An Error Components Model of the Impact of Plant Closing on Earnings

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Working Paper #144

August 1987

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The rise and fall of textiles in New England and the rise and decline of automobile and steel production in the Great Lakes region are among the most obvious examples of geographical reallocation of resources. While the result of this resource reallocation may yield net benefits to society, the distribution of the resulting costs may be of concern. This concern may focus on decreases in average incomes of those who are displaced or about increases in the proportion of workers falling below some minimum income level.

Several studies have focused on the change in mean earnings of workers displaced by plant closings (for example, Holen et al [1981] and Holtzblatz [1984]). They find that displaced workers' mean earnings drop substantially in the periods during and immediately after displacement, and then increase toward their pre-displacement level. This finding reinforces a view that displaced workers may require short-term assistance but do not suffer large long-term losses. Madden (1987) compares mean losses across different demographic groups.

Our focus is on the impact of plant closings on the probability that the income of displaced workers may fall below some low earnings threshold. We continue in the descriptive tradition of previous studies but expand the focus to include the distribution of costs among displaced workers. Plant closing may affect the shape as well as the mean of the earnings distribution for two different reasons. First, displaced workers may differ in their ability to adjust to a dislocation. While displaced workers on average may not experience long-term effects, this response may be the result of some workers making major career changes

which increase their earnings while others never fully recover from displacement. The second reason that the variance of earnings may change is that displaced workers may accept greater instability of earnings in order to maintain their prior mean level of earnings. For example, a displaced worker may accept a job on commissioned sales which may yield the same expected income as an assembly line job but at the cost of greater instability. These changes in the shape as well as the mean of the earnings distribution will in turn affect the proportion of workers falling below some fixed earnings threshold.

The paper is in two parts. The first presents the data. The second section develops a statistical model which allows us to separate the impact of changes in the mean from changes in the variance on the probability of having low earnings.

I. DATA

Since persons who are displaced through plant closings may not be a random subsample of the population, the data set we use should not be limited only to displaced workers. The data set should also follow individuals over a sufficiently long period of time to allow us to observe pre-and post-displacement earnings histories. Finally, the data set must identify when a person is displaced. The Panel Study of Income Dynamics (PSID) satisfies all these criteria. The Displaced Worker Survey (DWS) is a much larger data set but it does not include a control group, since only persons who were displaced are followed. Furthermore, it includes only retrospective information on prior work histories.

Wave XV of the PSID was used to create an extract of male heads of households in the initial SRC sample frame, who were less than 65 years old and not retired. The study is restricted to heads of households since information on reason for loss of job is only available for these individuals. The restriction to nonaged individuals allows us to focus on decreases in earnings which come during the working life, rather than during normal retirement. The sample period is 1975-81. Restricting attention to a seven-year period allows us to include persons who were not heads in other years of the sample.

By including non-displaced workers we are able to compare the experiences of displaced workers against a control group. With the exception of Madden (1987), previous studies have only compared pre- and post-displacement experiences of those affected by plant closings.

A displaced worker is defined by the answer to the question, "What happened to the job you had before--did the company go out of business, were you laid off, promoted, or what?" A person is classified as being displaced if the answer was that the company folded, changed hands, moved out of town, employer died, or went out of business.

II. ESTIMATED MODEL

In this section we develop an error components model which is used to estimate the impact of displacement on the mean and variance of log earnings. The impact of changes in the mean and variance are then combined to calculate the resulting change in the probability of receiving low earnings.

Specification. Building on the autoregressive error components model developed in Lillard and Willis (1978), we specify the following structure:

$$(1) \qquad Y_{it} = X_{it}\beta + \mu_{it}$$

$$(2) \qquad \mu_{it} = \delta_i + v_{it}$$

$$(3) \qquad v_{it} = \rho v_{it-1} + e_{it}$$

where Y_{it} is the log earnings of the ith person in period t, X_{it} is a vector of exogenous variables and μ_{it} is a random error, uncorrelated with X_{it}, which captures variation about the mean.

Equation 2 indicates that μ_{it} includes two components--an unobserved heterogeneity component, δ_i, and an autoregressive component. The former varies across individuals but is constant across time. It reflects unobserved characteristics which keep the individual above or below the mean profile ($X_{it}\beta$) of observationally equivalent persons. The first order autoregressive process (shown in equation 3) allows the individual's earnings to vary systematically around his mean log earnings profile (given by $X_{it}\beta + \delta_i$). The δ_i's and e_{it}'s are assumed to be the result of draws from independent normal distributions with zero means.

We allow displacement to affect both the mean and the variance of log earnings. The mean is allowed to vary by including variables which capture the displacement history of the individual in the X vector. The variance of log earnings is allowed to vary by estimating separate variances of δ_i and e_{it} across displacement histories.[1]

We summarize the history of displacement by dividing the seven-year period into the following displacement subperiods for a person displaced in period d: "before" indicates $t < d$, "during" indicates $t = d$, "following" indicates $t = d+1$ and "after" indicates $t > d+1$. Persons who experience displacement during the seven-year sample period are referred to as "ever" displaced while all others are "never" displaced.

The effect of displacement on the mean of Y is parameterized by including four dummy variables. These dummies mark pre, during, following and post displacement periods. Coefficients on these dummies indicate percentage increments to earnings relative to the never displaced. The coefficient on the "pre" dummy, for example, allows us to ask whether there are systematic differences between the earnings of those who will be displaced in future periods and those who are not.

The effect of displacement on the transitory variance of log earnings is captured by allowing separate variances for the five reference periods (before, during, following, after and never). These are denoted respectively as σ^2_{vb}, σ^2_{vd}, σ^2_{vf}, σ^2_{va} and σ^2_{vn}. Further, the variance of δ is allowed to differ between the ever ($\sigma^2_{\delta e}$) and never ($\sigma^2_{\delta n}$) displaced.[2]

Estimation. Anderson and Hsaio (1982) demonstrate that the consistency of estimation in models with autocorrelated errors in panel data depends critically on the assumptions made about intial conditions. We adopt their suggestion for a simple estimator of ρ which is robust to alternative assumptions. Following this approach, we estimate separate, unconstrained estimates of first period variance of e for the ever displaced and for the never displaced.[3]

To estimate the complete model in equations 1 through 3, we employ a four-step estimation procedure. This procedure significantly reduces the

computational burdens relative to a single step procedure, as well as reducing our reliance on restrictive assumptions while still yielding efficient estimates. In the first step, the NT observations are stacked and OLS is used to provide consistent estimates of $\underline{\beta}$, the vector of coefficients for displacement status in each reference period and for personal characteristics. The second step is to use the residuals from the first step (for individuals in the never displaced group) to estimate ρ, using the "simple consistent estimator" of Anderson and Hsiao. In the third step, maximum likelihood is used to obtain estimates of the remainder of the variance structure, holding the previously estimated value of ρ fixed. As a final step we compute FGLS estimates of $\underline{\beta}$, using the previously estimated variance matrix to weight the data and thus obtain efficient estimates (Theil, 1971).

A potentially important complication is caused by persons with zero earnings. Not only is the log of zero undefined but the concentration of mass at zero would violate our distributional assumption even if the dependent variable were not defined in terms of logs. Ideally a tobit type estimator would explicitly account for these censored observations. Given the complexity of our error structure developing such an estimator is beyond the scope of this paper. In the main body of the paper, we report results based on all persons in which $400 is added to the earnings of each person, allowing us to take the log of earnings for everyone.[4] To measure the sensitivity of our results to an alternative treatment of zero earners, we estimated the model dropping all persons with zero earnings. While this procedure is also imperfect, since it introduces the potential of selection bias, the results, shown in Appendix A, yield the same patterns as those discussed in the body of the

paper. The qualitative conclusions are not affected. This probably reflects the small proportion of observations with zero earnings (1.5 percent of all person months) and the fact that persons with zero earnings have displacement patterns similar to the rest of the sample. While comparing the results of two imperfect solutions to the "zero problem" does not settle the issue, we believe that this comparison suggests that as a practical matter, zeros do not have a substantial effect on our conclusions.

Findings. The estimated parameters of the earnings function specified in equation (1) are found in Table 1. The regression results are consistent with other estimated earnings functions. Holding constant for both the year of the observation and for the broad industry/occupation group of the worker in the period, whites earn 18 percent more than non-whites, while an additional year of education adds 9 percent to earnings. The disabled earn 36 percent less than the non-disabled.

In the periods prior to displacement, the ever displaced earn about 22 percent less than the never displaced. This may reflect the fact that those displaced have permanently lower earnings before displacement or that the negative impact of displacement sets in before displacement occurs. This negative effect may result from reduced work hours, temporary layoffs and/or wage reductions in the period leading up to displacement.

In the period of displacement, earnings decline by 11 percent to a level 33 percent less than the never displaced. As expected, the largest impact of displacement occurs in the periods during and immediately following displacement. Earnings increase in the after displacement period to a level 11 percent above the pre-displacement level. Note,

however, that this is still 10 percent less than the earnings of the never displaced.

The explanation for the post-displacement increase in mean earnings depends crucially on the reason why displaced workers had below average earnings prior to displacement. If low pre-displacement earnings reflected the prior effects of being in a plant which was having trouble, then the increase in earnings only indicates a successful transition out of a weak labor market. If on the other hand, the low earnings prior to displacement reflects a permanent condition, then the increase implies large costs (actual or perceived) of switching jobs, otherwise persons would have moved into the higher paying job before displacement. The "revealed preference" of workers to hold onto their pre-displacement jobs would indicate that the higher average wages of post-displacement jobs did not compensate for the cost of switching jobs. We have no way of distinguishing between these two alternative explanations.

Table 2 shows the estimated parameters of the error structure of the log earnings equation.[5] The equation exhibits statistically significant positive autocorrelation ($\rho = .31$), indicating multiple period effects of the random shock in any one period. The estimated variance of the heterogeneity component (δ_1) is slightly higher for the never displaced ($\sigma^2_{\delta n} = .08$) than for the ever displaced ($\sigma^2_{\delta e} = .07$), indicating that the distribution of permanent earnings among the never displaced is slightly less equal than the distribution for the ever displaced.

Of particular interest to this study is the change in the variance structure as workers are displaced. The estimated variance of the transitory component is slightly higher for the displaced group in the periods before displacement ($\sigma^2_{vb} = .28$) than for the never displaced

group ($\sigma^2_{vn} = .23$). This variance increases substantially during the year of displacement ($\sigma^2_{vd} = .34$) and immediately following displacement ($\sigma^2_{vf} = .37$) before returning its predisplacement level ($\sigma^2_{va} = .28$).[6]

Combining the effects of displacement on the mean and variance of earnings we find that during the period of displacement both the mean and the variance worsen--mean earnings decrease while earnings instability increases. The changes are reversed in the post-displacement period.

Our results allow us to calculate the impact of displacement on the probability of having low earnings. The expected proportion of people with earnings, E, below the threshold, L, in every year, conditional on their observed characteristics, X, is given by

$$(4) \qquad \Pr(E < L \mid X) = \Pr(X\beta + \delta + v < L)$$

$$= F\left(\frac{\ln(L) - X\beta}{\sigma^2_{\delta} + \sigma^2_{vt}}\right),$$

where F is the cumulative normal density whose variance depends on σ^2_{δ}, the variance of the heterogeneity distribution, and σ^2_{v}, a weighted sum of the variance of e_{it} before (σ^2_b), during (σ^2_d), following (σ^2_f), and after (σ^2_a) displacement. To simplify the discussion in this section we make the familiar assumption that the initial period variance of v is given by $\sigma^2_{vo} = 1/(1-\rho^2)$. In each later period, the term σ^2_{vt} is given by the recursive formula:

$$(5) \qquad \sigma^2_{vt} = \rho^2(\sigma^2_{v(t-1)}) + \mathrm{var}(e_{it}).$$

Since equation (4) gives the proportion of observationally identical people with low earnings, it includes the effect of displacement on the

variance of the heterogeneity component as well as on the transitory variance in earnings.

Table 3 shows the impact of displacement on the probability of having low earnings (based on equation 4) for an individual whose X variables (apart from the displacement dummies) are all set equal to their mean for the entire sample. Column 1 shows the year since displacement. Column 2 shows that the mean profile of log earnings for displaced workers drops from 3.81 to 3.70 in the year of displacement but increases to 3.92 two years after displacement. By contrast, the never displaced have mean log earnings of 4.03 in all years. Columns 2 and 3 show the total variance (including the variance of the heterogeneity component) and the expected proportion of persons with earnings less than $10,000 in each year. The variance increases from .309 to .371 in the year of displacement then drops to .310 three years after displacement.

The total impact of the changing mean and variance is that the proportion of persons with low earnings increases from .0034 to .0109 when displacement occurs. While this change in the proportion with low annual earnings during the year of displacement is dramatic, the proportion quickly falls below its initial level. Three years after displacement, the percentage with low earnings has fallen to .0018.

These results vary for persons who occupy different positions in the income distribution. Table 4 considers an individual with the X characteristics of a disadvantaged individual (a 25-year old, non-union black household head with 12 years of schooling) who has a much higher probability of having low earnings--.267 even for the never displaced. The probability of low earnings rises by 18 percent in the year of displacement. By three years after displacement it falls to a level 17 percent below

its pre-displacement level, but remains 38 percent above the level of the never displaced.

SUMMARY AND CONCLUSION

We have shown that displacement affects the shape as well as the mean of the earnings distribution. The initial distribution of earnings of workers who become displaced has a lower mean but the same variance as the earnings of workers who are not displaced. During the period of displacement the mean declines and the variance increases sharply. This leads to a sharp increase in the proportion with earnings below $10,000. However, in the post-displacement period the mean increases and the variance declines back to their pre-displacement levels.

Our study, therefore, shows that if the distributional concern is to avoid large increases in the proportion of persons with low earnings then there is a short-term problem but one which also seems to dissipate over time.

Notes

[1]Allowing v_{it} to be autocorrelated and the variance of δ_i to change across displacement histories makes a standard Hausman Taylor test inappropriate. Independence of the δ's and X's is a maintained hypothesis of the model that is not tested.

[2]A referee brought to our attention that autoregressive conditional heterscedasticity (ARCH) models also simultaneously estimate means and variances. Our model contrasts with ARCH models by decomposing the error into δ_i and v_{it} and allowing both of the variances to change. We also stipulate that these variances depend on X's instead of lagged values of Y.

[3]Our approach contrasts with the iterative method of Lillard and Willis (1978) which rests on more restrictive assumptions.

[4]This is equivalent to assuming that the distribution of earnings is displaced log normal.

[5]We also estimated unconstrained values for the transitory variances in the initial period of the sample. This assumption is consistent with our estimate of ρ. Since the initial variances capture the effects of the "history" of the autoregressive process, our estimation makes no assumptions about this history.

[6]A series of nested hypothesis tests were performed to examine how the variances differ with displacement status. The hypothesis that the variances are the same over time for the ever-displaced group can only be rejected at significance levels of 28 percent. The hypothesis that the variance is the same for the ever-displaced and never-displaced groups can be rejected at significance levels of 1 percent.

Appendix A

Estimates of Elements of the Variance Matrix for Sample Excluding Cases with Zero Earnings

Autocorrelation coefficient	.132
Never Displaced	
Variance of heterogeneity component	.066 (.003)
Variance of i.i.d. disturbance	.100 (.002)
Ever Displaced	
Variance of heterogeneity component:	.004 (.001)
Before-displacement variance	.193 (.017)
Period of displacement variance	.301 (.040)
Period following displacement variance	.266 (.036)
After-displacement variance	.200 (.017)

Note: Asymptotic standard errors are in parentheses.

Appendix B

Estimated Coefficients of Year, Region, Industry and Occupation for Log Earnings Equation

	Coefficient	Asymptotic Standard Error
Year Dummies		
1975	1.30	0.110
1976	1.30	0.108
1977	1.30	0.106
1978	1.29	0.104
1979	1.25	0.102
1980	1.14	0.100
1981	1.10	0.105
Region[1]		
Northeast	-0.009	0.022
Northcentral	-0.017	0.020
South	-0.045	0.020
Industry[2]		
Manufacturing or construction	0.087	0.016
Service sector[3]	-0.013	0.018
Wholesale/retail trade	0.056	0.023
Occupation[4]		
Blue collar--crafts and kindred workers	0.067	0.015
Blue collar--operatives and laborers (except farm)	0.009	0.019
Disabled or student	-0.705	0.038
Residual category	0.012	0.025
R^2	.92537	
Standard Error	1.05784	

[1]Region--West and off-continent omitted.

[2]Industry grouping--non-standard category omitted.

[3]Service sector includes business and repair, personal services, entertainment and recreation, professional and related services.

[4]Occupational grouping--white collar workers (professional, technical, managers, administrators, sales and clerical workers) omitted.

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Table 1

Estimated Coefficients of Displacement Status and Personal Characteristics in Log Earnings Equation

	Coefficient	Asymptotic Standard Error
Displacement Status in Current Period		
Before displacement	-0.217	0.044
During displacement	-0.325	0.059
Following displacement	-0.274	0.065
After displacement	-0.105	0.050
Personal Characteristics		
White	0.178	0.031
Disability	-0.359	0.023
Large city	0.191	0.017
Education	0.090	0.003
Age	-0.021	0.004
Experience	0.078	0.005
Experience squared/1000	-0.965	0.072
Single[2]	-0.082	0.025
Married[2]	0.163	0.031
Union member	0.125	0.017
Moved for productive reasons, to get nearer to work or in response to outside events[1]	-0.054	0.028

[1]Estimates of coefficients for year of observation, region, and industry/occupation dummies are located in Appendix A.

[2]Remarried omitted.

Table 2

Estimates of Elements of the Variance Matrix

Autocorrelation coefficient	.3089 (.0170)
Never Displaced	
Variance of heterogeneity component	.0796 (.0040)
Variance of i.i.d. disturbance	.2341 (.0039)
Ever Displaced	
Variance of heterogeneity component:	.0739 (.0142)
Before-displacement variance	.2796 (.0260)
Period of displacement variance	.3416 (.0430)
Period following displacement variance	.3796 (.0530)
After-displacement variance	.2797 (.0252)

Note: Asymptotic standard errors are in parentheses.

Table 3

Earnings Dynamics for Head of Household with Mean Characteristics

Years Since Displacement	Mean Log Earnings	Variance of Log Earnings	Proportion Earning Less than $10,000
-2	3.81	0.309	0.0034
-1	3.81	0.309	0.0034
0	3.70	0.371	0.0109
1	3.75	0.415	0.0123
2	3.92	0.319	0.0021
3	3.92	0.310	0.0018
4	3.92	0.309	0.0018
Never Displaced	4.03	0.259	0.0004

Table 4

Earnings Dynamics for Young Black Male Head of Household

Years Since Displacement	Mean Log Earnings	Variance of Log Earnings	Proportion Earning Less than $10,000
-2	2.40	0.309	0.429
-1	2.40	0.309	0.429
0	2.29	0.371	0.506
1	2.34	0.415	0.474
2	2.51	0.319	0.354
3	2.51	0.310	0.352
4	2.51	0.309	0.352
Never Displaced	2.62	0.259	0.267