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New evidence on the link between housing environment and children's educational attainments

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Abstract

There is extensive literature that posits the hypothesis that a better housing environment enhances a child's educational attainment. However, there is little causal evidence demonstrating the presence of this effect. In this study, we examine the effect of housing environment on a child's educational attainment using census files covering the entire population of Taiwan. Because the Taiwan census data contains unique address information for every household, we try to control the neighborhood effect and unobserved family heterogeneity by comparing a child with his peers of the same age cohort in the same neighborhood. After accounting for tens of thousand area dummies, the chance of high school enrollment for teens (aged 16 and 17) and college enrollment for young adults (aged 19 and 20) is found to be positively correlated with an increase in floor space, an increase in residential stability and with homeownership, but negatively correlated to an increase in housing crowdedness and an increase in building age. Among these housing variables, residential stability and homeownership are the ones generating the largest positive effects on the child's schooling.

JEL classification: R2; I2

Keywords: Housing environment; Educational attainment; Quantity-quality trade-off

1. Introduction

One of the long standing areas of interest in social science is to understand the connection between a child's educational attainments and their family environment, particularly their housing environment.[1] Housing environment can influence a child's schooling through several channels. It is widely believed that an overcrowded house impedes a child's learning ability due to excess interactions with family members and thus reduces his or her school performance (Gove et al., 1979; Goux and Maurin, 2005).[2] By contrast, residential stability is argued to benefit a child's schooling, since mobility leads to a loss of attachment to the school system, teachers, and peers (Aaronson, 2000; Astone and McLanahan, 1994). Furthermore, homeownership is claimed to enhance a child's educational performance because parents owning their house are more likely to provide a supportive home environment and have a stronger incentive to invest in the social and school capitals in the neighborhood (Aaronson, 2000; Boehm and Schlottmann, 1999; Green and White, 1997; Haurin et al., 2002). Clearly, the housing environment provided by the parents is considered of great importance in determining a child's educational attainment.

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[1] Haveman and Wolfe (1995) reviewed the empirical research on the link between home investment in children and children's educational attainments.

[2] The early studies regarding household crowdedness in the social sciences are primarily found in sociological literature. See Gove et al. (1979) for more discussion. In addition to discussions in social science, medical studies also conclude that individuals living or having lived in such conditions are generally sick more often than others, largely due to respiratory insufficiency and pulmonary problems, and transmit their infections to one another more easily. See Mann et al. (1992) and Prescott and Vestbo (1999) for further discussion.

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While researchers have proposed several mechanisms explaining how the housing environment affects a child's education, there is only limited empirical evidence supporting the presence of housing effect. Despite that many studies have found a strong correlation between housing variables and a child's schooling, these correlations may not necessarily be indicative of a *causal* effect. The fact that children raised in families in better housing environments have more schooling than those in worse environments is not necessarily due to their housing per se, but may reflect the omission of other unobserved variables; such variables include: parental preferences, household resources, and residence neighborhood. It is well known that children raised in families controlling more financial resources have better schooling than others with less financial resources. In addition, teenagers living in affluent neighborhoods are more likely to enter schools of high quality. Furthermore, children residing in a better neighborhood tend to engage in more activities with their neighbors or peers, resulting in a positive neighborhood effect (Aaronson, 1998; Crowder and South, 2003; Ellen and Turner, 1997).[3] Without controlling for the unobserved heterogeneity of family and neighborhood, results that demonstrate the importance of housing variables cannot be immune from the endogenous bias brought by housing variables.

In light of this potential bias, studies have sought ways to uncover the casual effect of housing environment on a child's education. Green and White (1997) employed an endogenous switching model to reduce selection bias from unobserved variables influencing housing tenure choice. To gauge the extent of neighborhood effect, Harkness and Newman (2003) used interaction of tenure status and average neighborhood characteristics (e.g. stability, the homeownership rate, and the poverty rate) to estimate the effect of homeownership on educational attainment. Goux and Maurin (2005) used exogenous variations of family size as instruments to investigate the effect of a household's crowdedness on a child's schooling. Likewise, Aaronson (2000) adopts two sets of instruments to sort out the individual effect of homeownership and mobility, since homeownership and residential stability are endogenously correlated. However, all the housing variables are to some extent endogenously determined; extending the instrumental variable method (IV) strategy is difficult to cases of more than two housing variables, since each housing variable requires one additional set of instruments.

In the similar spirit, this paper seeks to explore the underlying relationship between the housing environment and a child's educational attainment. Different from previous studies that control unobserved heterogeneity using instruments, we overcome this difficulty by comparing a child with his peers of the same age in the same very small neighborhood, the "lin," the smallest government jurisdiction in Taiwan, covering usually less than 0.1 square kilometers. Families residing in the same lin often share similar housing preferences and family incomes. More importantly, youths raised in the same lin generally have experienced the same neighborhood effect. Furthermore, under current regulations, children in the same lin are assigned to the same school for compulsory education. Thus, by comparing children with peers of the same age in the same lin, we control for the neighborhood effect, the quality of schooling, and to some extent unobserved family heterogeneity like household resources.

Our data are derived from the census files that cover the entire population of Taiwan, over 22 million, in the year 2000. The census data not only records detailed family and housing information, but also includes unique address information for every household. The large sample size, together with detailed address information, allows us to examine the chances of high school enrollment for teens (aged 16 and 17) and college enrollment for young adults (aged 19 and 20) while controlling for their unobserved heterogeneity. After including more than tens of thousand area dummy variables, our results confirm the importance of housing environment in determining a child's educational attainment. Specifically, our estimates show that the educational attainment of children is positively associated with an increase in housing floor space, an increase in residential stability, and the homeownership status, but negatively related to an increase in housing crowdedness and an increase in building age.

An important difference between our work and previous studies is that we include a wide range of housing variables. Therefore, the analysis is more capable of recognizing the individual contribution of every housing variable and comparing their relative importance. According to our estimates, residential stability and homeownership appear to be the two most important determinants of a child's educational attainment. By contrast, sharing a room with siblings matters the least, as does the size and age of the building, unless it is a very old or very small one.

Our paper also relates to another line of literature exploring the relationship between family size and the child's educational attainment, the quantity-quality trade-off model (Becker and Lewis, 1973; Becker and Tomes, 1976).[4,5] Although early studies by and large confirm this trade-off relationship in the regression analysis, recent papers attempting to investigate the causal effect of family size on a child's educational attainment found the coefficient of sibship size (i.e., the total number of siblings) becomes insignificant after controlling for unobserved family heterogeneity using the IV method (e.g. Angrist et al., 2005; Caceres, 2004; Conley and Glauber, 2005) or controlling for family fixed effect (e.g. Black et al., 2005; Guo and VanWey, 1999). Interestingly, our estimated results exhibit a similar

[3] Garner and Raudenbush (1991) suggest that the neighborhood effect on educational attainment could come from a wide variety of processes, ranging from individual personality to direct environmental influences.

[4] For a review of the economic literature on the link between family size and children's outcomes, see Schultz (2005). There have also been numerous discussions on this issue in sociology. For details, see Blake (1981, 1989), Powell and Steelman (1993), and Guo and VanWey (1999).

[5] Black et al. (2005) offers a different explanation: the family size itself might have little impact on the quality of every child, but more likely impacts the marginal children through the effect of birth order. In their findings, children of higher birth orders are likely to have poorer educational attainments.

pattern—the coefficient of sibship size becomes insignificant after controlling for area dummies. To some extent, the similarity confirms the validity of our approach in accounting for unobserved family and neighborhood heterogeneity.

This paper is organized as follows. In the next section, we outline the estimation problem and discuss the existing identification strategies as well as our own strategies. Section 3 describes the data source, sample selection, and measures of educational attainment, along with the basic statistics of our sample. Section 4 shows the results of the basic specification, the effect of area dummies, as well as estimates by different gender. Section 5 offers our concluding remarks.

2. Conceptual framework

2.1. Parameter of interest

Let

$$edu_i = X_i\alpha + \beta h_i + \nu_i + \varepsilon_i, \tag{1}$$

where edu_i is the measure of child i's educational attainment; X_i is the vector of i's observed personal and family characteristics (e.g. age, sex, number of siblings, education and working status of parents); h_i is the variable describing i's housing environment; ν_i represents the personal-specific unobserved determinant (e.g. parental preferences or residential neighborhood) and ε_i represents the idiosyncratic shock that is assumed to be independent from other factors.

The central parameter of interest is β, which is viewed as the contribution of h_i on the child's educational attainment. The housing variable of interest includes: homeownership (e.g. Green and White, 1997), housing crowdedness (e.g. Goux and Maurin, 2005) and residential mobility (e.g. Astone and McLanahan, 1994). Early studies generally found the coefficient to be significant in the OLS estimation and therefore inferred that substantial educational enhancement can be gained by improving the housing environment. However, the regression results are likely to be confounded by existing observed factors (e.g. parental educations) as well as unobserved determinants (e.g. residential neighborhood or quality of schooling). The omitted variable formula suggests that the OLS coefficient from the regression is

$$\beta_{\mathrm{OLS}} = \beta + \frac{\mathrm{cov}(h_i, X_i\alpha)}{\mathrm{var}(h_i)} + \frac{\mathrm{cov}(h_i, v_i)}{\mathrm{var}(h_i)}. \tag{2}$$

Therefore, even if children raised in better housing environments have more schooling than those raised in poor environment, the strength of the relationship could be driven by the correlation between h_i and X_i and ν_i, not necessarily the benefit from the housing environment.

2.2. Existing identification strategy

In light of the potential bias, the existing literature has adopted several methods to uncover the underlying relation between a child's educational attainment and housing environment. Some studies attempted to account for the potential bias caused by homeownership by including more housing variable controls, such as tenure length and housing quality (Green and White, 1997), average housing value (Boehm and Schlottmann, 1999), or quality of home environment (Haurin et al., 2002). However, adding more controls cannot rule out the possibility of an association between housing environment, educational attainment, and something immeasurable—ranging from parental preference, to residence neighborhood to quality of schooling. The problem is most severe because household characteristics are likely to be correlated with residence neighborhood. For instance, it is well known that homeownership is higher in affluent neighborhoods, which often provides residents good quality of education. If children of homeowners are likely to have higher education, it would be difficult to differentiate whether the result is the effect of homeownership or residence neighborhood or both. Therefore, several studies attempt to account for the neighborhood effect by including variables such as: neighborhood quality (Green and White, 1997),[6] community factors (Haurin et al., 2002), and average neighborhood characteristics (Harkness and Newman, 2003). Moreover, recent studies have taken different approaches to account for unobserved family heterogeneity. Aaronson (2000) uses the IV method to deal with the endogeneity problem of homeownership and residential mobility. Likewise, Goux and Maurin (2005) examines the impact of household crowdedness on a child's educational attainment using the sex-composition of children as instruments for the child's private space.[7]

2.3. Our identification strategy

In contrast to previous studies, our study seeks to identify the effect of a variety of housing variables on a child's educational outcome, such that:

$$edu_i = X_i\alpha + H_i\beta + v_i + \varepsilon_i. \tag{3}$$

The biggest difference between Eqs. (1) and (3) is that the housing environment is a vector of multiple variables (H_i) in Eq. (3) instead of one variable (h_i) as in Eq. (1). This setting raises substantial difficulties to employ the existing identification strategies. To some extent all housing variables are endogenously determined; adding more housing variables does not necessarily mitigate the concern of endogenous bias. One possible strategy is to find instruments for housing variables like Aaronson (2000) or Goux and Maurin (2005) have done. Nonetheless, controlling for the unobserved heterogeneity under this setting demands many more instruments.

We take a different approach to identify the causal link between housing variables and the child's schooling. Aside from including a detailed set of important variables of a child's family background (e.g. the child's birth order, sibship size, and

[6] They used the housing quality variable to be a proxy for neighborhood quality.

[7] Because Goux and Maurin (2005) also include the sibship size in the estimation, there are two endogenous variables: sibship size and child's private space in the estimation. Therefore, they employ two instruments—sex composition of the first two children and of the last two children respectively—to control for unobserved family heterogeneity.

parental age, work status, and education), we account for unobserved family heterogeneity by adding dummies of the child's residential neighborhood. Our unique data are derived from the census data that collects information on the entire Taiwan population, with detailed address information. Therefore, we are able to compare a child with his or her peers of the same age in the same but very small neighborhood, the lin. Families residing in the same lin tend to share similar housing preferences, parental incomes, as well as earning potentials. Moreover, youths raised in the same lin generally encounter the same neighborhood effect and typically attend the same elementary or junior high schools, allowing us to control for the quality of compulsory schooling prior to high school and college. In fact, given Taiwan's current education regulations, it is almost certain that children in the same lin are assigned to the same school.[8,9] Thus, by controlling area fixed effect, we account for the neighborhood effect, quality of schooling, and to some extent parental incomes and preferences. Of course the approach cannot be completely immune from biases brought by unobserved heterogeneity. We will discuss this point in the results section.

To be more specific, we estimate the following equation:

$$edu_i = X_i\alpha + H_i\beta + Area_i + \varepsilon_i, \tag{4}$$

where edu_i is a dummy variable equal to one if child i's highest educational attainment is general high school for teens or general college for young adults and zero otherwise; H_i is a set of variables on the housing environment, including: floor space, building age, tenure status, housing crowdedness, and residential stability; and $Area_i$ is a vector of area dummy variables included to control unobserved family and neighborhood heterogeneity. As discussed earlier, we compare children residing in the same lin. In Taiwan, lin is the fourth and smallest level of government jurisdiction, following county, town, and village. As such, the estimation includes more than tens of thousand area dummy variables.

3. Data and sample

3.1. Data source

The data for this study are derived from the 2000 Taiwan census, which is conducted every ten years by the Directorate of General Budgeting, Accounting, and Statistics (DGBAS). The Taiwan census files collect information on a fairly detailed questionnaire similar to the ones used to create the PUMS files for the US censuses (long-form), except that income related variables are excluded. For each household, the interviewer records every individual's basic demographics (race, sex, age, and martial status), highest completed education, relationship with the head of household, working and employment status within the last two weeks, as well as the industry in which he or she works. In addition, the interviewer records the residence's structure (number of living rooms, bedrooms, kitchens, and bathrooms), homeownership (rent or own), years lived in the residence, along with the location from which the family last moved if they moved within the last five years. The residence information is further linked with the housing registry from the Ministry of Interior to ascertain the floor space of the house, the building year, and the major construction material used for the residence. More importantly, the Taiwan census includes a scrambled, but unique, address for every household's residence. As seen below, this unique address information plays an essential role in the analysis.

The advantage of using the Taiwan census is that the files contain the full sample of Taiwan's residents—around 22 million in total or 300,000 individuals in most age cohorts. The large sample size, together with the detailed address information, provides an excellent opportunity to analyze the effect of housing environment on educational attainment. Ideally, we could examine the link using the completed education levels of adult respondents and their grown-up housing information. In practice however, this is not possible since the census files do not record the family information of those who no longer reside with parents and siblings. Obtaining the complete family background is thus difficult, especially for adult respondents because a large portion of them do not co-reside with parents and siblings. Moreover, the census files report only the respondent's relationship with the head of the household, but not with other members. Although we could match their relationships according to each member's age and gender, the identification becomes quite complicated when there are more than three adults in a household (e.g. co-reside with brothers and sister-in-laws).

3.2. Sample selection

For the purposes of this study, we restrict the sample in a number of ways. We select households with at least one unmarried child aged between 15 and 20 at the time of the census. To ensure that households have complete family information, we restrict to those in which the oldest sibling is no older than 22 because children older than that age may not co-reside with parents. We also restrict the sample to age over 15 because compulsory schooling in Taiwan ends at the level of junior high school (9th grade). To avoid mistakes arising from matching parents, we keep only nuclear families in the sample, eliminating households that live with grandparents, relatives or other friends. Furthermore, we drop households in which children are raised by a single parent to reduce complications, since various family structures may also affect a child's education. Finally,

[8] According to Taiwan's Compulsory Education Law, students residing in the same "lin" belong to the same public school district and thus are assigned to the same public elementary or junior high school. For instance, the school district for Beitu Elementary School in Taipei includes every Lin of Central and Da-Tong Villages, 1st–9th and 12th Lin of Chang-An, 2nd Lin of Hot-Spring Village, and 1st–10th Lin of Ching-Jiang Village. For details on the regulations, see http://www.tp.edu.tw/neighbor/elementary/e_beitu.jsp.

[9] One exception is that children hoping to enroll in better elementary or junior high schools may move their registries to residences of relatives or friends living in better school districts, but continue to live with their parents. In this case, those children are coded as "other relatives" in the households of friends or relatives in the census. Since our data drops children that co-reside with other relatives, we expect this proportion to be small in our sample.

Table 1
Youths used in the analysis (table entries are number of observations meeting selection criteria)

Age	Total number of youths available in the census	...and live in households that have at least one adult (aged over 35)	...and have no other relatives (nuclear families)
15	336,211	315,419	219,512
16	358,608	333,787	235,408
17	371,208	344,873	246,922
18	388,149	338,363	224,930
19	398,849	334,651	219,171
20	387,889	292,389	175,876

Age	...and have valid father and mother info (exclude single-parent families)	...and the eldest sibling is equal to or less than 22 years old	...and moved into the current residence at least 3 years ago
15	158,577	149,650	132,233
16	170,769	157,974	140,445
17	178,860	160,267	143,181
18	160,706	136,859	122,431
19	155,629	122,102	109,742
20	123,481	87,027	78,806

we include only samples that have stayed in the residence for at least three years because the housing effect usually takes a longer time to materialize.

To demonstrate the impact of exclusion criteria, Table 1 lists the observation number of children aged from 15 to 20 after every selection criteria. The first column lists the total number of children in the census by age cohort. As indicated by these numbers, the size of respondents gradually increases and peaks at the age of 19; this pattern is consistent with the birth numbers between 1970 and 1975 (aged from 15 to 20 in 2000) in Taiwan.[10] The vast majority of the children, particularly younger ones, co-reside with their families. This can be seen by comparing the difference between the first and the second column that shows the number of children who live together with at least one adult aged over 35. Nevertheless, more and more children, especially those over 20 years old, choose to live alone due to either marriage or work reasons. The fact that children live alone for other reasons may increase the risks of matching complete family information, a point we will return to later.

The largest reduction in the sample size occurs when restricting to only nuclear families. This is not surprising since about 67% of the elderly in Taiwan co-reside with their children.[11] Among these nuclear families, around 20% of the children do not have valid parental information—either they are no longer co-residing with both parents or growing up in single-parent families (three fifths are in the families of single mothers). Another 10 to 20% are dropped because of the age restriction on the oldest sibling; the older the respondent, the more likely they are to be dropped by this age constraint. Finally, around 7% are eliminated because they have lived in the current residence for less than three years. The final sample size consists of a little over one third of the original sample. Still, we have about 100,000 respondents in each age cohort.

3.3. Measure of educational attainment

Before describing our analysis sample, it is important to first discuss our measures of educational attainment. Previously used measures include the highest completed level of education (Angrist et al., 2005; Black et al., 2005; Boehm and Schlottmann, 1999; Harkness and Newman, 2003), private school attendance (Conley and Glauber, 2005), held back a grade in school (Conley and Glauber, 2005; Goux and Maurin, 2005), test scores (Guo and VanWey, 1999; Haurin et al., 2002), dropping out (Green and White, 1997), and graduating from school by a certain age (Aaronson, 2000; Harkness and Newman, 2003). Because our data are derived from the census files, we cannot make distinctions on the quality of the child's enrolled school (e.g. school ranking), or the child's academic performance in the school (e.g. grade or exam score). Therefore, we adopt the measure similar to the one used in Conley and Glauber (2005) that compares the respondent's age with the highest schooling that he or she is currently enrolled in or has completed to date. The education system in Taiwan is similar to that of the United States, except that the compulsory schooling is nine instead of twelve years. Therefore, children, beginning at the age of six, are required to take six years of elementary school and three years of junior high school. After finishing junior high school, those seeking additional education can go to senior high school (three years) and even higher after graduating from high school. Suppose a child 16 years old reports his highest schooling is junior high school. Then he either did not go for higher education or had been held back in grades in previous school years. By examining one's age and highest schooling, we can compare a child's educational attainment with that of peers in the same age cohort.

There are two complications with this measure, however. First is that the cutoff birthday for school admission may result in some children starting school late.[12] For instance, a September-born child may be almost one year older than another born the next August but they are in the same school grade. Since the census data only records an individual's age (in years) at the time of the census interview, we are unable to know whether a child meets the full age requirement at the time of school enrollment. Thus, some children 15 years old may already be in senior high school, while others are still in junior high school.[13] Second, there are two types of senior high schools (general and vocational) and two types of colleges (general and junior) in Taiwan. While the quality difference between various types of schools may be small in some countries, the

[10] The number of respondents obtained from the census data is very close to the births between 1970 and 1975; the difference is less than 3 percent in every age cohort.

[11] According to the Taiwan Elderly Survey in the year 2000, 67.3% of adults over 65 co-reside with their children.

[12] The cutoff birthday in Taiwan is similar to that of the United States: children must be six years old (full) by September 1st to be enrolled in the school.

[13] The 2000 Taiwan census was conducted at the end of that year. Therefore, roughly two thirds of children 15 years old are in junior high school while the rest are in senior high school.

Table 2
Summary statistics of the youth's education, family background, and housing

	Mean/percent			
	Age (16)	Age (17)	Age (19)	Age (20)
Child's characteristics				
Male	52.02%	52.21%	52.01%	40.66%
First born	49.38%	54.17%	63.56%	70.11%
Number of siblings (self included)	2.49	2.45	2.45	2.43
	(0.859)	(0.871)	(0.886)	(0.915)
Child's education				
Junior high school or less	8.71%	8.29%	6.86%	5.15%
Vocational high school	36.46%	40.36%	32.15%	25.13%
General high school	54.83%	50.88%	21.43%	14.85%
Junior college	0.00%	0.31%	22.21%	29.86%
General college or above	0.00%	0.15%	17.35%	25.00%
Parental background				
Female economic head	10.48%	10.79%	11.31%	11.50%
Mother's age	41.86	42.50	43.61	44.36
	(3.397)	(3.389)	(3.245)	(3.162)
Mother's education year (0–6)	28.31%	31.73%	40.30%	41.17%
Mother's education year (6–9)	28.59%	27.70%	26.19%	24.12%
Mother's education year (9–12)	31.02%	29.42%	24.75%	24.93%
Mother's education year (12+)	12.08%	11.15%	8.77%	9.77%
Mother's employment	60.03%	60.09%	58.67%	57.74%
Father's age	44.81	45.48	46.64	47.36
	(3.453)	(3.407)	(3.214)	(3.085)
Father's education year (0–6)	23.13%	26.09%	34.17%	34.29%
Father's education year (6–9)	24.67%	23.62%	22.17%	20.32%
Father's education year (9–12)	30.76%	29.85%	27.34%	27.02%
Father's education year (12+)	21.44%	20.44%	16.32%	18.37%
Father's employment	93.24%	92.74%	91.16%	90.98%
Housing environment				
Rent	6.54%	6.35%	6.66%	6.03%
Space (square meter/100)	1.32	1.32	1.31	1.32
	(0.697)	(0.703)	(0.699)	(0.696)
Number of rooms	3.52	3.53	3.53	3.53
	(1.269)	(1.265)	(1.279)	(1.260)
High crowdedness	34.02%	32.55%	32.56%	32.19%
Move from vicinity[a]	3.20%	3.05%	2.90%	2.64%
Move from distant area[a]	10.00%	9.27%	9.19%	9.11%
Building age (0–10 years)	22.57%	21.58%	19.71%	18.81%
Building age (10–20 years)	41.00%	40.77%	40.04%	40.15%
Building age (20+ years)	36.44%	37.65%	40.25%	41.04%
Number of observations	140,445	143,181	109,742	78,806

Standard deviations are in parentheses.
[a] The youth is considered as a new mover if his/her current address differs from that of 5 years ago.

gap is large here because students are enrolled in schools based on their test scores taken at school entrance exams. Generally speaking, general high schools are more difficult to enter; as are general colleges.[14]

To resolve the difficulties, we first restrict the sample to children aged 16 and 17, and 19 and 20 respectively. Samples of 15 and 18 year olds are dropped since their educational measures are likely to be contaminated by the role of cutoff birthday. Next, we check if the respondent's reported schooling matches the highest schooling of his age group. Specifically, we examine the chance of high school enrollment (non-vocational) for children aged 16 or 17, and that of general college enrollment (non-junior) for children aged 19 or 20. In the discussions that follow, we refer to the younger sample as the "teen" sample and the older one as the "young adult" sample.

3.4. Description of analysis sample

We work with two analysis samples, both described in Table 2. To demonstrate the effect of our sample selection criteria, we continue to list sample statistics by their age cohorts. In total, there are 283,626 teens and 187,548 young adults since more young adults are dropped during the selection process. In

[14] For instance, the minimum score for entering pubic high schools in Taipei in 2004 is 220, about 30 points higher than that of public vocational schools. Likewise, the minimum score for entering general college is considerably higher than that of junior college in Taiwan.

both samples, except for children at the age of 20, we have more males than females, reflecting the special gender preference in Taiwan.[15] Because of the sibling's age restriction, a higher proportion of first-borns are observed in the young adults than in the teens. No significant difference however, is observed in the average number of siblings among different age cohorts.

The educational attainments of the children are listed in the second row of Table 2. A little over 50% of teens were enrolled in general high schools at the time of the census, over 35% were in vocational high schools, while the remainder was out of school. The variation in schooling among young adults is larger. About 40–50% of young adults continued schooling after high school (e.g. general or junior colleges), while another 40–50% of them chose to stop after general or vocational high schools. Less than 10% of young adults stopped their education after compulsory schooling.

One concern with our educational measure is whether the cutoff birthday affects the schooling. If that is the case, we should observe a large discrepancy in schooling between two consecutive ages. Table 2 provides some evidence regarding this concern. For teens, there are only limited schooling differences between ages. In fact, the proportion of those attending general high school for 17 years old is actually lower than that of 16 years old, showing that the cutoff is not a concern for teens.

The schooling comparison among young adults is a little bit complicated. Our statistics on a child's education indeed show a rising trend of schooling between the two age cohorts. For instance, the proportion of children attending general college increases from 17 to 25% while the rate of junior college attendance increases from 22 to 30%. Nevertheless, this observation is not likely to be the result of the cutoff birthday, since the observation number of young adults in each age cohort enrolled in general and junior colleges remains almost the same.[16] Rather, the increase of schooling reflects that those who did not seek higher education left home for work. Because our sample rules out children that live alone, young adults that stayed with families at the age of 20 tended to be the ones getting higher education. In other words, the rising education trend is in large part due to our selection criteria, a point that will be discussed below.

Table 2 also reports variables describing the parental background of the child, including age, education and work status. The average parental age of young adults is comparatively two years older than that of teens, reflecting the age difference between teens and young adults. In both the teen and the young adult samples, mothers are less likely to have acquired higher levels of education than fathers. The difference in working status is also quite large—over 90% of fathers in both samples hold a full-time job, while around 60% of mothers do. About 10% of the sample is from female-headed households.

The Taiwan census data includes a wide range of descriptions of housing environment: floor space of the house, number of various types of rooms, age of the building, homeownership, years lived in the residence, and the location from which the family last migrated if they moved within five years. The floor space of the house is measured in square meters. On average, the typical respondent lives in a building 10–20 years old, with 3.5 rooms, and 130 square meters. To better account for overcrowdedness, we construct one dummy variable that compares the number of bedrooms in a house with the number of children in a family. Typically parents share a bedroom. So the comparison is based on the remaining bedrooms (minus the one for parents) and the number of children. A high-crowdedness variable equals one if some children share a room, and zero if every child can have one or even more than one room. By this standard, around 30% of respondents live in a house where at least one child needs to share his or her room with siblings and the rate remains almost unchanged with respect to both the teen and the young adult samples.

More than 90% of the children live in self-owned households, reflecting the high rate of owner-occupied houses in Taiwan.[17] Although the data records the number of years lived in the current residence, the exact location from which children were moved from is only available for those who had moved within five years. Therefore, we combine these two variables and check if children had stayed their current residence for five years. If not, we then check whether their last move was from the vicinity (within the same village) or a distant area (from a different village). As seen from the table, less than 14% of youths moved into their current residence within the last five years, of which around 3% moved from the local vicinity; the rest migrated from other villages.

3.5. Area dummies and family heterogeneity

Before showing the estimated results, it is useful to first provide some descriptions on area dummies, which aim to control quality of schooling, neighborhood effect, and to some extent unmeasured family heterogeneity. Since the census data records detailed address information, area dummies can be constructed from the highest level (county) to the lowest level (lin). For instance, Taipei, the capital of Taiwan, consists of 12 towns, 435 villages, 9741 lins. The average area (in square kilometers) of a town, village, and lin in Taipei are: 22.6, 0.624, and 0.028, respectively.[18] Not surprisingly, as one can read from Table 3, the sample number in one area drops sharply as the level of government jurisdiction moves lower. While there are on average 780 teens and 520 young adults in a town, each lin accommodates only 3.1 teens and 2.4 young adults. From the percentile distribution based on the lin, a substantial number of lins have only one teen and one young adult at the time of the census. Yet there is still a great deal of variation in many other lins in the

[15] The observation that there are more females than males at the age of 20 is likely to reflect the fact that males are more likely to work away from home. As a result, youths aged 20 that co-reside with parents are predominately females.

[16] The number of youths enrolled in general and junior colleges is 19,042 and 24,370 for 19 years old, and 19,703 and 23,534 for 20 years old.

[17] According to Statistical Yearbook of the Construction and Planning Agency, Ministry of Interior, the average homeownership in Taiwan was 83.9% in 2005 (source: http://w3.cpami.gov.tw/statisty/94/94_htm/index.htm).

[18] The total size of Taipei is 271.8 square kilometers.

Table 3
Observation number at various levels of government jurisdiction[a]

	High school enrollment (age 16/17)			College enrollment (age 19/20)		
	Town	Village	Lin	Town	Village	Lin
Min	1	1	1	1	1	1
Max	8695	371	95	6213	243	42
Percentile						
25%	129	11	1	82	7	1
50%	368	24	2	240	17	2
75%	989	55	4	628	36	3
Mean	779.19	37.78	3.09	517.99	25.39	2.40
	(1122.47)	(38.37)	(2.65)	(770.88)	(25.36)	(1.87)
# of jurisdictions	364	7508	91,883	364	7425	78,605

[a] The percentile is ranked based on the observation number (teens or young adults) at each individual jurisdiction.

sample. This can be seen from numbers of higher percentiles—the number of teens or young adults at the 75th percentile based on the whole sample distribution is four and three, respectively. Thus, in spite of the numerous area dummies included, we still can use samples residing in areas with more than one observation for the estimation.

4. Empirical analysis

4.1. Basic specification

Results of the basic specification using teen (age 16/17) and young adult (age 19/20) sample are presented in the first and the fourth column of Table 4 respectively. As stated earlier, our education measure is a dummy indicating whether a child aged 16 or 17 enrolls general high school and whether one aged 19 or 20 enters general college. Given that results of the linear probability model and the non-linear model are similar, in the following we report results of the linear probability model; results of the logit model with fixed effects (the conditional logit model) are displayed in Appendix A.[19] Our basic specification includes all variables displayed in Table 2 except the father's age, since father's age is highly correlated with mother's age. Due to the fact that one family may contribute more than one observation in either the teen or the young adult sample, the estimation also controls for the clustering effect on the household level.[20,21] As seen from the table, estimates from the teen and young adult samples are mostly similar. Thus, we first present the similarities of the two results, and then discuss the differences.

As is typical for regressions of this sort, our coefficients imply strong connections between a child's education and parental schooling—the better the parents' education, the more likely it is that children will seek higher education. Higher educational achievements are also positively associated with an increase in the mother's age and the father's employment status, but negatively related to the mother's employment status. There is no observed difference in the educational attainment of children raised in female-headed households.

Two variables of a child's characteristics deserve special attention. First, our results indicate that the sibship size produces a significant (in the young adult sample), but very small negative effect after controlling for area dummies. Second, our estimates indicate that being the first-born largely increases the chance of enrollment in a general high school and general college, by 6.7 and 3.2%, respectively.

Our results demonstrate a strong link between a child's education and housing variables. A positive correlation is observed between a child's education and the floor space. An increase of one hundred square meters, for instance, is associated with an increase in the chance of enrollment in general high school and general college by 1.4 and 1.2%, respectively. Similar to previous literature (e.g. Green and White, 1997), children living in owner-occupied houses have a higher chance of entering general high school and college, as do children living in newer houses. In fact, our estimates suggest tenure status is one of the most important housing variables in determining a child's educational achievement, particularly for young adults seeking to enter college (3.1% for teens and 5.9% for young adults). Consistent with Goux and Maurin (2005), our results confirm the importance of private space on a child's education; having one's own room increases the chance of enrolling into high school and college by 1%. Notice that our estimation also controls for a house's floor space and sibship size, so changing from high to low crowdedness does not refer to an increase of floor space and a decrease in sibship size at the same time. Rather, the effect should be interpreted as increasing the private space for children but reducing the shared space in a household (e.g. smaller living room). Our estimates suggest that moving the mixture of private and shared space in household toward children is beneficial for their education.

One key question in the housing literature is whether residential stability influences a child's educational performance (e.g. Astone and McLanahan, 1994). If residential stability reduces the effort necessary for children to adapt to the social network, one should expect that children that recently moved,

[19] Notice the observation number in the conditional logit model is smaller than that in regression analysis, because the model drops children from areas where children have identical educational outcomes.

[20] The proportion of repeated observations from the same household constitutes about 15% of both the teen and the young adult samples.

[21] We have also estimated another setting that includes only the eldest sibling of a household in the teen and young adult samples. All the estimates remain approximately the same.

Table 4
Results of the youth's educational achievements controlling for area dummies[a,b]

	High school enrollment[c]			College enrollment[c]		
	Age (16/17)		Age (17)	Age (19/20)		Age (19)
Child's characteristics						
Male	−0.005	−0.008	−0.008	0.001	0.002	−0.026
	(0.002)**	(0.002)**	(0.003)**	(0.002)	(0.002)	(0.003)**
First-born	0.067	0.071	0.073	0.032	0.030	0.017
	(0.002)**	(0.002)**	(0.003)**	(0.002)**	(0.002)**	(0.003)**
Number of siblings	−0.002	−0.013	0.001	−0.004	−0.008	−0.005
(self included)	(0.002)	(0.001)**	(0.002)	(0.002)**	(0.001)**	(0.002)*
Parental background						
Female economic head	−0.001	0.000	−0.002	−0.005	−0.007	−0.001
	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)*	(0.005)
Mother's age	0.019	0.02	0.027	0.037	0.034	0.015
	(0.005)**	(0.005)**	(0.008)**	(0.006)**	(0.005)**	(0.008)
Mother's education year (6–9)	0.034	0.04	0.033	0.018	0.02	0.014
	(0.003)**	(0.003)**	(0.004)**	(0.003)**	(0.002)**	(0.003)**
Mother's education year (9–12)	0.069	0.092	0.069	0.057	0.073	0.045
	(0.003)**	(0.003)**	(0.005)**	(0.003)**	(0.003)**	(0.004)**
Mother's education year (12+)	0.143	0.183	0.147	0.128	0.173	0.117
	(0.004)**	(0.004)**	(0.006)**	(0.005)**	(0.005)**	(0.007)**
Mother's employment	−0.008	−0.019	−0.007	0.000	−0.009	−0.001
	(0.002)**	(0.002)**	(0.003)*	(0.002)	(0.002)**	(0.003)
Father's education year (6–9)	0.033	0.046	0.029	0.024	0.031	0.015
	(0.003)**	(0.003)**	(0.004)**	(0.003)**	(0.002)**	(0.003)**
Father's education year (9–12)	0.059	0.086	0.054	0.06	0.076	0.054
	(0.003)**	(0.003)**	(0.005)**	(0.003)**	(0.002)**	(0.004)**
Father's education year (12+)	0.149	0.203	0.144	0.153	0.198	0.143
	(0.004)**	(0.004)**	(0.006)**	(0.004)**	(0.004)**	(0.006)**
Father's employment	0.024	0.026	0.02	0.027	0.031	0.026
	(0.004)**	(0.004)**	(0.006)**	(0.004)**	(0.003)**	(0.005)**
Housing environment						
Rental status	−0.031	−0.006	−0.024	−0.059	−0.032	−0.053
	(0.004)**	(0.004)	(0.006)**	(0.004)**	(0.003)**	(0.006)**
Space (square meter/100)	0.014	−0.01	0.008	0.012	−0.011	0.012
	(0.002)**	(0.001)**	(0.003)**	(0.002)**	(0.001)**	(0.002)**
High crowdedness	−0.01	0.005	−0.013	−0.013	−0.002	−0.011
	(0.003)**	(0.003)	(0.004)**	(0.003)**	(0.002)	(0.004)**
Move from vicinity	−0.024	−0.025	−0.027	−0.024	−0.015	−0.022
	(0.006)**	(0.005)**	(0.009)**	(0.006)**	(0.005)**	(0.008)**
Move from distant area	−0.040	−0.032	−0.041	0.001	0.001	−0.003
	(0.004)**	(0.003)**	(0.006)**	(0.004)	(0.003)	(0.005)
Building age (10–20 years)	−0.012	−0.001	−0.006	0.001	0.016	−0.005
	(0.004)**	(0.003)	(0.005)	(0.004)	(0.003)**	(0.005)
Building age (20+ years)	−0.024	−0.018	−0.023	−0.009	0.004	−0.016
	(0.004)**	(0.003)**	(0.006)**	(0.004)*	(0.003)	(0.005)**
Number of area dummies	91,883	0	71,246	78,605	0	62,051
Number of observations	283,626	283,626	143,181	188,548	188,548	109,742

* Significance at 5% level.
** Significance at 1% level.
[a] Standard deviations are in parentheses. The fixed-effect model controls for household clustering effect.
[b] The actual number of area dummies controlled in the estimation is listed at the bottom of the table.
[c] The dependent variable is a dummy indicating whether teens (aged 16 and 17) enroll general high school and whether young adults (aged 19 and 20) enroll general college.

particularly from distant areas, are likely to perform worse in school.[22] Our results largely support this hypothesis—children who recently moved (in the last 3–5 years) from other locations are less likely to be enrolled in general high school. Moreover,

[22] Residential stability often implies a more stable home and school (peer) environment, which helps invest in building social capital that enhances a child's outcomes. Therefore, a longer tenure tends to lead to better outcomes for children. For details, see Coleman (1988).

the adverse effect is larger for teens who migrated from a different village. Note that the later effect does not appear in the young adult sample. This could be due to the fact that the junior high schools are usually located very close to where teens live. By contrast, general high school admissions are based on the test scores of young adults. Therefore, many young adults cannot benefit from the existing social network as they did in junior high school, since they must attend distant general high schools.

Up to now our results controlling for lin dummies are by the large consistent with findings in the literature. It is thus interesting to learn how the inclusion of area dummies helps our estimation. If adding area dummies indeed mitigates the concern of unobserved factors, one should expect that the estimated coefficients change dramatically after the inclusion of lin dummies. Comparing estimates in the first and second column of table, the coefficient of sibship size in the teen sample changes from -0.013 (significant at 1%) when there are no area controls to -0.002 (insignificant) when controlling at the lin level. By contrast, the coefficient of homeownership becomes significant when lin dummies are included. Likewise, the coefficient of floor space in the young adult sample moves from negatively to positively significant after including area dummies. Obviously, controlling for lin dummies substantially changes the coefficients and move them in the direction consistent with the general expectation. More details will be discussed below.

As stated earlier, there maybe a risk of bias generated from our sample selection. For instance, young adults aged 20 have a higher chance of leaving home for work, particularly for those who do not seek higher education. For teens, the cutoff birthday constraint might affect the chance of entering general high school for teens aged 16. To examine the sample selection resulting in the bias in the estimation, we compare differences in results of teens aged 17 with those of the whole teen sample, as well as results of young adults aged 19 with those of the whole young adult sample. In the last column of teen and young adult sample, we list the estimated results of children in the age groups of 17 and 19, respectively. From the table, we observed only modest differences between results using the full sample and half the sample. None of the estimated coefficients flip their signs after restricting the sample. And, only one coefficient of the housing variables (building age 10–20 years in the teen sample) becomes insignificant. Both of these observations imply that our sample selection at most results in small biases in the estimation.

Thus far, our results by the large confirm the importance of housing variables. Nonetheless, interpreting these results warrants special caution. For instance, the coefficient of homeownership may be due to the fact that parents more willing to invest in physical houses are likely to create positive benefits for their children's education.[23] It is also possible that these coefficients may reflect our inability to control for household income. Perhaps larger, self-owned, new houses produce a positive effect simply because they are associated with a child's family well-being. We discuss this issue in the next sub-section.

4.2. Effects of area dummies

To address the concern that our findings are not driven by unobserved family and neighborhood heterogeneity, Table 5 lists the estimated results that control area dummies at the lin, village, and town level, as well as the one without area dummies. From the table, it is clear that including area dummies substantially change the estimates. To carefully compare estimates generated from different sets of area dummies, the bottom of the table lists the results of the Hausman test using any two sets of the estimates. All of them are statistically different at the 1% level by a large margin.[24]

One plausible explanation for the positive relationship between the child's education and housing variables (e.g. floor space and homeownership) is that these variables serve as a channel to display the income effect. If that is the case, one should anticipate the effect to diminish when more area dummies are included, since families residing in the same but smaller neighborhood are likely to have similar family assets and earnings. Throughout the table, however, estimates of housing variables continue to show significant effects on the child's educational outcome, some of which even become larger after controlling for many more area dummies. While it is still possible that our results are biased due to large variations within the same neighborhood, results here do not seem to support that our findings are driven by unmeasured household income.

Another way to examine the effect of area dummies is to compare our results with findings in other studies accounting for unobserved endogeneity through the IV method. Goux and Maurin (2005) found that the coefficient of sibship size turns insignificant, while that of household crowdedness becomes significant after the IV estimation. Although these two settings may not be directly comparable, our estimation actually yields a similar pattern—the coefficient of sibship size diminishes as the level of area control becomes finer.[25] At the level of lin, the estimate of sibship size for teens is only marginally significant at the 10% level, with the magnitude roughly one fifth of that in results without area controls. Additionally, the coefficient of household crowdedness becomes larger and statically significant when more area controls are added; this suggests that our

[23] Haurin et al. (2002) explained why homeownership might positively influence children's cognitive and behavioral outcomes. First, there is a stronger investment incentive for homeowners compared with renters. Better physical home environments increase the probability of success of children of homeowners. Second, there is a greater geographic stability creating a neighborhood network that is likely to promote a child's outcome.

[24] The smallest chi-square value occurs when comparing results of village fixed effect with that of lin fixed effect. Even for them, the value is 29.04 for young adults and 113.52 for teens, strongly rejecting the null hypothesis that these two sets of estimates are indifferent.

[25] Because our setting is different from that of Goux and Maurin (2005), a direct comparison between our results and theirs may be inappropriate. However, we have conducted another test that uses the average number of rooms per person as the proxy for a household's crowdedness. The results of this test are similar to that of Goux and Maurin (2005), as we still found a significant and negative impact for household's crowdedness on a child's education.

Table 5
Estimated results of the youth's educational achievements (various area dummies)[a,b]

	High school enrollment (age 16/17)				College enrollment (age 19/20)			
Level of jurisdiction	No	Town	Village	Lin	No	Town	Village	Lin
Number of dummies	0	364	7508	91,883	0	364	7425	78,605
Child's characteristics								
First-born	0.071	0.072	0.071	0.067	0.030	0.029	0.029	0.032
	(0.002)**	(0.002)**	(0.002)**	(0.002)**	(0.002)**	(0.002)**	(0.002)**	(0.002)**
Number of siblings	−0.013	−0.006	−0.004	−0.002	−0.008	−0.004	−0.004	−0.004
	(0.001)**	(0.001)**	(0.001)**	(0.002)	(0.001)**	(0.001)**	(0.001)**	(0.002)**
Housing environment								
Rental status	−0.006	−0.027	−0.030	−0.031	−0.032	−0.054	−0.058	−0.059
	(0.004)	(0.004)**	(0.004)**	(0.004)**	(0.003)**	(0.003)**	(0.003)**	(0.004)**
Space (square meter/100)	−0.010	0.017	0.016	0.014	−0.011	0.015	0.014	0.012
	(0.001)**	(0.002)**	(0.002)**	(0.002)**	(0.001)**	(0.001)**	(0.001)**	(0.002)**
High crowdedness	0.005	−0.004	−0.007	−0.010	−0.002	−0.011	−0.010	−0.013
	(0.003)	(0.002)	(0.002)**	(0.003)**	(0.002)	(0.002)**	(0.002)**	(0.003)**
Move from vicinity	−0.025	−0.032	−0.031	−0.024	−0.015	−0.021	−0.018	−0.024
	(0.005)**	(0.005)**	(0.005)**	(0.006)**	(0.005)**	(0.005)**	(0.005)**	(0.006)**
Move from distant area	−0.032	−0.041	−0.043	−0.040	0.001	0.001	0.003	0.001
	(0.003)**	(0.003)**	(0.003)**	(0.004)**	(0.003)	(0.003)	(0.003)	(0.004)
Building age (10–20 years)	−0.001	−0.017	−0.017	−0.012	0.016	0.002	0.001	0.001
	(0.003)	(0.003)**	(0.003)**	(0.004)**	(0.003)**	(0.003)	(0.003)	(0.004)
Building age (20+ years)	−0.018	−0.026	−0.027	−0.024	0.004	−0.007	−0.010	−0.009
	(0.003)**	(0.003)**	(0.003)**	(0.004)**	(0.003)	(0.003)**	(0.003)**	(0.004)*
Hausman test								
v.s. No area fixed effect		3902.30**	4276.97**	1851.65**		2494.26**	3909.36**	902.12**
v.s. Town fixed effect			455.22**	292.99**			198.92**	71.57**
v.s. Village fixed effect				113.54**				29.04**

* Significance at 5% level.
** Significance at 1% level.
[a] Standard deviations are in parentheses. In addition to variables listed above, the regressors include variables of parental background listed in Table 2. The estimation also controls for household clustering effect.
[b] The Hausman Test compares the coefficients of variables listed in Table 2. Coefficients of area dummies are excluded from comparison.

findings are consistent with studies intending to control unobserved heterogeneity using the IV method.

4.3. Gender difference

When discussing the effect of housing variables, one often raised question is: which, if any, housing variable plays the crucial role in determining the child's educational attainment. For parents, concerned with the child's schooling, should they buy a new but small house or rent an old but large one? Is it better to have a house with many private rooms but a small living room or one with a large living room but fewer private rooms? How relevant is it to find a house near our current residence? Given that our estimation includes a wide range of housing variables, it is possible to sort out the relative importance of each housing variable. According to our estimates, rental status and mobility are the ones that cause the largest negative effect on the children's schooling. By comparison, the child's private space, as well as the age and size of building, results in a relatively modest effect.

At this point we have discussed the individual contribution of every housing variable. Nonetheless, the findings may be misleading, since some effects are likely to differ with respect to the gender of children. For instance, it is widely believed that boys need a bigger house. It is also believed that girls need their own private space. To explore this possibility, Table 6 expands the estimation by allowing gender interactions on three variables: first-born, floor space, and household's crowdedness. Consistent with the general impression, first-born boys have a higher school enrollment than first-born girls; this is likely due to the fact that boys in Taiwan's society receive more social pressure than girls. Both the household's crowdedness and floor space exhibit some gender differences. The chance of college enrollment is higher for boys raised in households with larger floor space in the young adult sample, but no observable gender difference in the teen sample. For teens, girls raised in households of high crowdedness have a lower chance of getting into general high schools, but the gender difference drops sharply in the young adult sample. It appears that different housing needs are present for boys and girls after a certain age threshold.

5. Conclusions

Understanding the factors that determine the educational attainment of children is an important research question in social science. The answer is not only crucial for human capital formulation, a key driver of economic growth, but also essential for income distribution purposes, since education is considered a driver of income mobility. Among these components, the

Table 6
Results of the youth's educational attainments (with gender interactions)[a]

	High school enrollment age (16/17)	College enrollment age (19/20)
Child's characteristics		
First born (boy)	0.055	0.032
	(0.003)**	(0.004)**
First born (girl)	0.042	0.022
	(0.003)**	(0.003)**
Number of sibling	−0.009	−0.007
	(0.002)**	(0.001)**
Housing environment		
Rental status	−0.031	−0.058
	(0.004)**	(0.004)**
Space (square meter/100)∗boy	0.014	0.015
	(0.002)**	(0.002)**
Space (square meter/100)∗girl	0.014	0.009
	(0.002)**	(0.002)**
High crowded ness∗boy	−0.004	−0.013
	(0.003)	(0.004)**
High crowdedness∗girl	−0.009	−0.011
	(0.003)*	(0.003)**
Move from vicinity	−0.023	−0.023
	(0.006)**	(0.006)**
Move from distant area	−0.039	0.001
	(0.004)**	(0.004)
Building age (10–20)	−0.012	0.001
	(0.004)**	(0.004)
Building age (20+)	−0.025	−0.009
	(0.004)**	(0.004)*
Number of area dummies	91,929	78,707
Number of observations	283,626	188,548

* Significance at 5% level.
** Significance at 1% level.
[a] Standard deviations are in parentheses. In addition to variables listed above, the regressors include the variables of parental background listed in Table 2. The estimation also controls for household dusting effect.

housing environment provided by parents is often considered of great relevance. While it is widely believed that a better housing environment stimulates a child's learning, there is limited evidence as to the causal link between the housing environment and a child's schooling.

In this study, we seek to uncover the causal effect of the housing environment on children's educational attainment. Because housing variables are likely to be correlated with unobserved family and neighborhood heterogeneity, previous studies use the IV method to sort out the "true" contribution of the housing variables on the child's schooling. Different from previous studies, we attempt to control for the unobserved heterogeneity of family and neighborhood through their residential neighborhood. Generally, families living within a close distance, to some extent, share similar parental preferences, household assets, and earning potential. More importantly, children in the same neighborhood typically go to the same school and experience the same neighborhood effect. Using the Taiwan census files that include the unique address information of every household, we compare the chance of general high school or general college enrollment for children with their peers of the same age and from the same, very small neighborhood. After controlling for over tens of thousand area dummies, our results continuously show the importance of housing variables in determining a child's schooling. The educational attainment of children is positively associated with an increase in floor space, an increase of residence stability, and with homeownership, but negatively related to an increase in housing crowdedness and an increase in building age. Among these housing variables, homeownership and residential stability appear to be the ones having the largest effects; both to some extent support the hypothesis that the social network where children are raised matters substantially for their early development.

Several findings deserve special attention. First, a first-born child, particularly a boy, is more likely to perform well in school. While the finding may reflect the fact that parents, particularly those in Taiwan, tend to put more pressure on first-borns, our finding is consistent with Black et al. (2005), who argue that the birth order, not family size, matters for a child's outcome. A more careful analysis that explores a full range of effects of birth order and possibly its interactions with housing variables may be necessary.

Second, consistent with Goux and Maurin (2005), our results confirmed the importance of private space on a child's education. Because our estimation also controls for the size of the house and the number of children, the coefficient indicates that enlarging the division of the child's private space in the house increases the chance of school enrollment. Nonetheless, the effect of a child's private space is likely to be non-linear. Future studies can explore this issue by figuring out the optimal mixture between public and private space in a house.

Finally, and most importantly, our identification uses the neighborhood fixed effect to control unobserved heterogeneity of family and neighborhood. While we have shown evidence supporting this approach, we caution readers that there might be other factors left uncontrolled (e.g. the interactions between parents and children). Also, families residing in the same neighborhood may still be very different with regard to their parental preferences or household resources. Even for the neighborhood effect, our approach might be inadequate if there are interactions between neighborhood and housing variables. For instance, renters that have experienced and developed positive relationships with neighbors might end up buying the house near their current residence. In that case, the coefficient of homeownership is likely to be overstated, even controlling for the area dummies.

The main contribution of this paper is to provide the causal evidence regarding the effect of the housing environment on a child's educational attainment. Although many studies have attempted to establish the link between one or two housing variables and a child's educational achievement (e.g. homeownership and residential stability), our paper appears to be the first that offers a complete picture on the effect of a wide range of housing variables. In addition, our paper demonstrates the importance of a few key housing variables. Future studies could use our findings as the basis to consider more effective policy instruments to enhance a child's educational attainment through the design of housing policy.

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Appendix A
Conditional logit results of the youth's educational achievements[a,b]

	High school enrollment		College enrollment	
	Age (16/17)	Age (17)	Age (19/20)	Age (19)
Child's characteristics				
Male	−0.027	−0.036	0.008	−0.216
	(0.010)**	(0.017)*	(0.017)	(0.027)**
First-born	0.320	0.346	0.238	0.140
	(0.011)**	(0.019)**	(0.019)**	(0.031)**
Number of siblings (self included)	−0.012	0.001	−0.036	−0.053
	(0.008)	(0.013)	(0.014)**	(0.022)*
Parental background				
Female economic head	−0.009	−0.008	−0.038	−0.009
	(0.018)	(0.029)	(0.030)	(0.046)
Mother's age	0.084	0.113	0.477	0.305
	(0.027)**	(0.043)**	(0.055)**	(0.083)**
Mother's age square	−0.001	−0.001	−0.005	−0.003
	(0.000)*	(0.000)*	(0.001)**	(0.001)**
Mother's education year (6–9)	0.155	0.149	0.158	0.148
	(0.014)**	(0.023)**	(0.024)**	(0.039)**
Mother's education year (9–12)	0.304	0.302	0.39	0.371
	(0.016)**	(0.025)**	(0.026)**	(0.041)**
Mother's education year (12+)	0.733	0.741	0.681	0.679
	(0.024)**	(0.039)**	(0.036)**	(0.057)**
Mother's employment	−0.035	−0.03	−0.010	−0.029
	(0.011)**	(0.018)	(0.018)	(0.029)
Father's education year (6–9)	0.157	0.133	0.221	0.182
	(0.016)**	(0.025)**	(0.027)**	(0.042)**
Father's education year (9–12)	0.265	0.238	0.472	0.487
	(0.016)**	(0.025)**	(0.026)**	(0.041)**
Father's education year (12+)	0.702	0.668	0.875	0.915
	(0.021)**	(0.033)**	(0.032)**	(0.050)**
Father's employment	0.117	0.089	0.231	0.244
	(0.022)**	(0.034)**	(0.034)**	(0.054)**
Housing environment				
Rental status	−0.145	−0.121	−0.45	−0.453
	(0.023)**	(0.036)**	(0.040)**	(0.062)**
Space (square meter/100)	0.066	0.039	0.097	0.118
	(0.010)**	(0.016)*	(0.017)**	(0.027)**
High crowded ness	−0.046	−0.055	−0.077	−0.059
	(0.014)**	(0.023)*	(0.025)**	(0.039)
Move from vicinity	−0.111	−0.126	−0.191	−0.183
	(0.032)**	(0.052)*	(0.057)**	(0.089)*
Move from distant area	−0.187	−0.187	0.006	−0.036
	(0.020)**	(0.032)**	(0.033)	(0.053)
Building age (10–20 years)	−0.057	−0.024	0.001	−0.039
	(0.020)**	(0.031)	(0.034)	(0.053)
Building age (20+ years)	−0.119	−0.114	−0.072	−0.141
	(0.021)**	(0.033)**	(0.036)*	(0.056)*
Number of area dummies	40,364	20,701	20,004	9231
Number of observations	192,056	70,907	80,656	29,259

* Significance at 5% level.
** Significance at 1% level.
[a] Standard deviations are in parentheses. The number of observation is smaller here because the model drops observations where all children in the same area share identical schoolings.
[b] The actual number of area dummies controlled in the estimation is listed at the bottom of the table.

References

Aaronson, D., 1998. Using sibling data to estimate the impact of neighborhoods on children's educational outcomes. Journal of Human Resources 33, 915–946.

Aaronson, D., 2000. A note on the benefits of homeownership. Journal of Urban Economics 47, 356–369.

Angrist, J.D., Lavy, V., Schlosser, A., 2005. New evidence on the causal link between the quantity and quality of children. Mimeo.

Astone, N.M., McLanahan, S., 1994. Family structure, residential mobility and school dropout: A research note. Demography 31, 575–584.

Becker, G., Lewis, H.G., 1973. On the interaction between the quantity and quality of children. Journal of Political Economy 81 (2), 279–288.

Becker, G., Tomes, N., 1976. Child endowments and the quantity and quality of children. Journal of Political Economy 84 (4), 143–162.

Black, S., Devereux, P.J., Salvanes, K.G., 2005. The more the merrier? The effect of family composition on children's education. Quarterly Journal of Economics 120 (2), 669–700.

Blake, J., 1981. Number of siblings and educational mobility. American Sociological Review 50, 84–94.

Blake, J., 1989. Family Size and Achievement. University of California Press, Berkeley.

Boehm, T.P., Schlottmann, A.M., 1999. Does home ownership by parents have an economics impact on their children? Journal of Housing Economics 8, 217–232.

Caceres, J., 2004. Impact of family size on investment in child quality: Multiple births as natural experiment. Mimeo. Department of Economics, University of Maryland.

Coleman, J., 1988. Social capital in the creation of human capital. American Journal of Sociology 94, 95–120.

Conley, D., Glauber, R., 2005. Parental educational investment and children's academic risk: Estimates of the impact of sibship size and birth order from exogenous variation in fertility. NBER Working Paper #11302.

Crowder, K., South, S.J., 2003. Neighborhood distress and school dropout: The variable significance of community context. Social Science Research 32, 659–698.

Ellen, I.G., Turner, M.A., 1997. Does neighborhood matter? Assessing recent evidence. Housing Policy Debate 8 (4), 833–866.

Garner, C.L., Raudenbush, S.W., 1991. Neighborhood effects on educational attainment: A multilevel analysis. Sociology of Education 64 (4), 251–262.

Goux, D., Maurin, E., 2005. The effect of overcrowded housing on children's performance at school. Journal of Public Economics 89, 797–819.

Gove, W., Hughes, M., Galle, O., 1979. Overcrowding in the home: An empirical investigation of its possible pathological consequences. American Sociological Review 44, 59–80.

Green, R., White, M., 1997. Measuring the benefits of homeowning: Effects on children. Journal of Urban Economics 41, 441–461.

Guo, G., VanWey, L.K., 1999. Sibship size and intellectual development. American Sociological Review 64, 169–187.

Harkness, J., Newman, S., 2003. Effects of homeownership on children: The role of neighborhood characteristics and family income. Demography 31 (4), 575–584.

Haveman, R., Wolfe, B., 1995. The determinants of children attainments: A review of methods and findings. Journal of Economic Literature 33 (4), 1829–1878.

Haurin, D.R., Parcel, T., Haurin, R.J., 2002. Does homeownership affect child outcomes? Real Estate Economics 30 (4), 635–666.

Mann, S.L., Wadsworth, M.E., Colley, J.R., 1992. Accumulation of factors influencing respiratory illness in members of a national birth cohort and their offspring. Journal of Epidemiology and Community Health 46, 286–292.

Powell, B., Steelman, L.C., 1993. The educational benefits of being spaced out: Sibship density and educational progress. American Sociological Review 58, 67–381.

Prescott, E., Vestbo, J., 1999. Socioeconomic status and chronic obstructive pulmonary disease. Thorax 54, 737–741.

Schultz, T.P., 2005. Effects of fertility decline on family well-being: Evaluation of population programs. Draft for MacArthur Foundation Consultation Meeting, Philadelphia, PA.