Roles of Education in Social Mobility: A Unified Approach

Sho Fujihara
sho.fujihara@iss.u-tokyo.ac.jp
The University of Tokyo, Institute of Social Science

ISS Institute of Social Science, The University of Tokyo
Center for Social Research and Data Archives, Institute of Social Science, The University of Tokyo
SSJDA Social Science Japan Data Archive
Poster, References, and Replication Materials

Introduction

Education plays two roles in social mobility.

1. Education serves as a mediator, whereby the influence of social origin on destination is mediated through education (Blau and Duncan 1967; Breen 2004; Ishida et al. 1995).
2. Education acts as an effect modifier, whereby the impact of social origin on social destination varies by the level of education (Hout 1984, 1988; Torche 2011; Zhou 2019).

These two roles of education have been separately analyzed and discussed from the perspectives of **mediation** or **interaction**.

This study aims to introduce a method for decomposing the impact of social origin on destination into four components and provide a unified perspective that considers both mediation and interaction.

Method

- Y: outcome, A: treatment, M: mediator.
- Y_a: potential outcome of Y when $A = a$, M_a: potential outcome of M when $A = a$, Y_{am}: potential outcome of Y when $A = a$ and $M = m$.
- The average treatment effect (ATE) is then given by the comparison of the outcome Y between the cases when $A = a$ and when $A = a'$, expressed as $E[Y_a - Y_{a'}]$.
- By introducing $Y_{aM_{a'}}$, we can decompose the ATE into the natural direct and indirect effects (NDE and NIE) as follows (Pearl 2001):

$$\begin{aligned} ATE &= E[Y_a - Y_{a'}] \\ &= E[Y_{aM_a} - Y_{a'M_{a'}}] \\ &= E[Y_{aM_{a'}} - Y_{a'M_{a'}}] + E[Y_{aM_a} - Y_{aM_{a'}}] \\ &= NDE + NIE. \end{aligned}$$

The proportion of mediation (Promotion Mediated: PM) can be calculated by NIE/ATE. Furthermore, ATE is decomposed into four components as follows (Vanderwheel 2014):

$$\begin{aligned} NDE &= E[Y_{am} - Y_{a'm}] + \\ &\quad \left(E[Y_{aM_{a'}} - Y_{a'M_{a'}}] - E[Y_{am} - Y_{a'm}]\right) \\ &= CDE(m) + INT_{\text{ref}}(m), \\ NIE &= E[Y_{a'M_a} - Y_{a'M_{a'}}] + \\ &\quad \left(E[Y_{aM_a} - Y_{aM_{a'}}] - E[Y_{a'M_a} - Y_{a'M_{a'}}]\right) \\ &= PIE + INT_{\text{med}}, \\ ATE &= NDE + NIE \\ &= CDE(m) + INT_{\text{ref}}(m) + PIE + INT_{\text{med}}. \end{aligned}$$

- $CDE(m)$: Controlled direct effects when the mediator is fixed at m.
- $INT_{\text{ref}}(m)$: Reference interaction when the mediator is fixed at m.
- PIE: Pure indirect effect.
- INT_{med}: Mediated interaction.

Identification

1. $Y_{am} \perp\!\!\!\perp A|C$ (treatment-outcome),
2. $Y_{am} \perp\!\!\!\perp M|\{A, C\}$ (mediator-outcome),
3. $M_a \perp\!\!\!\perp A|C$ (treatment-mediator),
4. $Y_{am} \perp\!\!\!\perp M_{a'}|C$ (cross-world independence),

where C represent pre-treatment covariates.

Directed acyclic graph (DAG)

According to previous studies, we can depict the DAG as shown in Figure 1, where social origin A influences L (e.g., academic performance), and education M is influenced by L, thereby violating assumption 4.

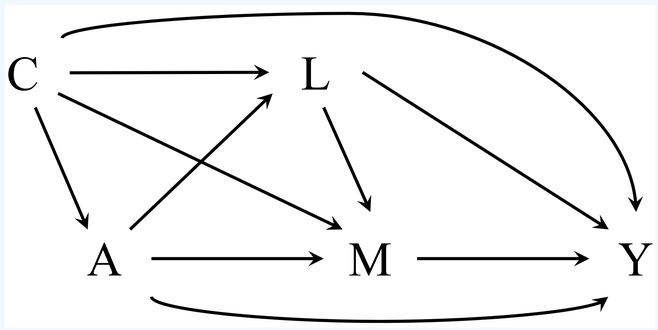

Figure: **Directed Acyclic Graph (DAG)**

Randomized intervention analogue of the effects

The randomized intervention analogue of the effects can be identified even in cases where assumption 4 does not hold.
Let $G_{a|C}$ represent values of M randomly drawn from the distribution of M conditional on C, when $A = a$. The randomized intervention analogue of average treatment effect (ATE) can be defined as $rATE = E[Y_{aG_{a|C}} - Y_{a'G_{a'|C}}]$. Similarly, $rINT_{\text{ref}}(m)$, $rPIE$, and $rINT_{\text{med}}$ are defined by replacing M_a with $G_{a|C}$.

$$\begin{aligned} rATE &= rNDE + rNIE \\ &= CDE(m) + rINT_{\text{ref}}(m) + rPIE + rINT_{\text{med}}. \end{aligned}$$

Estimation

- g-computation with the *CMAverse* package (Shi et al. 2021)
- RWR (regression with residuals) with *rwrmed* package (Wodtke and Zhou 2020)
- Multiple imputation (20) and bootstrap (1000).

Data and Variables

Data and Respondents

- Social Stratification and Social Mobility Survey (SSM Survey) conducted in 2005 and 2015.
- Employed individuals aged 25 to 64 and conducts separate analyses for males and females.

Variables

- Y (outcome): the rank of the socio-economic index (SEI) score.
- A (treatment): the rank of father's SEI score.
- M (mediator): university enrollment (including junior college and technical college for females)
- C (pre-treatment covariates): age, father's years of education, mother's years of education, and survey year dummy.
- L (post-treatment covariates): family resources at age 15, subjective living conditions at age 15, number of siblings, birth order, academic performance in the third year of junior high school, high school course, and high school rank.

Result

Decomposition of the effects for the cases where $a = 1$ (the highest rank of father's SEI) and $a' = 0$ (the lowest rank of father's SEI).

Table: **Overall, Direct and Indirect Effects**

Estimand	Men	Women
rATE	0.233 (0.020)	0.155 (0.020)
rNDE	0.171 (0.021)	0.123 (0.021)
rNIE	0.062 (0.010)	0.031 (0.008)
PM (%)	26.4	20.3

Note: Bootstrap standard errors in parentheses.

- The total effect is about 0.23 for males and 0.15 for females.
- The natural direct effect not mediated by university is approximately 0.17 for males and 0.12 for females.
- The indirect effect mediated by university is approximately 0.06 for males and 0.03 for females.
- The proportion mediated is 26% for men and 20% for women, which is smaller than those calculated using conventional regression methods (43% for men and 33% for women).

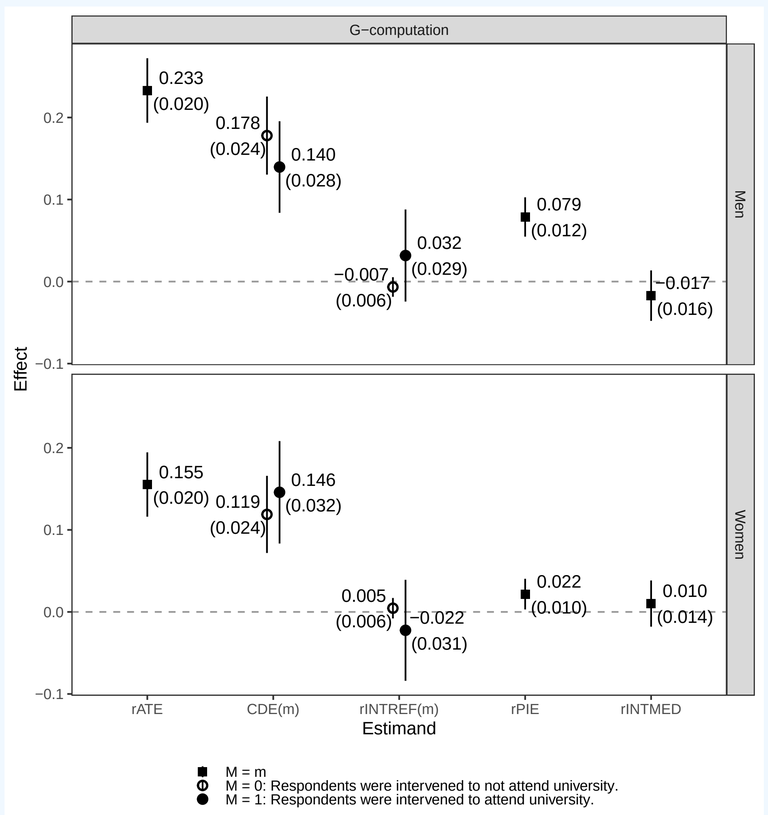

Figure: **Overall Effect and Four-way Decomposition (g-computation)**

- The controlled direct effect does not significantly vary across different values of m ($m = 0, 1$), and the interaction effect is not statistically significant.
- The interaction effect for the indirect effects is also small and not statistically significant.
- A straightforward pattern of influence for both the direct and indirect effects.

Conclusion

- The causal mediation analysis revealed that education mediates social mobility to a lesser extent compared to the conventional regression analysis.
- The effect of social origin on destination does not differ across levels of educational attainment in Japan (Fujihara and Ishida 2021).
- When considering the roles of education in social mobility, it is necessary to take into account not only education itself but also the selection process for educational attainment.

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