UPPSALA UNIVERSITET

Heterogeneous effects of a Swedish schooling reform? A GxE approach.

Rafael Ahlskog, Sven Oskarsson, Aysu Okbay,
Jonathan Beauchamp, Kevin Thom

Education as policy instrument

- Policymakers widely view education as a key element of the policy response to economic and social inequality.

- Compulsory schooling laws, in particular, have been studied across a range of contexts and outcomes: cognitive and non-cognitive skills, earnings, mortality, crime and political participation, to name a few.

UPPSALA UNIVERSITET

Education as policy instrument

- Compulsory minimum education may not affect everyone equally: some would have gotten the stipulated minimum level (and more) regardless, whereas others would have gotten substantially less.

- If economic inequality is a central motivating concern, then it is therefore particularly important to understand how such policies affect the outcomes of individuals with different ability levels or disparate socioeconomic backgrounds.

- Evidence on heterogeneous effects of compulsory education reforms is so far sparse and mixed.

An ideal Swedish reform to study?

- Compulsory general nine year schooling (up from seven in most places) was introduced in Sweden over the period 1949-1962 (along with several other changes, most notably a postponement of tracking).

- Introduced in a staggered manner.

- Makes a good candidate reform to study causal effects.

- Has been very closely studied (Meghir and Palme 2005, Holmlund 2007, Meghir et al. 2018, Lundborg et al. 2014, etc).

An ideal measure of heterogeneity?

- To study heterogeneity of reform effects, one generally wants a measure that is a) relevant to the reform effect on the outcome in question, b) is not itself affected by the reform, and c) is not ”self-selected” into.

- Genetic measures of propensity for certain outcomes satisfy these criteria:
    - For example, genetic propensity for education is plausibly a measure of the ”potential” reform effect, since those with a high propensity were probably going to get the extra years (and the downstream benefits) anyway.
    - Genetic measures are not affected by subsequent reforms (but the effect of the genetic measure could be).
    - Stable over time and thus not self-selected.

UPPSALA UNIVERSITET

How to measure genetics?

- Problem: single genetic variants are now recognized to have very small effects on complex human traits. Instead, complex traits are highly polygenic, i.e. influenced by a very large number of variants each with very small effect sizes.

- Solution: large-scale genome-wide association studies (GWAS) to identify significant variants, and summary measures of these at the individual level (as opposed to separate measures of all variants).

UPPSALA UNIVERSITET

Polygenic index

- A polygenic index (PGI) is an additive index of previously identifed variants (specifically single nucleotide polymorphisms, SNPs) associated with a particular outcome (i.e. educational attainment), weighted by their coefficients in a discovery sample.

- Technically, the PGI for a given trait, for individual and across variants , is simply defined as:

$$PGI_i = \sum_{j=1}^{n} \beta_j X_{ij}$$

UPPSALA UNIVERSITET

Our study

- We study the effect of the Swedish schooling reform on a wide range of life course outcomes, over trait-relevant PGIs for each. Included outcomes were selected based on a threshold of at least 1% explanatory power between the PGI and the outcome.
- We also study the possible difference in GxE interactions across socioeconomic background, and in men and women separately.
- Outcomes include: education, income, wealth, labor market variables, objective and subjective measures of health, health-related behaviors like tobacco use, and reproductive behavior.
- Sample: Swedish genotyped twins born between 1932 and 1965, data from STR and register data from SCB.

Our study

All analyses are pre-registered (https://osf.io/65wth/)

UPPSALA UNIVERSITET

Full list of PGI-outcome combinations

Outcome	Heterogeneity variable	Male sample			Female sample		
		All	Low SES	High SES	All	Low SES	High SES
Educational attainment (EA)	PGI of EA	✓	✓	✓	✓	✓	✓
Junior high	PGI of EA	✓	✓	✓	✓	✓	✓
High school	PGI of EA	✓	✓	✓	✓	✓	✓
College	PGI of EA	✓	✓	✓	✓	✓	✓
Cognitive performance (CP)	PGI of CP	✓	✓	✓			
Income	PGI of EA	✓	✓	✓	✓	✓	✓
Sick pay	PGI of EA	✓	✓	✓			
Social assistance	PGI of EA	✓	✓	✓	✓	✓	✓
Wealth, net	PGI of EA	✓	✓	✓	✓	✓	✓
Depressed (DEP)	PGI of DEP				✓	✓	✓
Self-rated health (SRH)	PGI of SRH	✓	✓	✓	✓	✓	✓
BMI	PGI of BMI	✓	✓	✓	✓	✓	✓
Ever smoker	PGI of Ever smoker	✓	✓	✓	✓	✓	✓
Cigarettes per day (CPD)	PGI of CPD	✓	✓	✓	✓	✓	✓
Ever snuff	PGI of Ever smoker	✓	✓	✓	✓	✓	✓
Snuff boxes per week	PGI of CPD	✓	✓	✓			
No. of drinks per week (DPW)	PGI of DPW	✓	✓	✓	✓	✓	✓
Subjective wellbeing (SWB)	PGI of SWB	✓	✓	✓	✓	✓	✓
Number of children (NEB)	PGI of NEB				✓	✓	✓
Age at first birth (AFB)	PGI of AFB	✓	✓	✓	✓	✓	✓

UPPSALA UNIVERSITET

Models

- Modeled as a diff-in-diff with a multiplicative interaction term between having been exposed to the reform and the individual PGI.

- Controls for birth year fixed effects, reform municipality clusters fixed effects (i.e. clusters of municipalities that implemented the reform in the same year), genomic principal components and a set of time-varying municipal political measures (electoral participation, size of the voting population, and vote shares for the five major parties), as well as interactions between both the reform and all controls, and the PGI and all controls, i.e.:

$$y_{icm} = \beta_0 + R_{cm}\beta_R + PGI_{icm}^{y}\beta_s + \left(R_{cm} \times PGI_{icm}^{y}\right)\beta_{RS} + \boldsymbol{C}_{icm}{}'\boldsymbol{\beta}_C + \left(\boldsymbol{C}_{icm}{}' \times R_{cm}\right)\boldsymbol{\beta}_{CR} + \left(\boldsymbol{C}_{icm}{}' \times PGI_{icm}^{y}\right)\boldsymbol{\beta}_{CS} + \varepsilon_{icm}$$

UPPSALA UNIVERSITET

Models

- Standard errors clustered by municipality.

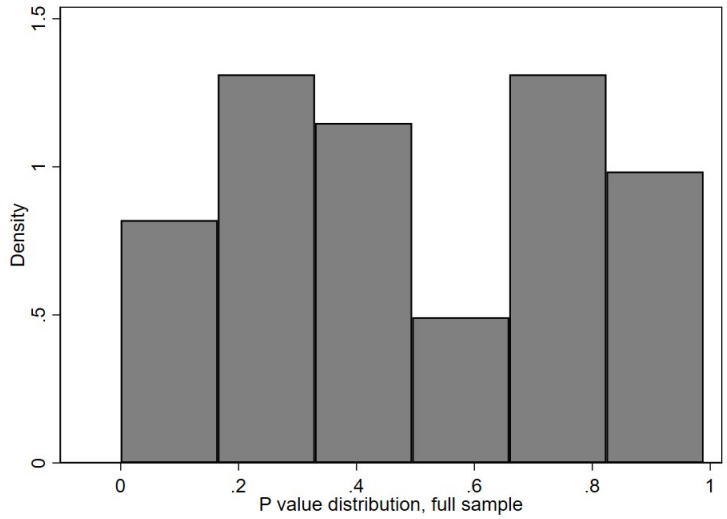
- Results adjusted for multiple testing (Benjamini-Hochberg).

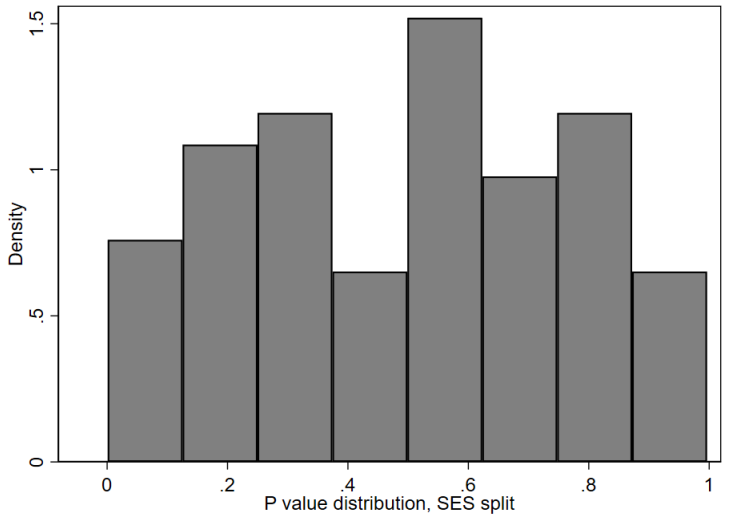
UPPSALA UNIVERSITET

Pre-registered analyses

- Very few clear signals of GxE effects.
- Some GxE terms are naively significant, but do not pass multiple testing corrections.

Pre-registered analyses – unadjusted P distributions



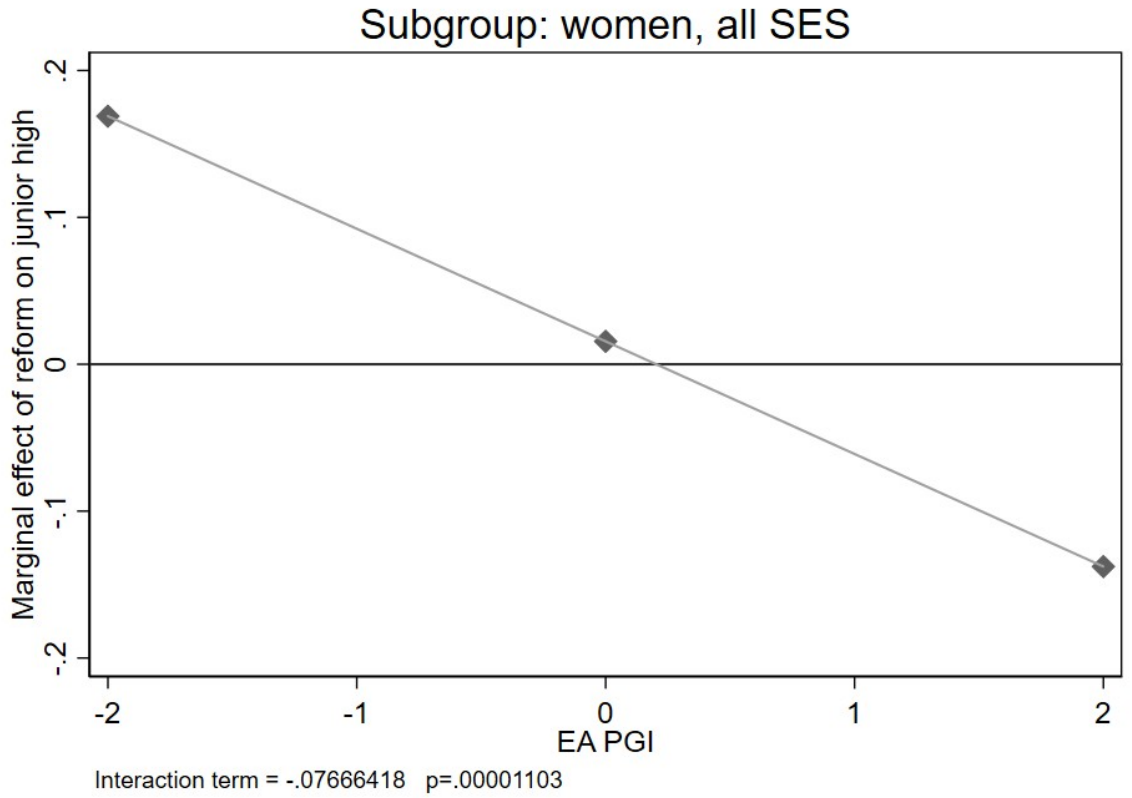


UPPSALA UNIVERSITET

Naively (weakly) significant outcomes

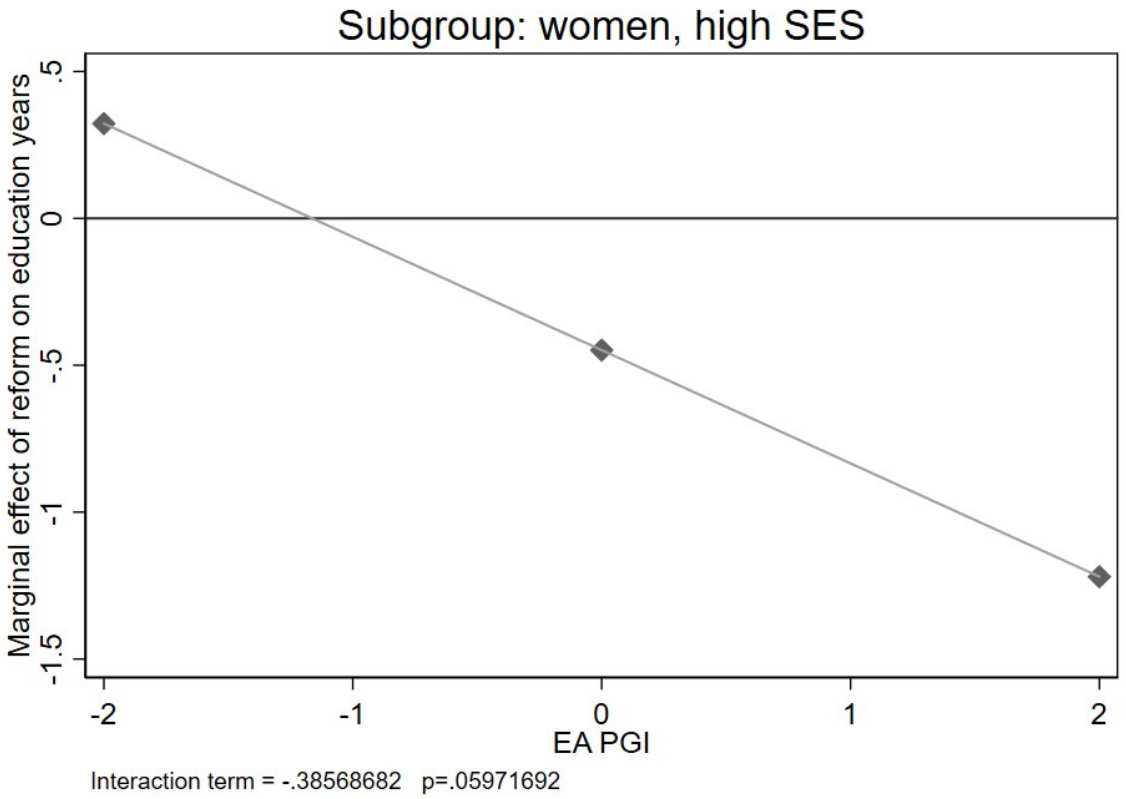
UPPSALA UNIVERSITET

Junior high completion



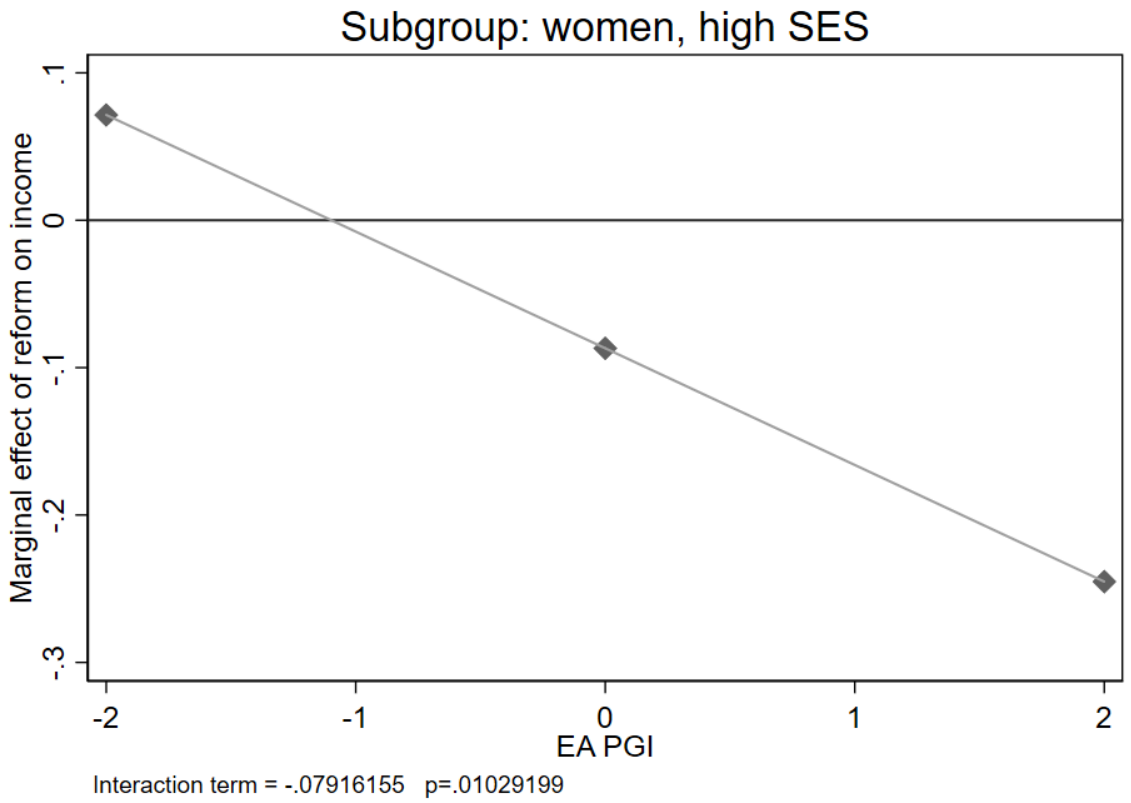
UPPSALA UNIVERSITET

Education years



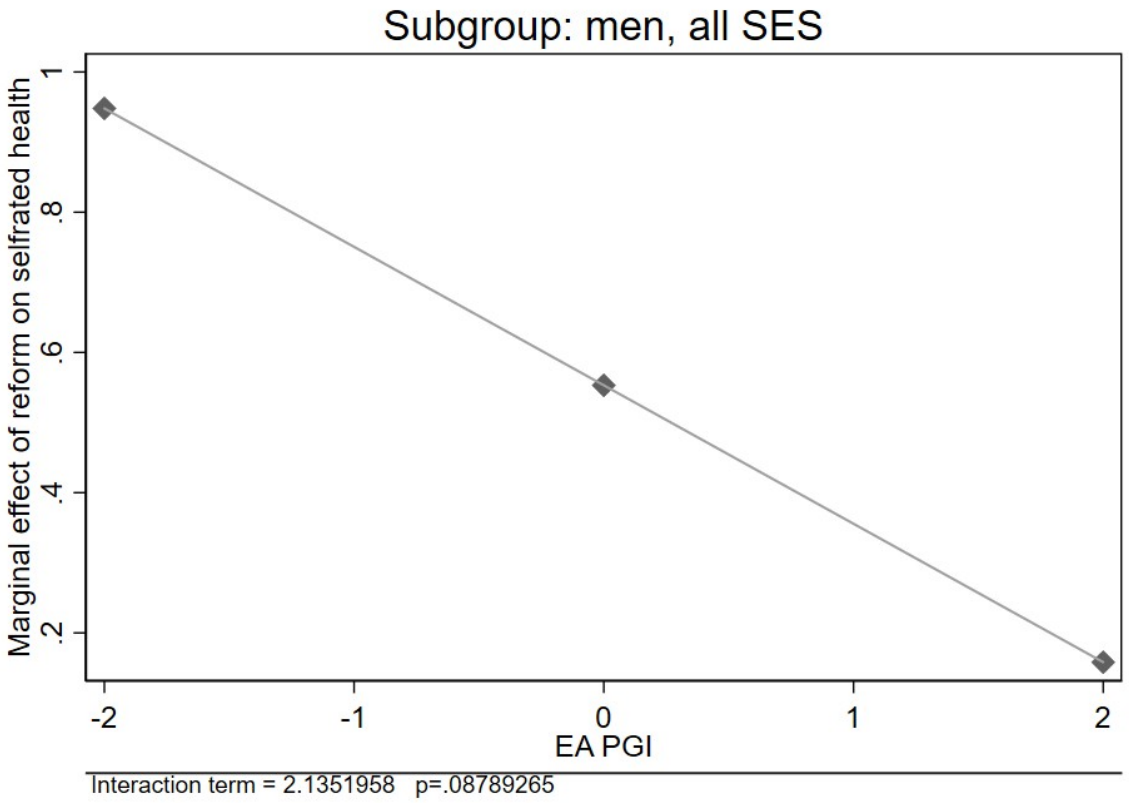
UPPSALA UNIVERSITET

Income, log



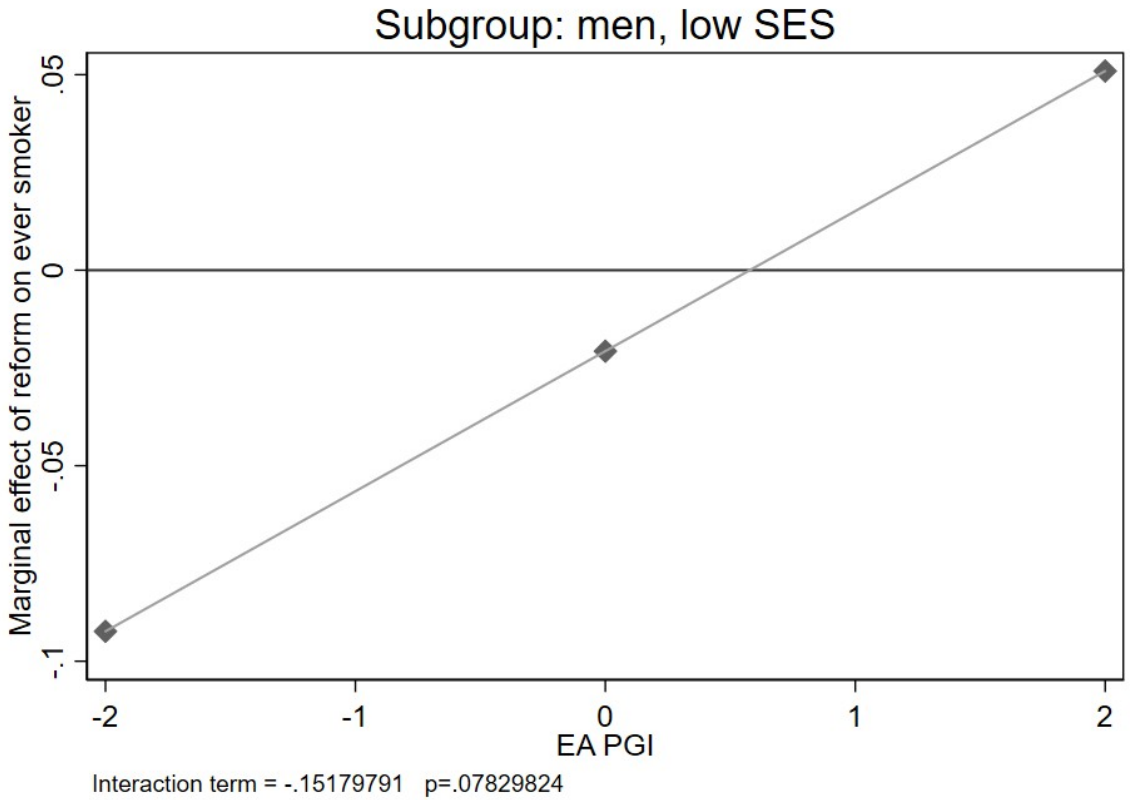
UPPSALA UNIVERSITET

Selfrated health (0-100)



UPPSALA UNIVERSITET

Ever smoker



UPPSALA UNIVERSITET

Preliminary lessons

- The mechanical effect of the reform (mandated extra years of education) hit differently in the expected manner: the positive effect on junior high school completion is most prominent among those with a lower polygenic index for education – but this is only visible for women. This might capture a unique aspect of the time period under consideration – i.e. prereform boys were more likely to continue school a priori (this is no longer the case).

- Income effects need some disentangling, but it appears that at least among women from a higher SES background, being affected by the reform may have had *negative* earnings effects – but only among those with a higher polygenic index for education. Speculatively, may have to do with other aspects of the reform, such as the postponement of tracking.

UPPSALA UNIVERSITET

Preliminary lessons

- Also some hints att heterogeneous effects on health among men: the reform had positive effects on selfrated health, but not among those with a high polygenic index of education.
- Similarly, there is a tendency for the reform to decrease smoking among low SES men, but not among those with a high polygenic index of education.

UPPSALA UNIVERSITET

Thanks!