

FINANCIAL ECONOMETRICS
SHANGHAI JIAO TONG UNIVERSITY
SUMMER SCHOOL – 2025
EMPIRICAL EXERCISE – 1 –
With Solutions

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Reference: Stock, J.H. and Watson, M.W., Introduction to Econometrics (4th Edition, Global Edition)

Data: CPS96_15.csv from <http://www.pearsonglobaleditions.com>

Empirical Exercise 3.1. On the text website, you will find the data file CPS96_15, which contains an extended version of the data set used in Table 3.1 of the text for the years 1996 and 2015. It contains data on full-time workers, ages 25–34, with a high school diploma or a B.A./B.S. as their highest degree. A detailed description is given in CPS96_15_Description, available on the website. Use these data to complete the following.

(a) Using the data for both years:

- (i) Compute the sample mean for average hourly earnings (AHE) in 1996 and 2015.
- (ii) Compute the sample standard deviation for AHE in 1996 and 2015.
- (iii) Construct a 95% confidence interval for the population means of AHE in 1996 and 2015.
- (iv) Construct a 95% confidence interval for the change in the population means of AHE between 1996 and 2015.

(b) In 2015, the value of the Consumer Price Index (CPI) was 237.0. In 1996, the value of the CPI was 156.9. Repeat (a), but use AHE measured in real 2015 dollars

(\$2015); that is, adjust the 1996 data for the price inflation that occurred between 1996 and 2015.

- (c) If you were interested in the change in workers' purchasing power from 1996 to 2015, would you use the results from (a) or (b)? Explain.
- (d) Using the data for 2015:
- (i) Construct a 95% confidence interval for the mean of AHE for high school graduates.
 - (ii) Construct a 95% confidence interval for the mean of AHE for workers with a college degree.
 - (iii) Construct a 95% confidence interval for the difference between the two means.
- (e) Repeat (d) using the 1996 data expressed in \$2015.
- (f) Using appropriate estimates, confidence intervals, and test statistics, answer the following questions:
- (i) Did real (inflation-adjusted) wages of high school graduates increase from 1996 to 2015?
 - (ii) Did real wages of college graduates increase?
 - (iii) Did the gap between earnings of college and high school graduates increase? Explain.
- (g) Table 3.1 presents information on the gender gap for college graduates. Prepare a similar table for high school graduates, using the 1996 and 2015 data. Are there any notable differences between the results for high school and college graduates?

Table 3.1: Gender Gap in Average Hourly Earnings for College Graduates

(All values in real 2015 dollars)

Year	Men			Women			Difference (M – W)		
	$\bar{Y}_m$	s_m	n_m	$\bar{Y}_w$	s_w	n_w	$\bar{Y}_m - \bar{Y}_w$	SE	95% CI
1996	24.22	9.54	1594	20.56	7.69	1368	3.66	0.32	(3.04, 4.28)
2015	28.25	13.89	1728	23.23	10.45	1934	5.02	0.40	(4.23, 5.81)

Source: Current Population Survey (CPS). Sample: Full-time workers, ages 25–34, with a B.A./B.S.

Solution:

Data Overview

The dataset contains 13,201 observations on full-time workers aged 25–34:

Variable	Description	Coding	Summary
year	Survey year	1996, 2015	$n_{1996} = 6,103$; $n_{2015} = 7,098$
ahe	Average hourly earnings	Continuous (\$)	Range: \$1.36 – \$105.77
bachelor	Education level	0 = HS, 1 = College	48% college graduates
female	Gender	0 = Male, 1 = Female	42% female

Key Notation and Formulas

Let $\bar{Y}$ denote the sample mean, s_Y the sample standard deviation, and n the sample size.

Standard Error of the Mean:

$$SE(\bar{Y}) = \frac{s_Y}{\sqrt{n}}$$

95% Confidence Interval for the Population Mean:

$$\bar{Y} \pm 1.96 \times SE(\bar{Y})$$

Standard Error for Difference of Two Independent Means:

$$SE(\bar{Y}_1 - \bar{Y}_2) = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

Inflation Adjustment Setup

To compare wages across time, we must adjust for inflation using the Consumer Price Index (CPI):

Parameter	Value	Source
CPI in 1996	156.9	Given in problem
CPI in 2015	237.0	Given in problem
Adjustment factor	$237.0/156.9 = 1.511$	Calculated

Conversion Formula:

$$\text{Real Wage}_{1996} = \text{Nominal Wage}_{1996} \times \frac{CPI_{2015}}{CPI_{1996}} = \text{Nominal}_{1996} \times 1.511$$

This answers: “What could a 1996 wage actually *buy* if measured in 2015 prices?”

(a) Average Hourly Earnings, Nominal Dollars

Summary Statistics

Year	Mean ($\bar{Y}$)	Std. Dev. (s)	Sample Size (n)
1996	\$12.69	\$6.36	6,103
2015	\$21.24	\$12.12	7,098

Observations:

- The mean wage increased from \$12.69 to \$21.24—a 67% increase in nominal terms.
- The standard deviation *doubled* (from \$6.36 to \$12.12), indicating substantially increased wage inequality by 2015.
- Large sample sizes ($n > 6,000$) provide high statistical precision.

Confidence Intervals for Each Year

The standard error measures how precisely we estimate the population mean:

$$SE(\bar{Y}_{1996}) = \frac{6.36}{\sqrt{6103}} = 0.081 \quad SE(\bar{Y}_{2015}) = \frac{12.12}{\sqrt{7098}} = 0.144$$

Year	Mean	$SE(\bar{Y})$	95% Confidence Interval	
1996	12.69	0.081	12.53	12.85
2015	21.24	0.144	20.96	21.52

Interpretation: We are 95% confident the true population mean hourly earnings in 1996 lies between \$12.53 and \$12.85. The narrow confidence intervals reflect the large sample sizes.

Confidence Interval for the Difference

$$SE(\bar{Y}_{2015} - \bar{Y}_{1996}) = \sqrt{\frac{6.36^2}{6103} + \frac{12.12^2}{7098}} = 0.165$$

	Difference	SE	95% CI
$AHE_{2015} - AHE_{1996}$	8.54	0.165	(8.22, 8.87)

Hypothesis Test: Testing $H_0 : \mu_{2015} - \mu_{1996} = 0$ yields $t = 51.68$ with $p \approx 0$. The nominal wage increase is highly statistically significant.

Part (a) Summary

Result: Nominal wages increased by **\$8.54/hour** between 1996 and 2015.

But: Does this mean workers are actually \$8.54 richer? Not necessarily—this ignores inflation.

(b) Average Hourly Earnings, Real 2015 Dollars

Summary Statistics

After converting 1996 wages to 2015 dollars (multiplying by 1.511):

Year	Mean (Real \$2015)	Std. Dev.	Sample Size
1996	\$19.17	\$9.61	6,103
2015	\$21.24	\$12.12	7,098

Observations:

- The 1996 mean is now \$19.17 (not \$12.69)—reflecting 2015 purchasing power.
- The 2015 mean is unchanged at \$21.24 (already in 2015 dollars).
- The gap has shrunk dramatically: from \$8.54 nominal to \$2.07 real.

Confidence Intervals

Year	Mean	$SE(\bar{Y})$	95% CI	
1996 (in \$2015)	19.17	0.123	18.93	19.41
2015	21.24	0.144	20.96	21.52
Difference	2.06	0.189	1.69	2.44

Hypothesis Test: $t = 10.90$, $p \approx 0$. The real wage increase is statistically significant, but much smaller than the nominal increase.

Comparing Nominal vs. Real Wage Growth

Measure	Wage Increase	% of Nominal
Nominal (Part a)	\$8.54	100%
Real (Part b)	\$2.06	24%

Part (b) Summary

Result: Real wages increased by only **\$2.06/hour**—not \$8.54.

Implication: **76% of the apparent wage growth was a monetary illusion**—prices rose almost as fast as wages.

(c) Which Results Should Be Used?

Answer: Use Part (b)—real wages.

Question	Appropriate Measure	Reason
“How many dollars do workers receive?”	Nominal (a)	Counts currency units
“What can workers actually <i>buy</i> ?”	Real (b)	Measures purchasing power
“Are workers <i>better off</i> ?”	Real (b)	Welfare depends on consumption

Nominal wages in part (a) include the effects of inflation. The \$8.54 nominal increase *overstates* the improvement in workers’ living standards because prices also rose during this period. By adjusting for inflation using the CPI, part (b) isolates the *real* change in what workers can purchase with their earnings.

Conclusion: For purchasing power analysis, always use inflation-adjusted (real) figures. The real wage increase of \$2.06 represents the actual improvement in what workers can buy.

(d) Education Premium in 2015

Summary Statistics by Education

Education Level	Mean	Std. Dev.	Sample Size
High School (<code>bachelor = 0</code>)	\$16.38	\$8.54	3,365
College (<code>bachelor = 1</code>)	\$25.62	\$13.17	3,733

Observations:

- College graduates earn \$25.62/hour vs. \$16.38 for high school—that's 56% more.
- Wage dispersion is also higher among college graduates (SD = \$13.17 vs. \$8.54).

Confidence Intervals

Education Level	Mean	<i>SE</i>	95% CI	
High School	16.38	0.147	16.09	16.67
College	25.62	0.216	25.19	26.04
College – HS	9.23	0.261	8.72	9.75

Note: The confidence intervals for HS and College do not overlap, providing visual evidence of a significant difference.

Hypothesis Test: $t = 35.38$, $p \approx 0$. The education premium is highly statistically significant.

Part (d) Summary

Result: In 2015, the college wage premium was **\$9.23/hour**.

College graduates earned 56% more than high school graduates on average.

(e) Education Premium in 1996 (Real \$2015)

Summary Statistics by Education

Education Level	Mean (Real \$2015)	Std. Dev.	Sample Size
High School	\$16.27	\$7.67	3,484
College	\$23.04	\$10.51	2,619

Confidence Intervals

Education Level	Mean	SE	95% CI	
High School	16.27	0.130	16.01	16.52
College	23.04	0.205	22.64	23.44
College – HS	6.77	0.243	6.29	7.25

Comparing Education Premiums Across Time

Year	College Premium	95% CI
1996 (in \$2015)	\$6.77	(6.29, 7.25)
2015	\$9.23	(8.72, 9.75)
Change	+\$2.46	—

Part (e) Summary

Result: The college premium in 1996 was **\$6.77/hour** (in 2015 dollars). This is *smaller* than the 2015 premium of \$9.23, suggesting returns to education have *increased* over time.

(f) Did Real Wages Increase? Did the Gap Increase?

(i) High School Graduates: Real Wage Change

	1996 Mean	2015 Mean	Difference	95% CI
High School (Real \$2015)	\$16.27	\$16.38	+\$0.11	(−0.50, 0.27)

Hypothesis Test: $t = 0.57$, $p = 0.565$

Interpretation: The 95% confidence interval **includes zero**. We *cannot* reject the null hypothesis of no change. The \$0.11 increase is **not statistically significant**.

Answer (i): Real wages of high school graduates did **NOT** significantly increase. They essentially *stagnated* over 19 years.

(ii) College Graduates: Real Wage Change

	1996 Mean	2015 Mean	Difference	95% CI
College (Real \$2015)	\$23.04	\$25.62	+\$2.58	(1.99, 3.16)

Hypothesis Test: $t = 8.65$, $p \approx 0$

Interpretation: The 95% confidence interval is **entirely positive** (does not include zero). The increase is **statistically significant**.

Answer (ii): Real wages of college graduates **DID** significantly increase by approximately \$2.58/hour.

(iii) Did the Education Gap Increase?

Year	College–HS Gap	SE	95% CI
1996	\$6.77	0.243	(6.29, 7.25)
2015	\$9.23	0.261	(8.72, 9.75)
Change in Gap	+\$2.46	—	—

Interpretation: The confidence intervals for 1996 and 2015 **do not overlap** (6.29–7.25 vs. 8.72–9.75), indicating the change is statistically significant.

Answer (iii): Yes, the education gap **DID** significantly increase by \$2.46/hour. The returns to education have grown—college became *more* valuable over these 19 years.

Part (f) Summary: The Divergence Story

Group	Real Wage Change	Significant?	p-value
High School	+\$0.11	No	0.565
College	+\$2.58	Yes	≈ 0
Education Gap	+\$2.46	Yes	CIs don't overlap

The Big Picture: The labor market increasingly rewards education. High school workers saw *no real gains* in 19 years, while college graduates pulled significantly ahead. This divergence drives contemporary policy debates about education access and income inequality.

(g) Gender Gap for High School Graduates

1996 Gender Gap (Real \$2015)

Gender	Mean (Real \$2015)	Std. Dev.	Sample Size
Male	\$17.78	\$8.24	2,168
Female	\$13.77	\$5.83	1,316

Gender Gap: $\$17.78 - \$13.77 = \$4.02$, $SE = 0.239$, 95% CI: (3.55, 4.48)

Test: $t = 16.80$, $p \approx 0$ — highly significant.

2015 Gender Gap

Gender	Mean (Real \$2015)	Std. Dev.	Sample Size
Male	\$17.50	\$9.03	2,222
Female	\$14.21	\$7.00	1,143

Gender Gap: $\$17.50 - \$14.21 = \$3.29$, $SE = 0.282$, 95% CI: (2.74, 3.84)

Test: $t = 11.67$, $p \approx 0$ — highly significant.

Summary Table (Matching Table 3.1 Format)

Gender Gap in Average Hourly Earnings for High School Graduates

(All values in real 2015 dollars)

Year	Men			Women			Difference (M – W)		
	$\bar{Y}_m$	s_m	n_m	$\bar{Y}_w$	s_w	n_w	Gap	SE	95% CI
1996	17.78	8.24	2,168	13.77	5.83	1,316	4.02	0.24	(3.55, 4.48)
2015	17.50	9.03	2,222	14.21	7.00	1,143	3.29	0.28	(2.74, 3.84)

Comparison with College Graduates (Table 3.1)

Education	Gap 1996	Gap 2015	Change	Trend
High School	\$4.02	\$3.29	−\$0.73	Narrowed
College	\$3.66	\$5.02	+\$1.36	Widened

Key Findings

1. **Gender gap exists in both groups:** Men earn significantly more than women among both high school and college graduates (all $p \approx 0$).

2. **Opposite trends by education level:**

- High school: Gender gap *narrowed* from \$4.02 to \$3.29 (down \$0.73)
- College: Gender gap *widened* from \$3.66 to \$5.02 (up \$1.36)

3. **Relative magnitude:** In percentage terms, both gaps represent approximately 18–23% of female earnings.

4. **Notable difference:** The diverging trends—narrowing for HS, widening for college—suggest different labor market dynamics across education levels. Possible factors include occupational sorting, glass ceiling effects at higher levels, and differences in unionization.

The Big Picture: Gender inequality *decreased* for high school workers but *increased* for college workers between 1996 and 2015. This pattern suggests that progress toward gender equality has been uneven across the education distribution.

Summary: Key Takeaways

Question	Answer	Evidence
Did nominal wages rise?	Yes, +\$8.54/hr	$p \approx 0$
Did <i>real</i> wages rise?	Modestly, +\$2.06/hr	$p \approx 0$
Did HS workers gain?	No (+\$0.11, not significant)	$p = 0.565$
Did college workers gain?	Yes (+\$2.58/hr)	$p \approx 0$
Did education premium grow?	Yes (\$6.77 $\rightarrow$ \$9.23)	CIs don't overlap
HS gender gap?	Narrowed (\$4.02 $\rightarrow$ \$3.29)	Both significant
College gender gap?	Widened (\$3.66 $\rightarrow$ \$5.02)	Both significant

The Big Picture

Three major U.S. labor market trends emerge from this analysis of 1996–2015 data:

1. **The Inflation Illusion:** Nominal wage gains vastly overstate real improvements. Of the apparent \$8.54/hour increase, 76% was merely inflation—real purchasing power grew by only \$2.06.
2. **Rising Returns to Education:** The college wage premium increased from \$6.77 to \$9.23/hour. Education became *more* valuable in the labor market, not less.
3. **Divergent Outcomes:**
 - *By education:* College graduates saw real wage growth; high school graduates experienced stagnation.
 - *By gender:* The gender gap narrowed for high school workers but widened for college workers.

These patterns underlie contemporary policy debates about education access, minimum wage policy, income inequality, and labor market polarization.

Calculations performed using Stata. See accompanying `EE_1_solution.do` file.