Time Series Minimum Wage Studies

Meta-Analysis

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Introduction

The effect of minimum wage on the employment and especially on the employment among teenagers is a well-known research problem that was addressed multiple times in the past. Conducted studies usually refer to a negative impact of minimum wage increase on the employment rate. In other words, the coefficient for minimum wage as an independent variable is negative, when the dependent variable considered is the unemployment rate.

There are numerous ways on how to examine this relationship. Among papers related to this problem, we found evidence of panel data models, cross-sectional data models as well as aggregated time series data models. Although the majority of researchers consider only the United States data, we found examples of different regions such as European or Asian countries analysed as well.

We believe that reproducing results obtained by other researchers is a crucial part of science, especially when it comes to conclusions of that importance. Therefore, the main goal of this research paper is two-fold. First, we aim to reproduce the results of a well-known meta-analysis conducted in the late 1990s by Card and Krueger (1995). In the aforementioned paper, authors examined 15 studies on this topic and drew multiple conclusions considering the quality of the cited studies. Moreover, authors put an emphasis on the problem of *publication bias*, while conducting their own research. When it comes to meta-research, the obtained and aggregated results, such as coefficients are not the most important factors. In this type of research, authors usually look for various biases that could lead to wrong conclusions, which were later replicated over time by other scientists. After reproducing the results obtained by Card and Krueger, we aim to further enhance the analysis by adding additional papers, especially focusing on these, which were published later than the meta-analysis we reproduce. This is important considering the fact that in the original meta-analysis authors claimed that the sample size can have a substantial effect on the t-statistics obtained by the researchers. With research papers published later, the probability of a higher sample is naturally greater.

The next section presents the process of reproducing the meta-analysis done by Card and Krueger. Then we enrich the analysis with two additional papers and present the obtained results. Last section concludes.

Previous Meta-Analysis

Original paper that we aim to reproduce was published in 1995. In the past, more than 25 years ago, reproducibility was not considered such an important topic as it is today. Although the authors presented a reliable meta-analysis, they did not include the original data such as *t-statistics* in their research. We not only reproduce the obtained results in a form of replicating the modeling and visualization process, but we need to look for the required information in original papers or in other meta-analyses. Two research papers were especially helpful. One has explored the older studies (Brown, Gilroy, and Kohen 1982), while the other was aggregating newly published research papers as well (Neumark and Wascher 2006).

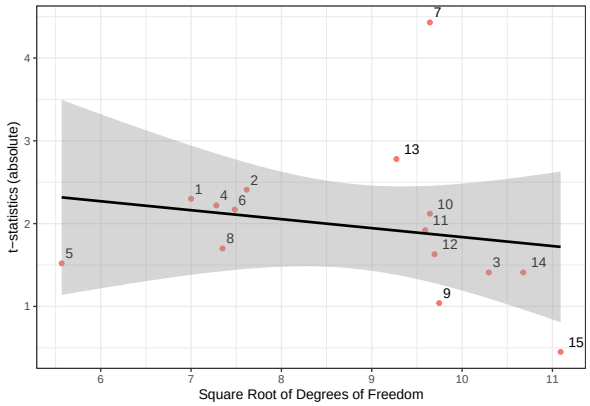
For the purpose of reproducibility, we have gathered the information of all 15 papers analysed in the original meta-analysis. Our dataset consists of the author(s), date of publication (`year`), *t-statistic* in absolute terms[1] (`t_stat`), *degrees of freedom* (`df`), coefficient of the minimum wage variable in absolute terms[2] (`coef`), number of explanatory variables of the model (`no_exp_var`), the error of the model (`error`) and two dummy variables. One binary variable is set to 1, when there was a logarithmic specification of the model (`log_spec`) and the second one is set to 1, when the autoregression correction was applied (`autoreg_correction`). We additionally calculate the square roots of `df` and the natural logarithm of the square root of `df` as in the original research paper, and name these variables `sqrt_df` and `l_sqrt_df`, respectively. Due to lack of sufficient information from the original meta-analysis authors, we lack the binary variable indicating whether the model had taken the subsample of teenagers, rather than the total population. We had gathered the information for all research papers considered but one. In result, we were missing one datapoint, which is the number of explanatory variables for Klerman's study published in 1992, but we have managed to find that number by looking at the mean of this variable given in the original Card and Krueger paper.

Authors originally looked at earlier meta-research, similarly as we are. They extended the previous study by an additional three papers. Looking for a direct specification of the models, rather than just for the coefficient values is an exceptional effort. Most studies either show only the narrow results or they are not available to find in an open source research aggregators. Nevertheless, we have managed to find the details for two papers published after the Card and Krueger publication in 1995. To be more precise, we will enrich our analysis by adding paper by Bernstein and Schmitt (2000) as well as by Bazen and Marimoutou (2002). We have also looked for information on detailed model specification in other papers such as Williams and Mills (2001) but we were unable to find sufficient information to support the analysis. First, we present the results of the reproduced original research, with the exclusion of teenager sub-sample variable.

[1] All considered t-statistics are negative.
[2] All considered coefficients are negative.

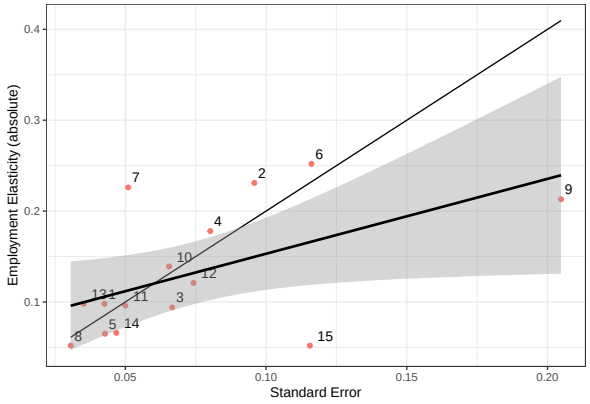
On the Figure 1, we present the reproduced results for the relationship between absolute t-statistics and square root of `df`. On the Figure 2, we present the estimated elasticities for employment compared to the standard error estimates.

Figure 1. Estimated t-statistics compared to Degrees of Freedom



Note: Presented sample is the one analysed by Card and Krueger. The fitted regression line is simple linear model with 95 pct. confidence intervals.

Figure 2. Estimated Employment Elasticity compared to Standard Error Estimate



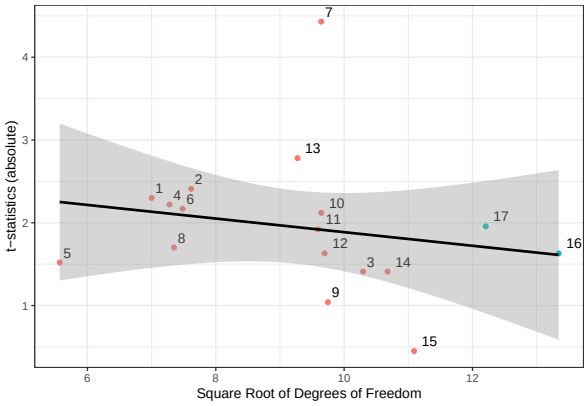
Note: Presented sample is the one analysed by Card and Krueger. The fitted regression line is simple linear model with 95 pct. confidence intervals. Line without confidence intervals represent the Standard Error multiplied by 2.

We present the reproduced regressions in Table 1, in the Appendix. Additionally, on Table 3, 5 and 7 model specifications fitted on subsets of dataset are presented accordingly to original paper methodology. Table 3 presents the reproduced results for subset of studies with study number 7 excluded, Table 5 presents the reproduced results for subset of studies using logarithmic specification, and Table 7 presents the reproduced results for subset of studies published before year 1983

Extended Meta-Analysis

The results of our reproducible research seem to be satisfying and confirm the trend observed by Card and Krueger (1995). As the papers added by us to the analysis were more recent they were based on a bigger sample and therefore also the degrees of freedom have had higher values. The dependence between t-statistics and the square root of degrees of freedom is following the pattern seen in the original paper, as presented of Figure 3. The general rule in the meta-research is that the more degrees of freedom the lower is the t-statistics which is counterintuitive but goes in line with the conclusions derived from the original analysis (Card and Krueger 1995).

Figure 3. Estimated t-statistics compared to Degrees of Freedom (Extended)



Note: Presented sample is the one analysed by Card and Krueger extended by two additional studies published after the publication of the original meta-analysis. The fitted regression line is simple linear model with 95 pct. confidence intervals. Blue colour indicates the studies added to the reproduced original meta-analysis by Card and Krueger.

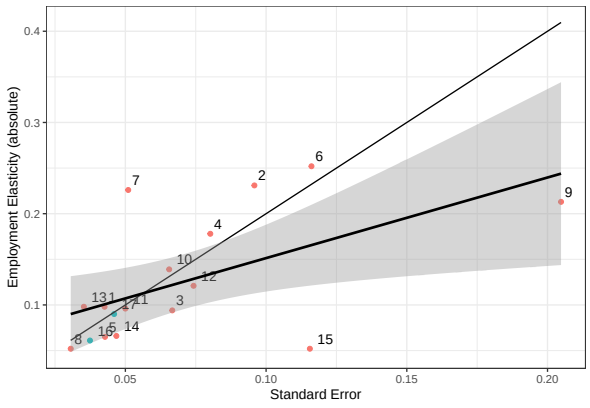
In order to control the potential impact of other research characteristics on this dependence, we performed regressions with the logarithm of absolute t-ratio as the dependent variable. Selected independent variables were the logarithm of the square root of degrees of freedom, a number of explanatory variables in given research, and binary variables indicating whether the model specification in given research was logarithmic and if the autoregressive correction was implemented. This specification is similar to the one used in the original meta-analysis except we did not manage to find the information about the teenage subsample being used in all papers. We also performed regressions with these specifications for subsamples suggested in the reproduced paper (Card and Krueger 1995). First subset consists only of the papers published not later than 1982. Although we reproduced the results for the original meta-analysis, we did not include this specification in our extended analysis, as we added papers published after 1995. Second, authors fitted a regression model without the study number 7, which was considered an outlier, the original results are presented in Table 3, while our extended model is presented in Table 4. Third specification was based only on the studies with logarithmic specification. These results are presented in Table 5, while our exended models are presented in Table 6. We generally see, that the models fitted on subsets are similar and directionally in line with the ones described in the origina meta-analysis. Across all specifications, with the addition of our studies, the coeffcients are close to zero, but far from the theoretically correct values.

Although our dataset is replicated as seen in the original analysis, we see that there are subtle differences in p-values and in the coefficients - especially when it comes to Intercept coefficients. This is surprising, given by the fact that we reproduced the original results and mean values for the independent variables are the same as in the original paper. We used the `lm()` function from R, to fit the regression models, and we believe that slight differences can be due to different algorithms used in the implementation of the original paper or our environment. The misalignment can be also caused by the fact that we were not able to include exactly the same data, but up to two decimals of precision due to low data availability, as mentioned multiple times in this paper. Nevertheless, for all reproduced and the extended models, coefficients for the key independent variable, which is the logarithm of the square root of degrees of freedom are negative and far from 1, which once again indicates that the selected papers suffered from the bias. For an unbiased analysis,

the coefficients should be equal to 1 as the higher the degrees of freedom, the higher should be the t-statistic. Here we observe an opposite relation.

Similarly, our analysis suggests the same dependence between the standard error and elasticity as in the original research (Card and Krueger 1995) as seen on Figure 4. The t-ratio is calculated with formula $t - stat = coef * \frac{1}{error}$, which means, that if there is a bias towards publishing only papers with t-ratio equal or close to 2 or higher, then we will observe the positive relationship. After adding studies selected by us, the positive dependence between these two statistics holds. As there should be no dependence between standard errors and the t-statistic, we can conclude that the old as well as newly added publications were biased.

Figure 4. Estimated Employment Elasticity compared to Standard Error Estimate (Extended)



Note: Presented sample is the one analysed by Card and Krueger extended by two additional studies published after the publication of the original meta-analysis. The fitted regression line is simple linear model with 95 pct. confidence intervals. Line without confidence intervals represent the Standard Error multiplied by 2. Blue colour indicates the studies added to the reproduced original meta-analysis by Card and Krueger.

Conclusion

The results of our research are in line with those achieved in the original meta-analysis done by Card and Krueger (1995), where authors suggest that these counterintuitive results are caused by the fact that in the beginning, when the available data was not that vast the researchers used specifications that allowed them to find a significant negative relationship between minimum wage and youth employment that they expected. However, as it was fragile the significance decreased with more data being used. The papers added by us confirmed that this research-biasing trend is vital and still present and for the papers published later than the 15 papers Card and Krueger looked at, with even bigger data samples the t-ratios were even lower.

To conclude, there is strong evidence that research is often biased. A lack of self-awareness and an over-trust in available literature can be misleading. Researchers, who trust biased science could perform analyses that might have low scientific value due to bias rooted in the predecessors' work.

Appendix

Table 1. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.81	−0.64	−0.94
	(0.69)	(0.66)	(0.62)
autoreg_correction		−0.07	−0.11
		(0.27)	(0.24)
log_spec		−0.55*	−0.63**
		(0.28)	(0.26)
no_exp_var			0.05*
			(0.03)
Constant	2.31	2.41	2.61*
	(1.49)	(1.40)	(1.27)
Observations	15	15	15
R^2	0.10	0.33	0.50
Adjusted R^2	0.03	0.15	0.30
Residual Std. Error	0.50 (df = 13)	0.47 (df = 11)	0.43 (df = 10)
F Statistic	1.37 (df = 1; 13)	1.83 (df = 3; 11)	2.51 (df = 4; 10)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 2. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Extended)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.54	−0.31	−0.47
	(0.53)	(0.54)	(0.52)
autoreg_correction		−0.05	−0.07
		(0.26)	(0.24)
log_spec		−0.52*	−0.57**
		(0.27)	(0.25)
no_exp_var			0.04
			(0.03)
Constant	1.76	1.69	1.65
	(1.18)	(1.13)	(1.07)
Observations	17	17	17
R^2	0.06	0.28	0.40
Adjusted R^2	0.001	0.11	0.20
Residual Std. Error	0.48 (df = 15)	0.45 (df = 13)	0.43 (df = 12)
F Statistic	1.02 (df = 1; 15)	1.64 (df = 3; 13)	2.00 (df = 4; 12)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger extended by two additional studies published after the publication of the original meta-analysis. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 3. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Subset 2: Study 7 excluded)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−1.03	−0.84	−1.13*
	(0.59)	(0.63)	(0.57)
autoreg_correction		−0.11	−0.15
		(0.25)	(0.22)
log_spec		−0.33	−0.41
		(0.29)	(0.26)
no_exp_var			0.05*
			(0.03)
Constant	2.72*	2.65*	2.84**
	(1.27)	(1.31)	(1.15)
Observations	14	14	14
R^2	0.20	0.30	0.52
Adjusted R^2	0.14	0.10	0.30
Residual Std. Error	0.43 (df = 12)	0.44 (df = 10)	0.38 (df = 9)
F Statistic	3.05 (df = 1; 12)	1.46 (df = 3; 10)	2.42 (df = 4; 9)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 4. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Extended) (Subset 2: Study 7 excluded)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.62	−0.42	−0.57
	(0.47)	(0.52)	(0.50)
autoreg_correction		−0.08	−0.11
		(0.24)	(0.23)
log_spec		−0.31	−0.38
		(0.29)	(0.27)
no_exp_var			0.04
			(0.03)
Constant	1.87*	1.76	1.72
	(1.03)	(1.08)	(1.01)
Observations	16	16	16
R^2	0.11	0.20	0.35
Adjusted R^2	0.05	−0.005	0.11
Residual Std. Error	0.42 (df = 14)	0.43 (df = 12)	0.40 (df = 11)
F Statistic	1.74 (df = 1; 14)	0.98 (df = 3; 12)	1.46 (df = 4; 11)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger extended by two additional studies published after the publication of the original meta-analysis. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 5. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Subset 3: Only studies with logarithmic specification)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.97	−0.92	−1.27*
	(0.69)	(0.72)	(0.61)
autoreg_correction		−0.18	−0.29
		(0.30)	(0.25)
log_spec			
no_exp_var			0.06*
			(0.03)
Constant	2.53	2.53	2.71*
	(1.50)	(1.56)	(1.28)
Observations	11	11	11
R^2	0.18	0.22	0.54
Adjusted R^2	0.09	0.02	0.34
Residual Std. Error	0.46 (df = 9)	0.48 (df = 8)	0.39 (df = 7)
F Statistic	2.00 (df = 1; 9)	1.11 (df = 2; 8)	2.71 (df = 3; 7)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 6. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Extended) (Subset 3: Only studies with logarithmic specification)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.49	−0.43	−0.57
	(0.54)	(0.58)	(0.55)
autoreg_correction		−0.12	−0.19
		(0.29)	(0.27)
log_spec			
no_exp_var			0.05
			(0.03)
Constant	1.54	1.48	1.34
	(1.21)	(1.27)	(1.18)
Observations	13	13	13
R^2	0.07	0.09	0.30
Adjusted R^2	−0.01	−0.10	0.06
Residual Std. Error	0.45 (df = 11)	0.47 (df = 10)	0.43 (df = 9)
F Statistic	0.83 (df = 1; 11)	0.47 (df = 2; 10)	1.26 (df = 3; 9)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger extended by two additional studies published after the publication of the original meta-analysis. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

Table 7. Regression Models for the Logarithm of Absolute t-statistics of Minimum Wage Emplyoment Effect (Subset 1: Studies published after 1982 excluded)

	Dependent variable:		
	log(t_stat)		
	(1)	(2)	(3)
l_sqrt_df	−0.06	−0.21	−0.21
	(0.64)	(0.54)	(0.61)
autoreg_correction		0.01	0.01
		(0.21)	(0.23)
log_spec		−0.51**	−0.51*
		(0.21)	(0.22)
no_exp_var			−0.0003
			(0.03)
Constant	0.79	1.43	1.43
	(1.35)	(1.14)	(1.24)
Observations	11	11	11
R^2	0.001	0.47	0.47
Adjusted R^2	−0.11	0.25	0.12
Residual Std. Error	0.39 (df = 9)	0.32 (df = 7)	0.35 (df = 6)
F Statistic	0.01 (df = 1; 9)	2.10 (df = 3; 7)	1.35 (df = 4; 6)
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: The sample used to estimate regression models is the same as in original meta-analysis by Card and Krueger. The binary variable for teenager sub-sample was removed, due to lack of information available to authors.

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