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Environmental Regulation and the Cost of Job Displacement*

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Abstract

Data from the Displaced Worker Supplement linked to Environment Protection Agency data are aggregated at the industry/state level to examine the impact of environmental regulation on the displacement of workers and the cost of that displacement. Changes in the environmental regulation of different industries, across states, are used as a mechanism that randomly displaces workers from their job, independently of their own actions, or industry and area demand shocks. The results indicate that environmental regulation did have an effect on the displacement of workers, with approximately 60,000 workers being displaced because of the regulation over the years 1979-92. Workers displaced for reasons of environmental regulation are no worse off that other displaced workers. It appears that environmental regulation, while displacing workers (in which individual cases may suffer some considerable non-pecuniary coasts). Does not affect their earnings capability vis-á-vis other displaced workers. The cost of job displacement from environmental regulation (as a wage difference for an average year over the 1979-92 time period) appears to lie in the range of $80 to $136 million (in 1992 dollars). This is a limited cost estimate and does not account for workers in unemployment at the time of the survey, the potential continued loss of wages over the workers career path, or any other costs imposed on workers and their families.

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1. Introduction

Recent studies have begun to take a detailed look at the costs and benefits of environmental regulations. Research appears to be divided on the impact the environmental regulations have had on employment (and the labor market in general). Studies that argue for a positive effect on employment (Berman and Bui, 1998) can be countered by others that argue for a negative effect (Greenstone, 1999).[1] However, most studies do not actually provide a direct estimate of job loss, or the associated cost to workers in the form of forgone pay.[2] This paper proposes to both estimate the extent of job loss over the 1979-92 time period, and estimate the cost in terms of wages to the workers.

Although environmental regulation has been cited as a possible cause for job displacement (Jacobson, LaLonde, and Sullivan, 1993), there have been few previous large scale studies that have examined if there is any cost in terms of wages for the workers who lose their jobs. Data from the Displaced Worker Supplements (DWS) and the Current Population Surveys (CPS) is used, aggregated into industry/state/year cells, and matched to Environmental Protection Agency (EPA) data, to measure the jobs lost due to environmental regulation and assess the costs of job loss for those who lose jobs because of environmental regulations.

The EPA data comes from the monitoring of compliance by companies to the Clean Air Act standards. The Clean Air Act represents one of the largest interventions by Government in the post-War period. The legislation was enacted in 1963, with amendments in 1970, 1977, and 1990. It is the period since the second amendment that affects the work presented here. The 1977 amendments strengthened the original legislation so that the compliance to environmental standards became more stringent for companies that polluted.

Examining the impact of environmental regulations has an added benefit in that it can be seen as a random displacement mechanism that re-allocates workers independently of their own actions or idiosyncratic state or industry demand shocks. Changes in the regulation of pollutants are measured as variation in constructed state by industry indices. The indices infer that workers were randomly reallocated to another job because of the manner in which the environmental regulation affects workers within the same state, within the same industry, and over time. If workers are displaced from a polluting industry because of regulation, then this occurred because of circumstances beyond the workers individual control, and independently of other confounding factors (such as industry specific, or state specific demand shocks). Workers displaced because of environmental regulation are viewed as randomly displaced into a new job.[3] The analysis, while examining the effects of environmental regulation

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[1] On a related issue, there is limited evidence to suggest that the environmental legislation affects the location of plants (and therefore jobs). While Levinson (1996) finds no noticeable effect, Gray (1997) finds that there are fewer plant openings in regulated areas.

[2] Only one other study has looked at the effect on wages from environmental regulation (Bartel and Thomas, 1987), and found for aggregate measures of wages, that there was a difference across regions for manufacturing industry.

[3] Results from this work can also be seen as an extension of Gibbons and Katz (1991, 1992). Gibbons and Katz use the DWS to examine worker selection effects from their pre-displacement industry. Using an asymmetric information model, Gibbons and Katz

on the displacement and potential earnings losses of workers, also allows a test of pre-displacement selection effects.

Data on workers are drawn from the CPS and the DWS for the years 1979-92. The data from the DWS were particularly suitable for this study as the questionnaire is specifically designed to elicit responses on displacement as being laid-off (without recall), a plant closing, or the employer going out of business. This is separate from a workers wish to quit or leave a job for their own reasons. The DWS is also a large, nationwide, survey that has sufficient coverage of industries and states to make the construction of cells statistically viable. However, as the DWS is a retrospective survey concerning a worker's previous main job, there are obvious measurement error issues on when actual displacement from a job occurred. This is compounded as the DWS asks not about the actual last job held, but the last main job. Ash and Kane (1999) report on the extent to which this method of data collection on displacement under-reports the time-series pattern.

Section 2 begins by describing the Federal air quality regulations and how they allow the adoption of the research design used in this work. Ideally, to observe if environmental regulations have had an effect on the displacement of workers, and their earnings paths, it would be optimal to observe the workers' earnings histories, the employers for whom they work, and whether or not the employer was monitored by the EPA. Such data are currently unavailable. As a means of examining the impact of environmental regulation on displacement and earnings the DWS and the CPS data were used aggregated to industry/state/year cells. Section 3 describes how the industry/state/year cells were constructed both for the group affected by the regulation and the control group. The analysis proceeds in 2 stages. First, establish if there is a significant link between environmental regulations and the displacement of workers. Second, given that the first stage result exists, examine the implications for earnings loss for workers displaced, and for those displaced for reasons of environmental regulation. To pre-empt the results (to some degree) the findings are that approximately 60000 jobs were lost because of environmental regulation over the period 1979-92. The cost to workers, in terms of the annual difference in wages between being displaced, against staying in the same industry and state, totals about $80 to $136 million. It should be stressed that this estimate is only for individual's employed at the time of the DWS survey, and refers only to the annual average difference in wages, rather than the difference in the wage path between workers some years into the future. Selection effects appear to play a minor role in the calculation of this estimate.

(1991) argue that in a world where firms can chose to layoff the least able in the presence of an adverse shock, then the post displacement wages of workers should be lower compared against workers laid-off for reasons unassociated with their performance. Using the DWS for 1984 and 1986, Gibbons and Katz find some evidence to suggest that this was the case for white-collar workers. For workers laid-off for reason of plant-closing, there was little difference between the pre and post displacement wage. For workers laid-off for reason of shift-abolished, or slack work, there was a difference. There is some endogeneity of choice for firms in selecting which workers get laid-off as they change shift work, or are experiencing some form of adverse demand shock.

2. A Research Design Using the Federal Air Quality Regulations

An ideal design with which to examine the effects of environmental regulation on workers jobs and pay would be to randomly assign the regulation to employers, and observe the effects on the treated against the control group. The EPA does not follow such a procedure in regulating industrial activity. We use the EPA federally mandated environmental regulations that were imposed on particular types of plants, in some counties, at different points in time to isolate the variation in environmental regulation.

To curb emissions of highly concentrated air pollutants Congress passed the 1970 Clean Air Act Amendment (CAAA). The CAAA was to bring into compliance each county into either a high or low regulation status based on whether the federal maximum allowable pollution concentrations had been exceeded. The pollutants that the CAAA was concerned with, and the maximum allowable pollution levels, are given on Table 1. There were four pollutants: carbon monoxide (CO), sulphur dioxide (SO_2), ozone (O_3), and total suspended particulates (TSPs). The 1977 Amendment to the Clean Air Act reinforced the 1970 legislation that directed States to develop and enforce pollution abatement to ensure that counties were compliant.

Each state had to submit a State Implementation Plan (SIP) which detailed the pollution abatement activities required of every major source of pollution in the high regulation counties. The 1977 Amendments made the SIPs both state and federal law. This statutory power enabled the EPA to use the judicial system to enforce their interpretation of the implementation plans. States that had failed to comply had construction bans imposed upon them, could have federal monies withheld, or have the EPA implement its own implementation plan. In 1979, except in Wyoming, all States had a construction ban in at least one county. The federal EPA could also take action against employers. The action against employers constituted the initiation of administrative orders, monetary penalties, civil and/or criminal actions against plants that did not comply. Greenstone (1998) details a number of studies that show that the enforcement of the Amendment did have noticeable effects.

The EPA lists the industries that it considers to be the emitters of pollutants, against all other non-emitting industries (see Greenstone, 1998). Table 2 lists the industries, the type of pollutant that each industry emits, and the conversion from the 1972 SIC (Standard Industrial Classification) to the 1970 and 1980 CIC (Census Industrial Classification). As Table 2 shows, industries could be emitters of more than one pollutant; 'metal mining', for example, emits ozone, sulphur dioxide, and total suspended particulates. The pattern of emissions across industries allows the categorization of them into 8 different grouped industries, depending on the pollutants they emitted. The fact that industries emitted a combination of the pollutants in most cases makes it necessary to simultaneously evaluate the four county regulations.

The structure of the regulation across the four pollutants gives rise to variation both across industries, but also across states, and across time. A workers employer was susceptible to the air pollution regulations along three dimensions. The first was along the spatial dimension. The regulations were to be monitored and enforced at the county level; counties were designated either high or low regulated. This controls for factors that are specific to the highly regulated industries and coincident to the onset of the regulation. The second dimension is that only the industries emitting in a high regulation county were regulated. For example, if a county was high regulated for sulphur dioxide, but not for ozone, firms in the 'miscellaneous plastic products' industry would be monitored, but those in the 'miscellaneous fabricated metal products' would not. This allows for factors that are common to industries within an area. The third source of variation is that the regulatory status of counties varied over time as their air pollution concentrations changed. This provides a longitudinal time variation.

This research design is argued to be credible for evaluating the relationship between environmental regulations on industrial activity on the basis that the regulations are federally mandated at the county level. The regulations are less likely to be related to the characteristics or underlying economic conditions across counties. Although the pollution levels are not completely assigned randomly to an area, chance factors (such as the weather and local topographical features) contribute to assignment that is independent to local industrial activity.

3. Data Sources and Data Construction.

The approach for this paper is to use the variation in environmental regulation, aggregated to the State level, across industries and time to identify the random displacement of workers from their jobs. This paper is an advance on the displacement and the cost of job loss literature as previous work suffers from the lack of identification over workers separating from their place of employment. Although data sets such as the DWS and PSID (Panel Study of Income Dynamics) have self-reported reasons for separation, there is no ready identification mechanism that randomly allocates workers out of jobs across the same industries. Changes in the environmental regulations varying across states, industry and time are used to provide the random variation to identify the displacement of workers and the associated costs that this might entail.

3.1. Data Sources

There are two separate data sources for the estimates. The first was to use the CPS and the DWS for information on workers. The DWS was preferred over the PSID or the NLSY (National Longitudinal Survey on Youth) for 2 main reasons. The first is that the DWS sample is that much larger than the PSID and NLSY with regard to displaced workers. The second is that the DWS is a specialist survey directed at obtaining information on displaced workers; workers separating from their previous employment for reasons of plant closure, or the extensive restructuring of employment. Although the DWS has its problems, the argument is that given the method, these problems are minor and the substantive results would probably remain unchanged in the light of more detailed data. Chiefly, the problems with the DWS are listed as a tendency for respondents to under-report earnings in the new job, a lack of a suitable comparison group, no knowledge of pre-displacement activity (job history), and a tendency for workers to not report the more remote instances of job loss (Jacobson, LaLonde, and Sullivan, 1993).

Given that the DWS data are used, the first problem is inescapable. Although the under reporting of earnings is a problem when comparing earnings differences for the displaced against those remaining, use of instrumental variables will remove some of the measurement error. The other point to make is that if there is a tendency to under-report current earnings, then the estimates will represent an upper bound on the potential lost earnings to displaced workers. In order to overcome the problem of a suitable comparison group, a series of cell means were constructed for the same industry/state/year cells as the displaced workers from the CPS (Farber, 1997). While this also has its own problems in terms of the selection of workers that are observed in a particular cell between two points in time, on average, this should provide a robust set of workers to act as a comparison to the workers in the DWS. The lack of any job history on the DWS respondents is perhaps the greatest omission in information on the displaced workers.[4] There is no way of correcting for this other than making an adjustment to the number displaced in each cell. Data Appendix 1 provides further details. Basically, the adjustment scales up the number of displaced by a given amount because certain individuals will tend to be displaced from their jobs more frequently than others at a longer time horizon (say 4 years). These individuals would contribute to an under count of the number of workers displaced in any industry/state/year cell. These individuals are also the same workers who are likely to forget the more remote instances of job loss simply because of the frequency with which they are displaced. This final problem is subsumed into the correction for repeat spells of displacement occurring by particular workers. This problem is compounded by the fact that the DWS only asks for information on the longest job loss if the worker has suffered more than one in the past five year period. An attempt is made to control for this by including the average number of jobs held by workers in a particular industry/state/year cell.

The results for this paper use industry/state/year cells. Data Appendix 1 provides a more detailed description on the construction of the industry/state/year cells from the CPS and DWS data. What is important to recognize is that the construction of the cells for the displaced, and the comparison group, contain the same variables. Each cell contained the following information for full-time workers (both at displacement and in their new job): the average log difference (post and pre displacement) of the weekly wage in 1992 dollars, the average age of the workers, the proportion of female workers, the proportion of non-white workers, the proportion in nine different occupational groups, the proportion that graduated college, high school, the proportion that finished some college,

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[4] See Ash and Kane (1999) for a detailed look at this problem. Data Appendix 1 provides details of adjustment on the basis of their calculations. A note should also be made that the correction made little difference to the substantive results on earnings loss, but did

whether the industry emitted a pollutant (and which type), the number of workers observed in each cell, the number of displaced workers (where relevant), the number of observations, the average number of weeks lost between jobs (where relevant), and the average number of jobs held between major employment spells (where relevant). The workers selected had been displaced for reasons of plant closing, job or position abolished, or slack work. While there are known reasons why it is preferable to use only the displaced workers by reason of plant closing (Gibbons and Katz, 1991), this left too few observations on displaced workers in the industry/state/year cells.[5] There are, however, a couple of arguments in favor of using all displaced workers (except 'other'). One argument is that regulated polluting industries are mainly comprised of blue-collar jobs. Gibbons and Katz (1991) results showed that workers in blue-collar jobs experienced little difference between post-displacement wages by reason of job loss within the DWS. The other argument is that environmental regulation should displace workers for reasons unconnected with individual worker performance, industry, or state wide demand shocks, and provides a further test on possible selection bias in estimating the cost of worker displacement.

3.2. Data Construction.

Working with industry/state/year cells does not affect inference if the objective is to obtain an estimate of mean effects. As the objective was to examine the average earnings loss from displacement for workers displaced from environmental regulation, working with cell means does not necessarily entail a loss of information. Working with industry/state/year cell means also meant the possibility of constructing a comparison group of workers for the same cells from the out-going rotation groups of the monthly CPS. This has a definite advantage. The DWS only records the year in which someone is displaced, not the month. Hence the comparison was the average weekly wage for workers in the CPS in any year with the wage at displacement from the DWS, and the January weekly wage for the observation year. The time frame was further restricted to the 1979-1992 period. The DWS for 1984, 1986, 1988, 1990, and 1992 was used to cover this time period. Each of these DWS contained a question that related to job displacement in the subsequent five years. This allowed the maximum retrospective history on job displacement consistent across the time frame.[6] Finally, working with industry/state/year cells allows the merging of worker information with the environmental regulation data. Matching at this level of aggregation was necessary on two counts. The first is that the environmental regulation data is (currently) only released at a county level as

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scale up the estimated number who lost their job by about a third.

[5] There are also issues of what type of job loss the DWS questions actually measure. Farber (1997) discusses the possibility that the distinction between quits and layoffs may not always be clear, and that the DWS may under state the extent of involuntary job loss. Gibbons and Katz (1991) find some evidence for this in their paper. If firms have discretion over who they layoff in an adverse demand shock, then they layoff the least able first. These workers, in an asymmetric information model, should have lower wages for their re-employment wage than observationally equivalent workers laid-off for reasons beyond their individual control, but have the same pre-displacement wage. A comparison of blue and white collar workers in the DWS for 1984 and 1986 found that white collar workers did suffer a decline in their re-employment wage, but that blue collar jobs were mainly unaffected.

[6] Farber (1997) and Topel (1990) argue that there may be substantial recall bias in the longer time frame of recalling job displacement. However, truncating the years of observation used, when the question refers to a longer time frame also entails a correction bias for omitted job separations. Farber (1997) provides details of such a correction using an outside source (PSID) of information on worker

a lowest level of spatial dis-aggregation. The second factor is that the public use files of the DWS only have the state level location identifier included within the file. It therefore became necessary to aggregate the county level observation on regulation to the state level.

Aggregation of the environmental regulation data to the state level was done on the following basis. For each county within a state, the county was designated either a high pollution (with a value of 1) or low pollution (with a value of 0) area for each type of pollutant. The state specific index for each pollutant was constructed by weighting the high-regulation county for that pollutant by the number employed in the pollution emitting industry. For example, suppose that a hypothetical state has 2 counties, and only 2 industries: steel and insurance. If total employment for the state equals 1800, 1200 in the low-pollution county and 600 in the high-pollution county, divided evenly between the two industries, then the regulation index would read 0.167. The environment regulation index varies with the number of counties in a state being regulated, and with the number employed in the designed emitting industries. Indices for each state were produced over time (as an annual indicator) and by industry: the eight types of polluting industry, manufacturing minus the polluting industries, services minus the polluting industries, and energy/construction minus the polluting industries. Data Appendix 1 contains further details.

The analysis concerns two questions. First, does the number of employed and the displacement rate, as measured by the CPS and the DWS, produce statistics in keeping with other work on the effects on employment in environmentally regulated industries? Second, as a consequence of the recorded job change, do workers displaced for reasons beyond their individual control suffer earnings losses? If they do suffer earnings losses, are the losses of equivalent dimensions when workers are randomly displaced because of the environmental regulation of industry?

Calculating employment was relatively straightforward. This was a simple count using the weights given in the CPS. Employment is defined as an individual working full-time in a private sector job for an employer.[7] Table 3 provides a summary of the overall level of employment from the CPS for the years 1979-92. Table 3 also gives the proportion in each of the pollutant emitting industries. The proportion figures were calculated as the number in the pollutant type of industry (as given on Table 2) divided by the total number employed. Obviously, some of the industries overlap into different types of pollutant, as shown on Table 2. What Table 3 illustrates is the approximate proportion of the population at risk from being displaced because of environmental regulation by each pollutant type. On average, for each type of pollutant, the population at risk constituted approximately 5-8 percent of the workforce. Table 3 also illustrates that the population at risk of displacement declined throughout the time period in all pollutant categories. The cause of the observed decline was not simply due to environmental regulation, it was

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separations.

[7] The paper concentrates on full-time workers as recorded in the CPS and the DWS to make the pre and post weekly wage comparisons

also the fact that the industries designated as pollutant emitting were also declining as a sector. The research design allows for these confounding factors by using emitting industries across high and low regulation areas, and over time.

The rate of displacement for each industry/state/year cell required some additional calculations. Rather than use the weights given in the DWS (attached to the displaced workers), an adjustment was made for the fact that some workers lose jobs more frequently than others did. The displacement rate was then the average number displaced in any cell as given by the adjusted weight (see Data Appendix 1), divided by the average number of people employed in that cell (given by the CPS weight). The displacement rate for industry *j*, in state *s*, in year *t* is denoted d_{jst}.

As the main focus of the paper is on the cost of job displacement, wage changes for workers experiencing the job loss are measured in relation to workers who remained in the same industry/state/year cell over the same time frame. Constructing the cell means as described in Data Appendix 1 implies that we are observing the average effects for workers when they are displaced against workers continually in a job. This method provides valid inference providing the averaging within cell removes any systematic bias towards particular groups of workers. Using cell means on age, gender, race, education, and occupation, we can control for a number of systematic differences across displaced and continuing workers. Providing other workers are randomly distributed across cell means, then cell means can provide a valid assessment of the average effects of displacement on workers earnings. However, there is the suspicion that worker selection effects operating across industries, between the displaced and the 'stayers', bias estimates of the cost of job displacement. In terms of the 'stayers', part of the problem relates to workers who may chose to take a cut in pay rather than lose their job. Worker behavior of this nature would understate the difference between earnings loss for the displaced against those who stay. For workers who leave, there are selection issues about which workers are displaced.[8]

For the inference to be valid, a comparison group for the displaced workers in the DWS from the CPS was constructed. The unit of observation was an industry/state/year cell, and a comparison group of the same cells was constructed from the CPS. For example, for examining the wage difference between workers displaced in 1986 in the DWS in 1988, condition on the characteristics of workers in the industry/state cell at the time of displacement. The difference in log weekly wages would be the observed 1988 (January) wage minus the reported 1986 wage. The comparison group from the CPS was constructed by taking everyone in the same industry/state cell in 1986, obtaining the weighted mean wage and characteristics. For the same industry/state cell from the 1988

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based on 'equal hours' jobs.

[8] Note that the analysis concentrates on the initial displacement of workers from a polluting regulated industry. There are also selection effects concerning the fact that only the workers who have found a job by the DWS survey date are observed. These selection issues are ignored.

CPS, weighted mean weekly wage (for January) were obtained and this figure was used to subtract the weighted average figure for the weekly wage for 1986. The mean characteristics of the workers referred to the industry/state cell for 1986. Obviously, such a method of choosing the comparison wage is open to problems of selection bias. However, given that the analysis is dealing with mean effects using industry/state cells, the positive and negative selection effects for the end wage may cancel each other out. Selection effects are discussed further in a later section.

Table 4 provides a comparison of the characteristics for the displaced workers, those displaced from polluting industries (across regulated and non-regulated areas), and all workers in the CPS sample.[9] On average, displaced workers, irrespective of industry, suffered an earnings loss of approximately 11 percent. Displaced workers were also younger and better educated. The difference between workers displaced overall, and those displaced from the polluting industries, is that the workers displaced from the emitting industries were more likely to be blue collar, male, have slightly longer weeks of joblessness, be more susceptible to displacement, are more likely to be given notice, and are also more likely to return to a polluting industry.

4. Estimation and Results.

If the ideal evaluation data for randomly assigning environmental regulation to establishments existed, and had individual worker and establishment data, then it would be possible to estimate a very simple displacement or earnings equation. In this hypothetical world, assigning regulatory status is random and therefore orthogonal to the observable or unobservable characteristics of workers. As described above, in Section 2, the variation in environmental regulation is argued to be independent of the workers. The variation in the environmental regulation of industry is used in a two-stage process. First, examine if there is any impact from the environmental regulation of industry on the displacement of workers. Second, if there is an effect on displacement, are there costs in terms of workers wages. The modeling strategy pursued here is analogous to Angrist (1990).

4.1. Evaluating the Effect of Regulation on the Rate of Displacement and Changes in Employment.

The following equation specifies displacement in a particular year for individual workers:

$$\delta_{ijst} = \tau_t + \zeta_s + \varkappa_j + R_{ijst}'\phi + X_{ijst}'\beta + \varepsilon_{ijst} \qquad (1)$$

where δ represents an indicator variable that takes a value of 1 if the worker is displaced, and 0 otherwise; i indexes the individual worker, j the industry, s the state, and t the year. R represents the index for environmental regulation as the employment-weighted proportion of the state under environmental regulation. X_{ijst} represents observable

[9] Table A4 in Data Appendix 1 provides similar summary statistics across time by DWS survey.

worker characteristics at the time of displacement. The regression error is ε_{ijst}. For the moment, assume that the observable characteristics are not important, and that environmental regulation is truly random across counties, then the estimation of the parameter (ϕ) could be reduced to $\phi = (\delta_1 - \delta_0)/(R_1 - R_0)$; where δ_1 is the displacement rate for the county from environmental regulation, δ_0 is the displacement rate for the non-regulated counties, and R is the corresponding environmental regulation designation. The ratio is simply an adjustment of displacement for environmental regulation; nothing other than the regulation matters in the differences in displacement across individuals. If the difference in displacement is solely the result of environmental regulation, then any cost of job loss is also a result of regulation, and can be estimated as a simple ratio where the numerator is the difference in wages between the displaced and the non-displaced.

The analysis will deviate in two ways from this ideal. The first is that, as already discussed, the assignment of regulation is not strictly random. The second is that we do not observe the individual worker being directly affected by the environmental regulation. In the first case, although environmental regulation is not strictly random, it is probably sufficiently orthogonal to worker characteristics to provide valid inference as an indicator for random assignment of displaced workers. In the second case, as the environmental regulation variables are aggregated at the state/industry level, the DWS/CPS cells are at the same level of aggregation. Aggregating to the industry/state level provides the same valid inference as individual worker data as the above example demonstrated. What needs to be considered further are the effects from heterogeneity (not all pollutant emitting firms were regulated) and covariates (employers may chose to layoff the least able first).

Non-random variation should not be a problem in identifying the effect on displacement and earnings from regulation. R can be broken down into 2 indicators: polluting industries that were regulated (φ_j R), and polluting industries that were not regulated ($(1 - \varphi_j)$R), so that R $= \varphi_j$ R + $(1 - \varphi_j)$R. As only the effect of regulation on displacement is being examined the ($(1 - \varphi_j)$R) effects will be subsumed into the error term. The other possibility is that there are unobserved variables about workers and these influence displacement at the occurrence of an adverse random shock to the firm.[10] If such selection effects occur, then instrumental variable estimates of the effects of regulation on earnings will be biased. If employers let the 'least able' workers go from an adverse change in environmental regulation, then comparing workers displaced for regulatory reasons from the workers in the same industry/state cell, would bias down their earnings profile vis-à-vis the other workers. Alternatively, if environmental regulation occurs with an adverse demand shock, and the employer has to layoff 'higher ability' workers, vis-à-vis workers staying in the same industry/state cell, this would provide an upward bias to the cost of displacement. These arguments can be ruled out to some degree as the descriptive statistics, presented on Table 4, show that there was little difference in terms of education between displaced for all reasons and displaced from

[10] Note that omitting observable characteristics between workers should not confound the overall effect from the regulation of industry. The only difference is that the estimates would be 'biased' indicators of the 'true' effect on displacement from environmental regulation.

polluting industries, although the number of blue collar workers was higher in the latter group. Further, given the averaging over time (1979-92), it is possible that both selection effects have been averaged from the results.

To establish if there is a link between displacement and the environmental regulation of industry the following equation was estimated:

$$d_{jst} = \tau_t + \zeta_s + \varkappa_j + (\varphi_j R)_{jst}'\phi + X_{jst}'\beta + \varepsilon_{jst} \qquad (2)$$

The displacement rate (d_{jst}) measures the probability that an individual is displaced in that industry/state/year cell. It is essentially the aggregated version of equation (1) by industry and state. The results of estimating equation (2) are given in Table 5. The basic pattern of results is that there is an effect from the environmental regulation of industry on the displacement of workers. Overall, across columns 1-4 on Table 5, the effect is broadly positive although there is a great deal of variation. The variation arises from the number and type of covariates included in equation (2). In column 1, of Table 5, the only variables in the regression were the industry/state regulation variables (the instrument set). The effects of ozone and total suspended particulates on the displacement of workers are well-defined and positive. For sulphur dioxide, the effects are positive, but poorly defined. The effect from carbon monoxide regulation was well-defined and negative.

Introducing different sets of control variables does alter the point estimates of the effects of environmental regulation on the displacement rate of workers, but the basic pattern remains the same. Generally, there is a positive effect on displacement from the regulation of emitting industries. Including human capital and occupation control variables does alter the point estimates, showing some form of correlation with displacement. Columns 2 and 3, on Table 5, show that displacement from ozone regulation is positively related with human capital characteristics. Other pollutants show signs of being correlated with industry and state as column 3 indicates. Column 4 (Table 5), shows that including all state, industry, and time effects, and all interactions of these various groups, drive the coefficients on the regulation variables to be poorly determined. Although the point estimates remain the same sign, the magnitude is significantly reduced when all interaction effects are included.

Nonetheless, there does appear to be an overall positive effect on displacement from the regulation of environmental pollution. One way of quantifying this is to estimate the implied change in employment, given the point estimates on Table 5. Using the point estimates as given in column 4, Table 5, and multiplying them by the average (weighted) employment in each pollutant group, approximately 60000 jobs were lost due to environmental regulation during the 1979-92 period. This figure takes account of state, industry, and time effects that would otherwise bias an estimate of the number of jobs lost from <u>only</u> the environmental regulation.[11]

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[11] To give some idea of the robustness on this figure we used the estimates in column 1, Table 5, in the same way, the approximate job loss is 300000. Although the figure for job loss varies, it is a negative amount that indicates that environmental regulations did have an

There are very few nationwide estimates in the literature on the magnitude of job loss from environmental regulation. The estimate given here is almost half of the amount estimated by Greenstone (1998). Greenstone (1998) measures employment loss as across county, but within state. States that suffer net losses against those that receive a net gain, would not show the total employment loss of polluting industries against non-polluting at the national level. Greenstone based his estimates on employment growth between Census of Manufactures and does not measure employment loss or gains directly; rather, the estimates are differences in growth between regulated vis-à-vis non-regulated plants. Further, Greenstone's (1998) figure applies to all jobs for employees; and covers the period 1967-87, a time when the tightening of regulations was greater than the 1979-92 period used in this paper.[12]

4.2. Estimates of the Cost of Job Displacement.

The figures from Table 5 indicate that there was a definite effect on job loss from the polluting industries that were regulated. The estimates are independent of industry, state and time effects, and represent the number of jobs lost for reasons of environmental regulation. There are two methods that will be used to try and estimate the cost of job displacement. The first is a simple difference in differences approach that uses the change in wages from the DWS, against the counterfactual group in the CPS. This is the direct approach and does not rely on any particular functional form; only that the estimate of the number of jobs lost is accurate. As the estimates of the number of jobs lost are conditioned on cell mean worker characteristics, and there is reason to believe that the selection effects on the average wage movements by industry/state/year cell will average each other out, then the estimate will be the 'true' average.

The second method, that does not directly address the cost of job loss, but rather estimates the effects of environmental regulation on the rate of job loss, and with it the degree of wage loss, is to use the environmental regulation variables as instruments in a wage equation. This does not give the same estimate as the first method, as a wage equation: $\Delta w_{jst} = X_{jst}'\beta + \theta d_{jst} + u_{jst}$ measures how wage changes differ with the rate of displacement. Instrumenting the displacement rate with the environmental regulation variables, the wage equation indicates the increased wage loss from displacement when displacement is thought to be random in nature. In short, it shows the correction for selection bias from measuring simple difference in difference estimate in wages from a particular set of displaced workers. In creating the displacement rate for each cell, workers displaced for all reasons (except other) had to used to create a sufficient number of workers per cell. If there is a measurement error problem, or a selection issue on the part of the workers in which individuals were displaced, then the instrumental variable

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effect.

[12] There are some other figures in the literature, but these relate to specific areas or industries. Morgenstern, Pizer and Shih (1998) estimate that the pulp and paper, plastics, steel, and petroleum industries lost 4700 jobs between 1984 and 1994. Berman and Bui (1997) argue that the Los Angeles South Coast Basin region actually gained 8500 jobs as a result of regulation over the period 1979-91. Jaffe et al (1995) summarize the other results on employment and show that the results are mixed.

method would provide an unbiased estimate of the wage change from the rate of displacement. Once the coefficient is obtained, it is possible to estimate the increased wage change from being displaced because of environmental regulation.

Method 1: Difference in difference approach.

The difference in difference approach is the most straightforward. This is simply estimating the change in wages for the displaced workers relative to their counterfactual wage change from the same industry/state/year cell. Simply stated: Δw_{DWS} minus Δw_{CPS} equals the adjusted wage difference from displacement because of environmental regulation. It is the wage difference measure from individuals displaced from monitored polluting industries.

Table 6 presents the results. The figure of 60000 jobs lost from Table 5 is the starting point for the overall figure of the cost of the environmental regulations. The wage change from job displacement from the DWS (for regulated polluting industries) was –0.076, the counterfactual wage change from the CPS over all industries and states was 0.023. The difference of –0.099 represents the approximate 10 percent loss in wages displaced workers experience being displaced from regulated polluting industries over all other industries. Multiply the average wage loss by the average wage these workers receive before displacement from Table 4, and this gives the average lost pay for the average displaced worker from regulated polluting industries. The average weekly wage for workers displaced from the polluting industries was $397.81 (in 1992 dollars). The average wages lost (in 1992 dollars) was approximately $39 per week. Multiplied by 52 (weeks) and by the 60000 jobs lost from regulated polluting industry's gives a rough estimate of $123 million as the annual average wages lost from displacement for workers in 1992 dollars. It should be noted that this is a limited cost estimate and does not account for workers in not employed at the time of the DWS survey, the potential continued loss of wages over the workers career path, or any other costs imposed on workers and their families.[13]

The estimate on the cost of job displacement is dependent to some extent on the choice of the counterfactual wage. To examine the extent by which the estimate of job displacement varies with the choice of the counterfactual wage, Table 6 calculates the cost of job loss using two different estimates of the change in wages over the same time period. The first uses wages in all other industries except the polluting ones. Polluting industries (as Table 3 indicated) were in decline over the 1979-92 time period. It is unlikely that workers would have found re-employment (not re-called to the same job) in the same industry. Using the counterfactual wage from the CPS for this group of industries provides an estimate (given on Table 6) of $136 million. Although an increase, it does not differ greatly from the previous estimate.

Likewise, the second alternative calculation, which supposes that all displaced workers found jobs in the polluting industries, shows an overall cost of approximately $80 million. The estimate for the cost of job displacement, in terms of the annual average wages lost by individuals, lies somewhere in the range of $80 to $136 million. As a 'raw' estimate of the cost of job displacement from environmental regulation, the figure is reasonably low. It might be noted though that this is a simple 'annual' average cost calculation based on the wage data given. The 'true' cost will be borne for years to come for the workers that were displaced by the environmental regulations. Further, there are no counter estimates of the benefit from environmental regulation that may increase life expectancy, or benefit living conditions.[14] The cost estimate is purely in terms of the average annual wages lost by individuals, and does not include any other pecuniary costs that may have been incurred by these individuals (and perhaps their families) in moving from one job to another.

Although the estimate seems low, there are obvious selection problems (discussed earlier) in using the CPS as a counterfactual to the small number of workers from the DWS who are recorded as losing their job for reasons beyond their control. In particular, there is the concern that the workers in the DWS may have done so because they were fired, but reported on the DWS that their shift was abolished. This would lead to a negative selection problem and would over state the cost of displacement in terms of lost earnings for the displaced workers. Workers who were displaced with some form of negative selection would have lower earnings than the comparison group without job loss.

As an attempt to gain an estimate on the extent of selection bias contained in the figures on Table 6, Table7 provides a comparison by initial wage before displacement. The ratio compares the average wage for CPS for a particular industry (j) and time (t), with the wage of the individual (i) from the DWS for the same industry and time (w_{ijt}DWS/w_{jt}CPS). If the workers displaced are the same on average as the average for the same industry/year cell from the CPS, then there is little selection bias and the ratio would sum to one. The ratio on Table 7 shows that across nearly all the industries (the exception being energy and construction minus the polluting industries), the average wage for the displaced workers was lower. The results indicate that although slight, there is a negative selection bias on the part of workers being displaced. The displaced workers in the polluting industries did not seem any different from displaced workers in any other industry.

Method 2: Instrumental Variable Approach.

Another means of estimating the cost of job displacement is to try and obtain estimates for the change in wage from

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[13] Jacobsen et al. (1993) show that wage losses are sustained over the long-term and persist some years after job displacement.
[14] See papers by Chay and Greenstone (1999, 2000).

the displacement in the regulated polluting industries. The difference in log weekly wages (Δw_{jst}) was estimated with the following model:

$$\Delta w_{jst} = X_{jst}'\beta + \tau_t + \zeta_s + \varkappa_j + \theta d_{jst} + u_{jst} \qquad (3)$$

$$d_{jst} = (\varphi_j \, R)'\gamma + e_{jst}$$

where u_{jst} is a random error term.[15] By instrumenting d_{jst} with the state-wide variation in environmental regulation, across industry groups, workers are effectively allocated into the displaced category that is independent of their own characteristics, location, time, and industry.

To assess the costs of job loss from environmental regulation using equation (3), compare the costs of job loss in the absence of regulation, before considering the effects of regulation itself. Table 8 presents the estimates of displacement on earnings difference for all industries and the polluting industries. The results on Table 8 (upper tableau) shows that for all industries, across a number of different specifications, the difference in earnings from being displaced against staying in the same industry/state/year cell is of the order of 11-13 percent independent of individual demographics, industry, state, or year. This figure is in close agreement with Farber (1997), but lower than the suggested earnings losses in Jacobson, LaLonde and Sullivan (1993).[16]

The lower tableau on Table 8 shows the results for only the polluting industries. The same negative pattern is observed for the polluting industries as for the whole sample. Workers lose, on average, approximately 9-14 percent depending on the number and type of control variables included in the regression. There is little reason to suppose, on the basis of these estimates, that the workers in the polluting industries suffered a greater cost of job displacement over workers in any other industry. Obviously these estimates are potentially biased from selection effects on the part of workers. As the displacement figures include all reasons listed on the DWS questionnaire (apart from 'other'), they potentially suffer from reporting bias (Farber, 1997) or selection bias (Gibbons and Katz, 1991). The random displacement of workers can be approximated by using the environmental variables as instruments for the displacement rate.

Table 9 presents the results from estimating equation (3), using the environmental regulations as instrumental variables. Initially, (columns 1 and 2) on Table 9, the results show that the cost of job loss is greater (3 times higher) once the displacement rate is instrumented with the regulation variables. A larger wage loss implies that there is a large selection effect with OLS estimation that under-estimates the 'true' earnings loss from displacement. In the absence of conditioning on the observable quality of the workers, the OLS estimates appear to be biased upwards.

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[15] By analogous reasoning from equation 1, equation 3 could be written out for the individual worker as: $\Delta w_{ijst} = X_{ijst}'\beta + \tau_t + \zeta_s + \varkappa_j + \theta d_{ijst} + u_{ijst}$

[16] This may partially relate to the fact that tenure in the job was not available from the monthly CPS files, nor was it available for the post-displacement job in the DWS. As we wished to construct a set of comparison groups from the CPS for the DWS sample, we omitted the previous job tenure variable from the industry/state cells.

This indicates that lower quality workers based on observable characteristics are being laid-off first, endorsing Gibbons and Katz (1991) results.[17]

Once state and industry effects are included in the regression (column 3, Table 9), the effect of displacement from environmental regulation is essentially zero.[18] The coefficients on Table 9 (columns 3 and 4) shows that the cost of job loss is not significantly different from zero at almost any selected level of significance.[19] This implies that for workers being randomly displaced by changes in environmental regulations over industry and state, there is little or no increased cost to displacement. The random displacement from polluting industries indicates that the OLS estimation of wage differences due to displacement is biased down.

This downward bias may arise from the composition of displaced workers that are actually used. All workers displaced for reasons of plant-closing, slack work, or position abolished were used. There are obvious differences in the selection of workers to be displaced among these categories. Work by Gibbons and Katz (1991) and Farber (1997) shows that the plant-closing workers suffer less in comparison with others. However, there is still a cost to displacement for these workers too. Non-random selection from being displaced in an industry/state/year cell may be due to workers attributing displacement to slack work or position abolished, rather than claim they were dismissed or quit. Workers dismissed for reasons dependent on their performance would carry a negative signal into the next job. A worker displaced for reasons of environmental regulation would carry no such signal as they lost their job for reasons beyond their individual control.

The other result from Table 9 is that the instruments fail to reject the null (of independence) in the over-identification test. Each of the instruments would give a different result; that is, they affect the wage difference from displacement in different ways. As a check on this, a series of just identified versions of the model (equation 3) were estimated with each type of pollutant in turn. The results show that the coefficient on displacement does vary with the type of pollutant being regulated, but that none of the coefficients are significant (at any normally acceptable levels of significance).[20]

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[17] The implied figure of 30 percent on average is not far from the estimates of 25 percent from Jacobson, LaLonde and Sullivan (1993) and Schoeni and Dardia (1998) when conditioning on the observable characteristics of worker and the jobs from which they were displaced. Both Jacobson *et al* (1993) and Schoeni and Dardia (1998) use state UI data to examine earnings loss in an 'event history' type framework. Their analysis suffers from a lack of knowledge on the cause of displacement so that any selection effects on the part of workers in vacating their job remain unknown.

[18] Industry or state effects accounted for practically all the difference in wages between the pre and the post displacement job. Separate regressions of equation 3, omitting either states or industry effects, gave a coefficient (and standard error) of –0.032 (0.245) or –0.029 (0.167) respectively.

[19] It made no difference if the contemporaneous or lagged (by one or two periods) regulation variables were used.

[20] As the wage difference may vary over the time between displacement and the observation wage, we examined if the cost of displacement varied over the five-year time horizon. Results (on request) show that the costs of displacement did indeed vary over the five-year time horizon. Taking all CPS/DWS cohorts together indicates that the cost of displacement varies over the time since displacement. The OLS results show that even after 5 years, workers displaced from the previous job earn approximately 20 percent less than workers remaining in the same industry and state. The results also showed that the wage lost was far from constant over the five-year time frame. At different time intervals from displacement, the point estimate varied between 0.055 and –0.209. Apart from the

The results from Tables 8 and 9 can be used to provide an estimate in comparison to the difference in differences approach above. The difference between the estimates here and those on Table 6 is that the instrumental variable estimates will allow for the difference attributable to selection bias. If equation (3) is re-specified, ignoring the other variables: $\Delta w_{jst} = \alpha + \theta d_{jst}$, then the equation effectively measures the change in wages from the rate of displacement. In this context the constant (α) is the average wage loss for workers. The estimated parameter (θ) provides the variation in wage differences from the variation in displacement. The expected wage difference, given that a worker is displaced, is dependent on the estimate of the slope parameter (θ) and the expected displacement rate for the polluting regulated industries. Two estimates for θ are given on Tables 8 and 9. From Table 8 the OLS estimate for θ is approximately –0.086. From Table 9 the instrumental variables estimate of θ is basically zero. The expected increase in the rate of displacement from the regulated polluting industries is the polluting displacement rate minus the average displacement rate. From Table A3, this is 0.22 minus 0.9 (equal to 0.13). The average wage change from method 1 was -0.099 (see Table 6). Hence, for the equation $E[\Delta w \mid \text{displaced}] = E[\alpha] + \theta E[R]$, the OLS estimate, that is potentially biased because of the non-random displacement of workers, is –0.099 – 0.086*0.13, which equals –0.110. This is similar to the estimates from Table 6. The cost of job displacement would not be significantly greater than the estimates on Table 6. By comparison, calculating $E[\Delta w \mid \text{displaced}] = E[\alpha] + \theta E[R]$ using the IV estimate would result in the calculation: -0.99-0.016*0.13, which equals –0.101. The difference due to selection bias is not large, and the estimated cost of job displacement would lie within the range given on Table 6: between $80 - $136 million.

5. Conclusions

This paper is only a first step towards understanding if environmental regulation does have a cost in terms of worker displacement. The estimates relate to the cost to workers in terms of earnings between their previous main job and the job they currently hold at the time of the DWS survey. There is no ruling out that there are very real costs associated with job loss in terms of non-pecuniary factors (uncertainty of the future once job loss occurred, the possible break down of social relations around an employer, the search process and emotional costs imposed on the individual). The estimates are also devoid of any pecuniary costs imposed on the individual (and perhaps their families) such as earnings lost during the possible unemployment spell, or any costs involved in possibly changing location. As such, the results relate to whether the average annual earnings loss from being displaced due to environmental regulation.

estimates for 3 and 5 years, all others were not statistically different from zero. The IV results were poorly determined, although the pattern of the coefficients indicates that the earnings loss from the displacement was greater for those displaced further back in time.

The estimates are produced from data aggregated into industry/state/year cell means as this is all that publicly available data allows in terms of spatial dis-aggregation. Underlying the conclusions from the results were a number of untested aggregation assumptions that at the present time cannot be commented on. However, for the results measuring an average effect on earnings from displacement due to environmental regulation, the use of cell means was both tractable and valid for inference. The estimate of the number of workers losing their job due to environmental regulation was of the order of about 60000. This figure is lower than previous national estimates in the literature and may be due, in part, to the aggregation assumptions inherent in our identification of polluting industries and states. However, it appears that environmental regulation does have a noticeable effect on worker displacement. The estimate of the cost to workers, in terms of average annual wages, appears to lie in the range of $80 - 136 million. Allowing for the potential selection effects of workers does not alter this conclusion.

Further work is required, at a more detailed level of dis-aggregation (both over location and over industry) to discover if this is in-fact the case. Work along the lines of Greenstone (1998) provides reason to believe that at a more dis-aggregated level, it might be possible to disentangle if environmental regulation does cause firms to shed workers, and (providing worker records between firms can be traced) whether there are any temporary or lasting costs of displacement to individuals.

Table 1: Selected National Ambient Air Quality Standards (NAAQS)

Pollutant	Maximum Allowable Concentration (Primary Standard)
Carbon Monoxide (CO)	
Max 8 hour concentration	9 ppm *
Max 1 hour concentration	35 ppm *
Sulphur Dioxide (SO_2)	
Annual arithmetic mean	.03 ppm **
Max 24 hour concentration	.14 ppm **
Ozone (O_3)	
Max 1 hour concentration	.12 ppm *
Total Suspended Particulates (TSP)	
Annual geometric mean	75 mg/m^3 *
Max 24 hour concentration	260 mg/m^3 *

Notes

ppm = parts per million; mg/m^3 = micrograms per cubic meter.
* Not to be exceeded more than once a year.
** Never to be exceeded.

Table 2: Pollutant Industries and Types of Pollution Emitted.

Industry Description	CO	O_3	SO_2	TSP	1972 SIC	1970CPS	1980CPS
Metal mining		X	X	X	100-109	047	040
Nonmetallic mining & quarrying , except fuel		X	X	X	140-149	057	050
Pulp, paper, & paperboard mills	X	X	X	X	261-263	328	160
Newspaper, printing, & publishing		X			271	338	171
Printing, publishing, & allied industries, except newspapers		X			272-279	339	172
Plastics, synthetics, & resins		X			282	348	180
Drugs		X			283	357	181
Soaps & cosmetics		X			284	358	182
Paints, varnishes, & related products		X			285	359	190
Agricultural chemicals		X			287	367	191
Industrial & miscellaneous chemicals	X	X	X	X	281,286,289	368	192
Petroleum refining	X	X	X	X	291	377	200
Miscellaneous petroleum & coal products			X		295,299	378	201
Tires & inner tubes		X	X		301	379	210
Other rubber products, & plastics footwear & belting		X	X		302-304,306	379	211
Miscellaneous plastics products		X	X		307	387	212
Logging	X	X		X	241	107	230
Saw mills, planning mills, & millwork	X	X		X	242,243	108	231
Wood buildings & mobile phones	X	X		X	245	109	232
Miscellaneous wood products	X	X		X	244,249	109	241
Furniture & fixtures		X			250	118	242
Glass & glass products	X	X	X	X	321-323	119	250
Cement, concrete, gypsum & plaster products	X	X	X	X	324,327	127	251
Structural clay products	X	X	X	X	325	128	252
Pottery & related products	X	X	X	X	326	137	261
Miscellaneous nonmetallic mineral & stone products	X	X	X	X	328,329	138	262
Blast furnaces, steelworks, rolling & finishing mills	X	X	X	X	331	139	270
Iron & steel foundries	X	X	X	X	332	147	271
Primary aluminum industries	X				333-336	148	272
Other primary metal industries	X		X		336-336,339	149	280
Cutlery, handtools, & other hardware		X			342	157	281
Fabricated structural metal products		X			344	158	282
Miscellaneous fabricated metal products		X			341,343,347,349	168	300
Not specified metal industries		X				169	301
Motor vehicles & motor vehicle equipment		X	X	X	371	219	351
Electric light & power		X	X	X	491	467	460
Electric & gas, & other combinations		X	X	X	493	468	462

Table 3: Fraction of Employment Potentially Affected by the Environmental Regulation.

Year	Total Employment in All Industries	Proportion in CO emitting industries	Proportion in SO_2 emitting industries	Proportion in O_3 emitting industries	Proportion in TSP emitting industries
1979	73876	0.066	0.078	0.085	0.075
1980	74165	0.063	0.073	0.081	0.070
1981	75121	0.060	0.066	0.077	0.066
1982	73707	0.061	0.071	0.082	0.068
1983	74283	0.050	0.055	0.070	0.057
1984	78384	0.049	0.054	0.068	0.055
1985	80993	0.048	0.054	0.068	0.054
1986	82651	0.047	0.052	0.065	0.052
1987	84948	0.045	0.050	0.065	0.051
1988	87824	0.043	0.053	0.066	0.051
1989	90116	0.042	0.051	0.063	0.049
1990	91115	0.040	0.050	0.060	0.048
1991	89854	0.039	0.052	0.061	0.047
1992	89959	0.039	0.052	0.062	0.046

Table 4: Descriptive Statistics on the Workers in the CPS/DWS files, 1979-1992.

	Entire Sample	Displaced	Displaced from Polluting Industries
Δ in log real wage	0.030	-0.110	-0.115
	(0.280)	(0.487)	(0.507)
Previous wage		416.199	397.812
		(177.386)	(165.554)
Post wage		374.954	356.782
		(209.563)	(197.042)
Age*	35.680	32.067	32.482
	(5.601)	(10.130)	(10.154)
Female	0.274	0.414	0.288
	(0.239)	(0.492)	(0.453)
Blue Collar*	0.546	0.450	0.684
	(0.299)	(0.497)	(0.465)
College graduate	0.048	0.110	0.105
	(0.114)	(0.313)	(0.307)
High-school graduate	0.544	0.472	0.523
	(0.247)	(0.499)	(0.500)
Previous tenure		4.406	5.257
		(7.527)	(7.893)
Weeks of joblessness		20.836	22.402
		(62.491)	(40.861)
Number interim jobs		1.979	1.970
		(1.291)	(1.305)
Plant closing		0.436	0.448
Notice given		0.329	0.430
Post polluting industry		0.106	0.302

Notes

Figures in parentheses are standard deviations. * Indicates the value before displacement. All wage values are in 1992 dollars.

Table 5: Effects of Environmental Regulation on the Displacement Rate of Workers: CPS-DWS 1979-92.

DEPENDENT VARIABLE = DISPLACEMENT RATE	[1]	[2]	[3]	[4]
Carbon monoxide	-0.104	-0.088	-0.101	0.013
	[0.041]	[0.034]	[0.029]	[0.012]
Sulphur dioxide	0.008	-0.047	0.123	0.012
	[0.073]	[0.069]	[0.058]	[0.010]
Ozone	0.088	0.156	0.086	0.005
	[0.044]	[0.048]	[0.041]	[0.002]
Total suspended particulates	0.163	0.134	0.062	0.002
	[0.046]	[0.038]	[0.033]	[0.001]
Joint F-test on environmental regulations (4, 15872)	4.74	6.38	6.97	4.05
	[0.000]	[0.000]	[0.000]	[0.003]
Joint F-test on occupational dummies (10, 15872)		54.43		3.05
		[0.000]		[0.001]
Joint F-test on industry dummies (10, 15872)			81.58	8.05
			[0.000]	[0.000]
Joint F-test on state dummies (49, 15872)			9.31	1.37
			[0.000]	[0.047]
Implied number of job losses	300000			60000

Notes

Standard errors in parentheses; p-values in parentheses on F-tests.
Column [1] control variables were dummies for regulated industries, regulated states. Column [2] control variables were age, female, non-white, schooling, occupation dummies, regulated industries, and regulated states. Column [3] control variables were regulated industries, regulated states, industry dummies, state dummies, and time dummies. Column [4] control variables were regulated industries, regulated states, industry dummies, state dummies, time dummies, regulated industry/state/time interaction dummy variables, age, female, non-white, schooling, occupation dummies.

Table 6: Difference in Difference Estimates of the Cost of Job Displacement.

	Wage difference	Average weekly wage at displacement	Number of jobs lost	Total cost of displacement
Δw_{DWS} polluting & regulated	-0.076			
Δw_{CPS} all industries	0.023			
Difference ($\Delta w_{DWS} - \Delta w_{CPS}$)	-0.099	$397.81	60000	$122875532
Δw_{DWS} polluting & regulated	-0.076			
Δw_{CPS} all non-polluting industries	0.034			
Difference ($\Delta w_{DWS} - \Delta w_{CPS}$)	-0.110	$397.81	60000	$136528392
Δw_{DWS} polluting & regulated	-0.076			
Δw_{CPS} polluting & regulated industries	-0.009			
Difference ($\Delta w_{DWS} - \Delta w_{CPS}$)	-0.067	$397.81	60000	$79434680

Notes.

All figures are in 1992 dollars.
Calculation of total cost of displacement = Difference ($\Delta w_{DWS} - \Delta w_{CPS}$) * Average weekly wage at displacement(*52) * Number of jobs lost.

Table 7: Examining Selection Bias in Displaced Workers relative to the Workers in the same Industry/Year cell using Pre-Displacement Wages.

Industry	$\Sigma_t\, w_{jt}CPS$	Σ_t (median $w_{ijt}DWS$)	Σ_t ($w_{ijt}DWS$ / $w_{jt}CPS$)
1	6.201	6.133	0.989
2	6.296	6.219	0.988
3	6.082	5.931	0.975
4	6.202	6.095	0.983
5	6.049	5.923	0.980
6	5.932	5.871	0.989
7	6.223	6.085	0.978
8	6.150	6.094	0.992
9	6.080	5.961	0.980
10	5.952	5.958	1.001
11	5.962	5.887	0.988

Notes

Industry codes 1-8 represent the combination of pollutant types (see Table 2). Industry code 9 represents all Manufacturing except the polluting industries; code 10 represents energy and construction except the polluting Industries; code 11 represents the service sector.

Data Appendix 1: Aggregation to Cell Means and the Construction of Comparison Groups Using the CPS and DWS.

To provide inference on the average effects of environmental regulation on displacement and the earnings of workers, the bi-annual Displaced Worker Supplements to the Current Population Surveys for the years 1984 to 1992 (inclusive) were used. The cell means for job switchers and the comparison groups were constructed in the following manner.

Cell means by industry/state/year for the displaced workers were constructed by stacking the 5 separate DWS files. Cell means, by year of displacement, were provided on worker age, education, race, gender, and occupation. Age of the worker was adjusted by years since displacement for the pre-displacement job. The sample was restricted to workers who were aged between 16 and 60 at displacement. The sample was further restricted to individuals who worked in full-time private sector jobs both at displacement and in the new job. Farber (1997) details that hours can vary in the move. Workers had to record a wage in both the old job and the new one. A further restriction was made in that workers had to have separated for reasons of: plant closed down, slack work, position or shift abolished. A restriction on only plant closing down led to cell sizes that were too small to provide useful information. The sample as described provided the pattern of observations for displaced workers by year of survey as given on Table A1. Obviously, for some of the years at the beginning and end of the sample period the industry/state/year cells are very small, and in some cases contain zero entries.

There are question marks over whether or not this is the best procedure. All five years worth of the retrospective data were used to maximize the number of displacement observations. While this procedure maximized the observations available to us, it also has its problems. Other authors (Farber, 1993, 1997; Topel, 1990; Ash and Kane, 1999) who have used the DWS to assess job loss in the same manner have mainly worried over 2 factors. The first is recall bias. The further back in time an individual is asked to remember whether or not they lost a job, the more likely they are to overlook a more recent job loss event. There are a number of socio-economic reasons why some events in the past appear more important, and are usually connected with factors other than the event of losing their job. Recall bias is a random event that is essentially non-correctable within the confines of the data. Forgetting to recall certain job loss events in the past puts a downward bias on the job loss statistics.[21] An option that could be pursued would be to truncate the number of past years considered. Although the question asks the workers to recall over a five-year time period, only a two or three year time horizon for job loss could have been used.

This would introduce a second source of bias. The workers who were part of the DWS were asked to recall over a five-year time horizon. Truncating the observations used over a two or three-year time period would miss out on potential job losses that occurred during that time period as some workers could recall a more major job loss event over the extended time horizon. Once again, this introduces a downward bias to the job loss statistics. Farber (1993) truncates the observations used and argues that as the bias was consistent across the DWS for 1984-92, then using the truncated time horizon does not present a problem and is preferable as it removes some of the recall bias. Farber (1997) uses the DWS 1984-96. A change to the question on job displacement over a particular time horizon created problems for comparability between the DWS 1984-92 and the DWS 1994-96. Farber (1997) proposes an adjustment based on the PSID.

The displacement rate for a particular industry/state/year cell was calculated in the following manner. To obtain the representative number of individuals in a cell who are displaced the observations were weighted by the DWS weight. A second adjustment was made for the likelihood of obtaining individuals who repeatedly lost their job. This was done by multiplying the displacement number by a factor for each year from the ratios given in Ash and Kane (1999). Table 2 from Ash and Kane (1999) that describes the actual pattern of job displacement for male head of households in the PSID was used, as against the implied pattern of displacement from a DWS style of job

[21] A further complication is added by the fact that the DWS asks workers about their most prominent job loss. As all workers were used, irrespective of whether they report losing one or more jobs, this biases the displacement rate downward by a further degree.

selection. To provide an adjusted index the numbers observed from the DWS in index form (with the years 1983, 1985, 1987, 1989, and 1991 as 1) were then multiplied by the index from Table 2 in Ash and Kane (1999). This gave an adjusted displacement index for industry/state cells by year. For example, measuring the displacement of workers in 1981, for the 1984 DWS, multiply the average number displaced from an industry/state cell by 1.11. For years where the DWS surveys over-lapped, for example in 1985, take the average of the adjusted average displacement for each industry/state cell for the three years.

The displacement rate was then calculated as the adjusted average number of displaced in a specific industry/state/year cell by the average number of workers employed in that cell. To provide the comparison group for the year of displacement, use was made of the monthly out-going rotation group CPS files. As the month of separation was not known from the DWS files, the monthly CPS files were aggregated into yearly files and from these the average weighted industry/state/year cell means were constructed to act as the comparison observation for the year of separation DWS industry/state/year. All wage observations were appropriately indexed to provide real wages in 1992 dollars. Tables A2 and A3 provide a description of the number of observations for each year from the CPS and DWS, the number of industry/state/year cells available, and the average characteristics of workers by data set. Table A2 shows that the workers in the polluting and regulated industries had a far higher displacement rate than all other industries.

Coding conversions had to be made for industry, first from the SIC (Standard Industrial Classification) codes for the 1970 CPS code (1979-83), and then to the 1980 CPS code (1983-92). The conversions for the pollutant industries are given in Table 2. The Table details which industries are regarded as polluting and which type of pollutant they emit. A conversion also had to be undertaken for occupation and education. Occupation codes changed in the same years as industry. Education codes changed for the 1992 CPS. A conversion table produced by Kominski and Siegel (1992) was used to convert from years to the grade classification system. One of the surprising statistics from Table A4 is that the proportion of workers being displaced with a College education during the 1990-92 recession fell dramatically.

To try and keep the number of 'zeroed' cells to a minimum (cells with zero observations) 11 industry groups were designated. Eight different polluting industries given by the pattern of pollutants they emit: for example, just ozone, or ozone, carbon monoxide and sulphur dioxide. The three other groups were manufacturing (minus the polluting industries), energy, quarrying, mining, and construction (minus the polluting industries), and services. This gave a maximum possible number of industry/state/year cells for the 5 year cohort DWS (stacked over the five surveys used) as 2750 for each DWS cohort, or 13750 overall. The 15872 cells available for use are for the industry/state/year cells from both the DWS and CPS combined (a possible 27500 maximum). Table A3 describes the number of cells by DWS dataset.

Table A1: Number of Worker Observations for the Displaced Worker Supplements by Survey Years.

	Displaced Worker Supplement					
Year of Displacement	1984	1986	1988	1990	1992	Total
1979	396	0	0	0	0	396
1980	576	0	0	0	0	576
1981	717	483	0	0	0	1200
1982	895	663	0	0	0	1558
1983	674	622	425	0	0	1721
1984	0	625	458	0	0	1083
1985	0	632	610	406	0	1648
1986	0	0	646	492	0	1138
1987	0	0	586	542	374	1502
1988	0	0	0	486	423	909
1989	0	0	0	553	617	1170
1990	0	0	0	0	623	623
1991	0	0	0	0	694	694
1992	0	0	0	0	0	0
Total	3258	3025	2725	2479	2731	14218

Table A2: Estimated Weights for Displacement in the Displaced Worker Supplement.

	Weighted Index by Year				
Year of Displacement	1984	1986	1988	1990	1992
1979	0.75				
1980	0.89				
1981	1.11	0.90			
1982	1.62	1.67			
1983	1.00	1.07	1.06		
1984		1.08	1.06		
1985		1.00	1.41	1.13	
1986			1.49	1.39	
1987			1.00	0.86	0.56
1988				0.96	0.59
1989				1.00	0.82
1990					0.85
1991					1.00
1992					

Notes:
Source: Ash and Kane (1999).

Table A3: Summary Statistics on the Number of Observations and the Displacement Rate from the Displaced Worker Supplement (DWS) and the Current Population Survey (CPS): 1979-92.

	Number of Observations	Number of Cells	Displacement - Polluting/ regulated industries	Displacement - All other industries	Displacement - All industries
DWS 84	17615	959	0.26	0.11	0.13
CPS 84**	498208	2304			
DWS 86	17622	927	0.23	0.10	0.11
CPS 86**	482705	2295			
DWS 88	16908	779	0.19	0.09	0.10
CPS 88**	532241	2364			
DWS 90	16606	720	0.14	0.07	0.08
CPS 90**	533266	2394			
DWS 92	15987	766	0.25	0.11	0.12
CPS 92**	519616	2364			
Total		15872			

Notes
** Refers to the number of observations available for the January CPS of that year, and the aggregated number of monthly files for the preceding 5 years. For example, CPS88 refers to January 1988 and the aggregate number of observations for the 5 years: 1983-87 for all individuals with valid wage observations.

Table A4: Summary Statistics for the Displaced Worker Supplement (DWS) and the Current Population Survey (CPS) 1979-92.

	Δlog(wage)	Age	Female	College grad	HS grad
DWS 84	-0.240	31.220	0.303	0.128	0.536
	(0.445)	(7.847)	(0.354)	(0.249)	(0.384)
CPS 84*	-0.017	35.884	0.234	0.036	0.545
	(0.238)	(5.689)	(0.217)	(0.072)	(0.236)
DWS 86	-0.072	31.706	0.341	0.142	0.516
	(0.257)	(7.826)	(0.373)	(0.280)	(0.398)
CPS 86*	0.002	36.059	0.261	0.043	0.548
	(0.257)	(5.882)	(0.244)	(0.104)	(0.253)
DWS 88	-0.058	32.782	0.302	0.147	0.488
	(0.509)	(8.353)	(0.367)	(0.293)	(0.414)
CPS 88*	0.013	36.447	0.265	0.040	0.553
	(0.189)	(3.868)	(0.167)	(0.059)	(0.158)
DWS 90	-0.050	33.111	0.394	0.034	0.555
	(0.512)	(7.692)	(0.390)	(0.122)	(0.389)
CPS 90*	0.016	36.432	0.272	0.042	0.557
	(0.178)	(3.889)	(0.170)	(0.065)	(0.167)
DWS 92	-0.116	33.386	0.370	0.022	0.429
	(0.473)	(8.464)	(0.414)	(0.116)	(0.433)
CPS 92*	0.010	36.736	0.276	0.039	0.568
	(0.188)	(3.462)	(0.161)	(0.049)	(0.149)

Notes:
Standard deviations are in parentheses.
* Refers to the Means and (Standard Deviations) for up to five years from that date for the characteristics in the cell at the time of displacement recorded in the DWS.
Δlog(wage) = the log difference in real weekly wages (in 1992 prices); Age = the average age at displacement, or the average age of the comparison group at the displacement date; Female = the proportion female; College grad = the proportion of College graduates; HS grad = the proportion of high-school graduates.

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Table 8: OLS Estimates of Displacement on the Difference in Wages for all Industries and Polluting Industries: CPS-DWS 1979-92.

DEPENDENT VARIABLE = LOG CHANGE WEEKLY WAGE	[1]	[2]	[3]	[4]
All Industries.				
Displacement Rate	-0.137	-0.122	-0.152	-0.108
	[0.013]	[0.019]	[0.035]	[0.052]
Joint F-test on occupational dummies (10, 15872)		11.05	9.05	8.78
		[0.000]	[0.000]	[0.000]
Joint F-test on industry dummies (10, 15872)			2.60	10.76
			[0.004]	[0.000]
Joint F-test on state dummies (49, 15872)			5.88	6.16
			[0.000]	[0.000]

DEPENDENT VARIABLE = LOG CHANGE WEEKLY WAGE	[1]	[2]	[3]	[4]
Polluting Industries				
Displacement Rate	-0.139	-0.149	-0.124	-0.086
	[0.016]	[0.029]	[0.032]	[0.036]
Joint F-test on occupational dummies (10, 10543)		10.84	10.81	12.16
		[0.000]	[0.000]	[0.000]
Joint F-test on industry dummies (10, 10543)			3.33	14.54
			[0.002]	[0.000]
Joint F-test on state dummies (49, 10543)			6.94	7.37
			[0.000]	[0.000]

Notes

Standard errors in parentheses; p-values in parentheses on F-tests.
Column [1] control variables were age and female. Column [2] control variables were age, female, non-white, schooling, occupation dummies, weeks of work lost between jobs, and the number of 'short-term' jobs held. Column [3] control variables were the same as Column [2] , but included industry dummies, state dummies, and time dummies. Column [4] control variables were the same as column [3], but also included regulated industry/state/time interaction dummy variables.

Table 9: IV Estimates of Displacement on the Difference in Wages: CPS-DWS 1979-92.

DEPENDENT VARIABLE = LOG CHANGE WEEKLY WAGE	[1]	[2]	[3]	[4]
All Industries.				
Displacement Rate	-0.306	-0.391	0.134	-0.016
	[0.074]	[0.090]	[0.158]	[0.183]
$\chi^2(3)$ over-identification test	0.004	0.007	0.016	0.012
Joint F-test on occupational dummies (10, 15872)		5.91	9.58	4.77
		[0.000]	[0.000]	[0.000]
Joint F-test on industry dummies (10, 15872)			6.43	9.98
			[0.000]	[0.000]
Joint F-test on state dummies (49, 15872)			6.19	3.54
			[0.000]	[0.000]

Notes

Standard errors in parentheses; p-values in parentheses on F-tests.
Column [1] control variables were age and female. Column [2] control variables were age, female, non-white, schooling, occupation dummies, weeks of work lost between jobs, and the number of 'short-term' jobs held. Column [3] control variables were the same as Column [2] , but included industry dummies, state dummies, and time dummies. Column [4] control variables were the same as column [3], but also included regulated industry/state/time interaction dummy variables.