The Effect of the Minimum Wage On Covered Labor Demand

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ABSTRACT

Previous studies of the minimum wage have focused on its effect on overall employment, including uncovered jobs paying less than the minimum wage. These studies understate the loss of jobs due to the minimum wage because many workers whose wage was pushed up by the minimum wage lose their covered job but find employment in the uncovered sector. The wage elasticity of covered employment is larger than it is for all employment and may be near unity.

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I. Introduction

Most minimum wage studies examine the effect of the minimum wage on overall employment, including jobs not covered by the minimum wage. A large number of displaced covered workers take jobs in uncovered sector jobs paying less than the minimum wage. As a result, these studies seriously understate the job losses attributable to the minimum wage. The focus of this paper is to estimate the loss of jobs attributable to the minimum wage and to detail how this estimation depends on the way workers are classified as covered workers.

This article uses earnings per hour to sort workers to determine which sector they are classified in. This is a method of sorting workers subject to error. I argue that the extent of these errors can be quantified to get a reasonable estimate of the true job losses caused by the minimum wage. Accounting for possible misclassification errors, the decrease in covered employment due to the minimum wage is sizable and is large compared with the decline in overall employment. While sorting workers by wages is subject to error, assuming the transfer of jobs from the covered to the uncovered sector is zero is an even greater error.

As an analogy, when analyzing the welfare effects of unions, it is important to measure the effect of unions on the demand for labor covered by union contracts. Similarly, it is important in analyzing the welfare effects of the minimum wage to measure the effect of the minimum wage on the demand for labor effectively covered by the minimum wage. This is what this article seeks to do.

Job Losses Caused by the Minimum Wage. Because most studies investigate the effect of minimum wages on total employment, these studies may understate the loss of jobs due to the minimum wage. As a simple example, suppose a minimum wage hike caused 100 workers covered by the minimum wage to lose their job and 30 of these then took uncovered jobs. The estimated “job loss” would be 70 jobs while in fact 100 jobs were lost. While the authors of these studies are aware of this, they often present their results as “the loss in employment” due to the minimum wage. This is an unconventional use of the term "loss in employment." In examining the effects of other laws and institutions, labor economists are careful to separate affected jobs from unaffected jobs. For example, in examining the effect of unions on employment, economists take pains to separate union jobs from nonunion job and then investigate the effect of unions on union employment. The reasons for this are clear. The supply of adult labor is relatively inelastic. Consequently, any examination of gross employment will likely find a small loss in jobs (as most adults losing jobs in the union sector will take jobs in the nonunion sector rather than leave the workforce). Similarly, if the labor supply of teenage is inelastic, then the current method of looking at the total teenage employment will produce the same small effects. In this context, Wessels (2004) found the minimum wage had little or a negative effect on the size of the teenage labor force.

The Debate over the Minimum Wage. The empirical case against the minimum wage has been made by many economists, notably Neumark and Wascher (1992) and Deere, Murphy, and Welch (1995). Card, Katz, and Krueger (1994) and Card and Krueger (1995) criticized these researchers' findings on empirical grounds, arguing that their results are sensitive to model specification. In summarizing the findings, Brown (1999) states that "more recent studies…find [that] point estimates of the loss of teen employment from a 10% increase in the minimum wage was uniformly smaller than 1% and in some cases not statistically significant at conventional levels." Using more detailed Current Population Survey (CPS) data, Burkhauser et al. (2000) found larger effects for a 10% increase in the minimum wage, with a decrease in employment ranging from 0% to 4%. Neumark and Washer (2002) found still larger effects using a different estimation strategy[1]. This

[1] Regressing the ratio of the minimum wage to adult wages on the fraction of teenagers that are employed, they found a -0.41 effect when the minimum wage is binding (Table 4 of their paper). Their estimation strategy takes into account the likelihood that the minimum wage is binding on wages in a state. In this paper, by focusing only on covered workers, we are similarly likely to have estimated a binding state minimum wage effect. Running a regression with the same variables from

paper finds that for every 10% increase in the minimum wage, overall employment decreased by 0% to 2%, matching the changes found in most studies. It finds a stronger effect for covered employment: a decrease in covered employment ranging from 4% to 5%.

Jobs Paying Less than the Minimum Wage: The Uncovered Spillover Sector. In the two-sector model of the minimum wage, an increase in the minimum wage decreases employment in the covered sector and some displaced covered workers then find employment in the uncovered sector. Although these sectors are called "covered" and "uncovered," the titles economists use in the two-sector model do not match the legal definition of covered and uncovered sectors. For example, in the model, the covered sector corresponds to the sector where the minimum wage forces wages up and the uncovered sector absorbs some of the displaced workers. To approximately correspond to the economic model, in this article, "covered workers" includes all workers that are paid the minimum wage or more, and "uncovered workers" includes all workers whose wage falls below minimum wage. To illustrate why this definition is useful, consider that many legally uncovered jobs may pay the minimum wage or more in order to remain competitive. In the two-sector model, these jobs should be included in the covered sector. Similarly, those legally covered jobs that illegally pay less (see, for example, Ashenfelter and Smith, 1979, or Chang and Ehrlich, 1985) should be, and in this study, are in the uncovered sector.

Meyer and Wise (1983), using a similar set of definitions, estimated the employment effect of minimum wages by estimating the relationship between market employment and the distribution of wages. They analyzed out-of-school males 16-24 for the years 1973-1978. They found that "a substantial number of youth are employed a wage rates below the minimum" (p. 72).

The minimum wage used to sort workers is the higher of the state or federal minimum wage, not considering tip offsets or the youth minimum wage.

1979 to 1989 (comparable to the 1977 to 1989 in their paper) on <u>covered</u> workers, the coefficient was -0.392 (0.037). The similarity in results is interesting.

If a worker in the restaurant industry is paid less than the standard minimum wage, they are counted here as "uncovered workers." Federal law, if states do not legislate otherwise, allow a tip offset so that the legal minimum wage for tipped employees is below the standard minimum wage. There are two reasons we have treated these workers as uncovered workers in the context of the two-sector model. First, the federal minimum wage for tipped employees remained relatively unchanged over the sample period (recall that in the economic two sector model, the covered sector is where the minimum wage forces wages to go up). The federal tipped minimum wage was $2.01 for most of the 80's; It rose to $2.09 in 1990, and then to $2.12 in 1991, where it remains today. Because the tipped minimum wage has not been effectively increased, I allocated tipped workers paid less than the minimum wage to the uncovered sector. A second reason is restaurant jobs paying less than the standard minimum wage act like uncovered spillover jobs: when the minimum wage goes up, employment in these jobs grows. Table 1 shows tipped jobs that pay less than the standard minimum wage follow the pattern of the spillover sector: going up when the minimum wage goes up. Why is this? Wessels (1997) argues that when a restaurant increases the number of servers it employs, all servers serve fewer meals per hour and thus every server earns fewer tips per hour. To remain competitive, a restaurant must raise its wage when it hires more servers, making the restaurant a monopsony. This constrains the number of servers it hires. If the spillover of workers into the uncovered sector reduces the full wage (wage plus tips) that the restaurant can pay, then like a standard monopsony facing a lowered supply curve, it will employ more servers. This will be true even when it cannot lower its hourly wage; instead, it lowers the tips per hour for every server by hiring more servers[2]. A latter section will test how this classification of restaurant workers affects the results so those who disagree can adapt the estimates appropriately.

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[2] This result can be shown for both short and long runs. The short-run argument is as follows: Let t be the tip rate (which, to avoid complexity, is assumed to remain constant), P be the price of a meal, and S be the fraction of an hour a server takes per meal served. If the market full wage is F, the restaurant can pay an hourly money wage of $W = F - tP/S$, where $1/S$ is the number of meals the server serves in an hour. S is an input into P: $P = P(S)$. Holding the number of meals constant, as

Another issue is how to classify jobs paying the youth minimum wage. It is not clear whether these jobs should be economically classified as spillover uncovered-sector jobs or covered-sector jobs. In this paper, teenagers in jobs that initially pay the youth minimum wage but eventually pay the full minimum wage are classified as being in the covered sector[3]. Under pre-1989 law, employers in retail trade, agriculture, and higher education could pay full-time students 15% below the regular minimum wage. Freeman, Gray, and Ichniowski (1981) found that only 3% of student hours in the late 1970's were paid at the lower rate, suggesting this law had little effect. Under the legislation put into effect April 1990, the firm could pay the youth minimum wage ($3.35 for the first year after the hike and $3.61 until April 1993) for 90 workdays. The firm could continue to pay the lower wage for another 90 days if it showed that it was training workers. Katz and Krueger (1992) found that less than 2% of fast-food restaurants in Texas used the youth minimum wage in December, 1990 and less than 5% in July and August of 1991. An even smaller fraction of teenagers are paid the youth minimum wage as only a fraction of workers are eligible for the youth minimum wage[4]. . Under current legislation put into effect in 1996, a teenager can be paid $4.25 for 90 days. If a teenager stays more than 90 workdays, he or she must be paid the regular minimum wage. Additional evidence presented in the next section suggests that the number of teenagers paid the youth minimum wage is small.

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the restaurant hires more servers, *S* goes up; it faces a rising supply curve with respect to *S*. Suppose the minimum wage M constrains the wage such that *M* intersects the supply curve of *S*. The restaurant sets *S* so that $M = F - tP/S$. A decrease in *F* allows the restaurant to increase *S*. For a given number of meals, it will hire more servers.

[3] A worker in such a job more than 90 days must get the regular minimum wage. The estimation method estimates the change in employment over a year. If the worker stays in the job more than 90 days, the job becomes a job paying the minimum or more and is classified as being covered.

[4] Neumark and Wascher (1992) found a small effect from these laws.

II. Accounting for the Shift between Sectors

The Uncovered 'Spillover' Sector. According to the U.S. Department of Labor (2001), 28% of wage and salary workers are not covered by the federal minimum wage[5]. Also, 50% of the employees in retail trade or services enterprises having less than $500,000 in sales volume and not engaged in interstate commerce are non-covered employees. Most private household cleaners and childcare workers are exempt.

Table 1 shows the main occupations and industries of workers earning less than the minimum wage before, during, and after hikes in the federal minimum wage[6]. The data is from the outgoing rotation files of the Consumer Population Survey[7]. The table shows the dates the federal minimum wage was increased in bold. All periods shown in Table 1 are for a year. The exception is for the 11-month span between the 1996 and 1997 minimum wage hikes (numbers for this period between hikes have been increased by 12/11th to be comparable with adjacent cells). To create a homogeneous sample for the level and timing of minimum wage

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[5] Schiller (1994) examined who the below minimum wage workers are. Examining the National Longitudinal Surveys of Youth, he found 30% of young workers (14 -21) were being paid less than the minimum wage in at least one job in 1981. Many of these worked for employers with less than $500,000 in annual revenue. Many such employers were single-establishment firms.

[6] The entertainment industry is included for illustrative sake, showing the pattern common to the smaller industries. The household sector is shown, as it is one of the few industries where most of the workers belong to the uncovered sector.

[7] The sample sizes for 1990-1991 minimum wage time periods for working teenagers 16 to 19 are 8492, 7829, 6954, 6627, and 6677. This declining pattern was not present in the 1996-1997 minimum wage time periods, where the respective sample sizes are 6254, 5813, 6590, 6820, and 6994. Some readers have expressed surprise at the large size of sample. The outgoing rotation sample surveys one quarter of approximately 50,000 households monthly and our sample is summed over a year, so that the sample is of approximately 75000 households (1/8th of 12 x 50,000). As there are usually several persons in a household, the number of teenagers is not surprising.

increases, Table 1 only include states having the federal minimum wage throughout the sample period[8].

About 30% of the below-minimum-wage jobs are in restaurant occupations of servers (waiters and waitresses) and cooks. Below-minimum-wage restaurant employment follows the spillover pattern, going up when the minimum wage is increased. Other occupations and industries follow the same pattern. The main exception is the personal household service industry. Personal household workers are exempt from the federal minimum wage and few earn more than the minimum wage. However, this sector did not follow the spillover pattern.

Appendix Table 2 shows the main occupations and industries of workers paid the minimum wage or more before, during, and after hikes in the federal minimum wage. Their employment falls after the first hike, and then recovers.

Overall, the employment of workers sorted by wages follow the pattern predicted by the two-sector model for the uncovered sector.

Figure One shows a similar pattern for the monthly data for the fraction of teenage workers earning less than the minimum wage for the United States. Vertical lines indicate when the federal minimum wage was increased. The fraction of workers reported as earning below the minimum increases dramatically when the minimum wage is increased.

The effect of the youth minimum wage can be seen in the last row of Table 1. The youth minimum wage was $3.35 starting in April 1990, and 85% of the federal minimum wage starting in April 1991; it ended in April 1993. The table shows the number of workers earning within $.25 of the youth minimum wage (between $3.35 and $3.55 after the April 1990 hike, between $3.61 and $3.86 after the April 1991 hike, and between $4.25 and $4.50 for the 1996-97 hikes). For both sets of hikes, I used a wide range of wages, as too few jobs paid the lowest allowable youth minimum wage. The numbers in this wage range fall quickly; it does not appear that many firms used the youth minimum wage. More telling is what happened when the

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[8] Excluded states are Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Pennsylvania, Wisconsin, Minnesota, Iowa, Delaware, District of Columbia (excluded from all samples), Washington, Oregon, California, Alaska, and Hawaii.

sub-minimum wage expired in April 1993. There was no large decrease in workers being paid in the range of the previous youth minimum wage. This suggests that few in the range were being paid the youth minimum wage before its expiration. To confirm this observation, I ran a regression (similar to that shown in Table 3, column 7) on the fraction of teenagers that were paid less than the minimum wage. There was no significant change in uncovered employment when the youth minimum wage expired in April 1993. These results suggest the youth minimum wage was not widely used.

Misclassification Errors and Their Effect. The pattern shown in Table 1 could be due to shifts in employment. But it could also be due to how workers are classified. Recall that workers whose wages are at or above the current minimum wage are classified as covered workers; otherwise, they are classified as uncovered workers.

Because of using this method of classifying workers, three types of misclassifications could arise that might have created Table 1's pattern. These three potential misclassification errors are:

1) *Error Due To Lags in Adjusting Wages*. This error is due to lags in reporting current wages or to lags in compliance in paying the minimum wage (both have the same effect on misclassification). For example, suppose a teenager was earning the minimum wage of $5.15 and then the teenager's wage is increased by a new minimum wage to $6.75. His or her parent may not be immediately aware of the teenager's new wage, and as a result the parent reports the teenager as still earning $5.15. The teenager will be incorrectly classified as being displaced from their covered job.

2) *Error Due To Left-Behind Uncovered Workers*. This error arises when a legally uncovered worker was paid more than the minimum wage before a hike, but was paid less than the new minimum wage after the hike. Because such a person will be classified as covered before and uncovered after, the worker will be incorrectly counted as having "lost" a covered job even though the worker remained employed. For example, a worker that is paid $5.50 both before and after the

minimum wage is increased from $5.15 to $6.25 would be counted as having lost a covered job.

3) *Error Due To Rounding Down Reported Wage*. An example of this bias is if a worker earning $5.15 (the current minimum wage) reports earning $5.00. Such a worker will be mistakenly classified as being in an uncovered job.

Our focus on these possible errors in reporting may give the impression that there is widespread misreporting of wages. Yet, 17.1% of workers report earning <u>exactly</u> the minimum wage. Over the whole sample period, this percentage exceeds the number of workers earning less than the minimum wage (15.0%). In addition, this percentage goes up when the minimum wage goes up[9].

None of the three errors would affect the regression results in a way that overestimated disemployment if the percentage of workers misclassified remained constant over the sample period: the percentage of change in covered employment and measured covered employment would be the same. The only effect would be that of measurement error that would likely result in a lower estimated effect of minimum wages. However, these errors are more likely to occur when the minimum wage is increased.

There is reason to suspect that these errors are present and that they are more likely to occur when the minimum wage is increased. One reason is that is unlikely the uncovered sector could absorb such a large increase in workers. Table One and Figure One show that the minimum wage approximately doubles the fraction of jobs paying below the minimum wage. If all of these are new jobs, this would be a very elastic response. One does expect an elastic response. After all, teenage employment increases dramatically every summer, indicating that employers have the capacity to absorb a large influx of workers[10]. Also, if we measure workers in efficiency units, the increase in "standardized" employment will

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[9] Using the regression from column 5 of Table Three, the total impact of the minimum wage on the fraction of teenage workers reporting that they earn exactly the minimum wage is +1.61 (with a chi-square of 8.44 and significance level of 0.0037).

[10] Depending on the equation, summer time employment is somewhere between 10 and 30 percent higher than the rest of the year with no significant decrease in hourly wages.

be less than the increase in the number of jobs. Still, this increase is too large to be accepted at face value.

Our strategy for correcting these biases is based on identifying what fraction of workers classified by wages as being displaced from covered to uncovered jobs actually did lose covered job to take an uncovered job. To do this, we created a data set from the Current Population Survey (CPS) matching observations on the same worker before and after a hike a minimum wage hike. This data set consists of workers classified as being displaced from covered jobs (workers whose wage before the hike was at or above the old minimum wage and whose wage after the hike was below the new minimum wage). To illustrate, for a minimum wage hike from $4 to $5, a worker whose wage was $4.50 before the hike and $4.75 after the hike would be classified as being displaced. The issue is: did this worker really lose a covered job? Or is the $4.75 due to one of the three errors (a lag in adjusting the wage, the worker being in the same uncovered job, or reported wage being rounded down)? We employed the following criterion: if the displaced worker's after-hike wage is below their before-hike wage by fifty cents or more, we assume they lost a covered job. If their wage fell by less than fifty cents, we assume they are still in the covered sector. So if out of 100 displaced workers (whose pre-hike wage was above the minimum wage and whose post-hike wage is below the new minimum wage), 40 had post-hike wages that were fifty cents or more below their pre-hike wage, we would say 40% of displaced covered workers were correctly classified. The rationalization for this is as follows. First, covered employers who lag in raising their wages are not likely to lower their wage in the interim, thus this rule removes this source of miscounting. Second, the rule should remove most left-behind uncovered workers as a source of miscounting. This rule removes left-behind uncovered workers who continue to work at the same or higher wage. This still leaves uncovered workers whose wage may have been lowered due to the spill-over of workers into the uncovered sector. However, it is unlikely that that left-behind uncovered workers will have their wage fall by fifty cents or more. To show this, I examined the wages of workers classified as being in the uncovered sector before and after a hike in the minimum wage. They got higher, not lower, wages after the hikes in the minimum wage (28% higher in 1990, 12% higher in 1991, 10% higher in 1996, and 22% in 1997)[11]. Finally, the fifty cent decrease rule should account for the rounding down error. A rounding down of wages, even if not done before and only done after a hike, would not likely reduce wages by 50 cents or more. Note that data covers hikes in the federal minimum wage that have been 50 cents or less (45 cents in 1990, 45 cents in 1991, 50 cents in 1996 and 40 cents in 1997). As a result, the fifty cent decrease rule appears to be a conservative and reasonable cut-off.

Our calculations show the fraction "correctly classified" to be 50%. We will use the fraction to calculate the effect of the minimum wage on covered employment in two ways. In the first way, we estimate the elasticity of the minimum wage on covered employment and on total employment. Assume a 10 percent increase in the minimum wage decreases covered employment (as measured by our strategy of separating workers by wages) by 8% and reduced total employment by 2%. We assume 50% of the 6% difference is correct: our estimate will be that 6% of covered workers lost their jobs due to a 10% hike in the minimum wage (2% + 0.5 * 8%)[12]. Note that the corrected percent is the average of the two elasticities (2% and 8%). The second method takes out the lagged wage effect first. The correction for misclassification is then applied. I take account of the lag in adjusting wages by examining the change in covered employment over a year. Evidence cited below shows that wages adjust within a year. Suppose after taking out the lagged wage effect, 5% of covered workers lose their covered job for every 10% increase in the minimum wage and total employment falls by 2%. Using the 50% correction to capture the remaining errors (left-behind uncovered workers and rounding down), the estimated decrease in covered employment will be 3.5% (2% + 0.5 times the 3% difference between 5% and 2%).

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[11] The specifics are for the ratio of wages after to wages before: 1990: 1.28 (0.51) N=65, 1991: 1.12 (0.35) N=96, 1996: 1.10 (.38) N=28, 1997: 1.22 (.43) N=45. Standard deviation is in parenthesis.

[12] The actual calculation has to adjust for the fraction of covered jobs. To illustrate, suppose 90% of the jobs are covered jobs and that all jobs lost are covered jobs. The percent change in total employment, adjusted for this, is 2%/0.9, or 2.2%. The correct figure is thus 4.6% of covered workers lost jobs when the minimum wage goes up 10%.

Estimating the Corrected Fraction of Displaced Covered Workers. I matched records from the outgoing rotations of the CPS. In this way, I was able to examine the wages of teenagers who were classified as covered workers before the minimum wage hikes and were classified as being uncovered after the hikes of 1990, 1991, 1996, and 1997. Each household is interviewed twice in the outgoing rotation survey used in this study (compared to eight times for the normal CPS survey). The second interview takes place one year later. If the people in the household die or move, the new residents are interviewed in the second survey. Various strategies have been devised to sort out those households that no longer have the original occupants. We chose the strategy recommended by Madriam and Lefgren (1999). This was to merge observations with the same household identifiers, same household number (which increases by 1 if the household in the residence changes), the same line number (the individual's number in the household), and the same age, sex, and race. For the strategy used, Madriam and Lefgren (1999) estimate that the probability of merging two observations when members are not the same people is 1.8%.

A matched sample of teenagers 16 to 19 years old was created across each minimum wage hike. For example, a sample was taken of people who had their first interview before the April 1990 hike and another sample was taken of the same people having their second interview after the April 1990 hike. The data sets were then matched and merged; people not working or with missing data were removed. The data set includes all states, incorporating the appropriate state or federal minimum wage level for each state as the criterion of being paid more or less than the minimum wage. A sample of states with the federal minimum wage had similar results. Two of the data sets cover less than 12 months before and after the hike. The data set for the 1996 increase runs only 11 months after the increase, stopping before the 1997 increase. Similarly, the 1997 data set starts 11 months before the

1997 increase. To avoid the bias from hot decking[13] and misreported hours, only workers who reported earning an hourly wage and who reported their hourly wage are included in the sample.

Table 2[14] shows how wages changed for workers classified as being displaced from the covered sector. Using the strategy described above, only workers classified as being displaced whose wage fell by fifty cents or more are counted as being truly displaced from a covered job. Over the sample, 50% of the nominally displaced workers fit into this category (calculated by the average percent change or by summing over individual workers for the four periods).

Appendix Table 3 shows comparable data for matched displaced teenage workers in the years in which the federal minimum wage was not increased (1992-1994 and 1997-1999), each comparing the change in employment from a before and after period around the same month as when the previous increase in the federal minimum wage occurred). The two samples only included hourly workers reporting their hourly wage (except for 1994 when the CPS does not flag for allocating unreported wages). A higher percentage (66%) of displaced workers received wages that were 50 cents or more below their previous wage.

Appendix Table 4 shows comparable data for matched covered teenage workers (workers earning more than the minimum wage) before the hike[15]. Their post-hike status is not restricted (in contrast to above where we restricted the post-hike status to having a job paying below the minimum wage). About 25% of before-hike covered workers were not working after the hike. More importantly, around

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[13] If an hourly worker does not report their hourly wage, the Bureau of Labor Statistics (BLS) allocates a wage to them using rather broad categories to match the worker with data from other workers. Because most workers earn the minimum wage or more, workers with allocated wages are more likely to be classified as “covered”.

[14] Observations are not weighted as CPS weights are for cross-sectional, not longitudinal, weighting. Workers must be between ages 16 and 19 both before and after the hike.

[15] To correctly estimated the fraction losing jobs, the data set included all workers, hourly and nonhourly. This introduces some error due to the CPS imputing a wage to those who reported wages.

20% of those continuing to work received lower wages after the hike[16]. The sizable number receiving lower wages suggests the number of workers counted as flowing into uncovered jobs is not solely the result of misclassifications associated with an increase in the minimum wage.

Correction for Lags in Adjusting the Minimum Wage

In the second strategy, the error due to the lag in adjusting wages is accounted for before we adjust with the misclassification method detailed above (using the fraction of correctly classified workers). When a lag in adjusting wages is present, then after a hike, covered employment should first drop due to undercounting and then rebound as wages become correctly reported. Table 1 shows this pattern. The same pattern could also be explained by rehiring. However, to get a conservative estimate of lost covered jobs, I use the rebound in covered employment after a hike to offset the initial decrease in covered employment to correct for the possible lag in adjusting wage error.

In level regressions, the lag in adjustment is corrected for by entering a dummy variable for four quarters, the quarter of the hike and the three quarters following the hike (our data set is quarterly). This effectively removes these quarters from the regression. As a result, the change in employment reflected by the minimum wage coefficient is the change over a year, from the quarter before the hike to a year latter. This allows time for wages to adjust.

For first-difference regressions, we used a sufficient number of lags for the minimum wage variable to capture the “rebound employment” effect as wages become correctly reported. A simple example illustrates this point. Suppose that a minimum wage hike causes true covered employment to fall from 100 jobs to 95 jobs. When the hike occurs, 60 covered jobs have their wages increased immediately; 15 of the covered jobs’ wages are not reported correctly until one quarter later, and the remaining 20 jobs take two quarters to be reported correctly as

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[16] The percentage was slightly higher for years when the federal minimum wage was not increased. In the 1993 -1994 matched sample, 24.7% of covered workers continuing to work subsequently got lower wages. In the 1998 -1999 matched sample, this figure was 25.7%.

minimum-wage jobs. True covered employment has gone down by five jobs. However, measured covered employment (jobs paying the minimum wage or more) will be:

Period	Covered Employment	Change in Employment
Before	100	---
Hike	60	- 40
+1Qrt	75	+15
+2Qrt	95	+20
+3Qrt	95	0

The sum of the changes in employment equals -5, which is the true change in employment. Suppose we treat the minimum wage hike as a dummy variable[17] that equals 1 in the hike period and zero after that, and run change in employment regression on this minimum wage variable lagged from zero to three quarters. The current (lagged zero) minimum wage coefficient will be -40, matching to the change in employment in the hike period. One quarter later, the lagged one-quarter minimum wage dummy variable equals 1 and its coefficient is +15, capturing the change in employment occurring one quarter after the minimum wage is increased. Similarly, we will have +20 for the lagged second-quarter coefficient, and 0 for the lagged third-quarter coefficient. Summing the coefficients gives us the true change in covered employment: -5. In this way, we can net out the transitory effects from lags in adjusting wages (or from any other transitory event).[18]

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[17] When the minimum wage variable is equal to its percent change, the coefficients will be elasticities and the sum of the coefficients will be the "true" elasticity.

[18] The following illustrates the point algebraically. Suppose it takes three periods for all covered wages to catch up with a new minimum wage. Let N be the reported employment at or above the minimum wage; let EM be the actual employment at or above the minimum wage; and let M be the initial miscount at the time of the minimum wage hike. If the hike occurs at the beginning of time t, we have:

$N_{t-1} = EM_{t-1}$

$N_t = EM_t - M$

$N_{t+1} = EM_{t+1} - (1-\alpha_1)M$

$N_{t+2} = EM_{t+2} - (1-\alpha_1-\alpha_2)M$

The estimated effect of the minimum wage on covered employment was almost the same for both first-difference and level regressions.

Estimating the Rounding Down Error

*Rounding Errors. C*overed employment would be miscounted if people round down wages when answering the survey (for example, from $5.15 to $5.00).

If there is rounding error, the effect of this error can be bounded. There are various possible rounding errors one can imagine, but the most reasonable is to assume that people round down to the nearest "quarter point" (70% of wages are on quarter points such as $6.00, $6.25, $6.50, and $6.75). To estimate the possible effect of rounding down, we counted a displaced teenager (one whose wage when from above to below the minimum wage after a hike) as being misclassified if their post-hike wage was within a quarter point of the minimum wage. For example, a teenage earning from $5.00 to $5.15 after the 1997 hike to $5.15 was counted as being misclassified. Counting only displaced workers whose wage fell by 50 cents or more as being correctly counted as losing a covered job will include all those earning within a quarter point of the minimum wage. Consider another strategy: count only those whose wage is lower after the hike and those within a quarter point of the minimum wage as being correctly classified as losing a covered job. Since there is an overlap between those within a quarter point and those earning a higher wage after a hike, it would be double counting to add this overlap into the

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$N_{t+3} = EM_{t+3} - (1-\alpha_1-\alpha_2-\alpha_3)M$

In period t+1, α_1 of the misreported classification are corrected, α_2 are corrected in period t=2, and by t+3, all wages are reported accurately (so that $\alpha_1 + \alpha_2 + \alpha_3 = 1$). Next, consider the first differences:

$\Delta N_t = \Delta EM_t - M$

$\Delta N_{t+1} = \Delta EM_{t+1} + \alpha_1 M$

$\Delta N_{t+2} = \Delta EM_{t+2} + \alpha_2 M$

$\Delta N_{t+3} = \Delta EM_{t+3} + \alpha_3 M$

If, in a first-difference regression on N_t, the minimum wage and its lagged value up to three periods are included, the sum of the coefficients will equal the sum of ΔEM. The error from the lag in adjusting wages will be corrected. The same results can be shown for a log form.

misclassified workers. Thus, we only added those misclassified due to rounding error if they also got a lower wage after the hike. The estimated fraction of correctly classified, using this second strategy, was 57%. Note how close this figure (57%) is to the percent (50%) derived above by only counting workers whose wage fell by 50 cents or more as being correctly classified as being displaced.

This correction, to be valid, requires the assumption that no uncovered workers earn between the minimum wage and the round-down point. How reasonable is this assumption? In 1999, in states with the federal minimum wage of $5.15, 5.11% of teenage workers earned between $5.00 and $5.14. In the same year, in states with a minimum wage of $5.65 or higher, 4.95% of workers earned between $5.00 and $5.14. Because these workers are more likely to be uncovered in the higher minimum wage states, and as the percents are similar between both sets of states, this suggests that workers earning between $5.00 and $5.14 are uncovered workers.

The second type of rounding error is due to my estimating the hourly wage by the division of usual weekly earnings by usual hours of work. This occurred only for workers who did not report an hourly wages[19]. To get some sense of the possible size of this error, assume that numbers reported for wages on the "quarter point" ($4.25, $4.50, and so forth) are not due to this second error as it is unlikely that a misreported ratio will fall exactly on a quarter point. On the other hand, assume the numbers for workers earning wages between quarter points, within some range below the minimum wage, are all minimum wage workers. Of course, this is an extreme assumption, but it allows us to bound this error. In 1999, there were 521 workers reporting wages between $4.00 and $5.14 (in states with the federal minimum wage). In the same range, 426 had wages that were on the quarter point ($4.00, $4.25, $4.50, $4.75, and $5.00). Only 18% fell between quarter points, representing less than 0.6% of teenagers. As it is the change in the error

[19] According to Haugen and Miller (1990), usual hourly earnings (derived by dividing usual weekly income by usual weekly hours) are underreported by some workers because they report take-home pay rather than gross weekly earnings.

that matters (from before to after the hike), the impact of this error is likely to be small.

III. The Effect of the Minimum Wage on Total and Covered Employment

Model and Variables. A typical model[20] from Card and Krueger (1995) is:

$$E_{it} = a_0 + MW_{it}b + X_{it}c + T_t t_t + S_i d_i + e_{it},$$

where E_{it} is the log of the ratio of teenage (ages 16-19) employment to teenage population in state *i* at time *t*; MW_{it} is the log of the higher of the state or federal minimum wage; X_{it} is a set of explanatory variables; T_t is a set of year dummy variables; S_i is a set of state dummy variables, and *a*, *b*, *c*, and *d* are the respective vectors of coefficients. The ratio of teenage employment to teenage population was calculated using the Current Population Survey weights (this did not affect the results). The typical set of explanatory variables includes the log of adult wages, the fraction of teens in the population, the per-capita income, and the adult unemployment rate (all state-specific). For adult wages, I used the average hourly wages of adults ages 30 to 39[21]. Adults ages 30 to 39 were selected as a group that is close to teenagers but whose wages are only slightly affected by the minimum wage[22]. For the adult unemployment rate, I used the unemployment rate of white males, ages 35 to 55[23]. The unemployment rate of this group best reflects changes in aggregate demand, because their labor supply is inelastic.

Variables without unit roots were used to avoid false results (Appendix Table 5 shows the results of the *t-bar* test from Im, Pesaran, and Shin, 1997).

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[20] The following discussion is based upon Burkhauser, et al. (2000).

[21] Using first differences, regressing the log of the minimum wage on the log of adult wages, the coefficient was 0.0304, with a standard error of 0.0315 and $p = 0.3346$.

[22] Using a regression similar to that shown in column 7 of Table 3, a 10% increase in the minimum wage increases the wage of 30 to 39 year olds by 0.3%.

[23] Using first-differences, regressing the log of the minimum wage on the unemployment rate, the coefficient was 0.0114, with a standard error of 0.0094 and a $p = 0.2248$.

The Choice of Minimum-Wage Variables. The usual minimum wage variable in the literature is the minimum wage relative to the adult wage, for example, Neumark and Wascher (1994) or Card, et al. (1994) or the minimum wage deflated by a price index. I finesse the problem of selecting one or the other by using, as separate explanatory variables, the log of the minimum wage, the log of adult wages, and the log of the GDP deflator. It can be shown that the coefficient of the minimum wage variable will be the same whether (a) each variable is entered independently, (b) the wage-deflated minimum wage is used, with the log of adult wages and the log of the GDP deflator entered as separate variables, or (c) the price-level deflated minimum wage is used, with the log of adult wages and the log of the GDP deflator entered as separate variables. I tested other combinations; the results were unaffected. In choosing between using the relative minimum wage or the real minimum wage, the regression results suggest that the relative minimum wage (the minimum wage relative to adult wages) is the correct choice (see the coefficients of the price index and adult wages in Appendix Table 6).

A coverage variable (such as the fraction of jobs covered by the minimum wage) is not included. One reason is that most coverage variables are, by construction, endogenous to changes in the minimum wage. Another reason is that covered workers are separated from uncovered workers, which, in itself, partially controls for coverage.

Data and Selection. The data is drawn from the outgoing rotations of the Current Population Survey for 1979-2001. Quarterly data are used. Recent panel studies of the minimum wage use monthly data. This approach may not be advisable since the monthly cell size is small in many states. A small cell size leads to measurement error in the dependent variable (employment rates), which, in dynamic models, can bias the results[24]. One method to reduce this problem is to use

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[24] See, for example, Hsiao (1979) and Collado (1998).

a longer sampling period[25]. The result is a larger cell size, which also reduces other biases (see Harris and Tzavalis, 1999).

Covered sector employment is the fraction of the teenage population (ages 16 to 19) employed at a wage that equals or exceeds the higher of the state or federal minimum wage (not accounting for tips or the subminimum wage). The sum of covered workers and all workers was collected monthly, aggregated into quarterly data, and then formed into the appropriate ratios.

Reported hourly wages were used to sort 88.6% of the workers between the covered and uncovered sectors. An estimated usual hourly wage (created by dividing usual weekly earnings by usual weekly hours) was used to sort another 7.9% of the workers for whom hourly wage data was not available. Finally, 3.5% of the workers have insufficient data to estimate a wage for. They were assigned to sectors using the ratios from other workers[26].

First Differences. First differences has several advantages over level regressions, including the removal of fixed effects. I will not discuss the reasons one might prefer level or first-difference regressions since they had similar results. A disadvantage

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[25] An estimate of measurement error is $\wp(1-\wp)/N$, averaged across states and time, where $\wp$ is the predicted fraction of teenagers with covered jobs and N is the number of teenagers in the particular state-quarter cell. $\wp$ was derived from a panel-data regression with fixed effects and with an AR (24) error structure for the monthly data and AR (8) for the quarterly data (both covering two years). The estimated measurement error for quarterly data averaged 0.002509, compared to 0.006259 for monthly data. As illustrated, the estimated measurement error was 2.5 times larger in the monthly data. Greater gains could be achieved by going to yearly data, but as all minimum wage increases since 1990 have been midyear, quarterly data are more likely to capture the effects of these increases.

[26] The following method was used. The fraction of covered workers (covered workers to all workers) was calculated from the sample of workers that did have sufficient data to estimate hourly wages for. This fraction was then multiplied by the fraction of the teenage population that was employed (including those with insufficient data for estimating wages). The product is the fraction of the teenage population that was employed in the covered sector, if the distribution from the sample of workers with sufficient data applies to those without sufficient data.

of using first differences is that the estimated error term consists of a long declining set of AR coefficients. This error structure most likely resulted from an over-differenced error process that introduced a moving average (MA) into the error term. Since invertible MA terms can be accounted for with a sufficiently long series of AR terms, the long lag was used to account for this. Level regressions did not have this problem.

As discussed above, when removing the effects of lags in adjusting wages, the current and subsequent effect of the change in the minimum wage are included in the regression and their coefficients summed. The current and lagged values of the change in the minimum wage are explanatory variables. Theoretically, the other explanatory variables affect the impact of minimum wages. It follows then that the lagged values of the explanatory variables should also be included in the regression to avoid bias. The results for the first difference regression correcting for lags in adjusting wages are the sum of the minimum wage coefficients. I replaced the t-statistic with the Wald chi-square statistic for the null hypothesis that sum of a variable's coefficients equals zero.

Level Regressions. The level regression is more straightforward in that only the current value of all variables are used as explanatory variables. When accounting for lags in adjusting wages, a series of dummy variables is used to remove the quarters current and following the minimum wage hike (up to three quarters). The result is that minimum wage's coefficient reflects the change in employment from before to a year after the minimum wage's increase.

Lags in Adjusting Wages. For both the first difference and level adjustments, we assumed wages adjusted with four quarters. Four lags proved to be significant while adding a fifth did not. Also, regressions on covered wages showed that after four quarters the minimum wage had no more effect.

Results. Judson and Owen (1999) show that for a data set with sufficient time periods (over 30 periods), the best estimation techniques include the leastsquares dummy variable model (used here). The bias is still large for the lagged dependent variables (which the literature focuses on). On the other hand, the bias was small for explanatory variables (less than 1% of the true coefficient size) for either of these techniques. The bias is smaller for the method used here than it was for the various GMM procedures as well as the Anderson and Hasio (1981) estimator. This finding suggests the minimum wage results here are useful, since the number of time periods (92) is large.

Table 3 shows the results for regressions on the log of ratio of teenage employment to teenage population. The level regressions results are presented in columns 1 through 4. In the level regressions, all variables are in level form. The first different results are presented in columns 5 through 7. All variables are in first-difference form. The exception is for the intercept, seasonal, and yearly dummy variables.

Without adjusting for the lag in wages, the elasticity of covered employment to minimum wages appears to be near -0.8. The estimated elasticity was relatively unaffected by weighting or by correcting for an autoregressive error structure. The time series nature of panel data allows for an estimation of cross-sectional weights; these were used to weight the regression. Weighting by the number of teenagers is more appropriate for cross-section where this is the best weighting that can be done.

Regression 4 shows the effect of correcting for the lag in adjusting wages by adding dummy variables to remove the periods during and after the minimum wage hike (here, to three quarters after). The effect of minimum wages on covered employment is similar to those without the adjustment.

Regression 5 shows the unweighted first-difference results. In this regression, only the current value of each variable is entered. The estimated effect of the minimum wage is smaller (-.4 compared to -.8). Regression 6 shows why. Adding the correction for the autoregressive error structure did not change the estimated effect of the minimum wage (it was still -.4). On the other hand, adding the current and four lags of all explanatory variables except the minimum wage (whose current value only appeared in Regression 6) increased the effect of minimum wage to -.7. Regression 7 shows the effect of correcting for lags in adjusting wages by having the current and lagged value of the change in the minimum wage (here, up to four periods). Column 7 reports the sum of these minimum wage variables, the chi-squared statistic for the null hypothesis that the sum of their coefficients equals zero, and the *p*-value for the Wald chi-squared statistic. The minimum wage's effect on covered employment is shown to be smaller (-.6 instead of -.7).

The correction for lags in adjusting wages in column 4 and 7 both reduced the minimum wage's coefficient by more than 0.1.

Overall, a 10% increase in the minimum wage reduced covered employment by 6% to 8% and decreased overall employment from 1% to 3%. Accounting for the lag in adjusting wages, the decrease in covered employment was between 6% and 7%. We further correct these results below for left-behind covered workers and rounding down errors. The reader can do the same by taking the average of the minimum wage coefficients for covered and overall employment.

Comparison with Other Regressions. Table 4's columns 1 and 2 show the effect of adding yearly dummy variables to the regression. For level regressions, the minimum wage's coefficient went from -0.77 to -0.69. For first difference regressions, the coefficient went from -0.60 to -0.58. The effect was small.

Columns 3 through 5 show the results of running the first-difference equation from Table 3's column 7 over shorter time periods. The first time period (1982 to 1989) covered a period well after the previous federal minimum wage hike in 1981 and before the hike in 1990. Thus, the only hikes in this period were increases in state minimum wages. The minimum wage had an effect over this period (-0.63) almost as negative as it was over the whole sample period (-0.69).

Columns 5 and 6 compare the period for the first hikes in the federal minimum wage hikes in the 1990's (from \$3.35 to \$4.25 in 1990 and 1991) with the second period of hikes (from \$4.25 to \$5.15 in 1996 and 1997). A recession occurred in the first period while the economy was expanding in the second. The effect of minimum wages on covered employment was similar in both periods (-.56 and -.61). On the other hand, the minimum wage only decreased employment in the first period (1989

– 1994) while having no effect in the second (1995-2001). This most likely reflects the fact the second occurred in an expansionary period. However, the level results shown in columns 6 and 7 tell a different story for the second period: here, the minimum wage had no significant effect on covered employment and yet significantly increased total employment. The federal minimum wage, due to its being sporadically increased in large increments, acts like a shift dummy variable in level regressions (a shift dummy variable going from 0, 0, 0 to 1, 1, 1, ..). As a result, its coefficient is more likely to spuriously capture long-run trends in employment. For regressions over long periods where long-term trends do not exist, this is not a problem (this is verified by the results in columns 1 and 2 where the time series dummy variables control for time trends). However, in the late 1990's when the economy was expanding, the level's minimum wage coefficient is likely to be more positive that its actual value; the more negative first difference results suggest this is what occurred.

IV. Estimating the Impact of Minimum Wages on Covered Employment

Using the information from Table 2, 50% of displaced workers were correctly classified as being displaced. The corrected coefficient, as a result, is the average of the minimum wage's coefficient for total and covered employment.

Method 1: For this method, we start with the minimum wage's effect that did not include any correction for the lag in adjusting wages. The effect of the minimum wage on covered employment was -0.7268 (the first difference result from Table 3, column 6, which is used as it is smaller than the level results). Its effect on overall employment was -0.2003. The "corrected" estimate is -0.46.

Method 2: For this method, we start with the minimum wage's effect after the lag in adjusting wages error has been removed. The effect of the minimum wage, adjusting for the lagged error, was -0.6025 (the first difference result from Table 3, column 7, which is used as it is smaller than the level results). The effect of the minimum wage on overall employment was -0.2003. The resulting "corrected" coefficient is -0.40.

A Lower Bound. The fraction of teenagers employed in the covered sector was recalculated by rounding the minimum wage down to the next quarter point (for example, the minimum wage of $5.15 was rounded down to $5.00 but $4.75 was left unchanged). A regression similar to those in Table 3 were run on this recalculated teenage employment. The estimated impact of the minimum wage was smaller. The resulting effect of the minimum wage on covered employment was –0.4089 (chi-square of 66.9 and $p < 0.0000$), using the regression model from column 7 of Table 3 (recall that this equation also controlled for lags in adjusting wages). Using method 2, the recalculated "corrected estimate" is -0.30. This -.30 estimate is too low as it eliminates some workers twice from the "correctly classified" category.

V. SUMMARY

How many jobs paying the minimum wage or more are lost when the minimum wage is increased? Past studies have examined how many jobs, paying any wage, are lost. Because there is a notable transfer of jobs from the covered sector to the uncovered sector, this seriously understates job loss. The estimated elasticity of covered-sector employment to the minimum wage is significantly larger (in absolute terms) than that for all employment.

If misclassification is pervasive, the estimated elasticity of teenage covered employment with respect to the minimum wage is near or between -0.4 and -0.5. This is higher than the -0.2 elasticity observed for all workers.

Other specifications would, of course, would produce other ranges of results. Further research is needed to corroborate the results presented here.

References

Anderson, T.W. and C. Hsiao, "Estimation of dynamic models with error components," *Journal of the American Statistical Association* 76 (1981): 589-606.

Ashenfelter, Orley, and Robert S. Smith, "Compliance with the Minimum Wage Law," *Journal of Political Economy* 87 (April 1997): 333-50.

Brown, Charles, "Minimum Wages, Employment, and the Distribution of Income," in *Handbook of Labor Economics*, volume 3B, by Orley Ashenfelter and David Card, Elsevier, New York (1999): 2101-2163.

Burkhauser, Richard V., Kenneth C. Couch, and David C. Wittenburg, "A Reassessment of the New Economics of the Minimum Wage Literature with Monthly Data from the Current Population Survey," *Journal of Labor Economics*, 18 no. 4 (October 2000): 653-80.

Card, David, Lawrence Katz, and Allen B. Krueger, "Comment on David Neumark and William Washer, 'Employment Effects of Minimum and Subminimum Wages: Panel Data on State Minimum Wage Laws'," *Industrial and Labor Relations Review,* 48 (1994): 487-96.

Card, David and Alan B. Krueger, *Myth and Measurement: The New Economics of the Minimum Wage.* Princeton, NJ: Princeton University Press (1995).

Chang, Yang-Ming, and Isaac Ehrlich, "On the Economics of Compliance with the Minimum Wage Law," *Journal of Political Economy* 93 (February 1985): 84-91.

Collado, Dolores M., "Estimating Dynamic Models from Time Series of Independent Cross-Sections," *Journal of Econometrics* 82 (January 1998): 37-62.

Deere, Donald, Kevin M. Murphy, and Finis Welch, "Employment and the 1990-1991 Minimum-Wage Hike,' *American Economic Review* (May 1995): 232-237.

Freeman, Richard, Wayne Grey, and Casey E. Ichniowski, "Low Cost Student Labor: The Use and Effects of the Youth Subminimum Provisions for Full-Time Students." *Report of the Minimum Wage Study Commission*, Vol. 5. Washington D.C.: GPO, Washington, D.C, pp. 305-35.

Hsiao, Cheng, *Analysis of Panel Data*, New York: Cambridge University Press (1986).

Im, Kyung, Hasken Pesaran, and Yongcheol Shin, "Testing for Unit Roots In Heterogeneous Panels," *Department of Applied Economics Working Papers* Amalgamated Series No. 9526, revised version, University of Cambridge (December 1997).

Judson, Ruth A. and Ann L. Owen, "Estimating dynamic panel data models: a guide for macroeconomists," *Economic Letters*, 65 (1999): 9 – 15.

Haugen, Steven E. and Earl F. Miller, "Estimating the Number of Minimum Wage Workers," *Monthly Labor Review* (January 1990):70-74.

Harris, Richard and Elias Tzavalis, "Inference for Unit Roots in Dynamic Panels Where The Time Dimension is Fixed," *Journal of Econometrics*, 91 (August 1999): 201-26.

Hsiao, Cheng, "Measurement Error in a Dynamic Simultaneous Equations Model with Stationary Disturbances," *Econometrica*, 47 (March 1979): 475-94.

Katz, Lawrence F. and Alan B. Krueger, "The Effect of Minimum Wage on the Fast Food Industry," National Bureau of Economic Research, Working Paper 3997 (February 1992).

Kiviet, J. F., “On bias, inconsistency, and efficiency of various estimators in dynamic panel data models.” *Journal of Econometrics* 68 (1995): 53-78.

Neumark, David, and William Wascher, “Employment Effect of Minimum and Subminimum Wages: Panel Data on State Minimum Wage Laws, *Industrial and Labor Relations Review*, 46 (1992): 55-81.

Neumark, David and William Wascher, “Employment Effects of Minimum and Subminimum Wages: Reply to Card, Katz, and Krueger,” *Industrial and Labor Relations Review*, 47 (April 1994): 497-512.

Neumark, David and William Wascher, “State-Level Estimates of Minimum Wage Effects: New Evidence and Interpretations from Disequilibrium Methods,” *The Journal of Human Resources*, 37, 1 (2002): 35-62.

Neumark, David, Mark Schweitzer, and William Wascher, “The Effects of Minimum Wages Through Out The Wage Distribution,” NBER Working Paper 7519 (February 2000).

Schiller, Barry, “Below minimum-wage workers: implications for minimum-wage models.” *Quarterly Review of Economics and Finance*, 34, 2 (Summer 1994): 131-43.

U.S. Department of Labor, “Minimum Wage and Overtime Hours Under The Fair Labor Standards Act,” Employment Standards Administration, Wage and Hour Division, report (January 2001).

Wessels, Walter, "Minimum Wages and Tipped Servers," *Economic Inquiry* (April 1997): 334-349.

Wessels, Walter, “Does the Minimum Wage Drive Teenagers Out of the Labor Force?” *Journal of Labor Research*, forthcoming, 2004.

Table 1
Teenage Employment in Jobs Paying Less Than Minimum Wage
States With Federal Minimum Wage
Consumer Population Survey: Outgoing Rotation Files

	1989:04 – 1990:03	**1990:04** – 1991:03	**1991:04** – 1992:03	1992:04 – 1993:03	1993:04 – 1994:04
Occupation					
Servers	211	294	236	177	165
Cooks	40	110	94	48	67
Sales	81	195	153	104	89
Service	476	672	593	425	429
Industry					
Retail	364	680	579	348	356
Household	171	143	162	141	120
Entertainment	29	69	49	42	36
Other					
Total Uncovered	817	1216	1122	773	760
Total Covered	7675	6568	5832	5854	5917
Percent Uncovered	9.6%	16.1%	16.1%	11.7%	11.4%
Jobs Paying within 25¢ of Youth MW	*1881**	421	168	68	*66**
Occupation	1995:10 – 1996:09	**1996:10** – 1997:08*	**1997:09** – 1998:08	1998:09 – 1999:08	1999:09 – 2000:08
Servers	184	225	222	226	230
Cooks	32	96	126	66	56
Sales	60	147	241	142	111
Services	337	475	544	369	426
Industry					
Retail	306	540	690	463	460
Household	63	57	73	60	52
Entertainment	19	50	71	44	32
Other					
Total Uncovered	538	914	1184	870	756
Total Covered	5716	5427	5406	5950	6238
Percent Uncovered	8.6%	14.4%	18.0%	12.8%	10.8%
Jobs Paying within 25¢ of Youth MW	*992***	229	61	46	21

- The years appearing in bold are years during which the federal minimum wage was increased.
- Servers include waiters and waitresses, their assistants, bartenders, and fountain counter workers; Cooks include cooks and miscellaneous food preparers.
- Sales and Services are defined by the CPS major occupational code.
- Household occupations are private household services.

*1996:10 - 1997:08 figures were multiplied by 12/11ths to be comparable with yearly figures in other cells. The unadjusted total for uncovered was 838 and for covered, 4975.
**There was no youth minimum wage in this period (there was a full-time student subminimum wage in 1989, see text). Number shown is the number of workers falling within 25 cents of the youth minimum wage range of the adjacent period.

Table 2

Before and After Hike Comparison of Match Sample
Of Teenage Workers Classified As Having Minimum Wage or Above Job Before Hike and Below Minimum Wage Job After Hike:
Change in Hourly Wages

Hike	May 1990 $3.35 to $3.80	May 1991 $3.80 to $4.25	October 1996 $4.25 to $4.75	September 1997 $4.75 to $5.15
Wage Before	$4.06 ($1.16)	$4.47 ($0.98)	$4.90 ($0.73)	$5.47 ($2.15)
Wage After	$3.24 ($0.60)	$3.55 ($0.65)	$3.84 ($1.00)	$4.35 ($1.11)
Percentage Receiving Lower Wage	61.1%	75.9%	60.6%	55.1%
Percentage Lower Wage by 50 ¢ or more	47.0%	59.5%	53.5%	39.3%
Sample Size	149	116	71	89

Sample: Matched teenage workers (16-19) reported as earning minimum wage (higher of state or federal minimum wage) or more before hike and earning less than the new minimum wage after date of federal minimum wage hike. Standard deviation in parentheses. Data set includes only hourly workers reporting their hourly wages.

Table 3

The Effect of the Minimum Wage On the Log of the Ratio of Teenage Employment to Population: Netting Out Lags In Reporting In Covered Wages

First-Difference Equation With 4 Lags in Explanatory Variables

	Level Regression Results				First Difference Results		
Number	1 Not Weighted	2 Weighted	3 AR(4) Added	4 Lag Dummies Added	5 Weighted	6 AR(12) Added plus lags*	7 Adj. for Lag in Wage Change*
Dependent Variable: Log of Covered Employment							
Log Min. Wage							
Coefficient	-0.7801	-0.7867	-0.8443	-0.7730	-0.3579	-0.7268	-0.6025
t or (χ2)	-22.2	-26.9	-18.7	-12.6	-9.6	-16.5	*(122.5)*
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dependent Variable: Log of Overall Employment							
Log Min Wage							
Coefficient	-0.2390	-0.2463	-0.2395	-0.2801	-0.1518	-0.2200	-0.2003
t or (χ2)	-8.5	-10.6	-7.5	-5.6	-5.6	-6.5	*(20.1)*
p-value	>0.0001	>0.0001	>0.0001	>0.0001	>0.0000	>0.0001	>0.0001
Explanatory Variables in Regression							
Standard Variables and Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes 4*	Yes 4*
Weighting	No	Yes	Yes	Yes	Yes	Yes	Yes
AR	No	No	4	4	No	12	12

Note: Standard variables include the log of adult wages, the adult unemployment rates, the fraction of teenagers in the population, the log of per-capita income (in first difference regressions only due to unit root), the percent change in the GDP deflator, and quarterly dummy variables. All are state-specific except for the GDP deflator. Teenage employment population ratio calculated with CPS weights.

*In regressions 6 and 7, current and lagged values for all variables (except minimum wage in regression number 6) from current to four lags.

Table 4

The Effect of the Minimum Wage On The Log of the Ratio of Teenage Employment to Population

Various Equations

Number	1 Level, Column 4 Yearly Dummies	2 First Dif., Col. 7 Yearly Dummies	3 First Dif., Col. 7 1983-89	4 First Dif., Col. 7 1989-1994	5 First Dif., Col. 7 1995-2001	6 Level, Col. 4 1989-1994	7 Level, Col. 4 1995-2001
Dependent Variable: Log of Covered Employment							
Log Min. Wage							
Coefficient	-0.6903	-0.5795	-0.5191	-0.5553	-0.6113	-0.4739	-0.1132
t or ($\chi 2$)	-25.1	*(25.1)*	*(3.91)*	*(18.8)*	*(16.8)*	-4.0	0.1
p-value	<0.0001	<0.0001	0.0477	<0.0000	0.0004	0.0440	0.2550
Dependent Variable: Log of Overall Employment							
Log Min Wage							
Coefficient	-0.1455	-0.0351	-0.0212	-0.2354	0.0204	-0.2839	0.2516
t or ($\chi 2$)	-1.69	(0.04)	(0.01)	(4.7)	(0.03)	-3.01	3.01
p-value	0.0898	0.8514	0.9161	<0.0001	0.8700	0.0388	0.0026
Explanatory Variables in Regression							
D:First Difference, Level	L	D	D	D	D	L	L
Lags included	0	4*	4*	4*	4*	0	0
AR	0	12	12	12	12	0	0
Dates	1979:1-2000:1	1979:1-2000:1	1983:1-1988:4	1989:1-1994:4	1995:1-2001:4	1989:1-1994:1	1995:1-2001:4

Note: *Columns 2-5 has 4 lags for all variables including the minimum wage and the first column shows the sum of the minimum wage coefficients while the second column showsthe sum's chi-square. Explanatory variables are those used in Table 3 in the indicated column. All regressions are weighted using cross-sectional variances.

Figure One

Vertical Line indicates date Federal Minimum Wage Increased.

APPENDIX TABLE ONE

Mean and Variance of Variables

Mean for states (Standard Deviation)		
Teen Employment Rate	0.4649	(0.1059)
First Difference	-7.48 E-05	(0.0993)
Teen Covered Employment Rate	0.3947	(0.0975)
First Difference	5.70 E-04	(0.0953)
Teen Uncovered Employment Rate	0.0698	(0.0428)
First Difference	-6.45 E-04	(0.0434)
Unemployment Rate	0.0398	(0.0234)
Adult Wage Rate	$9.010	($2.046)
Fraction of Teens in Population	0.1369	(0.0226)
Per Capita Income	$17104	($ 5936.5)

US Means

	Covered Sector	Uncovered Sector
Fraction Male	0.5207	0.4149
Fraction White	0.8959	0.9015
Weekly Earnings	$130.79	$70.21
Weekly Hours	26.6	21.3

Appendix Table 2
Teenage Employment in Jobs Paying Minimum Wage or More
States With Federal Minimum Wage
Consumer Population Survey: Outgoing Rotation Files

	1989:04 – 1990:03	**1990:04** – 1991:03	**1991:04** – 1992:03	1992:04 – 1993:03	1993:04 – 1994:04
Occupation					
Servers	635	533	496	513	556
Cook	685	561	567	601	661
Sales	1714	1422	1254	1257	1272
Service	2193	1849	1771	1841	1938
Industry					
Retail	4019	3341	3059	3148	3221
Household	84	70	45	53	76
Entertainment	281	237	232	315	302
	1995:10 -- 1996:09	**1996:10** – 1997:08*	**1997:09** – 1998:08	1998:09 – 1999:08	1999:09 – 2000:08
Occupation					
Servers	494	411	405	480	527
Cook	557	509	523	509	506
Sales	1328	1226	1239	1342	1442
Services	1716	1477	1582	1818	1857
Industry					
Retail	3072	2804	2832	3065	3276
Household	49	48	32	38	38
Entertainment	345	340	315	403	354

Notes:
- The years appearing in bold are years during which the federal minimum wage was increased.
- Servers include waiters and waitresses, their assistants, bartenders, and fountain counter workers; Cooks include cooks and miscellaneous food preparers.
- Sales, Services, and Handlers are defined by the CPS major occupational code; Handlers include equipment cleaners, helpers, and laborers.
- Household occupations are private household services.

*1996:10 - 1997:08 figures were multiplied by 12/11ths to be comparable with yearly figures in other cells.

Appendix Table 3

Comparison in Between Years With No Hike In Federal Minimum Wage:

Comparison of Match Sample

of Displaced Teenage Workers Having Minimum Wage or Above Job In First Year and Below Minimum Wage Job in Second Year:

Change in Hourly Wages

Years	1992 to 1994	1997 to 1999
Wage Before	$5.67	$5.82
Wage After	$3.39	$4.36
Percent Receiving Lower Wage by 50 cents or more	64.9%	67.4%
Sample Size	*N*=77	*N*=46

1992 -1994 sample is from April 1992 to May 1994, matching over May 1993. The 1997-1999 sample is from October 1997 to September 1999, matching over October 1998. Data only includes hourly workers reporting hourly wages. The exception is for 1994, which includes wages allocated by BLS if not reported by the hourly worker.

Appendix Table 4 *Before and After Hike Comparison of Match Sample* *of Teenage Workers With Wage At or Above Minimum Wage Before Hike*				
Hike	May, 1990 $3.35 to $3.80	May, 1991 $3.80 to $4.25	October, 1996 $4.25 to $4.75	September, 1997 $4.75 to $5.15
Wage Before	$4.63	$4.88	$5.29	$5.61
Wage After	$5.11	$5.20	$5.97	$6.23
Percent No Job After Hike	27.8%	25.8%	26.7%	22.9%
Percent Receiving Lower Wage	20.4%	24.2%	20.6%	18.1%
Sample Size	2426	1521	1705	1611

Appendix Table 5 *Test for Unit Root* *Im, Pesaran, and Shin t-bar statistic for Panel Data*		
Variable	Constant	Constant plus trend
Log of Fraction of Teenagers Earning Minimum or More	-2.136**	-2.587**
Unemployment Rate for Prime Age White Males	-2.472**	-2.945**
Fraction of Teens in Population	-1.552	-2.015
First Difference of Fraction of Teens in Population	-3.146**	-3.637**
Log Wage Ages 30-39	-1.121	-2.716**
First Difference Log Wage Ages 30-39	-4.170**	-4.319**
Log Per Capita Personal Income	-0.928	-1.961
First Difference of Log Per Capita Personal Income	-3.189**	-3.128**
Log of Real GDP	0.7792	-2.945
% Change in Real GDP	-2.1004	-2.221
Log of GDP Deflator	-1.564	-0.774
% Change in GDP Deflator	-5.068***	-5.402***

** Significant at 1% level using table from Im, Pesaran, and Shin (1997). Unmarked statistics are not significant at the 10% level. Critical values for the second column are –1.81 (1%), –1.73 (5%), and –1.68 (10%). Critical values for third column are –2.44 (1%), –2.36 (5%), and –2.32 (10%). Eight lags were used in all tests.
***Significant at the 1% level for the augmented Dickey-Fuller test.

Appendix Table 6
Results of Table 3, Regression 7
Dependent Variable: Log of Ratio of Covered Workers to Population Ages 16-19, 1979-2001

Variable	Coefficient	Std. Error for sums: *chi-square*	Prob.
Log Minimum Wage(MW)	-0.8407	0.0954	0.0000
MW(lag 1 Qtr.)	-0.2083	0.1421	0.1428
MW(lag 2 Qtr.)	0.1977	0.1347	0.1422
MW(lag 3 Qtr.)	-0.0026	0.1211	0.9825
MW(lag 4 Qtr.)	0.2514	0.0936	0.0073
Sum	-0.6025	*122.5*	<0.0001
Sum*: Unemployment Rate*	-2.3256	*63.0*	<0.0001
Sum: *Fraction Teenagers*	+0.7783	*2.1*	0.1500
Sum: Log *Per Capita Income*	0.9179	*46.1*	<0.0000
Sum: Log *Adult Wage Rate*	-0.0709	*0.51*	0.4734

Sum:% *Change in GDP Price Deflator*	-0.5461	*5.9*	0.0151
Quarter 1	0.0879	0.0128	<0.0001
Quarter 2	0.2542	0.0121	<0.0001
Quarter 3	0.2643	0.0116	<0.0001
AR(1)	-0.8634	0.0163	<0.0001
AR(2)	-0.7821	0.0211	<0.0001
AR(3)	-0.6867	0.0252	<0.0001
AR(4)	-0.5067	0.0275	<0.0001

AR(8)	-0.2927	0.0282	<0.0001

AR(12)	-0.0617	0.0166	0.0002

First-difference regression results on quarterly data. Sum is sum of coefficients, current plus 1 through 4 lags. *X*(1) is variable X_t, lagged one period (that is, X_{t-1}). The null hypothesis that each coefficient in the set that equaled zero was rejected (at $p<0.0000$) for each of the following: the minimum wage, unemployment, per capita income, and the percentage change in the GDP price deflator. Adjusted R-square = 0.6078.