

WHEN THE MEN LEFT THE MINES

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BUPA Conference
October 17th, 2020

MOTIVATION & RESEARCH QUESTION

How does a male-specific labor shock (decline in the coal mining industry) impact women's labor market and human capital outcomes?



“Coal Miner and Family” The Little Cities Archive, Shawnee, Ohio.



As she and her husband watched the coal business falling apart, Amanda Lucas decided to go back to school to train for the job she now holds as a respiratory therapist. Maddie McGarvey for The New York Times

Campbell Robertson. (2019, September 14). In Coal Country, the Mines Shut Down, the Women Went to Work and the World Quietly Changed. *The New York Times*.

OUTLINE

Preliminary Work

1. Motivation & Research Question
2. Literature Review
3. Microeconomic Theoretical Model

Empirical Work & Results

4. Data & Summary Statistics
5. Empirical Specification
6. County Results
7. CZ Results
8. Conclusion
9. Questions

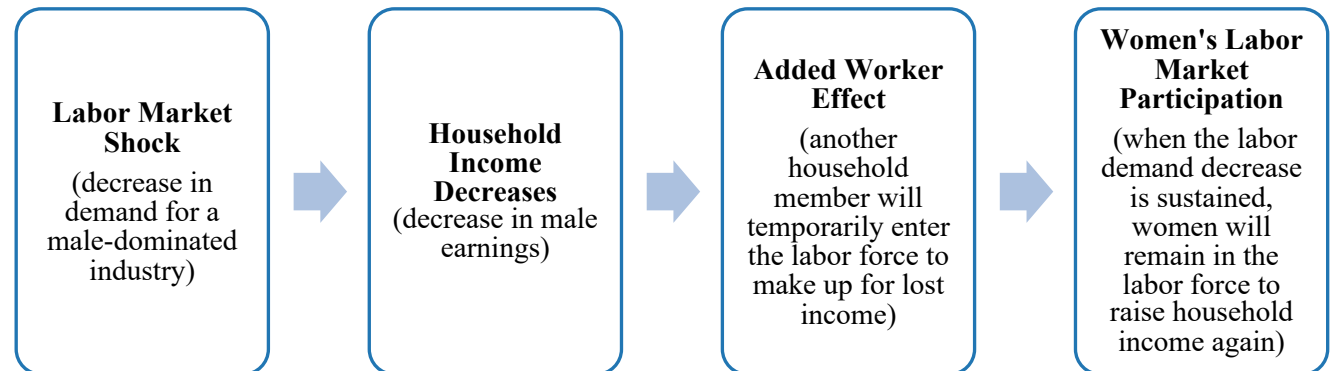
LITERATURE REVIEW

- Black, McKinnish, Sanders (2003, 2005) literature on the coal bust:
 - Eastern Appalachian coal-producing states: Kentucky, Pennsylvania, Ohio, West Virginia
 - Homogenous, male-dominated industry
 - Economic Impacts
 - Increase in jobs and earnings during the boom, spillover effects to non-mining sectors
 - Other indicators: transfer payments, returns to high school education
- Black, Kolesnikova, Sanders, Taylor (2013)
 - Fertility increases during the coal boom

THEORETICAL MODEL OVERVIEW

- Household specialization
 - Opportunity cost of household work expressed as wage
- Setup:
 - Household-level utility and budget constraint
 - Voluntary labor decisions
 - Children are exogenously given

Mechanisms:



THEORETICAL MODEL: SETUP

Utility Function:

$$(1) U(H_0, L_{0M}, L_{0F}) = H_0^{\alpha_1} L_{0M}^{\alpha_2} L_{0F}^{\alpha_3}$$

H_0 : Household Consumption

L_{0M} : Male Leisure

L_{0F} : Female Leisure

I combine a household income and household time constraint for a full budget constraint:

$$(2) w_m \left(\frac{1}{2} - L_{0M} \right) + w_f \left(\frac{1}{2} - L_{0F} \right) + TR - H_0 - Cn - E = 0$$

$w_m l_m$: Male Income

$w_f l_f$: Female Income

TR : Government Transfer Payments

H_0 : Household Consumption

Cn : Cost of Children (C cost per child x
 n number of children)

E : Education Expenses

THEORETICAL MODEL: EQUILIBRIA

Lagrangian Multiplier:

$$(3) \mathcal{L} = H_0^{\alpha_1} L_{0M}^{\alpha_2} L_{0F}^{\alpha_3} + \lambda(w_m \left(\frac{1}{2} - L_{0M}\right) + w_f \left(\frac{1}{2} - L_{0F}\right) + TR - H_0 - Cn - E)$$

- Solved using first-order conditions and a system of equations

Household consumption: (4) $H_0 = \alpha_1 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E\right)$

- Using equilibrium leisure, derived Male, Female Labor Supply:

Male Labor Supply: (5) $l_m = \frac{1}{2} - \left(\frac{1}{w_m} \alpha_2 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E\right)\right)$

Female Labor Supply: (6) $l_f = \frac{1}{2} - \left(\frac{1}{w_f} \alpha_3 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E\right)\right)$

THEORETICAL MODEL: PREDICTIONS

- The coal bust triggers a **decline in male wages** (observed in coal mining and in non-mining industries) as well as an **increase in government transfers** (Black et al. 2005)

Change in Male Wage

$$\frac{\partial H_0}{\partial w_m} = \frac{1}{2} \alpha_1 > 0$$

$w_m \downarrow, H_0 \downarrow$

$$\frac{\partial l_f}{\partial w_m} = -\alpha_3 \frac{1}{2w_f} < 0$$

$w_m \downarrow, l_f \uparrow$

Change in Government Transfers

$$\frac{\partial H_0}{\partial TR} = \alpha_1 > 0$$

$TR \uparrow, H_0 \uparrow$

$$\frac{\partial l_f}{\partial TR} = -\alpha_3 \frac{1}{w_f} < 0$$

$TR \uparrow, l_f \downarrow$

EMPIRICAL WORK

4. Data & Summary Statistics

5. Empirical Specification

6. County-level Results

7. CZ-level Results

8. Conclusion

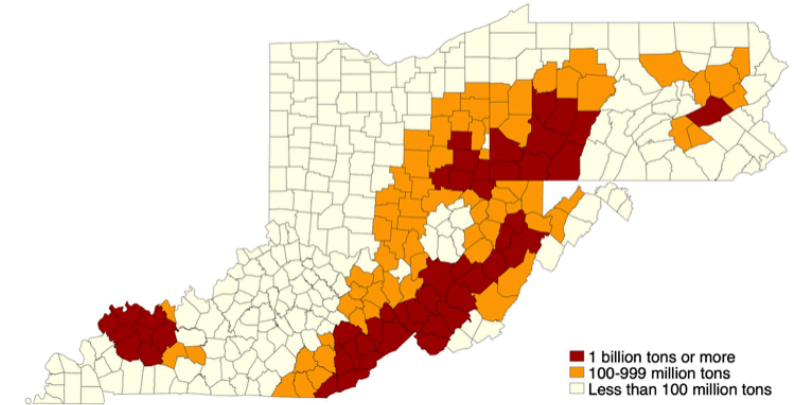
9. Questions

DATA: TREATMENT VARIABLES

- Treatment and control counties from Black et al. 2005
- Real price of coal (2005 dollars) as measure of the “health” of the coal industry
 - Chained 2005 dollars per short ton, calculated using GDP implicit price deflators by U.S. EIA
 - Substitutability issues with using relative prices of coal (U.S. EIA)
 - Total amount produced/consumed may not reflect fluctuations in labor demanded (Kolstad 2017)

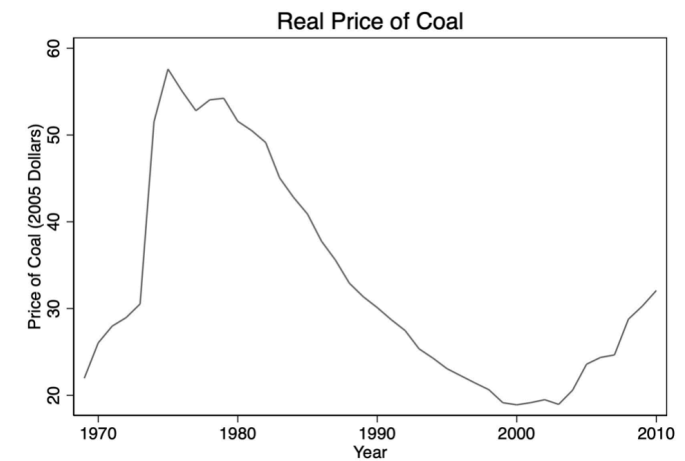


Figure 2
Coal Reserves by County



Note: High coal, medium coal, and low coal counties from Black et al. 2005. There are 47 high coal counties, 71 medium coal counties, and 212 low coal counties.

Figure (4)



Note: Price of coal is reported per short ton, in 2005 dollars as reported by the U.S. Energy Information Administration.

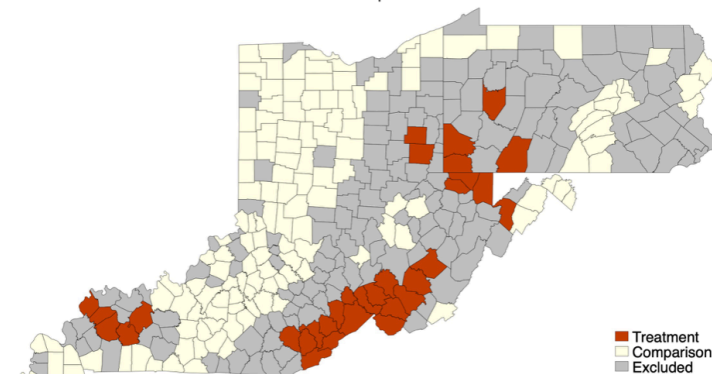
DATA: GEOGRAPHIES

County-Level



- NHGIS: Educational attainment and labor force status by sex
 - County-level: marital rates and households with children
- BEA: Transfer data by program

Figure (1)
Treatment and Comparison counties



Note: Treatment and comparison counties from Black et al. 2005. There are 120 counties in Kentucky, 67 counties in Pennsylvania, 88 counties in Ohio, and 55 counties in West Virginia.

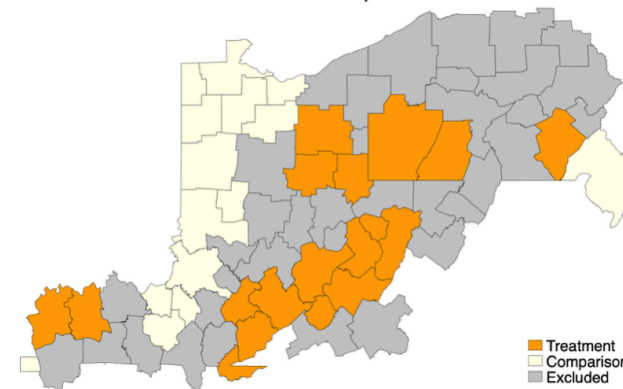
Commuting Zones



- IPUMS USA
 - Labor Statistics: status and type of income
 - Educational Attainment
 - Family structure: marital status, number of children

Figure 3

Treatment and Comparison CZs



Note: 1990 commuting zones that cover KY, PA, OH, and WV, and bordering states, created using [Maple](#) in Stata. There are 18 treatment CZs and 19 comparison CZs. Because of sampling in 2010, there is no data for 3 of the CZs included in my dataset, leaving 17 treatment CZs and 19 comparison CZs in 2010. Including all CZs, there are 15 CZs in Kentucky, 12 in Ohio, 10 in Pennsylvania, 8 in West Virginia, and 28 that overlap state boundaries.

SUMMARY STATISTICS: COUNTY

- Coal counties have lower male and female LFPRs
- Coal counties have lower levels of educational attainment

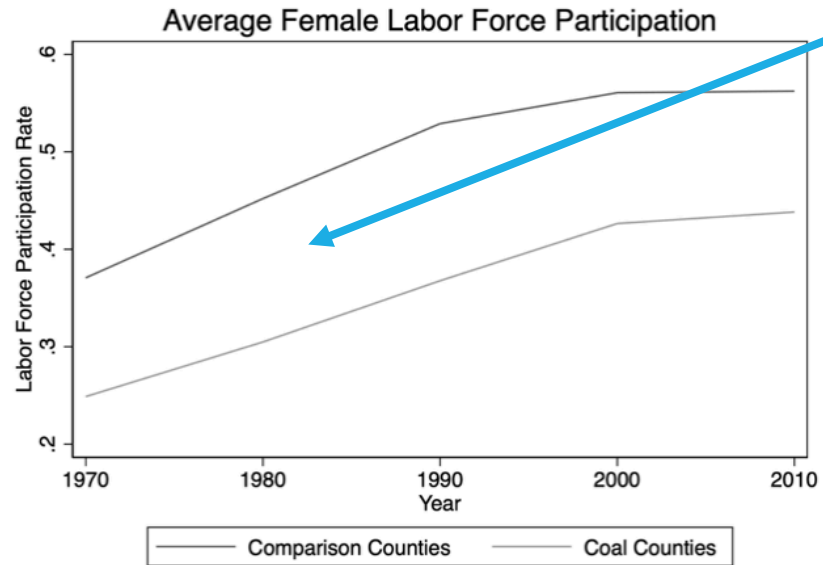
Table 1 – Descriptive Statistics by County

Summary Statistics: Historical Trends					
Outcome	1970	1980	1990	2000	2010
<i>Real Price of Coal</i>	\$26.05	\$51.58	\$30.11	\$18.91	\$28.78
Female Labor Force Participation Rate					
Coal	.2488 (.0574)	.3049 (.0620)	.3677 (.0738)	.4264 (.0719)	.4383 (.0795)
Comparison	.3707 (.0490)	.4520 (.0484)	.5289 (.0513)	.5607 (.0540)	.5623 (.0549)
Male Labor Force Participation Rate					
Coal	.6094 (.0833)	.6492 (.0531)	.6126 (.0559)	.5608 (.0925)	.5366 (.0930)
Comparison	.7415 (.0654)	.7358 (.0521)	.7237 (.0537)	.7022 (.0593)	.6654 (.0629)
Proportion of Women 25+ with less than a high school education					
Coal	.6700 (.1074)	.5268 (.0993)	.3870 (.0980)	.2801 (.0872)	.1990 (.0746)
Comparison	.5427 (.1123)	.4176 (.1048)	.2872 (.0939)	.1892 (.0696)	.1328 (.0528)
Proportion of Women 25+ with a high school education and some college					
Coal	.2862 (.1026)	.4071 (.0939)	.5318 (.0882)	.6131 (.0737)	.6641 (.0661)
Comparison	.4031 (.1052)	.5000 (.0918)	.6083 (.0761)	.6702 (.0585)	.6864 (.0566)
Supplemental Security Income Benefits in 2015 dollars					
Coal	\$3949.97 (2336.57)	\$5354.72 (3055.95)	\$7568.49 (4682.91)	\$13602.97 (8259.54)	\$14777.97 (8683.60)
Proportion of households female headed with children under 18					
Coal	.0505 (.0140)	.0561 (.0087)	.0751 (.0102)	.0818 (.0116)	.0802 (.0116)

Notes: The above statistics are based on averages across treatment and comparison counties in Kentucky, Pennsylvania, Ohio, and West Virginia. Data on labor force, educational outcomes, and household characteristics are from IPUMS-NHGIS as collected through the U.S. Census Bureau, and data on government transfers come from the Bureau of Economic Analysis. All proportions are reported as the proportion of the relevant population (e.g. women 25 and older, all households). The price of coal is a year dollars per short ton historical price reported by the Energy Information Administration.

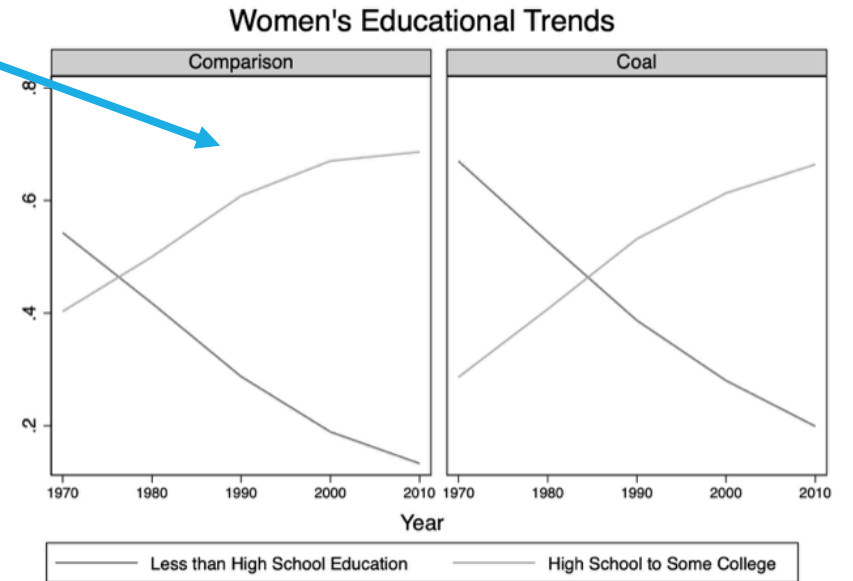
TRENDS

Figure 5



Parallel trends assumption

Figure (6)



Note: Data from IPUMS NHGIS and shows the average labor force participation rates across coal counties and comparison counties in a given year.

Note: Data from IPUMS NHGIS and shows average educational outcomes across comparison and coal county groups in a given year.

EMPIRICAL SPECIFICATION

- Difference-in-difference:

$$(7) Y_{c,t} = \alpha + \beta_1 pcoal_t + \beta_2 (pcoal_t * treatment_c) + \beta_3 X_{c,t} + FE_c + YFE_t + \varepsilon_{c,t}$$

- $Y_{c,t}$: outcome variable of interest (LFP or educational attainment)
- $pcoal_t$: real price of coal per short ton in 2005 dollars
- $pcoal_t * treatment_c$: main treatment indicator, interacts the real price of coal with the treatment status of the county
- $X_{c,t}$: panel of county (CZ) and year-level control variables
- FE_c : County (CZ) fixed effects
- YFE_t : Year fixed effects
- $\varepsilon_{c,t}$: error term, clustered at county (CZ) level

COUNTY RESULTS: FLFPR

- Evidence of OVB
- In coal counties, for each \$1 increase in the price of coal:
 - FLFPR ↓ by .049 percentage points
- 1980 – 2000, price of coal decreased by \$32.67
 - 1.6 percentage point increase in FLFPR
 - Change in FLFPR in coal counties from 1980 – 2000: 12.15%
 - decline of coal industry accounts for 13.18% of this change

Table 3 - Female Labor Force Participation: by County

	(1)	(2)	(3)	(4)
Price of Coal	0.0701*** (0.00122)	0.0344*** (0.00740)	0.0282*** (0.00806)	0.0211** (0.00920)
Treatment x Price of Coal	-0.000538*** (0.000140)	-0.000723*** (0.000128)	-0.000751*** (0.000140)	-0.000490*** (0.000184)
Children Under 6, H-W				-0.211*** (0.0808)
Children Under 6, Female				-0.655** (0.279)
Women Married, Not Sep				0.295 (0.184)
Women Married, Sep				0.385 (0.400)
SSI				5.53e-07 (3.96e-07)
Female Educational Cont.	No	Yes	Yes	Yes
Male Educational Cont.	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Observations	845	845	845	845
R-squared	0.923	0.932	0.933	0.935
Number of gisjoin_n	169	169	169	169
Adj R-squared		0.931	0.932	0.934

Note: OLS regression with clustered standard errors at the county level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. All variables besides government transfers are included as a proportion of that population (women in the labor force as a proportion of women over age 16, households with children under 6 as a proportion of total households). The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. A full table showing all estimated control coefficients can be found in [Appendix Table 4](#).

COUNTY RESULTS: EDUCATION

- Evidence of OVB
- Not significant with bachelor's degree
- In coal counties, for each \$1 decrease in the price of coal:
 - Proportion of women with less than a high school education ↓ by .0851 percentage points
 - 1980 – 2000, a 2.78 pctg point decrease
 - Proportion of women with a high school education and some college ↑ by .0831 percentage points
 - 1980 – 2000, a 2.71 pctg point increase
- Coal bust accounted for 11% of the change in rate of women not finishing high school

Table 5 – Women's Educational Outcomes: by County

	(1)	(2)	(3)
<i>A. Women over 25 with Less than a High School Education</i>			
Price of Coal	-0.154*** (0.00201)	-0.158*** (0.00222)	-0.172*** (0.00551)
Treatment x Price of Coal	0.000400*** (0.000153)	0.000351** (0.000151)	0.000851*** (0.000228)
R-squared	0.968	0.970	0.973
Adj R-squared		0.969	0.973
<i>B. Women over 25 with a High School Education and Some College</i>			
Price of Coal	0.110*** (0.00288)	0.117*** (0.00329)	0.114*** (0.0108)
Treatment x Price of Coal	-0.000824*** (0.000214)	-0.000724*** (0.000208)	-0.000831*** (0.000312)
R-squared	0.894	0.908	0.916
Adj R-squared		0.907	0.915
<i>C. Proportion of Women over 25 with a College Education or More</i>			
Price of Coal	0.0440*** (0.00161)	0.0406*** (0.00175)	0.0580*** (0.00755)
Treatment x Price of Coal	0.000423*** (0.000120)	0.000373*** (0.000118)	-1.94e-05 (0.000163)
R-squared	0.791	0.814	0.826
Adj R-squared		0.812	0.824
<i>Controls</i>			
Education Assistance	No	Yes	Yes
Marital and Child	No	No	Yes
Year FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Observations	845	845	845
Number of Counties	169	169	169

Note: OLS regression with clustered standard errors at the county level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. All variables besides government transfers are included as a proportion of that population (educational attainment as the number of women with that level of education over all women 25 and over, households with children under 6 as a proportion of total households). Educational variables are converted as follows: completed 12th grade as completed a high school education and completed 4 years of college as a college education. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Full tables showing control coefficients can be found in [Appendix Table 5](#), [Appendix Table 6](#), and [Appendix Table 7](#).

CZ RESULTS: FLFP

- Individual-level data: LPM regression
- Insignificant results
 - Because of different geographic treatment level?
 - Because of individual-level controls?
- Differences by marital status?
 - Two separate regressions for married and single women
 - Only significant results for married women, whose LFP is positively related with the price of coal (opposite of prediction)
 - Positive relationship for married women because of spillover effects to coal boom?

FLFP BY MARITAL STATUS

Table 9 – Married Women’s Labor Force Participation: by CZ

	(1)	(2)	(3)
Price of Coal	0.0984*** (0.0155)	0.0566*** (0.0137)	0.0563*** (0.0131)
Treatment	-0.134*** (0.0167)	-0.145*** (0.0162)	-0.154*** (0.0165)
Treatment x Price of Coal	1.91e-05 (0.000478)	0.000945* (0.000480)	0.00100** (0.000487)
Welfare Income	-5.76e-06*** (1.55e-06)	-7.05e-06*** (1.32e-06)	-6.82e-06*** (1.28e-06)
Age		-0.00460*** (0.000258)	-0.00588*** (0.000403)
Children Under 5			-0.0572*** (0.0109)
Education Controls	No	Yes	Yes
Hispanic Controls	No	Yes	Yes
Race Controls	No	Yes	Yes
CZ FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	17,654	17,654	17,654
R-squared	0.056	0.143	0.150
Adj R-squared		0.140	0.147

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe for labor force participation includes all women over the age of 16 who are currently married with their spouse present. A full table showing control coefficients can be found in [Appendix Table 9](#).

Table 10 – Single Women’s Labor Force Participation: by CZ

	(1)	(2)	(3)
Price of Coal	0.0866*** (0.00890)	0.0289*** (0.00633)	0.0284*** (0.00618)
Treatment	-0.0511*** (0.0170)	-0.0918*** (0.0168)	-0.0922*** (0.0164)
Treatment x Price of Coal	-0.000410 (0.000499)	0.000570 (0.000469)	0.000566 (0.000452)
Welfare Income	-5.02e-06*** (5.27e-07)	-8.30e-06*** (5.32e-07)	-7.71e-06*** (5.10e-07)
Age		-0.00569*** (0.000160)	-0.00626*** (0.000190)
Children Under 5			-0.0424*** (0.00383)
Education Controls	No	Yes	Yes
Hispanic Controls	No	Yes	Yes
Race Controls	No	Yes	Yes
CZ FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	66,121	66,121	66,121
R-squared	0.050	0.168	0.171
Adj R-squared		0.167	0.170

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe for labor force participation includes all women over the age of 16 who are either not currently married or are married with their spouse not present. A full table showing control coefficients can be found in [Appendix Table 10](#).

CZ RESULTS: EDUCATION

- Significant relationships around high school education level
- For each dollar decrease in the price of coal:
 - .0367 percentage points more likely to have graduated high school
 - 1980 – 2000: \$32.67 price drop
 - 1.2 percentage points more likely to have graduated high school in a coal CZ

Table 8 – Women’s Educational Outcomes: by CZ

	(1)	(2)	(3)
<i>A. Women with Less than a High School Education</i>			
Price of Coal	-0.146*** (0.00234)	-0.156*** (0.00256)	-0.154*** (0.00259)
Treatment	0.122*** (0.00643)	0.138*** (0.00595)	0.134*** (0.00594)
Treatment x Price of Coal	0.000253 (0.000209)	0.000347* (0.000189)	0.000367* (0.000190)
<i>R-squared</i>	0.106	0.208	0.215
<i>Adj R-squared</i>		0.208	0.215
<i>B. Women with More than a High School Education</i>			
Price of Coal	0.146*** (0.00234)	0.156*** (0.00256)	0.154*** (0.00259)
Treatment	-0.122*** (0.00643)	-0.138*** (0.00595)	-0.134*** (0.00594)
Treatment x Price of Coal	-0.000253 (0.000209)	-0.000347* (0.000189)	-0.000367* (0.000190)
<i>R-squared</i>	0.106	0.208	0.215
<i>Adj R-squared</i>		0.208	0.215
<i>C. Women with 4 Years of College or More</i>			
Price of Coal	0.0657*** (0.00450)	0.0678*** (0.00476)	0.0668*** (0.00460)
Treatment	-0.0443*** (0.0136)	-0.0507*** (0.0137)	-0.0480*** (0.0131)
Treatment x Price of Coal	0.000396 (0.000453)	0.000323 (0.000446)	0.000277 (0.000429)
<i>R-squared</i>	0.036	0.067	0.074
<i>Adj R-squared</i>		0.0669	0.0735
Children Under 5	No	No	Yes
Marital Controls	No	No	Yes
Hispanic Controls	No	Yes	Yes
Race Controls	No	Yes	Yes
CZ FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1,527,631	1,527,631	1,527,631
<i>R-squared</i>	0.106	0.208	0.215
<i>Adj R-squared</i>		0.208	0.215

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe includes all women over the age of 25. Full tables showing coefficients on control variables can be found in [Appendix Table 11](#), [Appendix Table 12](#), and [Appendix Table 13](#).

CONCLUSION

- Ambiguous changes to women's labor force participation
 - Conflicting theoretical predictions, lack of job prospects during an economic downturn
- Women increase their educational attainment as a direct result of the coal bust
 - Increased pressure to work a high-paying job
- Changing expectations and gender norms
 - Even if not directly attributable to the coal bust, women's LFPR increases over time
 - Industrial declines create higher educational attainment
 - Likely seeking different types of careers

THANK YOU! QUESTIONS?

Thank you to all who helped me with my proposal, model, data cleaning and interpretation of results

Dr. Clark Ross

Dr. Mark Foley

Dr. Angela Cools

Dr. Siobhan O'Keefe

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THEORETICAL MODEL: DETAILED

Household income constraint:

$$w_m l_m + w_f l_f + TR = H_0 + Cn + E$$

Household time constraint:

$$T = L_{0M} + L_{0F} + l_m + l_f \rightarrow \frac{T}{2} = L_{0M} + l_m = \frac{1}{2} \text{ and } \frac{T}{2} = L_{0F} + l_f = \frac{1}{2}$$

Full Household Budget constraint:

$$w_m \left(\frac{1}{2} - L_{0M} \right) + w_f \left(\frac{1}{2} - L_{0F} \right) + TR - H_0 - Cn - E = 0$$

Utility Function:

$$U(H_0, L_{0M}, L_{0F}) = H_0^{\alpha_1} L_{0M}^{\alpha_2} L_{0F}^{\alpha_3}$$

$w_m l_m$: Male Income

$w_f l_f$: Female Income

TR : Government Transfer Payments

H_0 : Household Consumption

Cn : Cost of Children (C cost per child x
n number of children)

E : Education Expenses

H_0 : Household Consumption

L_{0M} : Male Leisure

L_{0F} : Female Leisure

THEORETICAL MODEL: DETAILED

Lagrangian Multiplier:

$$\mathcal{L} = H_0^{\alpha_1} L_{0M}^{\alpha_2} L_{0F}^{\alpha_3} + \lambda(w_m \left(\frac{1}{2} - L_{0M}\right) + w_f \left(\frac{1}{2} - L_{0F}\right) + TR - H_0 - Cn - E)$$

First-Order Conditions

$$(1) \quad \frac{\partial \mathcal{L}}{\partial H_0} = \alpha_1 H_0^{(\alpha_1-1)} L_{0M}^{\alpha_2} L_{0F}^{\alpha_3} - \lambda = 0$$

$$(2) \quad \frac{\partial \mathcal{L}}{\partial L_{0M}} = \alpha_2 H_0^{\alpha_1} L_{0M}^{(\alpha_2-1)} L_{0F}^{\alpha_3} - w_m \lambda = 0$$

$$(3) \quad \frac{\partial \mathcal{L}}{\partial L_{0F}} = \alpha_3 H_0^{\alpha_1} L_{0M}^{\alpha_2} L_{0F}^{(\alpha_3-1)} - w_f \lambda = 0$$

$$(4) \quad \frac{\partial \mathcal{L}}{\partial \lambda} = w_m \left(\frac{1}{2} - L_{0M}\right) + w_f \left(\frac{1}{2} - L_{0F}\right) + TR - H_0 - Cn - E = 0$$

THEORETICAL MODEL: DETAILED

1) and 2)

$$H_0 = \frac{w_m \alpha_1}{\alpha_2} L_{0M} \text{ and } L_{0M} = \frac{\alpha_2}{w_m \alpha_1} H_0$$

2) and 3)

$$L_{0F} = \frac{w_m \alpha_3}{w_f \alpha_2} L_{0M} \text{ and } L_{0M} = \frac{w_f \alpha_2}{w_m \alpha_3} L_{0F}$$

1) and 3)

$$H_0 = \frac{w_f \alpha_1}{\alpha_3} L_{0F} \text{ and } L_{0F} = \frac{\alpha_3}{w_f \alpha_1} H_0$$

Plug into 4), budget constraint

$$\text{Household consumption: } H_0 = \alpha_1 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E \right)$$

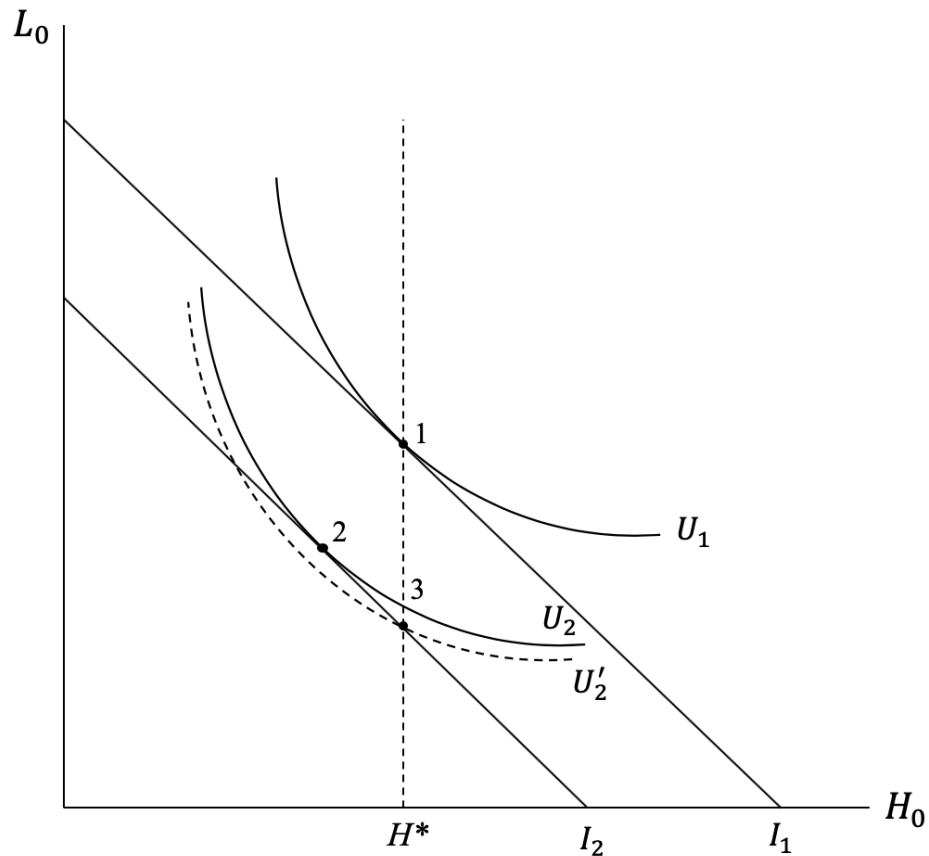
$$\text{Male Leisure: } L_{0M} = \frac{1}{w_m} \alpha_2 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E \right)$$

$$\text{Female Leisure: } L_{0F} = \frac{1}{w_f} \alpha_3 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E \right)$$

$$\text{Male Labor Supply: } l_m = \frac{1}{2} - \left(\frac{1}{w_m} \alpha_2 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E \right) \right)$$

$$\text{Female Labor Supply: } l_f = \frac{1}{2} - \left(\frac{1}{w_f} \alpha_3 \left(\frac{w_m}{2} + \frac{w_f}{2} + TR - Cn - E \right) \right)$$

SUBSISTENCE LEVELS OF HOUSEHOLD CONSUMPTION



A household will fall below subsistence levels to maximize utility, but to keep consumption above subsistence level household leisure may decrease below the optimal level (which is associated with a rise in labor from one or both householders)

SUMMARY STATISTICS: COUNTY

- Coal counties have lower male and female LFPRs
- Coal counties have lower levels of educational attainment
- Black et al. - increase in transfer payments and single mothers from coal bust

Table 1 – Descriptive Statistics by County

Summary Statistics: Historical Trends					
Outcome	1970	1980	1990	2000	2010
<i>Real Price of Coal</i>	\$26.05	\$51.58	\$30.11	\$18.91	\$28.78
Female Labor Force Participation Rate					
Coal	.2488 (.0574)	.3049 (.0620)	.3677 (.0738)	.4264 (.0719)	.4383 (.0795)
Comparison	.3707 (.0490)	.4520 (.0484)	.5289 (.0513)	.5607 (.0540)	.5623 (.0549)
Male Labor Force Participation Rate					
Coal	.6094 (.0833)	.6492 (.0531)	.6126 (.0559)	.5608 (.0925)	.5366 (.0930)
Comparison	.7415 (.0654)	.7358 (.0521)	.7237 (.0537)	.7022 (.0593)	.6654 (.0629)
Proportion of Women 25+ with less than a high school education					
Coal	.6700 (.1074)	.5268 (.0993)	.3870 (.0980)	.2801 (.0872)	.1990 (.0746)
Comparison	.5427 (.1123)	.4176 (.1048)	.2872 (.0939)	.1892 (.0696)	.1328 (.0528)
Proportion of Women 25+ with a high school education and some college					
Coal	.2862 (.1026)	.4071 (.0939)	.5318 (.0882)	.6131 (.0737)	.6641 (.0661)
Comparison	.4031 (.1052)	.5000 (.0918)	.6083 (.0761)	.6702 (.0585)	.6864 (.0566)
Supplemental Security Income Benefits in 2015 dollars					
Coal	\$3949.97 (2336.57)	\$5354.72 (3055.95)	\$7568.49 (4682.91)	\$13602.97 (8259.54)	\$14777.97 (8683.60)
Proportion of households female headed with children under 18					
Coal	.0505 (.0140)	.0561 (.0087)	.0751 (.0102)	.0818 (.0116)	.0802 (.0116)

Notes: The above statistics are based on averages across treatment and comparison counties in Kentucky, Pennsylvania, Ohio, and West Virginia. Data on labor force, educational outcomes, and household characteristics are from IPUMS-NHGIS as collected through the U.S. Census Bureau, and data on government transfers come from the Bureau of Economic Analysis. All proportions are reported as the proportion of the relevant population (e.g. women 25 and older, all households). The price of coal is a year dollars per short ton historical price reported by the Energy Information Administration.

SUMMARY STATISTICS: CZ

- Similar trends to county-level statistics
- Different result with welfare income—decreases with bust
 - Receiving other forms of transfer payments?

Table 2 – Descriptive Statistics by Commuting Zone

Summary Statistics: Historical Trends					
Outcome	1970	1980	1990	2000	2010
Female Labor Force Participation Rate (16 or older)					
Coal	.3143 (.0594)	.3667 (.0665)	.4304 (.0689)	.4690 (.0661)	.4894 (.0686)
Comparison	.3724 (.0460)	.4655 (.0341)	.5358 (.0383)	.5723 (.0392)	.5655 (.0432)
Male Labor Force Participation Rate (16 or older)					
Coal	.6772 (.0665)	.6814 (.0558)	.6533 (.0591)	.6168 (.0739)	.5796 (.0825)
Comparison	.7481 (.0629)	.7376 (.0417)	.7224 (.0358)	.7047 (.0366)	.6676 (.0542)
Proportion of Women 25+ with Less than a High School Education					
Coal	.5960 (.0983)	.4741 (.0941)	.3340 (.0818)	.2358 (.0762)	.1617 (.0510)
Comparison	.5359 (.0914)	.4005 (.0845)	.2642 (.0723)	.1754 (.0538)	.1296 (.0335)
Proportion of Women 25+ with High School to Some College					
Coal	.3757 (.4843)	.4989 (.5000)	.6000 (.4899)	.6589 (.4741)	.6600 (.4737)
Comparison	.4259 (.4945)	.5239 (.4994)	.6227 (.4847)	.6519 (.4764)	.6497 (.4771)
Proportion of Women 25+ with 4 Years of college or More					
Coal	.0459 (.0109)	.0757 (.0116)	.0994 (.0189)	.1243 (.0299)	.1629 (.0449)
Comparison	.0561 (.0142)	.0920 (.0220)	.1170 (.0359)	.1538 (.0469)	.2068 (.0511)
Welfare Income in 1999 Dollars					
Coal	\$4086.04 (634.94)	\$4519.83 (441.83)	\$4151.29 (380.99)	\$2140.99 (508.43)	\$2102.58 (401.42)
Proportion of Households with Children Headed by Women					
Coal	.2018 (.0164)	.2037 (.0126)	.2548 (.0174)	.2951 (.0163)	.3655 (.0424)

Notes: The above statistics are based on year Commuting-Zone level averages, and all data comes from IPUMS-USA, with data collected through the U.S. Census Bureau. The 1970 Form 2 Metro, 1980 5%, 1990 5%, 2000 5%, and 2010 ACS samples are used, and geographical units are converted to commuting zones using David Dorn's crosswalk files.

COUNTY: EDUCATION H/M/L

- Significant results only in high coal areas
- Follows pattern of labor force participation rate results

Table 6 – Women’s Educational Outcomes, High Medium and Low Reserve Counties

	(1)	(2)	(3)
<i>A. Women over 25 with Less than a High School Education</i>			
Price of Coal	-0.156*** (0.00147)	-0.159*** (0.00153)	-0.168*** (0.00446)
High x Price of Coal	0.000352** (0.000142)	0.000301** (0.000140)	0.000569*** (0.000170)
Medium x Price of Coal	5.32e-05 (0.000128)	1.40e-05 (0.000125)	0.000130 (0.000138)
R-squared	0.967	0.969	0.972
Adj R-squared		0.969	0.972
<i>B. Women over 25 with a High School Education and Some College</i>			
Price of Coal	0.112*** (0.00212)	0.119*** (0.00204)	0.112*** (0.00762)
High x Price of Coal	-0.000757*** (0.000192)	-0.000650*** (0.000186)	-0.000561*** (0.000212)
Medium x Price of Coal	-0.000325* (0.000188)	-0.000244 (0.000181)	-0.000202 (0.000178)
R-squared	0.967	0.969	0.972
Adj R-squared		0.905	0.914
<i>C. Proportion of Women over 25 with a College Education or More</i>			
Price of Coal	0.0439*** (0.00111)	0.0403*** (0.00102)	0.0561*** (0.00479)
High x Price of Coal	0.000404*** (9.30e-05)	0.000349*** (9.01e-05)	-7.92e-06 (9.50e-05)
Medium x Price of Coal	0.000272*** (0.000101)	0.000230** (9.96e-05)	7.15e-05 (8.48e-05)
R-squared	0.798	0.827	0.840
Adj R-squared		0.826	0.839
County and Year FE	Yes	Yes	Yes
Education/Training		Yes	Yes
Assistance Control			
Marital and Child Controls			Yes
Observations	1,650	1,650	1,650
Number of Counties	330	330	330

Note: OLS regression with clustered standard errors at the county level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. All variables besides government transfers are included as a proportion of that population (educational attainment as the number of women with that level of education over all women 25 and over, households with children under 6 as a proportion of total households). Educational variables are converted as follows: completed 12th grade as completed a high school education and completed 4 years of college as a college education. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA.

COUNTY: FLPFR H/M/L

- Effects concentrated in high coal counties
- Estimated coefficient is twice the magnitude in high coal counties

Table 4 - Female Labor Force Participation: by High, Medium, and Low Reserve Counties

	(1)	(2)	(3)	(4)
Price of Coal	0.0702*** (0.000910)	0.0324*** (0.00640)	0.0282*** (0.00699)	0.0257*** (0.00722)
High x Price of Coal	-0.000549*** (0.000123)	-0.000603*** (0.000120)	-0.000637*** (0.000119)	-0.000502*** (0.000134)
Medium x Price of Coal	-0.000233** (0.000111)	-0.000274** (0.000108)	-0.000280** (0.000108)	-0.000245** (0.000111)
Husband-Wife Households Children Under 6				-0.187*** (0.0550)
Female Households Children Under 6				-0.472** (0.220)
Women Married, Not Sep				0.402*** (0.136)
Women Married, Sep				0.486 (0.307)
SSI				1.03e-08 (4.33e-08)
Female Educational Cont.	No	Yes	Yes	Yes
Male Educational Cont.	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Observations	1,650	1,650	1,650	1,650
R-squared	0.915	0.920	0.921	0.924
Number of g isjoin_n	330	330	330	330

Note: OLS regression with clustered standard errors at the county level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. All variables besides government transfers are included as a proportion of that population (women in the labor force as a proportion of women over age 16, households with children under 6 as a proportion of total households). The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA.

CZ: FLFP

- Insignificant
 - Because of different geographic treatment level?
 - Because of individual-level controls?
- Differences by marital status?

Table 7 – Female Labor Force Participation: by CZ

	(1)	(2)	(3)
Price of Coal	0.0883*** (0.00716)	0.0343*** (0.00462)	0.0344*** (0.00464)
Treatment	-0.0655*** (0.0151)	-0.103*** (0.0148)	-0.106*** (0.0139)
Treatment x Price of Coal	-0.000373 (0.000439)	0.000617 (0.000428)	0.000650 (0.000398)
Welfare Income	-5.10e-06*** (6.08e-07)	-7.92e-06*** (3.59e-07)	-7.49e-06*** (3.46e-07)
Age		-0.00550*** (0.000157)	-0.00645*** (0.000240)
No. Children Under 5			-0.0457*** (0.00469)
Married, Spouse Present			-0.00214 (0.00526)
Married, Spouse Absent			0.0197* (0.0117)
Separated			0.00687 (0.00494)
Divorced			0.0363*** (0.00668)
Widowed			0.0291*** (0.00622)
Race/Hispanic	No	Yes	Yes
Education	No	Yes	Yes
CZ FE	Yes	Yes	Yes
YFE	Yes	Yes	Yes
Observations	83,775	83,775	83,775
R-squared	0.050	0.161	0.166
Adj R-squared		0.160	0.165

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe for labor force participation includes all women over the age of 16. A full table showing coefficients on control variables can be found in [Appendix Table 8](#).

CZ RESULTS: FLFP BY MARITAL STATUS

Table 9 – Married Women’s Labor Force Participation: by CZ

	(1)	(2)	(3)
Price of Coal	0.0984*** (0.0155)	0.0566*** (0.0137)	0.0563*** (0.0131)
Treatment	-0.134*** (0.0167)	-0.145*** (0.0162)	-0.154*** (0.0165)
Treatment x Price of Coal	1.91e-05 (0.000478)	0.000945* (0.000480)	0.00100** (0.000487)
Welfare Income	-5.76e-06*** (1.55e-06)	-7.05e-06*** (1.32e-06)	-6.82e-06*** (1.28e-06)
Age		-0.00460*** (0.000258)	-0.00588*** (0.000403)
Children Under 5			-0.0572*** (0.0109)
Education Controls	No	Yes	Yes
Hispanic Controls	No	Yes	Yes
Race Controls	No	Yes	Yes
CZ FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	17,654	17,654	17,654
R-squared	0.056	0.143	0.150
Adj R-squared		0.140	0.147

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe for labor force participation includes all women over the age of 16 who are currently married with their spouse present. A full table showing control coefficients can be found in [Appendix Table 9](#).

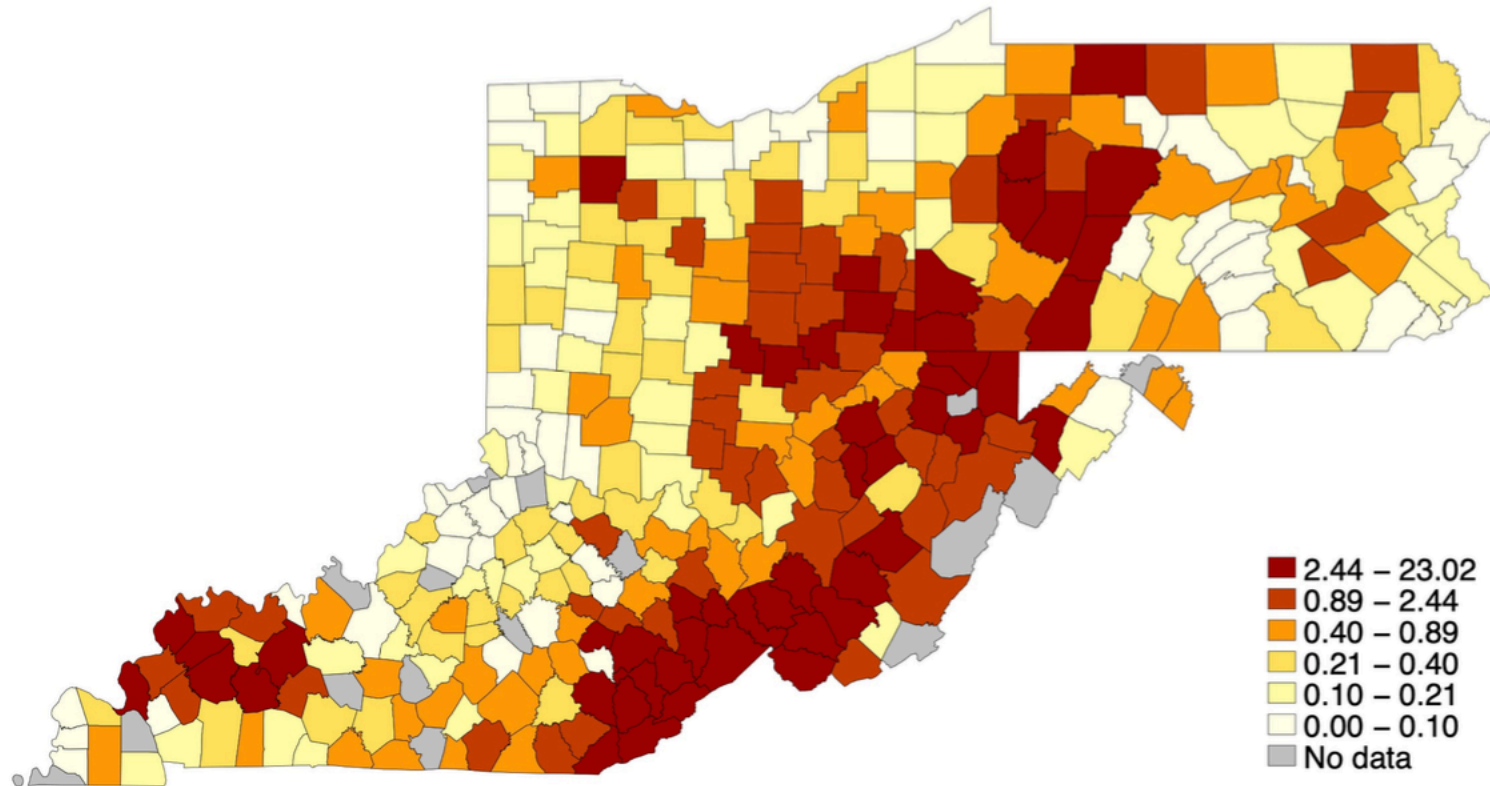
Table 10 – Single Women’s Labor Force Participation: by CZ

	(1)	(2)	(3)
Price of Coal	0.0866*** (0.00890)	0.0289*** (0.00633)	0.0284*** (0.00618)
Treatment	-0.0511*** (0.0170)	-0.0918*** (0.0168)	-0.0922*** (0.0164)
Treatment x Price of Coal	-0.000410 (0.000499)	0.000570 (0.000469)	0.000566 (0.000452)
Welfare Income	-5.02e-06*** (5.27e-07)	-8.30e-06*** (5.32e-07)	-7.71e-06*** (5.10e-07)
Age		-0.00569*** (0.000160)	-0.00626*** (0.000190)
Children Under 5			-0.0424*** (0.00383)
Education Controls	No	Yes	Yes
Hispanic Controls	No	Yes	Yes
Race Controls	No	Yes	Yes
CZ FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	66,121	66,121	66,121
R-squared	0.050	0.168	0.171
Adj R-squared		0.167	0.170

Note: LPM regression with clustered standard errors at the commuting zone level, reported in parenthesis. Asterisks denote level of significance: *** p<0.01, ** p<0.05, * p<0.1. Data is from IPUMS-CPS and all control variables are included as a set of dummies. The price of coal is real and in 2005 dollars, calculated by GDP implicit price deflators by the U.S. EIA. Regression universe for labor force participation includes all women over the age of 16 who are either not currently married or are married with their spouse not present. A full table showing control coefficients can be found in [Appendix Table 10](#).

EMPLOYMENT IN COAL BY COUNTY

Appendix Figure (1)
Employment in Coal - 1970

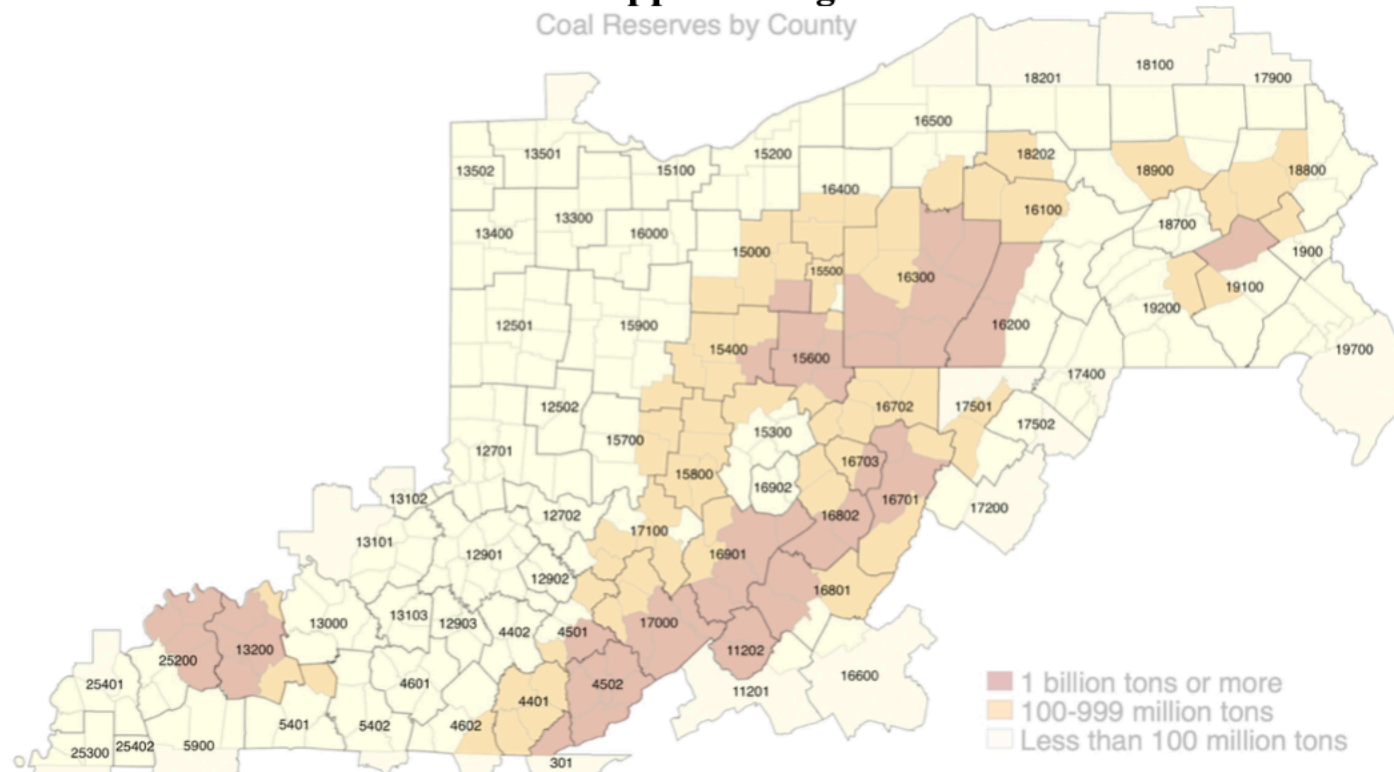


Note: Treatment and comparison counties from Black et al. 2005. There are 120 counties in Kentucky, 67 counties in Pennsylvania, 88 counties in Ohio, and 55 counties in West Virginia.

CZ TREATMENT SETUP

Appendix Figure 2

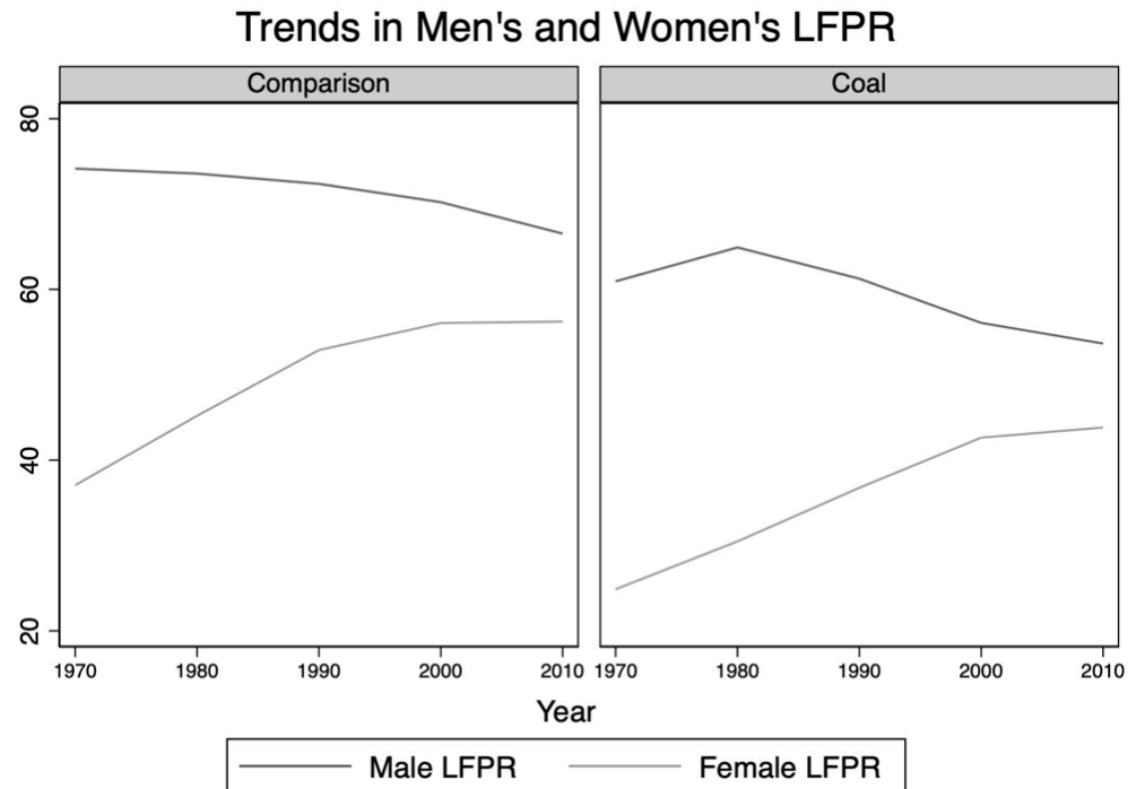
Coal Reserves by County



Note: 1990 commuting zones that cover KY, PA, OH, and WV, and bordering states, created using Mantle in Stata with David Dorn's crosswalk file. Overlaid on Figure 2 using Photoshop (with thanks to my mom, Susan Brodie!) There are 18 treatment CZs and 19 comparison CZs.

MEN'S AND WOMEN'S LFPR

Appendix Figure 3



Note: Data from IPUMS NHGIS and shows the average labor force participation rates by gender across coal counties and comparison counties in a given year.