Examining Neighborhood Effects in a Hierarchical School System Structure: How School Mediates Neighborhood Effects on University Enrollment in Japan

Fuyuki Owa

Osaka Metropolitan University; Japan Society for the Promotion of Science

Abstract

In recent years, a growing body of research has emerged on how neighborhoods and schools affect children's academic achievement. However, little is known about how the mechanism of school-mediated neighborhood effects is affected by the school system, which varies from country to country. This study analyzes how the causal effect on university enrollment of living in a disadvantaged neighborhood is mediated by the selectivity of high schools in Japan, where high schools have a hierarchical structure based on academic selectivity. Using panel data and causal mediation analysis, I confirm that high schools mediate approximately 40% of the causal effect of living in disadvantaged neighborhoods on university enrollment in Japan. This finding implies that, in countries or regions with a hierarchical school system, such as Japan, the upper secondary school will be an important mediator of neighborhood effects on educational outcomes.

Introduction and Research Question

Examining the relationship between neighborhood effects and school effects has been a central concern in the realm of neighborhood effects research (Jencks & Mayer 1990; Sanbonmatsu et al. 2006; Harding et al. 2010; van Ham et al. 2012). A robust geographical and administrative link exists between students' residential neighborhoods and the school they attend. In theory, it is expected that factors such as the resources provided by the school, quality of programs, and peer influence mediate the impact of neighborhood effects on academic achievement and fallowing life course outcomes. However, the majority of existing studies on neighborhood effects have not simultaneously addressed the relationship between schools and neighborhoods, and there has been a lack of consistent findings regarding the interplay between neighborhood and school influences. (Nieuwenhuis & Hooimeijer 2016; Rich & Owens 2023).

As noted by Rich and Owens (2023), if the neighborhood-school structure emerges from a context of policies and institutional practices in which neighborhoods and schools mutually influence and reshape each other, then the manifestation of school effects should vary depending on the institutional context of the schools. Analyzing the relationship between neighborhoods and schools requires examining not simply whether school effects exist but also what effects schools have within a specific institutional context.

In this study, I examine the case of Japan, which features a secondary education system with some aspects that contrast with those of the United States, where a relatively large amount of analysis has been done on neighborhood-school relations. Japanese high schools, while sharing similarities with American high schools in terms of their low vocational specificity, diverge significantly by stratifying students based on academic

performance through standardized nationwide selection mechanisms (Müller & Shavit 1998; Ishida 1998; Taki 2020). Consequently, unlike the within-school tracking system found in the United States, tracking in Japan occurs between schools. Therefore, given this context, investigating whether Japanese high schools mediate neighborhood effects on life course outcomes would be beneficial for understanding the relationship between school system and the manifestation of neighborhood effects.

I focus on four-year university enrollment rate as the outcome of this study for the following reasons. In contemporary Japan, whether one graduates from university significantly impacts their subsequent life course inequality. Graduating from university is an important variable that determines one's future occupational status, and the socioeconomic benefits gap between university graduates and non-graduates has been historically maintained (Ishida 2017; Hannum et al. 2019). As of 2019, the university enrollment rate for children in Japan was 53.7% (MEXT 2019). It has been confirmed that the causal effect of growing up in a disadvantaged neighborhood substantially reduces university enrollment rate. Children raised in disadvantaged neighborhoods have a 12.3 percentage point lower university enrollment rate compared to those growing up in non-disadvantaged neighborhoods (Owa 2022).

Previous studies on neighborhood effects in Japan have revealed that neighborhood effects become more pronounced as children progress through elementary, middle, and high school and that disparities in study time emerge based on neighborhood advantage or disadvantage (Matsuoka 2017, 2019). However, it has not been examined whether high schools causally mediate the impact of neighborhoods on university enrollment under the high school system where students are sorted based on academic ability.

Thus, in this research, I conduct causal mediation analysis to quantify the extent to which high schools mediate the impact of neighborhoods on four-year university enrollment.

Data

I used data from the Japanese Life Course Panel Survey J (JLPS-J) for the period of 2015–2022. The JLPS-J is a nationally representative longitudinal survey conducted by the Institute of Social Science at the University of Tokyo. It includes a cohort study of 1,854 children and their mothers starting in 2015 (45.0% response rate), when the children were aged 14/15 years (third grade of junior high school). The first wave study was conducted in 2015 and the second wave study in 2017, when the children were aged 16/17 years (second grade of high school). Follow-up studies conducted in 2019 (third wave), 2020 (fourth, fifth, and sixth waves), 2021 (seventh wave), and 2022 (eighth wave) follow the children's academic history. This data comprises a nationally representative sample of ninth graders and their mothers in Japan as of 2015. In Japan, it is very common for students to enter university immediately after graduating from high school, without a significant time lag. By utilizing this data up to 2022, it is possible to accurately identify the university enrollment rate for this cohort.

Measurement and Method

This research uses causal mediation analysis to examine how high schools mediate the influence of neighborhoods on university enrollment. In causal mediation analysis, the treatment of post-treatment confounders is crucial when identifying the effect of mediating variables (VanderWeele 2015). In this analysis, I construct a model

that considers variable *L*, as presented in Figure 1, which is influenced by both confounding variables and the treatment variable and affects the mediating variable and the outcome.

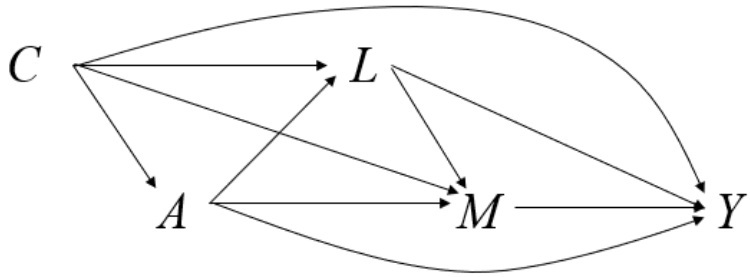

Figure 1. DAG of hypothesized causal relationships in this study. *C*: baseline confounders; *A*: treatment (neighborhood disadvantage index at age 15/16); *L*: post-treatment confounder (academic performance at the third grade of junior high school); *M*: mediator (high school rank [*hensachi*]); Y: outcome (four-year university enrollment)

The variables used in the analysis are as follows. The baseline confounders (*C*) include a women dummy, number of siblings, mother's age, mother's subjective wealth at 15 years old, father's years of education, mother's years of education, father's occupation, mother's occupation, household income, household savings, mother's marital status, house ownership, residential area (ward or city or town/village), and residential prefecture (located in three metropolitan areas or not). These variables were obtained from the first wave of the panel survey.

The treatment variable (*A*) is the neighborhood disadvantage index of Japan. This index was calculated with a principal component analysis by Fujihara (2022) based on the analysis of Wodtke et al. (2011) and its online supplement. It serves as an indicator of

neighborhood disadvantage nationwide in Japan and ranges from 0 to 1, where 1 represents the most disadvantaged neighborhoods and 0 the most advantageous ones. The neighborhood index is constructed at the block level (*cho-cho-moku* in Japanese), which is the smallest unit in Japan's national census. This measure of neighborhood disadvantage was composed using data from the 2015 Japanese national census. The index was created through principal component analysis, incorporating variables such as the proportion of individuals with a bachelor's degree or higher, the rate of individuals with less than a high school diploma, the proportion of professional and managerial workers, the unemployment rate, and the rate of individuals separated due to death or divorce.

The post-treatment confounder (L) is influenced by intervention A and has an impact on the mediating variable M and the outcome Y. The content of this variable comprises the students' academic performance at school in the third grade of junior high school, obtained in the second wave.

I used high school rank score (*hensachi* in Japanese) as an indicator of school selectivity(M). In Japan, private educational companies publish the hensachi of high schools nationwide with a mean of 50 and a standard deviation of 10; this de facto measure of scholastic achievement (Goodman & Oka 2018) is widely referenced by schoolteachers, students, and parents when making decisions about high school selection. In contrast to the within-school tracking system in the United States, this high school rank score is well suited as a variable for assessing the quality of education among high schools within Japan's unique between-school tracking system.

The outcome (*Y*) is four-year university enrollment. In Japan, whether people can enroll in a four-year university greatly impacts their future occupational status and potential earnings. Thus, it becomes a variable for predicting outcomes over the life course rather than merely the ability to attend a four-year university (Ishida 2017). Therefore, I used enrollment (or not) in a four-year university as the outcome variable, using the respondents' academic history data from waves three through eight of the survey, conducted between 2019 and 2022.

Descriptive statistics of variables used for mediation analysis (N=1854)

Variable		Mean	SD
Baseline confounders（C）	Women dummy	0.5081	0.5001
	Nunmber of siblings(ref. no siblings)		
	two siblings	0.5399	0.4985
	three or more siblings	0.3873	0.4873
	Mother's age	45.2086	3.9346
	Mother's subjective wealth at fifteen years old	1.9902	0.8970
	Father's years of education	14.0944	2.0967
	Mother's years of education	13.5528	1.4564
	Father's occupation dummy（ref. blue and gray collar work）		
	professional and managerial work	0.3452	0.4332
	Mather's occupation dummy（ref. blue and gray collar work）		
	professional and managerial work	0.1804	0.3580
	Household income (logged)	6.4340	0.5323
	Household savings (logged)	5.5507	1.5381
	Mother's marital status (single dummy)	0.0765	0.2512
	House ownership dummy (ref. rental house)		
	owner-occupied house	0.9107	0.2852
	Residential area（ref. ward）		
	city	0.3743	0.4841
	town or village	0.3851	0.4868
	Residential Prefecture (ref. ward）		
	three metropolitan area (Tokyo, Nagoya, Osaka)	0.4132	0.4925
Treatment (*A*)	Neighborhood disadvantage index (0: most advantaged-1:most disadvantaged)	0.5003	0.2880
Mediator (*M*)	High school rank (hensachi)	50.8972	9.5028
Outcome (*Y*)	Four-year university enrollement (1=enrolled)	0.6117	0.4875

Table 1. Descriptive statistics of variables used for mediation analysis.

Estimand

The primary aim of this analysis was to clarify the extent to which high school selectivity (*M*) mediates the impact of neighborhood effects on university enrollment. A critical concern is the presence of the post-treatment confounder (*L*).

When examining the mechanism of how neighborhood influences university enrollment, it is crucial to recognize that, apart from the effect mediated by high school, the possibility exists that a child's individual-level academic performance as developed through their junior high school years directly affects the university enrollment rate without the mediation of high school. Furthermore, conducting an analysis in which only high school rank is used as the mediating variable—without considering the existence of variable *L* and estimating the natural direct effect (NDE) and natural indirect effect (NIE)—may not meet the essential assumptions for causal mediation analysis (VanderWeele 2015) and could pose the risk of confounding individual-level performance and school effects. Therefore, this analysis took post-treatment confounder *L* into account and aimed to estimate the causal mediating effect of high school rank (*M*).

Recent years have seen the development of methods that enable the estimation of causal mediation effects while including post-treatment confounders in the model (VanderWeele et al. 2014; Shi et al. 2021). In this study, I estimated randomized analogues of natural indirect effect (rRNIE), randomized analogues of natural direct effect (rRNDE), total effect (RTE), and randomized analogues of proportion mediated (rPM) on the ratio scale when high school was designated as the mediating variable. I conducted this estimation using R's CMAverse 0.1.0 package (Shi et al. 2021). To address missing data, multiple imputation was employed; for estimation, point estimates and standard errors were obtained through bootstrapping (100 iterations).

Results and Robustness Check

In the analysis conducted under the aforementioned settings, the RTE was found to be 0.6326 and significant at the 5% level. The effect via paths other than high school, represented by rRNDE, was not significant. However, the effect via the high school path, represented by rRNIE, was significant at the 0.1% level. Additionally, the mediation proportion represented by rPM was significant at the 10% level, with a mediation proportion of 40.03%. The results are shown in Table 2. Even when considering grades at the time of junior high school as a variable *L* that is influenced by confounders *C* and treatment *A* and that influences the mediating variables *M* and outcome *Y*, the effect of high school remained significant.

	Estimate	Std. Error
RTE	0.6326 *	0.1344
rRNDE	0.7774	0.1462
rRNIE	0.8183 ***	0.0678
rPM	0.4003 +	0.6423

+p<0.1, *p<0.05 **p<0.01 ***p<0.001

Table 2. Estimation of RTE, rNDE, rRNIE and rPM

As a robustness check, I conducted sensitivity analysis using e-value, to evaluate the effects of unmeasured confounding (VanderWeele & Ding 2017). The e-value for RTE was 2.54, and the e-value for rRNIE was 1.76. Based on the RTE e-value, if unobserved confounders explain the risk ratio over 2.54 times more than the observed confounding variables used in the analysis, then the risk ratio of 0.63 estimated as the RTE can be attributed to those unobserved confounding variables. Similarly, the risk ratio of 0.81 for rRNIE would be attributed to the unobserved confounding variables if they explain the

risk ratio 1.76 times more than the observed confounding variables used in the analysis. If these conditions are met, the hypothesis that high school rank mediates the causal effect of neighborhood on university enrollment should be accepted.

Discussion and Further Steps

The chosen causal mediation analysis approach is capable of accommodating models that account for post-treatment confounders (VanderWeele et al. 2014, Shi et al. 2021). Through this methodology, I estimated the extent to which high schools mediate the impact of neighborhoods on university enrollment. My findings indicate that the relative reduction in university enrollment rates associated with residing in disadvantaged neighborhoods is substantially mediated by high school ranking, accounting for approximately 40% of the effect. This suggests that, in Japan, students' neighborhood during their junior high school years impacts the academic performance of their subsequent high school, consequently affecting their likelihood of enrolling in a university. Despite the inconsistent findings of school effects research in other countries, the substantial figure of around 40% in Japan underscores the essential role schools play as key mediators of neighborhood effects within the Japanese educational context.

The estimand obtained in the causal mediation analysis, rRNIE (the mediating effect of schools), requires detailed examination in future analyses. The reasons that high schools attended by children from disadvantaged neighborhoods tend to have lower rankings can be attributed to various factors. These factors may include associated neighborhood-based educational aspirations and students' subsequent enrollment decisions (such as their study habits and choice of school). It could also be due to the relative location of highly selective high schools, which are often situated in urban areas

with fewer disadvantaged neighborhoods. Limited out-of-school learning opportunities in disadvantaged neighborhoods, such as access to private tutoring, may also contribute to this phenomenon. Recognizing that school effects are influenced by both the educational system and the behaviors of students and parents, it becomes essential to explore the underlying mechanisms to effectively interpret these effects.

Previous research on neighborhood-school relations in the United States, such as that of Wodtke et al. (2023), suggests that the school itself has a limited or null mediation effect on educational attainment. Often, this lack of a significant school effect is attributed to the fact that parents and students make school choices without a precise understanding of which school offers the best education (Abdulkadiroglu et al. 2014; Billingham & Hunt 2016). In the Japanese school system, however, which exhibits clear stratification and provides explicit school quality rankings, high schools play a pivotal role in mediating the influence on neighborhood university enrollment.

Japanese ethnographic and quantitative studies have highlighted that, by the time students reach junior high school, parents and children's future educational prospects are already shaped by their neighborhoods. This divergence in educational outlook results in disparities in children's motivation to learn and ultimately influences their choice of high school (Nishida 2012; Matsuoka 2017). It is reasonable to suspect these mechanisms as potential explanations for why high schools significantly mediate the impact of neighborhoods in Japan. In addition, the findings may suggest the potential existence of such high school mediating mechanisms in countries or regions where school stratification, standardization, and competitive dynamics in secondary education are prevalent, such as in East Asia.

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