alpha,\ -\frac{M - X\beta}{\sigma}\ ;\ \rho\right]\cdot(1 - R) \qquad = \Pr(5)\cdot(1 - R)$$

We see from (i) that the probability that an individual is not employed is given by the probability of not being employed without the minimum, $\Pr[E < 0]$; plus the probability that without the minimum he would be employed at a wage below M, times the probability that he is <u>not</u> employed below the minimum or at the minimum $(1 - P_1 - P_2)$. The probability that a person is employed with a wage W less than M is given by the probability of being employed without the minimum, with wage rate $W = w$, $\Pr[E > 0,$

$W = w]$, times the probability of being employed below M in the presence of the minimum, P_1, times the probability R of reporting a wage rate. Similar explanations pertain to the remaining expressions.

The log-likelihood function for N observations is then given by

(5) $$= \sum_{i=1}^{N_1} \ln \Pr(1)_i + \sum_{i=1}^{N_2} \ln \Pr(2)_i + \ldots + \sum_{i=1}^{N_5} \ln \Pr(5)_i \ ,$$

$$+ (N_2 + N_3 + N_4) \ln R + N_5 \ln (1-R)$$

where i indexes individuals and $N_1 + N_2 + \ldots + N_5 = N$. Thus as long as R does not depend on parameters that enter elsewhere in the likelihood function, it may be disregarded in estimation. Equation (5) is maximized with respect to α, β, σ, P_1, P_2, and ρ.

Now suppose that, given X, E and W are uncorrelated so that $\rho = 0$. Equation (4) may then be rewritten as follows:

(i) Pr[Not employed]

$$= 1 - \Phi[X\alpha] + \Phi[X\alpha]\cdot\Phi[(M - X\beta)/\sigma]\cdot(1 - P_1 - P_2)$$

(ii) Pr[Employed with a wage w less than M]

$$= \Phi[X\alpha]\cdot f(w)\cdot P_1\cdot R$$

(6) (iii) Pr[Employed with a wage w equal to M]

$$= \left\{\Phi\left[X\alpha, \frac{M_2 - X\beta}{\sigma}; -\rho\right] - \Phi\left[X\alpha, \frac{M_1 - X\beta}{\sigma}; -\rho\right]\right\}\cdot R + \Phi[X\alpha]\cdot\Phi[(M_1 - X\beta)/\alpha]\cdot P_2\cdot R$$

(6) (iv) Pr[Employed with a wage w greater than M

$$= \Phi[X\alpha]\cdot f(w)\cdot R$$

(v) Pr[Employed without a wage]

$$= \Phi[X\alpha]\cdot\Phi[(M - X\beta)/\sigma](P_1 + P_2)(1 - R)$$
$$\Phi[X\alpha]\{1 - \Phi[(M - X\beta)/\sigma]\}(1 - R)$$

The probability of <u>having</u> an observed wage is equal to 1 - (i) - (v), which is given by

(7) Pr[Employed with an Observed Wage]

$$= R\cdot\Phi[X\alpha]\{1 - \Phi[(M - X\beta)/\sigma](1 - P_1 - P_2)\}$$
$$= R\cdot\Phi[X\alpha]\cdot D \ ,$$

where $D = \{1 - \Phi[(M - X\beta)/\sigma](1 - P_1 - P_2)\}$.

The distribution of the observed wage rates, conditional on observing a wage, can be derived by dividing equations (6, ii), (6, iii), and (6, iv), by (7). If we denote observed wage rates by h(w), then their distribution is given by

$$(8) \qquad h(w) = \begin{cases} \dfrac{f(w)\cdot P_1}{D} & \text{of } w < M_1 \ , \\[2ex] \dfrac{\Phi[(M_2-X\beta)/\sigma] - \Phi[(M_1-X\beta)/\sigma] + P_2\cdot\Phi[M_1-X\beta)/\sigma]}{D} & \text{if } M_1 < w < M_2 \ , \\[2ex] \dfrac{f(w)}{D} & \text{if } M_2 < W \ , \end{cases}$$

From this expression, we can form a likelihood function and estimate P_1, P_2, β, and σ. Thus, given our assumptions, consistent estimates can be obtained from the single equation model if $\rho = 0$.

But in this model, a zero correlation does not mean that employment and wage equations can be estimated separately with no loss of information. Estimation of the two equations jointly provides information that cannot be duplicated by estimating each separately. Indeed a market employment equation cannot be estimated without considering a wage function as well. There is no employment equation analogous to the conditional wage function that does not depend on the wage function. And estimating the two equations jointly provides additional information on wage rates, even with a zero correlation. As usual, the use of more information constrains the parameter estimates to reflect more empirical fact and to this extent provides better estimates, but in this case the information does not "separate" as might be expected on the basis of experience with more standard models.[1]

C. A Direct Specification of the Single-Equation Model

We find empirically that indeed the correlation between the disturbance terms in the employment and wage equations is not significantly different from zero. Thus because of computational ease we shall present

---

1. Suppose, however, that the probability of $w < M$ were known and that $P_3 \equiv 1 - P_1 - P_2$. Then the probabilities of employment and non-employment are given respectively by

$$\Pr[\text{Employed}] = \Pr[E > 0] - \Pr[E > 0] \cdot \Pr[w < M] \cdot P_3 \ .$$

$$\Pr[\text{Not Employed}] = \Pr[E < 0] + \Pr[E > 0] \cdot \Pr[w < M] \cdot P_3 \ .$$

the likelihood function formed from these terms could be used to estimate α in $E = X\alpha + \varepsilon_1$, together with the non-employment parameter P_3. From this perspective, other single employment equation formulations of the effect of the minimum can be thought of as incorporating the term $\Pr[E > 0] \cdot \Pr[W < M] \cdot P_3$ in an ad hoc way by including $M \div$ (an average wage) as one of the X variables.

a substantial number of results based on the single equation model. For expository purposes, we shall also present in this section a direct derivation of this specification.

Again, consider a group of youth characterized by a vector of measured attributes X. Suppose that in the absence of a minimum wage, the distribution in the population of wages paid to employed persons with attributes X would be described by the density function f(W), the "underlying" or market distribution of wages. Graphically, think of it as the solid line in Figure 8.

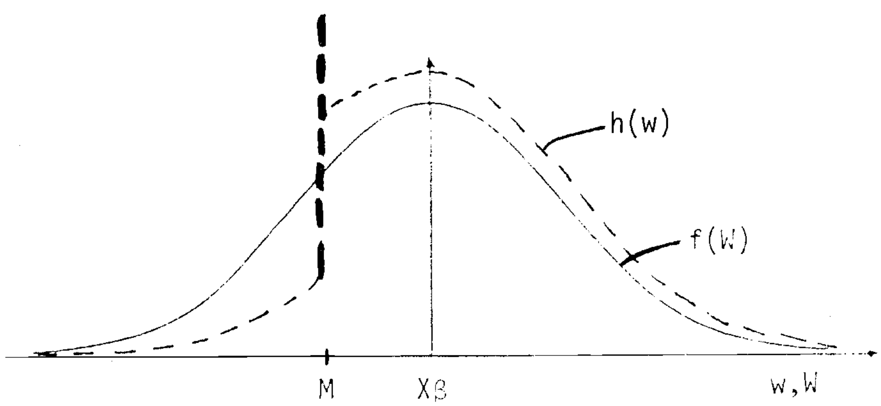

Figure 8

Recall the discussion in Section A above and suppose that the minimum is set at level M. Persons with an underlying wage below M, and who would have been employed without a minimum, in the presence of the minimum will receive a wage below this level with probability P_1. Also, for the reasons set forth above, with probability P_2, a person with an underlying wage below the minimum will be employed and paid the minimum. Those with market wage rates below M who are not hired at or below the minimum are without work because of it, with probability $1 - P_1 - P_2$.

These ideas can be described more formally as follows. Suppose that the expected underlying wage of individuals with measured personal and regional attributes X is given by $X\beta$ and that the variance of wage rates among persons with characteristics X is σ^2. This gives rise to a wage distribution f(W) like that shown in Figure 8. That is,

$$W = X\beta + \varepsilon \tag{9}$$

where ε is a disturbance term with variance σ^2.

With a minimum wage M, wage rates may be distributed as represented graphically by the dotted function in Figure 8. The form of this function depends on the values of P_1 and P_2. For example, if P_2 were zero, there would be no pile-up of wages at M, only a jump in the density function at M. If both P_1 and P_2 were zero, the density function would be truncated at M.

Let the likelihood of observed wage rates be given by h(w). It may be rewritten as

$$h(w) = \begin{cases} \dfrac{f(w)\cdot P_1}{D} & \text{of } w < M_1 \,, \\[2ex] \dfrac{\Phi[(M_2-X\beta)/\sigma] - \Phi[(M_1-X\beta)/\sigma] + P_2\cdot\Phi[M_1-X\beta)/\sigma]}{D} & \text{if } M_1 < w < M_2 \,, \\[2ex] \dfrac{f(w)}{D} & \text{if } M_2 < W \,, \end{cases} \tag{10}$$

where $D = 1 - \Phi[(M_1-X\beta)/\sigma]\cdot(1-P_1-P_2)$, and M is again a one cent interval from M_1 to M_2. This formulation is identical to equation (8) in Section B.[1] It may be arrived at by assuming that a random sample is drawn from the underlying distribution of market wage rates. Then, of the values below M, some are set to M (with probability P_2), while others are discarded (with probability $(1 - P_1 - P_2)$). Then h(w) is the distribution of observed wage rates in terms of the underlying distribution f. The denominator D may be thought of as a normalizing factor assuring that the density function integrates to 1.[2] One can also think of h(w) as the conditional distribution of wages, given that a wage is observed. The other elements of the function may be explained in the following way. A value of $w < M$ will be observed with likelihood P_1 times the likelihood of an underlying wage $W = w$. The likelihood of an observed wage at the minimum (1 cent interval) is equal to the likelihood of an underlying wage at the minimum, plus the probability that the underlying wage is below the minimum, but is raised to the minimum. Observed wage rates above the

---

1. Following standard practice, the log of wages is used as the dependent variable in our wage model. Since our results are likely to be sensitive to this distributional assumption, we have also experimented with other transformations of wages, in particular the Box-Cox transformation:

$$w^{(\lambda)} = \begin{cases} \dfrac{w^{\lambda} - 1}{\lambda} & \text{if } \lambda \neq 0 \\ \log w & \text{if } \lambda = 0 \end{cases}$$

As expected we find that the predicted unemployment from the minimum wage is least when wages are assumed to be log normal (i.e., $\lambda = 0$) and greatest when nominal wages are assumed to be normally distributed (i.e., $\lambda = 1$).

2. It is the probability that an individual who would have an observed wage rate in the absence of the minimum will also have one after the introduction of the minimum. Or it is the probability that a person who is employed without the minimum will also be employed with the minimum.

minimum follow the distribution of the underlying wage, except that a larger proportion of observed than of underlying wages may be above the minimum, as indicated by the denominator D.

Suppose that among N persons with observed wage rates, N_1 are below M, N_2 are "at" M and, N_3 are above M. For these N persons indexed by i, the log-likelihood of the realized observations would be

$$L = \sum_{i=1}^{N_1} \ln h(w_i) + \sum_{i=1}^{N_2} \ln h(w_i) + \sum_{i=1}^{N_3} \ln h(w_i), \tag{11}$$

with the specification of $h(w_i)$ for each group taken from equation (3). This function is maximized with respect to β, σ, P_1 and P_2.

Strictly speaking, the results of this model should be interpreted as pertaining only to hourly wage employees. In practice, however, the results based on this model do not differ substantially from those based on the two equation model, that is based on data for all persons, including both hourly and salaried youth.

III. Parameter Estimates

We shall first describe the variables used in the analysis. Then estimates based on the single equation model are presented, followed by estimates based on the two-equation specification.

A. The Variables

The variables used in the estimation are defined as follows:

Age: Age in years.

School: Number of years of school completed.

Race: Equal to 1 for blacks and zero otherwise.

Never Married: Equal to 1 if the person has never married and zero if married, widowed, or divorced.

Area Wage: The average wage of adult manufacturing workers in the SMSA or state in which the person lives, usually entered as the logarithm of area wage.

Area Unemployment: The adult unemployment rate in the SMSA or state in which the person lives.

Wage: The logarithm of the hourly wage rate.

Employment: An indicator variable equal to 1 if the individual is employed or zero otherwise.

Youth Differential: Dichotomous calendar year variables for 1976, 1977, and 1978.

Only the youth differential variables require explanation. We assume that youth wages increase over time with the adult wage index a_t, but may deviate from this index in year t according to the multiplier d_t. Then the wage rate of a youth who lives in area k in year t is given by

$$W_{kt} = e^{X_{kt}\beta_1} \cdot a_t \cdot d_t \cdot e^{\varepsilon_2} \text{ , with}$$

(12)

$$\ln W_{kt} = X_{kt}\beta_1 + \ln a_t + \ln d_t + \varepsilon_2 \text{ .}$$

The adult index a_t we know from published data and thus it may be subtracted from the left-hand side of the equation; the d_t must be estimated. Alternatively, a_t can be thought of as a wage deflator with estimation of the real wage equation

(13) $$\ln (W_{kt}/a_t) = X_{kt}\beta_1 + \ln d_t + \varepsilon_2 \text{ .}$$

The results are virtually invariant to the use of an adult wage index or the Consumer Price Index for a_t.[1] To estimate the d_t, we have entered calendar year indicator variables for 1976 through 1978.

These variables pick up shifts in the distribution of youth wage rates over time, relative to adult wage rates. Estimates of them will reflect overall movement in youth wages resulting from changes in the minimum wage, but they also reflect other determinants of youth wage rates relative to adult rates, like the relative numbers of young and older persons. We shall argue below, however, that the estimates themselves together with trends in the real minimum wage are inconsistent with an important upward shift in the distribution of youth wage rates with

---

1. The results reported in the paper are based on an index calculated from area wage data. Virtually the same results are obtained using the Consumer Price Index.

increases in the minimum.[1]

B. Single Equation Estimates

We shall first present pooled estimates by age group and then by race. Most of our simulation results are based on these estimates. We shall then present estimates based only on 1973 data and estimates based only on 1978 data and shall also discuss the "fit" of the model for 1978.

1. Pooled Years Parameter Estimates by Age Group

Parameter estimates based on the data from four years pooled together are shown in Table 1, by age group.

Consider first the estimates of P_1 and P_2 for out-of-school young men 16 to 24. The estimates indicate that during the period 1973 to 1978 approximately 37 percent of youth who otherwise would have been employed at market wage rates below the minimum are still employed below the legislated minimum. Another 36 percent of those with market sub-minimum wages are employed at the minimum. Approximately 27 percent (1-.374-.357) of this group are without work because of the minimum.

The youngest sub-minimum group are the most likely to be employed below the minimum; the oldest are the least likely to be employed below this level. Whereas 49 percent of 16 to 17 year olds who otherwise would be employed below the minimum are still employed below M, only 33 percent of the subminimum workers in the 20 to 24 age group are employed below the

---

1. If there were such a shift, we could think of an upward shift in the wage distribution with the minimum imposed on this shifted distribution. Then our calculated employment effects reflect the estimated employment effect on those whose market wage rates are still below the minimum. Our estimates would not capture the negative employment effect of such an overall increase in youth wages.

Table 1 : Parameter Estimates for Out-of-School Male Youth, Pooled Years, by Age Group[a]

Variable	Age Group			
	16-24	20-24	16-19	16-17
Age	0.062 (16.283)	0.041 (8.434)	0.107 (13.224)	0.053 (2.114)
School	0.022 (6.582)	0.019 (6.128)	0.027 (6.447)	0.009 (1.148)
Black	-0.062 (2.754)	-0.067 (3.187)	-0.103 (4.564)	-0.058 (1.553)
Never Married	-0.156 (10.249)	-0.172 (12.188)	-0.134 (6.720)	-0.089 (1.559)
Log Area Wage	0.566 (12.570)	0.586 (13.325)	0.302 (7.630)	0.119 (1.721)
Area Unemployment	-0.005 (1.160)	-0.006 (1.537)	-0.003 (0.732)	-0.010 (1.423)
Youth Differential: 1976	-0.047 (1.921)	-0.046 (1.814)	-0.077 (3.371)	-0.028 (0.623)
1977	-0.051 (2.337)	-0.027 (1.192)	-0.122 (6.036)	-0.082 (2.294)
1978	-0.021 (1.023)	-0.031 (1.508)	-0.088 (4.474)	-0.107 (2.919)
Constant	-0.399 (4.800)	-0.105 (0.948)	-1.255 (9.051)	-0.213 (0.497)
P_1	0.374 (9.136)	0.334 (7.064)	0.397 (12.421)	0.490 (8.881)
P_2	0.358 (8.502)	0.391 (7.338)	0.367 (11.039)	0.341 (7.335)
σ	0.345 (70.375)	0.347 (71.085)	0.321 (82.414)	0.297 (65.001)
N	3000	3000	3000	921

[a] T-Statistics are in parenthesis.

minimum. The estimated proportion raised to the minimum (the P_2 values) do not differ a great deal by age group although P_2 is highest for those 20 to 24 (.39) and lowest for the 16 to 17 group (.34). The percentage employment effects implied by these values depend not only on their magnitudes but on the proportion of sub-minimum workers in each age group. The simulations presented below reflect both of these factors. The absolute employment effects depend in addition on the number of workers in the age group.

The remaining parameter estimates on the variables X all have the expected signs, but some of the magnitudes are of interest. Youth wage rates vary across regions with adult wages but less than in proportion to the wages of older workers. For all youth, a one percent increase in adult wages is associated with a .56 percent increase in youth wages. For 16 to 17 year olds the elasticity is close to zero (.12).

The estimated youth differentials indicate that the market wage rates of young workers fell relative to the wage rates of older workers between 1973 and 1978. In particular, this is true for the youngest age groups, as indicated by the following tabulation. In part at least, these declines reflect the

Tabulation 1. Youth Differentials by Age Group (see Table 1)

	16-24	20-24	16-19	16-17
1976	-4.7	-4.6	-7.7	-2.8
1977	-5.1	-2.7	-12.2	-8.2
1978	-2.1	-3.1	-7.7	-10.7

relatively larger proportion of youth in the labor market. In direction, they are not unlike the relationships between average observed wage rates for young versus older employed workers. These estimates, however, are corrected for the truncation effects of the minimum. That is, a substantial number of low-wage workers are without work and thus have no observed wage rate and are not included in the averages of surveyed workers. Market wage rates fell faster than the uncorrected survey results would suggest. This is especially true for black youth. (We shall return below to separate estimates by race.)

Although it is not possible to distinguish shifts in the wage distribution due to the minimum from shifts due to other causes, such as the increase in the relative number of youth, the year effects appear to be inconsistent with the possibility that increases in the minimum result in noticeable overall upward shifts in the market wage distribution of youth. The real minimum, relative to the 1973 minimum, together with the estimated youth differentials for each year are shown below in tabular and in graphical form.

Tabulation 2. Youth Differential Versus Real Minimum

Year	Real Minimum	Youth Differential
1973	base	base
1976	+13.8%	-4.7%
1977	+ 3.8	-5.1
1978	+10.0	-2.1

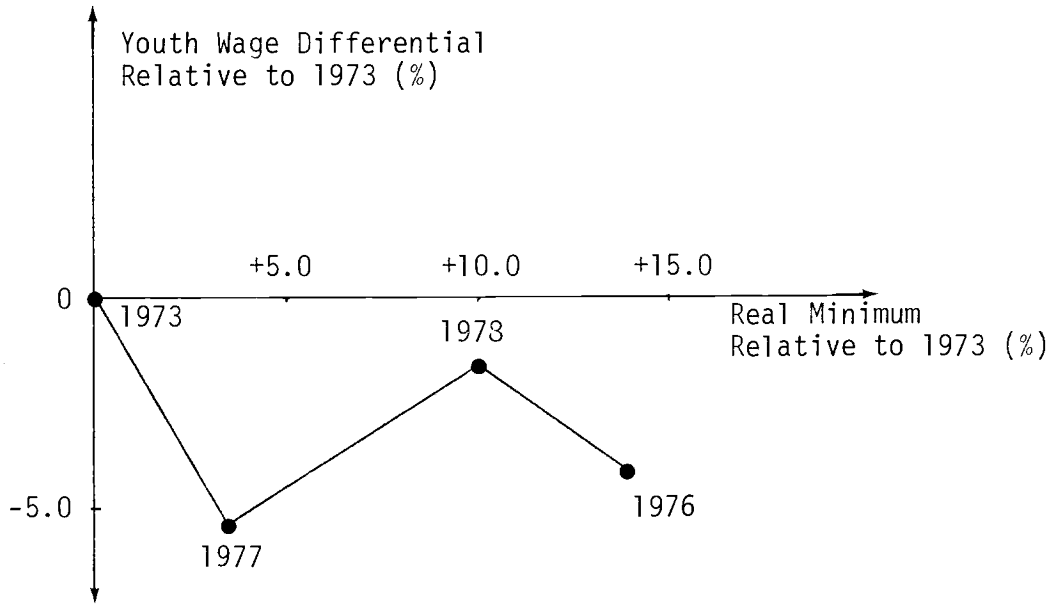

Figure 10. Youth Differential Versus the Real Minimum

Whereas the real minimum was higher in each of the years 1976 to 1978 than it was in 1973, youth wage rates were lower relative to adult wage rates in each of these years. In addition, there is no systematic relationship between the real minimum and the youth differential. To be a bit more systematic we could think of the youth differential as being a function of a time trend, possibly due to demographic effects, and the minimum. Then we could graph the youth differential against calendar year and "fit" a line to these points. Even this formulation does not yield residuals from the time trend that are high when the minimum is high and vice versa.[1] Of course, we only have the information for four years and

1. Although we have mentioned the possibility that youth wage rates were falling over this period because of the increasing number of young persons in the labor force, we believe that this explanation is not a powerful one. The proportion of youth in the population rose only about 1 percentage point between 1971 and 1980, whereas during the previous decade the percent of youth in the population increased from 12 to 16.

additional data could reveal a relationship. The weight of this evidence, however, does not point to a general increase in all youth wage rates with increases in the minimum. We do not observe a general bumping up effect. Thus in the simulations below we have assumed that changes in the minimum do not lead to shifts in the whole wage distribution but we do allow for the estimated shifts in youth market wage rates over time.

2. Pooled Years Parameter Estimates by Race

Estimates for out-of-school youth 16 to 24 are shown in Table 2 by race. The estimated P_1 value for whites is virtually the same as for blacks (.364 versus .358), with the estimated P_2 value for whites somewhat lower than for blacks (.354 versus .400). According to these estimates, 28 percent of whites who would otherwise be employed are without work because of the minimum, while 24 percent of sub-minimum blacks are without work for this reason. Thus effects of the minimum for a sub-minimum black are not much different than for a sub-minimum white. But a larger proportion of blacks than whites have subminimum market wage rates and thus the employment effect is proportionately greater for blacks than for whites, as shown below.

The estimates also indicate that youth market wage rates for both blacks and whites were falling over the period, relative to adult wages. The youth differentials by race are shown below.

Table 2: Parameter Estimates for Out-of-School Male Youth, Pooled Years, by Race[a]

Variable	Race: White	Race: Black
Age	0.061 (15.880)	0.058 (10.469)
School	0.022 (6.537)	0.035 (5.854)
Never Married	-0.157 (-10.413)	-0.152 (-6.361)
Log Area Wage	0.567 (12.424)	0.596 (10.297)
Area Unemployment	-0.007 (-1.628)	-0.001 (-0.129)
Youth Differential: 1976	-0.049 (-1.998)	0.016 (0.373)
1977	-0.051 (-2.368)	-0.074 (-2.031)
1978	-0.025 (-1.219)	-0.077 (-2.120)
Constant	-0.350 (-4.221)	-0.607 (-4.745)
P_1	0.364 (9.002)	0.358 (6.998)
P_2	0.354 (8.381)	0.400 (6.688)
σ	0.344 (69.064)	0.355 (45.456)
N	3000	1300

[a] T-statistics are in parenthesis.

Tabulation 3. Youth Differentials by Race, Based on Separate Estimates for Whites and Blacks 16 to 24 (see Table 2)

	White	Black
1976	-4.9	+1.6
1977	-5.1	-7.4
1978	-2.5	-7.7

These estimates are in contrast to average wage rates that show declining wages for white youth, but not for blacks.[1] As mentioned above, our estimates correct for the minimum wage disemployment effects that affect blacks to a relatively greater extent than whites. Because the minimum reduces the employment of low wage workers, it also tends to make observed average wage rates higher than they would be without the minimum. In presenting market estimates, our results correct for this effect. In addition, our estimates control for the individual attributes listed in the tables, in particular age and schooling.

The remaining parameter estimates except schooling do not differ substantially by race. The black estimated schooling coefficient, however, is 60 percent higher than the estimate for whites (.035 versus .022). These estimates are consistent with higher rates of return to college education for blacks than for whites, as found by Freeman [1976]. But these estimates are not limited to college versus high school education, they reflect average returns over all observed levels.

3. 1973 Versus 1978

Parameter estimates for 1973 and for 1978 are shown in Table 3. The

---

1. See Freeman and Wise [1979] for wage rates of youth relative to adults for 1967 and 1977.

Table 3 : Parameter Estimates for Out-of-School Male Youth 16 to 24, 1973 and 1978[a]

Variable	Year 1973	Year 1978
Age	0.054 (15.099)	0.065 (15.943)
School	0.028 (8.007)	0.034 (8.636)
Black	-0.117 (5.929)	-0.107 (4.078)
Never Married	-0.178 (12.075)	-0.196 (11.482)
City[b]	-- --	-0.032 (2.005)
Area Wage	0.128 (12.243)	0.084 (10.773)
Area Unemployment	0.013 (3.271)	0.008 (1.517)
Constant	-0.783 (8.566)	-0.822 (7.476)
P_1	0.312 (7.033)	0.229 (9.202)
P_2	0.249 (6.531)	0.451 (9.719)
σ	0.340 (79.285)	0.373 (64.293)
N	3115	3005

[a] T-statistics are in parenthesis.

[b] This variable was not available for 1973.

estimated β coefficients for 1973 are very close to those for 1978. Although the estimates for P_1 and P_2 do differ between the years, their sums are quite similar--.56 in 1973 and .68 in 1978. Thus the likelihood that youth with market wage rates below the minimum are out of work because of the minimum $(1 - P_1 - P_2)$ is by these estimates .44 in 1973 and .32 in 1978.

Recall that we have not allowed P_1 and P_2 to depend on the difference between the market wage rates and the minimum. We believe, however, that persons with market wage rates below but close to the minimum are more likely than those with lower market wage rates to receive the minimum. If the minimum is nearer the tail of the distribution, a relatively small proportion of those below it will have market wage rates close to the minimum. This could explain a lower proportion of those with sub-minimum market wage rates receiving the minimum in 1973 than in 1978. It could also explain the higher value of P_1 in 1973 than in 1978, indicating that a larger proportion of those with market wage rates below the minimum continued to be hired below M in 1973 than in 1978.[1] Nonetheless, we shall base most of our simulations on a model with P_1 and P_2 the same for all years. Although this may not be accurate for any individual year, we believe that our estimates provide good average values and thus realistic average employment effects.

The pooled data of course allow us to observe different portions of the underlying market wage distribution, depending on the level of the

---

1. In addition, the coverage of the minimum wage legislation was increased somewhat between 1973 and 1978 (in 1974) and this would have reduced somewhat the likelihood of employment below the minimum.

minimum in a given year. Combining these observations we believe provides more accurate estimates for the time period than those provided by data for any single year. As mentioned above, however, it may be that employment effects for a single year are most accurately obtained from data based on that year only. For purposes of comparison, we shall present below simulations based on the various model estimates. In general, the results are quite similar.

4. The Model Fit

Unlike most more traditional methods of analysis, the distributional assumptions play a key role in our work. It has become standard practice to assume that wage functions are log-normal, and the results reported above are based on a log-normal distribution as well. However, to check the sensitivity of our results to this assumption and to determine a "best" fit, we also experimented with other distributions, using a Box-Cox transformation of wage rates.[1]

A comparison of the 1978 empirical distribution of wage rates by interval for out-of-school male youth 16 to 24 versus the predicted distribution based on the log-normal wage distribution is shown in Figure 9. It appears from the graph that the fit is quite close, especially at the tails where alternative distributions are likely to give different results. Thus if we can fit the tails in particular, we have added confidence in our results. The actual percentages below the minimum, at the minimum (interval), and above $5.90 are 4.9, 15.6, and 21.1 respectively; the predicted percentages are 5.0, 16.1, and 18.8. No continuous distribu-

---

1. See footnote 1, page 30.

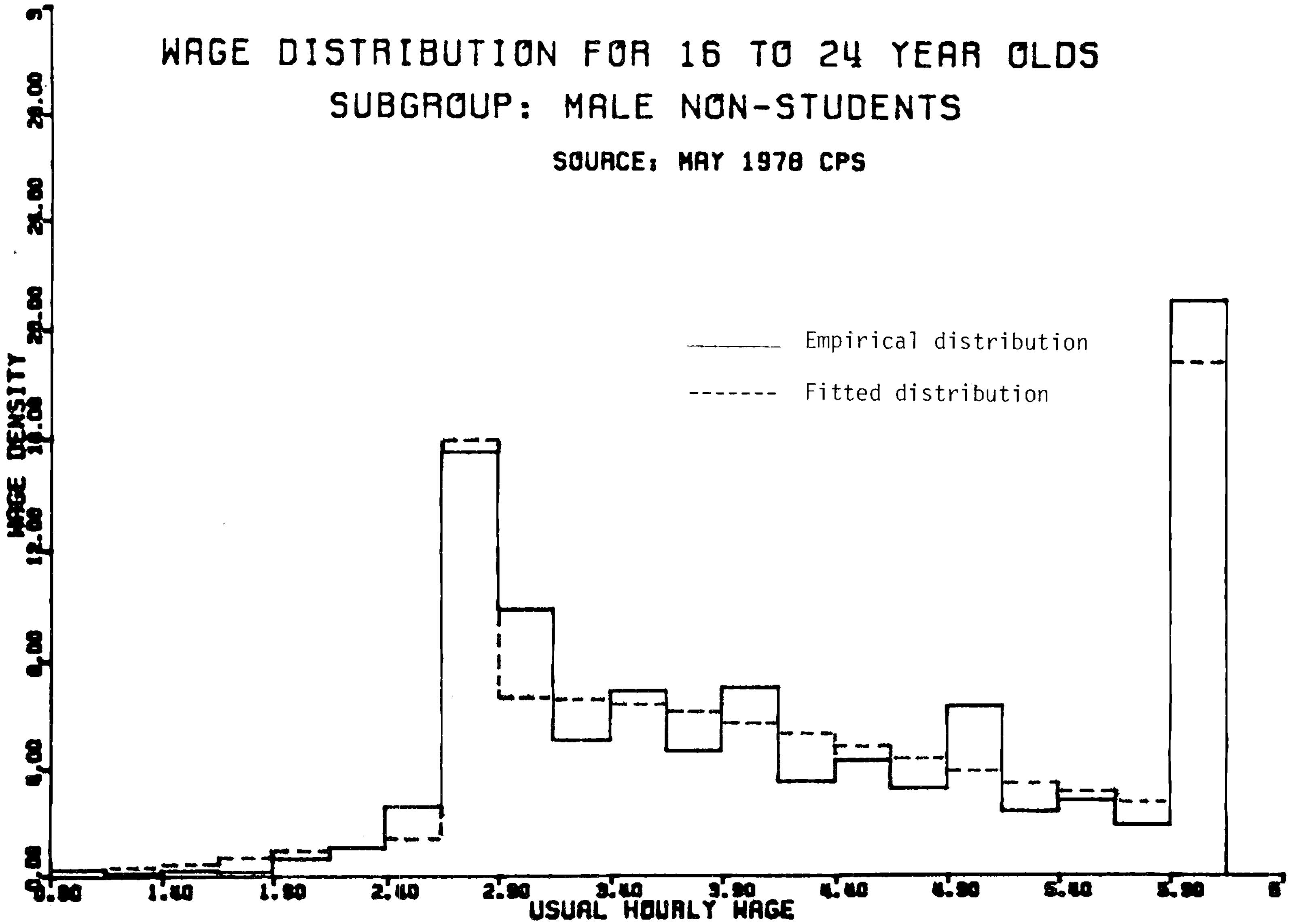
WAGE DISTRIBUTION FOR 16 TO 24 YEAR OLDS
SUBGROUP: MALE NON-STUDENTS
SOURCE: MAY 1978 CPS
Empirical distribution
Fitted distribution
WAGE DENSITY
USUAL HOURLY WAGE
0.90
1.40
1.90
2.40
2.90
3.40
3.90
4.40
4.90
5.40
5.90

Figure 9

tion, of course, can capture precisely the pile-up of wage rates at "magnet" values like \$3.00, \$4.00, or \$5.00.

A somewhat more formal way to measure the fit is to calculate a chi-square statistic based on the differences between the empirical and predicted frequencies within the intervals. The statistic:

$$\chi^2 = \sum_{j=1}^{J} \frac{(n_j - \hat{n}_j)^2}{\hat{n}_j} ,$$

(where n_j is the number of observations in the j^{th} interval, and J is the number of intervals) has a chi-square distribution with N-(J - 1 + K) degrees of freedom, where K is the number of parameters estimated in our model. Among a wide range of distributions that we tried, the log-normal gives the smallest chi-square value. It is very much smaller than the chi-square value based on the assumption of normality for example (286.1 versus 548.7).* Although we have not made formal tests for each year, we have used the log-normal throughout.†

C. Two-Equation Estimates

Estimates based on the two-equation model described in Section II-B are shown in Table 4. The estimated P_1 and P_2 values are very close to the single-equation estimates shown in Table 2 for the 16 to 24 age group. The wage equation β parameters are also very close to the single equation estimates. The estimated value of ρ, the correlation between the distur-

---

1. This section has been reproduced from Meyer and Wise [1981].

2. We could have allowed the distribution to vary from sample to sample, but we concluded that the complexities inherent in such a procedure would not be offset by appreciably improved estimates.

Table 4: Two-Equation Estimates for Out-of-School Male Youth 16 to 24, Pooled Years[a]

Variable	Wage Equation	Employment Equation
Age	0.061 (13.940)	-0.011 (0.648)
School	0.019 (3.369)	0.116 (9.439)
Black	-0.048 (1.207)	-0.636 (8.734)
Never Married	-0.140 (5.765)	-0.464 (6.943)
Log Area Wage	0.609 (10.244)	-0.779 (3.293)
Area Unemployment	-0.003 (0.518)	-0.062 (3.712)
Youth Differential: 1976	-0.034 (1.211)	0.092 (0.830)
1977	-0.039 (1.543)	0.161 (1.642)
1978	-0.025 (1.036)	0.175 (1.862)
Constant	-0.348 (3.357)	0.725 (1.875)
P_1	0.364 (9.116)	
P_2	0.392 (6.225)	
ρ	-0.251 (0.716)	
σ	0.352 (30.228)	
N	5000	

[a] T-statistics are in parenthesis.

bance terms in the market wage and employment equations, is not significantly different from zero.[1]

The market employment equation estimates reveal two unexpected results. First, once we correct for schooling, race, and marital status (as well as the regional and calendar year variables) there is no relationship between age and the probability of employment. This is in contrast to much tabular employment data that shows a substantial relationship between age and employment. According to our results, however, this is a spurious result reflecting schooling and, in particular, marital status. Evaluated at the mean of other variables, our results indicate that married youth are about .11 more likely to be employed than single young men, and that a year of schooling increases the likelihood of employment by about .03. Controlling for other variables black youth are about .16 less likely to be employed than white youth. Although it is plausible that wage rates and employment status affect marriage decisions, we believe that the estimates reflect at least a strong relationship between marital status and cost of non-employment, or conversely, between marital status and the value of income. There is likely to be a causal relationship between marital status and the desire for employment and higher paying jobs.

Second, the market probability of employment increased somewhat

---

1. The estimated value is negative. Because it is estimated very imprecisely, it may not be appropriate to rationalize it. However, our estimates control for marital status which is not common among other estimates of employment and wage equations. Since marital status has a positive effect on both the wage and employment equations, its exclusion would tend to induce a positive correlation between the disturbance terms.

between 1973 and 1978 according to the calendar year differentials, while youth market wage rates were falling relative to adult wages. This would suggest, for example, that if demographic trends tended to reduce the youth employment ratio, they were more than offset by falling youth wage rates. Without the minimum, youth would have been 2.3 percent more likely to be employed in 1976 than in 1973, 3.9 percent more likely in 1977, and 4.3 percent more likely in 1978.[1] These estimates of course control for adult area unemployment rates.

---

1. The estimates represent the derivative of the probability of employment with respect to the calendar year indicator variables, evaluated at the mean of the other variables.

IV. Simulated Employment and Wage Effects of the Minimum

We shall first present results based on the single-equation model and then some results based on the two-equation model that cannot be inferred from the single-equation parameter estimates only. The simulation results were obtained by calculating appropriate employment and wage rate values for each person in our sample and then summing over all youth.[1]

A. Simulations Based on the Single-Equation Model

Simulated employment and wage effects of the minimum based on the pooled years estimates (see Table 2) are shown below.

Tabulation 3. Simulated Employment and Wage Effects by Age Group Based on Pooled Years Model (See Table 1)

	16-24	20-24	16-19	16-17
Percent Increase in Employment if no Minimum	3.9	2.2	7.1	8.7
Expected Market Wage[a]	2.68	2.95	2.11	1.74
Expected Wage With Minimum[a]	2.67	2.94	2.11	1.77
Expected Wage with Minimum[a] Conditional on Employment	2.78	3.01	2.23	1.86

a. In 1973 dollars.

1. Details are provided in the appendix to Meyer and Wise [1981].

According to these estimates, without the minimum, employment of out-of-school male youth would have been 3.9 percent higher over these years than it was. It would have been 8.7 percent higher for 16 to 17 year olds, but only 2.2 percent higher for those 20 to 24.

Expected earnings of youth were not affected much by the minimum. Without the minimum, the expected market wage would have been \$2.68. In the presence of the minimum, the expected wage of this group, that would have been employed without the minimum, was \$2.67. While the expected wage conditional on employment was higher than the market expected wage (\$2.78 versus \$2.68), this increase was just offset by the zero earnings of those without work because of the minimum.

On the one hand, it can be argued that the minimum has not hurt youth because their expected earnings are not affected much by it. On the other hand, youth who are not employed lose current income and more importantly will have lower incomes in the future because of non-employment in early years. Wage increases come in large part with work experience.[1] Indeed, if the minimum prevents some youth from gaining work experience, it may prolong non-employment by prolonging the length of time that their market wage is below the minimum. We are implicitly assuming in making these arguments that at the margin leisure is not valued much by a youth with no employment.

We observe that the average market wage rate of youth 16 to 17 was 1.74. The real minimums over these four years were \$1.60, \$1.82, \$1.66, and \$1.76 in 1973, 1976, 1977, and 1978 respectively. Thus the minimum was

---

1. See for example Ellwood [ ] and Meyer and Wise [ ].

set on average very close to the central tendency of the market wage distribution for these youth. It is thus not surprising to observe a relatively large dis-employment effect for this group.

For comparison we have also obtained analogous employment and wage estimates based on separate estimates for 1973 and for 1978 (see Table 3). They are as follows:

Tabulation 4. Simulated Employment and Wage Effects Based on Separate Estimates for 1973 and 1978 (See Table 3)

	1973	1978
Percent Increase in Employment if No Minimum	4.0	6.8
Expected Market Wage	2.77	3.87
Expected Wage With Minimum	2.75	3.78
Expected Wage With Minimum Conditional on Employment	2.87	4.14

The results are in order of magnitude commensurate for those based on the pooled data. In both years, however, these estimates indicate a slight decline in expected wage rates with the minimum, versus market wage rates without the minimum. (The estimates are in current year dollars.) We also find a larger employment effect in 1978 than in 1973. The real minimum was 10 percent higher in 1978.

One check on the distributional assumptions of our model is to predict the potential employment gain in 1973, based on estimates derived from 1978 data. This provides some confirmation of the specification because the 1978 data exhibits a relative absence of observations just below the 1978 minimum, and thus there is no way to observe the assumed market distribution in this range. The 1973 data, however, included observations in this range because the minimum was lower. Thus for 1973, one can argue it is possible to observe a part of the market distribution that was not observable in 1978. Thus if both sets of data lead to the same conclusions, we have greater confidence in our distributional assumptions. Based on 1978 data and parameter estimates, we estimate that the disemployment effect of the 1973 minimum was about 4.3 percent, very close to the 4 percent figure based on 1973 data and parameter estimates. The match is improved if we take account of the shift in the market wage distribution between 1973 and 1978, as exhibited in the pooled years estimates.

To show the moderating effect of inflation on the employment effects of a fixed minimum, we calculated the percent increase in employment that would have resulted had the minimum been held at its 1973 value throughout the period. These results are shown in the second row of the tabulation below. For comparison, we have also included the effect of no mini-

Tabulation 5. Simulated Employment Effects by Age Group, Based on Pooled Years Model (See Table 2)

	16-24	20-24	16-19	16-17
Percent Increase in Employment if No Minimum	3.9	2.2	7.1	8.7
Percent Increase in Employment if 1973 Minimum ($1.60) Had been Maintained	2.8	1.7	5.0	5.9
Percent Increase in Employment if Minimum Had Been $1.25	3.0	1.8	5.2	6.2

mum, reproduced from the first tabulation above, and the percent increase in employment had there been a $1.25 minimum throughout the period. If the minimum had been maintained at its 1973 level, inflation would have led to youth employment increases equal to about two-thirds of the potential increase in employment that could have been achieved by elimination of the minimum. A $1.25 minimum would gain about 80 percent of the potential increase in employment if there were no minimum, according to our estimates.

Simulated employment effects by race and age based on the pooled years model are as follows:

Tabulation 6. Simulated Employment Effects by Race and Age Based on Pooled Years Model (See Table 1)

Age Group	Total	White	Black
16-24	3.9	3.7	5.6
20-24	2.2	2.1	3.5
16-19	7.1	6.9	10.1
16-17	8.7	8.6	10.1

The precent increase in employment if there were no minimum is higher for blacks than for whites in each age group. For youth 16 to 24, the effect for blacks is 50 percent higher than the effect for whites. Since the estimated values of P_1 and P_2 are about the same for blacks as for whites, this result is due to the greater proportion of blacks with attributes associated with low wage rates. The effect for the youngest age group is only 17 percent higher for blacks than for whites. Thus these results imply that the differences in the attributes of black and white high school dropouts are relatively small compared to the difference in the attributes of older blacks and whites. Among youth 20 to 24, the black effect is 67 percent higher than the effect on whites. Apparently this is not the result of a difference by age group in the race effect, since according to the estimates in Table 2, the race effect is only slightly higher for the 20 to 24 age group than for the 16 to 17 group.

Again, for comparison we also calculated employment effects by race for 16 to 24 year olds, based on separate estimates by race. They are:

Tabulation 7. Simulated Employment Effects by Race, Based on Pooled Years Model Estimated Separately for Whites and Blacks 16 to 24 (see Table 2)

White	Black
3.9	5.3

These estimates are very close to those based on the pooled years model (Tabulation 6) that does not estimate separate parameters for blacks and whites, other than an additive race effect. Again, because the black market wage distribution is lower than the white distribution, the part of the market distribution not observed because of the minimum is different for blacks and whites. Thus these results also help to support our distributional assumptions.

B. Simulations Based on the Two-Equation Model

Selected simulated employment effects based on the two-equation model, by race, are shown below.

Tabulation 8. Simulated Employment Effects for Out-of-School Male Youth 16-24, Based on Two-Equation Model, Pooled Years, by Race (see Table 4)

	Total	White	Black
Percent Increase in Employment if No Minimum	3.3	3.2	5.0
Percent Increase in Employment if 1973 Minimum ($1.60) Had Been Maintained	2.4	2.3	3.3
Percent Increase in Employment if Minimum Had Been $1.25	2.6	2.5	3.6

These estimates indicate that if there had been no minimum, employment would have been 3.3 percent higher than it was. The comparable estimate based on the single equation model is 3.9 percent, as shown in Tabulation 5. Recall that the two-equation estimates are based on both wage and salary workers, whereas the single-equation estimates are based on hourly wage employees only. Salaried workers on average have attributes associated with higher wage rates than hourly workers and thus should be expected to be affected less by the minimum. The other values in Tabulation 8 are close to the comparable values in Tabulations 5 and 6, based on single-equation estimates (although Tabulations 5 and 6 do not contain counterparts to every value in Tabulation 8).

These estimates of course are based in large part on observed employment outcomes, that were not incorporated in the data used to derive the single-equation estimates. There is substantial information in the employment data and they could certainly lead to estimates at variance with the single-equation results. That they do not again suggests that our results are not simply determined by the market wage distribution assumptions.

Tabulations 9 through 11 present simulations of employment status by market wage rate, with and without the minimum wage legislation. These results cannot be obtained from the single-equation estimates only, because the simple model does not allow estimates of employment status by market wage rate.

Tabulation 9. Simulated Employment Status by Market Wage Rate, With and Without the Minimum, Men 16-24

	Employed	Not Employed	Total
	Without a Minimum Wage		
Market Wage Rate Below Minimum	89.2	10.7	12.3
Market Wage Rate Above Minimum	86.3	13.7	87.3
Total	86.7	13.3	100.0 (4999)
	With the Minimum Wage		
Market Wage Rate Below Minimum	67.5 32.5<M 35.0 at M	32.5	12.3
Market Wage Rate Above Minimum	86.3	13.7	87.3
Total	83.9	16.1	100.0 (4999)

Tabulation 10. Simulated Employment Status by Market Wage Rate, With and Without the Minimum, White Men 16-24

	Employed	Not Employed	Total
Without a Minimum Wage			
Market Wage Rate Below Minimum	92.0	8.0	12.1
Market Wage Rate Above Minimum	88.3	11.7	87.9
Total	88.7	11.3	100.0 (4454)
With the Minimum Wage			
Market Wage Rate Below Minimum	69.5 33.5<M 36.1 at M	30.5	12.1
Market Wage Rate Above Minimum	88.3	11.7	87.9
Total	86.0	14.0	100.0 (4454)

Tabulation 11. Simulated Employment Status by Market Wage Rate, With and Without the Minimum, Black Men 16-24

	Employed	Not Employed	Total
Without a Minimum Wage			
Market Wage Rate Below Minimum	74.7	25.3	18.2
Market Wage Rate Above Minimum	68.8	31.2	81.8
Total	69.9	30.1	100.0 (545)
With the Minimum Wage			
Market Wage Rate Below Minimum	56.6 27.3<M 27.3 at M	43.4	18.2
Market Wage Rate Above Minimum	68.8	31.2	81.8
Total	66.6	33.4	100.0 (545)

We shall explain the results in Tabulation 9, for both blacks and whites together. The separate estimates by race are analogous.

Without the minimum, 10.7 percent of youth with subminimum wage rates would be without work and 89.2 percent would be employed. With the minimum, 32.5 percent are without work and only 67.5 percent are employed. (Of this latter group, 32.5 percent are employed with wage rages below the minimum and 35 percent are employed with wage rates equal to the minimum.) Total non-employment is increased from 13.3 percent without a minimum to 16.1 percent with the minimum. Thus not only does the minimum wage increase non-employment among youth, but it also concentrates non-employment among youth with the lowest market wage rates.[1]

The results for white youth are quite close to the results for both races together because a large majority of youth are white. The estimates for black youth are similar in direction, but the proportion not employed is higher both with and without the minimum. Among black youth with market wage rates below the minimum, non-employment is increased from 25.3 percent without the minimum to 43.4 percent with the minimum, according to these estimates.

A possibly anomalous result is that the non-employment rate without the minimum is shown as lower for persons with sub-minimum than for those with above-minimum market wage rates. This results from assuming the estimated correlation coefficient which is negative, although very imprecisely measured and not significantly different from zero by any reasonable criterion. Thus this aspect of the simulations should not be given much cre-

---

1. Our model specification of course prescribes that any employment effect be on this group but it does allow no employment effect at all.

dence.[1]

V. Conclusions

We have estimated the employment and earnings effects of the minimum wage by parameterizing a hypothesized relationship between underlying market employment and wage relationships versus observed wage and employment distributions in the presence of a legislated minimum.

If there had been no minimum during the 1973-78 period, we estimate that employment among out-of-school men 16 to 24 would have been approximately 4 percent higher than it in fact was. Among young men 16 to 19 employment would have been about 7 percent higher and among those 20 to 24 2 percent higher. Employment among black youth 16 to 24 would have been almost 6 percent higher than it was, as compared with somewhat less than 4 percent for white youth. Thus the proportional employment effects of the minimum are greater for the younger than for older youth and are greater for black than for white youth.

The aggregate effect on employment, however, depends not only on the proportion of each group without work because of the minimum, but also on the number of youth in each group who were employed. For example, there are about 10 times as many out-of-school youth 20 to 24 as 16 to 17. Thus if the potential employment increase is 2.2 percent for 20 to 24 year olds and 8.7 percent for those 16 to 17, elimination of the minimum would add to the employment roles about two and one-half times as many youth 20 to 24

---

1. An alternative would be to base the simulations on an assumed correlation of zero, which would have produced a non-employment rate for sub-minimum workers higher than for the above minimum group, if there were no minimum. See, for example, the two-equation estimates for 1978 presented in Meyer and Wise [1981].

as 16 to 17. Our estimates apply to out-of-school youth, however, and most young persons 16 to 17 are in school. Nonetheless, it is clear that the desirability of a youth minimum, for example, depends on the goals sought through it. If aggregate employment increase were the goal, more could be gained by reducing the minimum for older than for younger youth. Indeed, if the minimum were reduced for all, the majority of the gain could come from the older group.

Although it is sometimes argued that the adverse employment effects of the minimum are offset by increased earnings, we find virtually no earnings effect. Even though some youth with market wage rates below the minimum are paid the legislated minimum, the increased earnings of these youth is offset by the non-employment and thus zero earnings of others. Expected earnings of youth are about the same with the minimum legislation as they would be without it.

Had the minimum not been raised over the 1973-78 period, inflation would have greatly moderated the adverse employment effects of the minimum. According to our estimates, if the minimum had remained at its 1973 level, approximately two-thirds of the potential employment gains from elimination of the minimum would have been attained.

Our statistical procedure emphasizes the effect of the minimum on youth who otherwise would be employed at subminimum market wage rates. But we have also allowed for estimation of possible upward shifts in all youth wage rates with increases in the minimum. The weight of the evidence provided by our estimates, however, is inconsistent with a general increase in youth wage rates with increases in the real minimum. Thus our findings support the hypothesis that the effects of the minimum are indeed concentrated on youth with sub-minimum market wage rates. We find no evidence that the wage rates of youth with market rates above the minimum are bid up. Although we cannot identify an effect of the minimum on youth 16 to 24 with above-minimum market wage rates, our evidence does not strictly speaking rule out an increase in the employment of older workers with increases in the minimum.

A concomitant of our procedure is estimation of market wage and employment functions. In particular, we are able to estimate the trend in youth wage rates corrected for the disemployment effects of the minimum. The average of wage rates among employed youth show white youth wages falling relative to adult wages between 1967 and 1977 but show no decline for black youth. We find, however, that market wage rates of blacks as well as whites were falling over the period of our analysis. Apparently the greater disemployment effect of the minimum on black youth made it appear as though their wage rates were not falling, whereas in fact low wage black youth were disproportionately without work. Thus their market wage rates were not incorporated in the averages of observed wage rates.

Ashenfelter, Orley and Robert S. Smith, "Compliance with the Minimum Wage Law," Journal of Political Economy, Vol. 87, April 1979.

Cunningham, James, "The Impact of Minimum Wages on Youth Employment, Hours of Work, and School Attendance: Cross-sectional Evidence From the 1960 and 1970 Censuses," mimeograph, January 1980.

Ehrenberg, Ronald G. and Alan J. Marcus, "Minimum Wage Legislation and the Educational Outcomes of Youth," mimeograph, July 1979.

Ellwood, David, "Teenage Unemployment: Permanent Scars or Temporary Blemishes?" in Freeman and Wise (eds.), The Youth Employment Problem: Its Nature, Causes, and Consequences, University of Chicago Press, 1982.

Freeman, Richard B., The Overeducated American, New York: Academic Press, 1976.

Freeman, Richard B. and David A. Wise, "Youth Unemployment," NBER Summary Report, 1979.

Gramlich, Edward M., "The Impact of Minimum Wages on Other Wages, Employment, and Family Incomes," Brookings Papers on Economic Activity, 1976.

Hall, Robert E., "The Minimum Wage and Job Turnover in Markets for Young Workers," in Freeman and Wise (eds.), The Youth Employment Problem: Its Nature, Causes, and Consequences, University of Chicago Press, 1982.

Hamermesh, Daniel S., "The Minimum Wage and the Demand for Labor," mimeograph, October 1980.

Hausman, Jerry A. and David A. Wise, "Social Experimentation, Truncated Distribution and Efficient Estimation," Econometrica, May 1977.

Hausman, Jerry A. and David A. Wise, "Stratification on Endogenous Variables and Estimation: The Gary Income Maintenance Experiment," in Structural Analysis of Discrete Data: With Econometric Applications, Charles Manski and Daniel McFadden (eds.), M.I.T. Press, 1981.

Meyer, Robert H. and David A. Wise, "Discontinuous Distributions and Missing Persons: The Minimum Wage and Unemployed Youth," NBER Working Paper No. 711, July 1981.

Meyer, Robert H. and David A. Wise, "High School Preparation and Early Labor Force Experience," in Richard B. Freeman and David A. Wise (eds.), The Youth Employment Problem: Its Nature, Causes, and Consequences, University of Chicago Press, 1982.

Mincer, Jacob, "Unemployment Effects of Minimum Wages," Journal of Political Economy, August 1976.

Mincer, Jacob and Linda Leighton, "Effect of Minimum Wages on Human Capital Formation," NBER Working Paper No. 411, February 1980.

Welch, Finis and James Cunningham, "The Effects of Minimum Wages on the Level and Age Composition of Youth Employment," Review of Economics and Statistics, February 1978.

Wessels, Walter J., "The Effect of Minimum Wages in the Presence of Fringe Benefits: An Expanded Model," Economic Inquiry, Vol. 18, April 1980.