Bootstrap analysis of the relationship between female education and fertility rates

Using resampling techniques to understand cross-national demographic trends

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Introduction

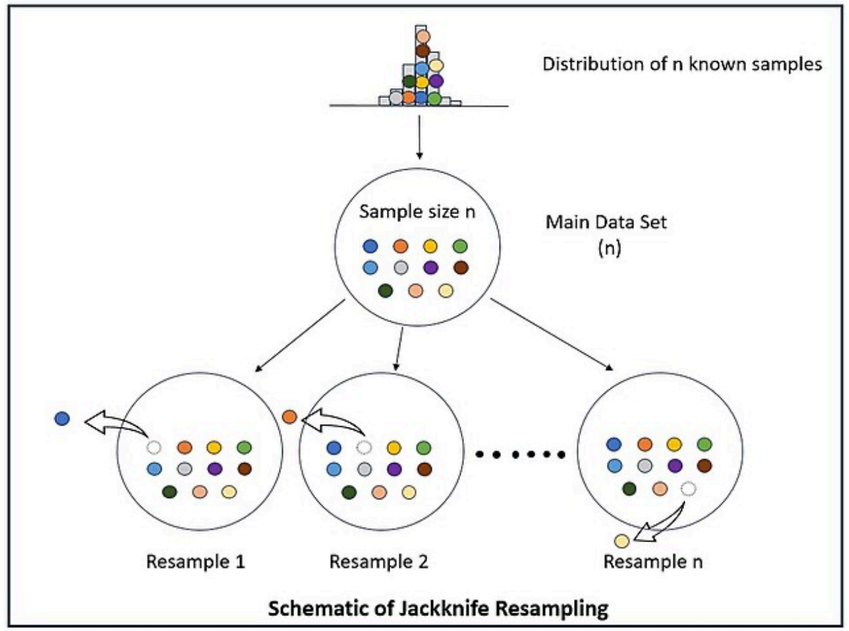
How does women's education relate to fertility across countries?

- Can we assess the strength and reliability of this relationship using statistical methods?
- Hypothesis: More education leads to lower fertility.

Methodology

Why Bootstrap ?

- Data across countries is heterogeneous and not necessarily normally distributed.
- Bootstrap is a non-parametric method:
- No strong distributional assumptions
- Estimates variability and bias reliably



Dataset overview

- Source: Gapminder dataset
- Years analyzed: 1970, 1990, 2000, 2010

Variables

- Female education: average years in school
- Fertility rate: children per woman

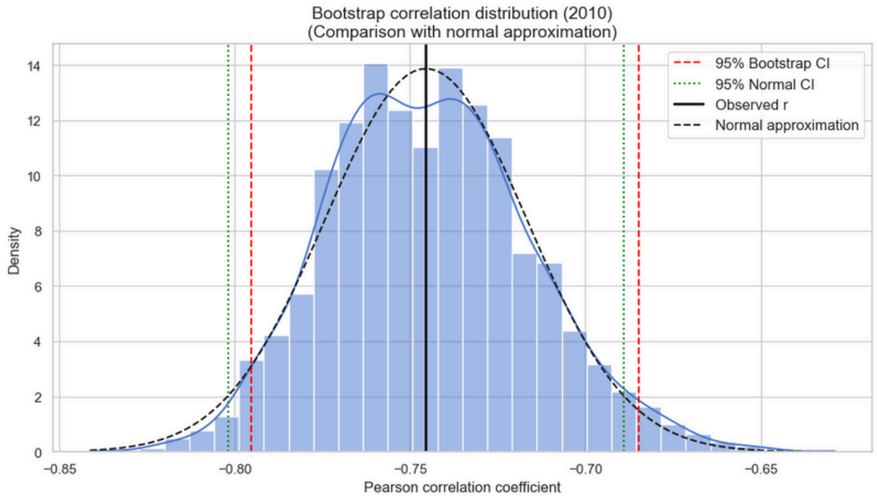
	country	1960	1961	1962	1963	1964	1965	1966	1967	1968	...	2014	2015	2016	2017	2018	2019	2020	2021
0	Aruba	4.57	4.42	4.26	4.11	3.94	3.80	3.62	3.45	3.28	...	1.94	1.90	1.85	1.78	1.73	1.70	1.66	1.63
1	Afghanistan	7.28	7.28	7.29	7.30	7.30	7.30	7.32	7.34	7.36	...	5.77	5.65	5.54	5.43	5.33	5.24	5.14	5.04
2	Angola	6.71	6.79	6.87	6.95	7.04	7.12	7.19	7.27	7.33	...	5.86	5.77	5.69	5.60	5.52	5.44	5.37	5.30
3	Albania	6.38	6.27	6.11	5.93	5.71	5.47	5.33	5.31	5.32	...	1.72	1.63	1.55	1.49	1.42	1.40	1.37	1.36
4	Andorra	2.54	2.54	2.55	2.60	2.69	2.71	2.76	2.78	2.77	...	1.17	1.22	1.18	1.13	1.05	1.04	1.03	1.06

Fertility data sample:

	country	1970	1971	1972	1973	1974	1975	1976	1977	1978	...	2006	2007	2008	2009	2010	2011	2012	2013
0	Afghanistan	0.11	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.15	...	0.39	0.40	0.42	0.43	0.45	0.46	0.48	0.49
1	Angola	0.47	0.49	0.50	0.52	0.54	0.56	0.58	0.60	0.62	...	1.57	1.62	1.68	1.73	1.79	1.84	1.90	1.96
2	Albania	4.38	4.50	4.62	4.74	4.86	4.99	5.12	5.25	5.38	...	9.75	9.92	10.10	10.30	10.40	10.60	10.80	10.90
3	Andorra	5.38	5.52	5.65	5.79	5.93	6.07	6.22	6.36	6.51	...	11.10	11.30	11.40	11.60	11.80	11.90	12.10	12.20
4	UAE	1.06	1.11	1.15	1.20	1.25	1.30	1.35	1.41	1.47	...	4.92	5.07	5.22	5.37	5.52	5.68	5.83	5.98

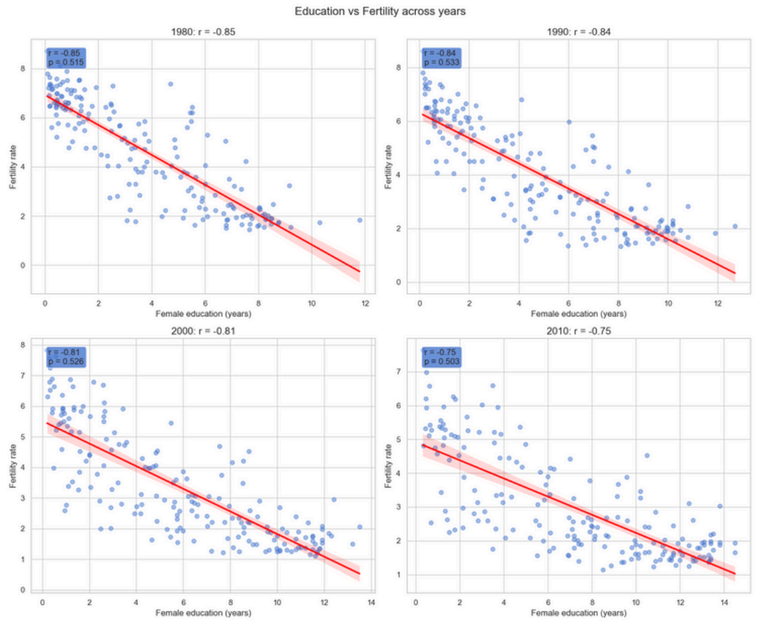
Education data sample:

Bootstrap distribution analysis (2010)



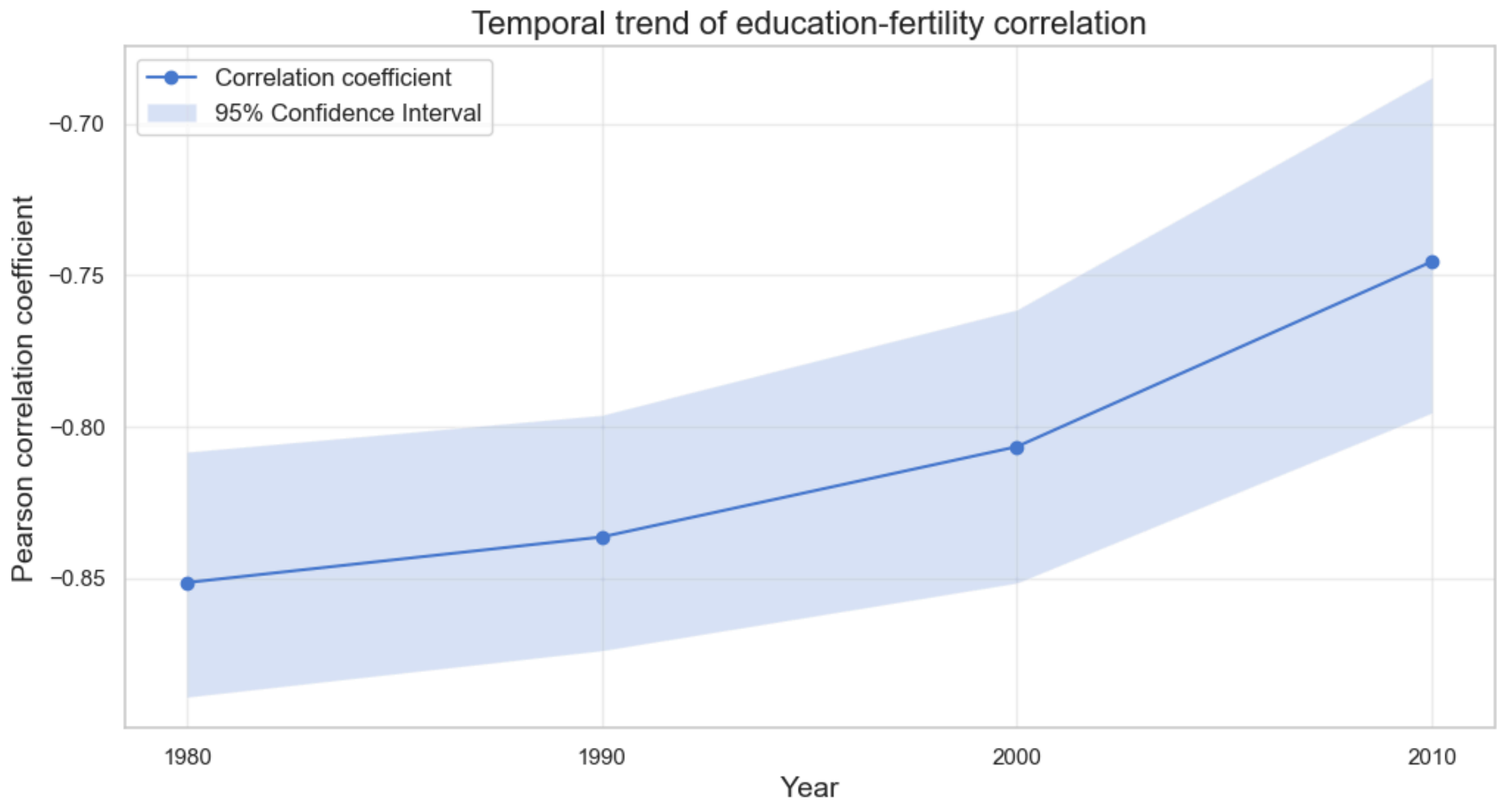
- Observed correlation r = -0.78 with minimal bias.
- 95% confidence interval: [0.87, 0.66].
- Comparison with normal approximation highlights robustness of bootstrap.

Correlation patterns over time

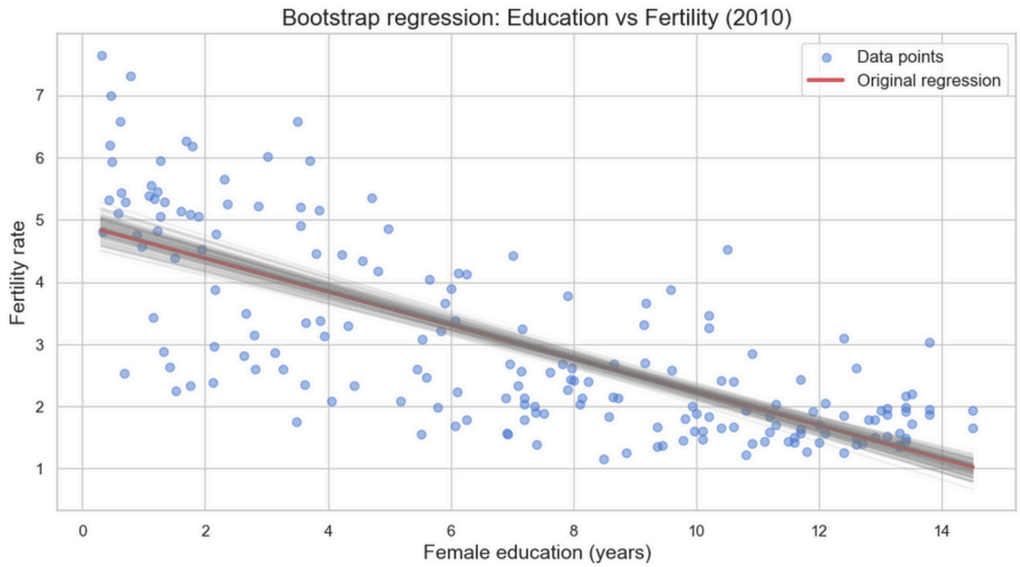


- Consistent negative relationship between education and fertility from 1970 to 2010.
- Correlation in 1970: r = -0.85 ; in 2010: r = -0.78

Temporal trend of correlation



Bootstrap regression analysis



- fertility = β0 + β1 * education
- Clear negative slope in regression line.
- 95% confidence interval for slope: [-0.308, -0.231].

Conclusion

Summary of findings

- Strong negative relationship between female education and fertility confirmed.
- Variability in relationship strength over decades.

Methodological strength

- Bootstrap methods provide robust estimates without parametric assumptions.