Time-Series Minimum-Wage Studies: A Meta-analysis

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One of the best-known predictions of standard economic theory is that an increase in the minimum wage will lower employment of low-wage workers. The evidence that is frequently cited in support of this prediction is based on aggregate time-series studies. There have been over 30 published time-series studies of the effect of the minimum wage on employment in the United States since 1970. Most of these studies correlate the employment-to-population rate of teenagers with the relative level of the minimum wage. In their landmark survey Charles Brown et al. (1982 p. 508) summarized the time-series evidence up to the early 1980's as follows:

> In summary, our survey indicates a reduction of between one and three percent in teenage employment as a result of a 10 percent increase in the federal minimum wage. We regard the lower part of this range as most plausible because this is what most studies, which include the experience of the 1970s and deal carefully with minimum-wage coverage, tend to find.

More recent time-series studies (Allison Wellington, 1991; Jacob Klerman, 1992) have found an even smaller effect of the minimum wage.

In contrast to the time-series literature, a number of recent studies based on cross-sectional comparisons (Card, 1992a, b; Lawrence Katz and Krueger, 1992; Card and Krueger, 1994; Stephen Machin and Alan Manning, 1994) have estimated negligible or even marginally positive employment effects of the minimum wage. Because of the central role that the time-series evidence has played in the minimum-wage literature, and the apparent discrepancy between the time-series evidence and the cross-sectional studies, it is important to assess the validity of the time-series estimates. In this paper we present a "meta-analysis" of the published time-series literature. Our analysis builds on the observation that more recent studies have access to many more observations than earlier studies. Basic sampling theory suggests that there should be a simple "inverse-square-root" relationship between the sample size and the t ratio obtained in different studies. We test this prediction using the estimates from the time-series minimum-wage literature.

Our findings are difficult to reconcile with the hypothesis that the literature contains an unbiased sample of the coefficients and t ratios that would be expected given the sample sizes used in the different studies. Specifically, we find that the t ratios reported in different studies are *negatively* correlated with the underlying sample sizes. In addition, the estimated employment effect of the minimum wage tends to be about twice its standard error, regardless of the size of the standard error. These findings suggest that the time-series literature may have been affected by a combination of specification searching and publication bias, leading to a tendency for statistically significant results to be overrepresented in the published literature.

I. Publication Bias

It has long been argued that academic journals have a tendency to publish papers

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with "statistically significant" results (Colin Begg and Jesse Berlin, 1988; Bradford De Long and Kevin Lang, 1992). Statistical significance is usually judged by whether the t ratio for the main explanatory variable(s) exceeds 2 in absolute value. Because a statistical analysis is deemed more decisive if the null hypothesis of zero is rejected (i.e., if one can reject the hypothesis that the key explanatory variable has no effect), there is a natural tendency for reviewers and editors to look more favorably on studies with statistically significant results.

Furthermore, in the case of the minimum wage, economists have a strong theoretical presumption that a rise in the minimum wage will lower employment. This presumption leads to two additional sources of publication bias. First, reviewers and editors may be predisposed toward accepting papers that show a "significant negative effect" of the minimum wage. Second, researchers may use the criterion of a negative and significant employment effect as a guide in choosing their empirical specifications. Researchers have a great deal of discretion over the control variables they include, the functional form they impose, the sample they analyze, and the estimation technique they use. This discretion may inadvertently lead to biases if particular choices are determined in part by whether they generate negative and statistically significant employment effects.

II. Meta-analysis

Meta-analysis is the quantitative analysis of a body of studies. Meta-analytic techniques may be used to summarize a set of related studies (Stephen Jarrell and T. D. Stanley, 1990) or to evaluate the reliability of the findings in a statistical literature. Meta-analysis can also be used to test for publication bias. For example, Begg and Berlin (1988) interpret the lack of association between sample size and statistical significance in clinical trials of cancer treatments as evidence of publication bias.

In the context of time-series minimum-wage studies, a natural test for publication bias arises from fact that more recent studies use more data. The first of these studies were conducted in the early 1970's, when the available time series were relatively short, typically going back only to 1954. More recent studies can use up to twice as many observations as the early studies. A doubling of the sample size should lower the standard error of the estimated employment effect and raise the absolute t ratio by about 40 percent if the additional data are independent and the statistical model is stable. More generally, the absolute value of the t ratio should vary proportionally with the square root of the number of degrees of freedom, and a regression of the log of the t ratio on the log of the square root of the degrees of freedom should yield a coefficient of 1.

Aggregate time-series data are unlikely to be independent. In recognition of this fact, two-thirds of the time-series studies have corrected their estimates for serial correlation. In principle, this adjusts for the dependence in the data. Studies that do not make this adjustment are implicitly assuming that the data are independent, so the relationship between the t statistic and sample size still provides a valid test of publication bias. Furthermore, even with dependent observations, one would expect the t ratio to increase with the sample size.

What might prevent the t ratio from rising with the sample size? One obvious possibility is publication bias. If studies are only published if they achieve a t ratio of 2 or more, and if researchers choose their specifications in part to achieve statistically significant results, then the early studies may tend to have high t ratios despite their small samples. Another possibility is that structural change may alter the statistical model. In this case, the t ratio might rise or fall with sample size. If the effect of the minimum wage has become weaker over time, then the t ratio could remain constant or even fall as the available sample size increases.

III. Results

To explore the possibility of publication bias we related the t ratios found in differ-

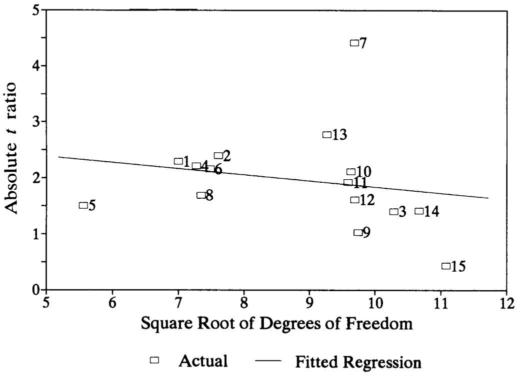

FIGURE 1. RELATION OF ESTIMATED t RATIOS TO SAMPLE SIZE

Note: The numbers in the figure refer to the following studies: 1) Hyman Kaitz, 1970; 2) Jacob Mincer, 1976; 3) Edward Gramlich, 1976; 4) Finis Welch, 1976; 5) James Ragan, 1977; 6) Michael Wachter and Choongsoo Kim, 1979; 7) George Iden, 1980; 8) Ragan, 1981; 9) John M. Abowd and Mark R. Killingsworth, 1981; 10) Charles Betsey and Bruce Dunson, 1981; 11) Brown et al., 1983; 12) Daniel Hamermesh, 1981; 13) Solon, 1985; 14) Wellington, 1991; 15) Klerman, 1992.

TABLE 1—DESCRIPTIVE REGRESSION MODELS FOR THE LOG OF THE ABSOLUTE t RATIO OF THE MINIMUM-WAGE EMPLOYMENT EFFECT

Explanatory variables	Mean [SD]	Specification (i)	(ii)	(iii)
Log of square root of degrees of freedom	2.16 [0.20]	−0.81 (0.70)	−0.86 (0.77)	−0.98 (0.86)
Autoregression correction (1 = yes)	0.67 [0.49]	—	0.02 (0.35)	−0.02 (0.39)
Sub-sample of teenagers (1 = yes)	0.27 [0.46]	—	0.28 (0.40)	0.37 (0.49)
Logarithmic specification (1 = yes)	0.73 [0.46]	—	−0.37 (0.45)	−0.30 (0.51)
Number of explanatory variables	9.93 [4.06]	—	—	0.02 (0.04)
Intercept	1.00 [0.00]	2.87 (1.36)	2.87 (1.65)	3.02 (1.76)
Adjusted R^2	—	0.02	0.10	0.01
P value for joint significance of explanatory variables:	—	0.27	0.31	0.45

Notes: Standard errors are shown in parentheses. The sample includes the 15 studies specified in the note to Figure 1.

ent studies to the sample sizes and other characteristics of the studies. We focus on the 15 studies that analyzed quarterly data: 12 studies published before 1981 that were included in the review by Brown et al. (1982); and three later studies (Gary Solon, 1985; Wellington, 1991; and Klerman, 1992). Where possible, we selected the t ratio on the minimum-wage variable in what we judged to be the author's preferred logarithmic specification. For studies that estimated only a linear specification, we selected the t ratio from the author's preferred linear specification. (See Card and Krueger [1995] for a detailed discussion of our procedures). Because functional form is one of the elements that researchers have discretion over, it is appropriate to combine estimates based on different functional forms. Nevertheless, we experimented with limiting the sample to the subset of studies that use a log specification, and our conclusions are similar.

Figure 1 graphs the relationship between the absolute value of the t ratio reported in a study and the square root of the degrees of freedom in the study. The number beside each point in the graph refers to the study listed in the note to the figure. The fitted regression line is also displayed on the graph. *Contrary to the expected upward-sloping relationship between the t ratio and the sample size, the graph displays a downward-sloping pattern.* Study 7, by Iden (1980), is clearly an outlier. The other studies cluster fairly closely around the line.

To control for other characteristics of the studies that might be correlated with sample size, we estimated the descriptive multivariate regressions presented in Table 1. The dependent variable in these regressions is the log of the t ratio for each study. The key independent variable is the log of the square root of the degrees of freedom, which is predicted to have a coefficient of 1 by sampling theory. In addition, we include a dummy variable that equals 1 if the specification was logarithmic, a dummy variable that equals 1 if the sample contained a subset of teenagers (as opposed to all teenagers), a dummy variable that equals 1 if an autoregressive correction was used in estimation, and a variable representing the number of covariates included in the original model.

As suggested by Figure 1, the estimates in Table 1 show a negative relationship between the t ratios and the degrees of freedom. The coefficient on the square root of the degrees of freedom is quite far from 1, its theoretical expectation. The inclusion of additional explanatory variables does not change the sign of the coefficient or reduce its effect.

We have also estimated similar models for three subsets of studies. First, we eliminated the three studies published after 1982. In the pre-1982 subsample we continue to find a negative correlation between the t ratio and the degrees of freedom. Second, we performed the regression analysis omitting the outlying study, number 7 (see Fig. 1). When this study is eliminated from the sample, the relationship between the t ratio and the degrees of freedom becomes stronger. Finally, we performed the analysis on the subset of 11 studies that use a logarithmic specification. In this subsample we continue to find a negative relationship between the t ratio and degrees of freedom.

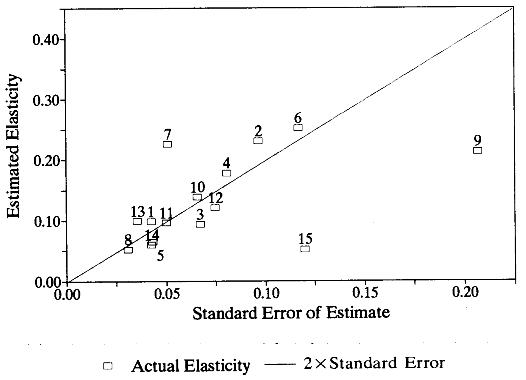

FIGURE 2. RELATION OF ESTIMATED EMPLOYMENT ELASTICITY TO STANDARD ERROR

IV. Is the t Ratio Always 2?

Another type of meta-analysis relates the magnitude of the coefficient in each study to its estimated standard error. If the same statistical model holds in different time periods, one would expect to find *no* systematic relationship between the estimated coefficients and their standard errors. But if publication bias induces a tendency toward the publication of studies with t ratios that exceed 2 in absolute value, we would expect to find a positive relationship between the magnitude of the estimated employment effect and its standard errors. For example, suppose that journals follow a rule of only publishing studies with t ratios above 2 and suppose that authors manipulate their specifications (by varying functional forms, changing the set of included covariates, etc.) until they achieve such a result. Then there will be many published papers with t ratios equal to or just above 2. Since the t ratio is given by $t = b/\text{SE}$, where b is the estimated employment effect and SE is its standard error, this process will generate a positive correlation across studies between the coefficient estimates and their associated standard errors.

One difficulty with examining the relationship between coefficients and standard errors is that different studies estimate different functional forms, so the coefficients are not directly comparable. To overcome this problem, we use estimates of the employment effect associated with a 10-percent increase in the minimum wage. We derive the implicit standard error for these estimated employment effects using the reported t ratios for the underlying estimates.

Figure 2 presents a scatter diagram of the absolute value of the minimum-wage effects against their standard errors. The figure also shows a line corresponding to 2 times the standard error. The line fits the data rather well. The estimates from study 9 (Abowd and Killingsworth, 1981) and study 15 (Klerman, 1992) lie noticeably below the line, whereas the estimate from Iden's (1980) study is well above the line. Otherwise, the estimates cluster fairly close to the line. In contrast to what one would predict if the true employment effect of the minimum wage were constant over time and the estimated coefficients in the literature were unbiased, the estimates of the elasticity of employment with respect to the minimum wage are generally close to 2 times their standard error.

V. Conclusion

What might explain the combined tendency for the t ratios in the literature to fall with sample size, and for the t ratios to equal 2 irrespective of the magnitude of the estimated minimum-wage effect? Structural change is one possibility: the true effect of the minimum wage may have declined over time, and it may have done so at a faster rate than the decline in the estimated standard error. But the validity of the time-series approach is called into question if there has been a structural change. The published studies have not allowed for a break in the structure; instead, they assume that it is constant. Moreover, if there has been a structural change, then one would probably conclude that the minimum wage now has an insignificant effect on employment, based on the time-series estimates that include the most recent data (Wellington, 1991; Klerman, 1992).

Rather than structural change, we think a more plausible explanation for these results is that the studies in the literature have been affected by specification-searching and publication biases, induced by editors' and authors' tendencies to look for negative and statistically significant estimates of the employment effect of the minimum wage. As Edward Leamer (1978) stresses, nonexperimental econometric studies are particularly prone to specification-searching and data mining. We conjecture that, in the early studies, certain combinations of control variables, sample definitions, and functional forms were found to yield statistically significant and negative estimates of the minimum-wage effect. Because some researchers and some reviewers follow an implicit criterion of selecting specifications that achieve t ratios in excess of 2, these specifications are overrepresented in the early published studies. Later researchers felt some compulsion to replicate the specifications and data constructs used in the earlier literature. But because the relationship was fragile in the first place, the later studies discovered weaker effects of the minimum wage.

The main conclusion we reach is that researchers may have to temper the inferences they draw from a body of published studies—even from a literature that appears to provide strong support for a particular finding. As De Long and Lang (1992 p. 1258) have emphasized, "...even a careful review of the existing published literature will not provide an accurate overview of the body of research in an area if the [published] literature itself reflects selection bias." This may be especially true for cases in which the research concerns a parameter that is predicted to have a certain sign by conventional economic theory. In this case, insignificant or "wrong-signed" results may be substantially underreported in the published literature.

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