Immigrant Exposure and Native Students' Educational Outcomes[†]

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Abstract

This paper provides causal evidence on how immigrant exposure in K–12 education affects native students' short- and long-run outcomes. Conceptually, immigrant inflows can affect natives through congestion—i.e., by changing the quantity and quality of resources per student—and through peer effects—whose sign depends on immigrant characteristics. We study this in Chile, a setting where a sharp immigration shock increased the immigrant share from less than 1 percent to roughly 8 percent in a decade. Using administrative records for all K–12 students, linked to parent, teacher, and student surveys, we first show that Chile's fertility decline left schools with substantial slack capacity, suggesting limited scope for congestion. We then show that, although immigrants score below natives on average, they sort into schools where they outperform local peers and bring stronger parental backgrounds, higher aspirations, and greater study effort. To estimate the causal effect of immigrant exposure on native students' outcomes, we exploit within-family variation and instrument younger siblings' immigrant exposure with the immigrant share they would have faced in their cohort at their older sibling's school. We find that greater immigrant exposure improves native outcomes across a broad set of measures, including elementary- and high-school test scores, on-time high-school completion, and higher-education enrollment. To investigate mechanisms, we build on the same empirical approach and first show, consistent with the descriptive patterns, that there is no evidence of congestion: teacher-student ratios and teacher characteristics, including test scores, education, experience, and tenure, remain unchanged with greater immigrant exposure. We then show that positive effects are concentrated among natives exposed to immigrants above the school-cohort median in an index of academic motivation and grit, whereas exposure below the median worsens outcomes. Overall, our results indicate that the effects of immigration depend on the composition of immigrant inflows and how immigrants sort into schools.

Keywords: Immigration, education, congestion, peer effects.
JEL Codes: I20, J15, J61.

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1 Introduction

Over the past two decades, international migration has become one of the most contentious policy issues in receiving countries. A recent and important literature documents that natives tend to overestimate both the size of immigrant populations and their impact on the economy and society (Ajzenman et al., 2022, 2023; Alesina et al., 2023). These concerns extend to schools, where immigrant inflows are often associated with stereotypes, native flight, and segregation pressures, while causal evidence on native students' learning effects remains mixed (Alesina et al., 2024; Betts and Fairlie, 2003; Cascio and Lewis, 2012; Contreras and Gallardo, 2022; Ohinata and Van Ours, 2013; Geay et al., 2013; Schneeweis, 2015; Jensen and Rasmussen, 2011; Ballatore et al., 2018; Gould et al., 2009; Figlio and Özek, 2019; Figlio et al., 2024; Assaad et al., 2023).

This paper provides causal evidence that exposure to immigrant classmates improves native students' educational outcomes in Chile. We exploit a sharp and unexpected immigration shock to estimate the causal effects of immigrant exposure on academic performance and longer-term educational attainment. Between 2010 and 2020, Chile experienced a large and sudden immigration shock that rapidly transformed its K–12 school system. The foreign-born share of fourth-grade students increased from about 1% to nearly 8%, dramatically altering school cohorts and generating substantial variation in immigrant exposure across schools and over time. Our analysis focuses primarily on fourth grade, where standardized tests are administered annually to all students, and extends to outcomes observed later in the educational trajectory including high school completion and post-secondary enrollment.

Conceptually, immigrant inflows can affect native students through two broad channels. The first is congestion: if schools cannot absorb new students, immigrant inflows may reduce resources per pupil and harm learning. The second is peer effects: immigrant classmates may affect study norms, aspirations, classroom behavior, and effort, with effects that can be positive or negative depending on immigrant characteristics.

Estimating these effects poses fundamental identification challenges. Exposure to immigrant peers is not randomly assigned. Immigrant students may sort systematically into particular schools, and schools receiving larger immigrant inflows may differ along dimensions that independently affect achievement. Much of the existing literature focuses on

addressing this form of immigrant sorting, typically through school fixed effects or related strategies.

A second, and equally important, challenge has received far less attention: native families may respond endogenously to changes in school composition. If native students—particularly those from more advantaged backgrounds—systematically leave schools experiencing rising immigrant shares, estimates that fail to account for this endogenous native sorting may remain biased even after controlling for school characteristics. With few exceptions, this channel has been largely overlooked in the immigration and education literature. A notable exception is Figlio et al. (2024), who document substantial selection of native students into and out of schools in response to immigrant inflows and show that failing to account for this behavior can distort estimated peer effects.

Following Figlio et al. (2024), we explicitly address both sources of selection within a unified empirical framework. Our preferred specification relies on mother fixed effects and an instrumental variable strategy that instruments a student's actual immigrant exposure with the exposure she would have experienced at her older sibling's school. This design uses within-family variation while accounting for endogenous school choices of younger siblings, which is central in our setting. For mechanism analyses, where precision is more demanding, we implement an extension that increases sample size by including families with two children and controlling for fixed effects defined by the eldest sibling's school and entry cohort. This comparison among natives whose older siblings started first grade in the same school and year allows us to retain the same identification logic while improving precision.

Before presenting causal estimates, we document descriptive patterns that are informative about the two conceptual channels. First, Chile's fertility decline generated substantial slack capacity in schools, suggesting limited scope for congestion. Second, although immigrants have lower average test scores in the full population, they sort into schools where they compare favorably to local peers and are positively selected along non-cognitive dimensions such as academic motivation, grit, and self-efficacy. These selection and sorting patterns are not specific to Chile; indeed, Dustmann et al. (2024); Card (2001); Saiz (2007); Glitz (2014) describe similar immigrant selection and sorting into neighborhoods in Germany, the United Kingdom, and the United States. Taken together, this descriptive evidence is consistent with a setting in which peer composition, rather than resource

dilution, is likely to be central.

Naive comparisons yield negative correlations between immigrant exposure and native achievement. However, once we account for both immigrant sorting and endogenous native responses, we find that exposure to immigrant peers has positive and statistically significant effects on native students' outcomes. Our preferred estimates imply that a one standard deviation increase in immigrant exposure—approximately four percentage points, or roughly one additional immigrant student per classroom—raises fourth-grade test scores by about 0.03 standard deviations in both language and mathematics. These gains persist into later educational stages, increasing on-time high school completion and post-secondary enrollment. We also find evidence of non-linearities, with positive effects driven primarily by schools exposed to relatively large immigrant shares rather than by schools receiving only marginal increases in immigrant exposure.

To further investigate mechanisms, we conduct a set of additional exercises based on our empirical framework and its extensions. Because some mechanism variables are not available for all cohorts, we improve statistical power by replacing mother fixed effects with fixed effects for the eldest sibling's first-grade school interacted with the eldest sibling's first-grade entry year. This extension allows us to include families with at least two children, whereas the main specification relies on families with at least three children. Reassuringly, when estimated on the original sample, this alternative approach yields results that are nearly identical to our baseline estimates.

We then use this extended design to study mechanisms in detail. We first examine school resources and find no evidence of congestion: class size, teacher–student ratios, and teacher characteristics remain broadly unchanged as immigrant exposure rises. We next study peer channels by characterizing immigrants and natives within the same school-cohort across a broad set of variables related to academic motivation, grit, and self-confidence. Because self-efficacy questions are not consistently available across cohorts, we build an index of academic motivation and grit using the survey items available over time and classify immigrants by whether they are above or below the school-cohort median. Instrumenting exposure to high- and low-index immigrants using the same identification logic as in the main design, we find that the positive effects on short- and mid-term outcomes are driven by exposure to high-motivation, high-grit immigrants, while exposure to low-motivation, low-grit immigrants tends to worsen native outcomes. Consistent with

these results, students exposed to more immigrants report better school and learning environments, as well as some improvements in teacher practices. Teacher surveys do not indicate systematic changes in teaching practices, but they do report better classroom environments and fewer disruptions. Taken together, these patterns suggest that part of the peer effects of immigrant exposure operate indirectly through improved learning conditions generated by more academically motivated classmates.

Our findings contribute to two main literatures. First, they contribute to the literature on immigration and education in receiving countries. Existing evidence is mixed, with some studies finding negative effects in specific contexts, including Chile (Contreras and Gallardo, 2022), and others documenting neutral or positive effects when school systems can absorb inflows or adapt institutionally (Ohinata and Van Ours, 2013; Geay et al., 2013; Schneeweis, 2015; Jensen and Rasmussen, 2011; Ballatore et al., 2018; Gould et al., 2009; Figlio and Özek, 2019; Figlio et al., 2024; Assaad et al., 2023). We add to this literature in three ways. First, we estimate effects using a strategy that simultaneously addresses immigrant sorting and endogenous native responses—a source of selection that has received comparatively little attention. Second, we show that positive effects extend beyond the short run to high school completion and higher-education enrollment. Third, we provide direct evidence on mechanisms: we show that immigrants are positively selected along non-cognitive dimensions relative to local peers, and that positive effects on native outcomes are driven by exposure to immigrants with high academic motivation and grit, while exposure to immigrants below the school-cohort median on these dimensions can worsen outcomes. These results align with descriptive evidence on immigrant skill dynamics in school settings (Hull and Norris, 2020) and with the patterns we document in Chile—slack capacity and positive non-cognitive selection—lending coherence to the overall set of findings. Relative to the peer-effects literature—see Barrios-Fernández (2023) and Sacerdote (2014) for comprehensive reviews—our estimates are at the upper end, but similar to those in closely related immigration settings such as Figlio et al. (2024) and Carrell et al. (2018).

Second, we contribute to the broader literature on the economic and social consequences of immigration. There is extensive evidence on the effects of immigration on labor markets (Borjas, 2003; Lewis, 2011; Dustmann et al., 2013, 2017; Hanson, 2020; Verme and Schuettler, 2021), security and social outcomes (Pinotti, 2017; Langella and

Manning, 2019; Ajzenman et al., 2023), and fiscal externalities (Storesletten, 2000; Dustmann and Frattini, 2014). However, a growing literature shows that perceived effects of immigration often diverge from actual effects (Ajzenman et al., 2022, 2023; Alesina et al., 2024). In our setting, public attitudes toward immigration in education turned increasingly negative over the period we study, yet our estimates show that the actual effects on native students' learning and educational attainment are positive. This contrast between perception and evidence underscores the policy relevance of rigorous causal work in this area.

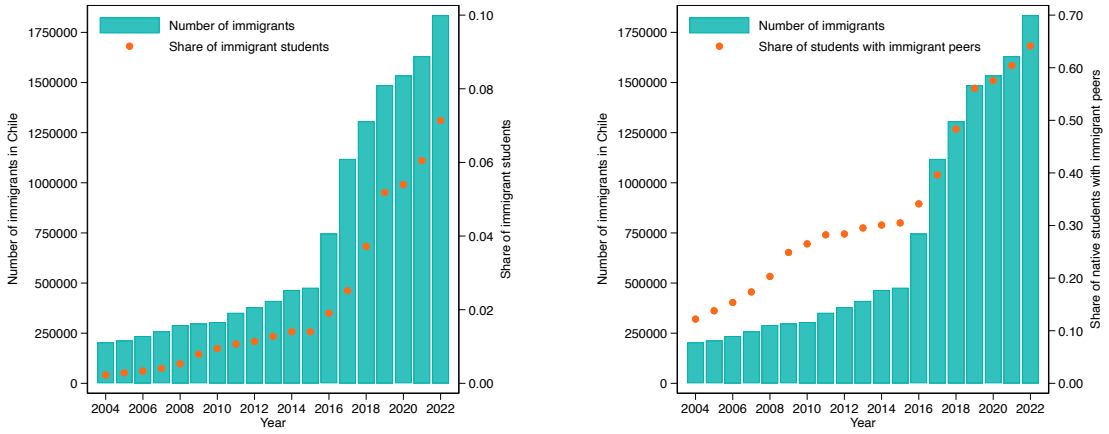
The remainder of the paper is organized as follows. Section 2 describes the institutional context of the Chilean school system and recent immigration patterns. Section 3 presents the data and summary statistics. Section 4 outlines the empirical strategy. Section 5 presents the main results. Section 6 explores mechanisms. Section 7 concludes.

2 Institutional Background

2.1 Immigration to Chile

Over the past fifteen years, Chile has experienced a profound transformation driven by a large and sudden increase in international immigration. This process reshaped the demographic composition of the country and, in particular, of its K–12 school system. Figure 1 summarizes this change at the national level. Panel (a) shows the abrupt increase in immigrant population over time, alongside we document a substantial rise in the share of foreign-born students in elementary schools, which grew from about 1% in 2008 to roughly 8% by 2022. This translated into a rapid increase in native students' exposure to immigrant peers. Panel (b) documents this pattern directly: the share of native fourth-grade students with at least one immigrant classmate rose from approximately 20% in 2010 to about 65% by 2022.

While Figure 1 focuses on national aggregates, immigration to Chile exhibited substantial regional heterogeneity. Immigrant settlement was highly spatially concentrated, with especially large inflows into northern regions and the Metropolitan Region (see Figure B.I in the Online Appendix). Importantly, both the timing and magnitude of these inflows were largely driven by external economic and political shocks in countries of origin, rather than by changes in the Chilean education system or local school conditions.



(a) Immigration Evolution

(b) Native Exposure to Immigrants

Figure 1: Immigration trends and native exposure at the national level

Notes: Bars show the total number of immigrants in Chile between 2004 and 2022. In Panel (a), dots indicate the share of immigrant students enrolled in the school system. In Panel (b), dots indicate the share of native students exposed to immigrant peers.

The composition of immigration to Chile has evolved markedly over time. In the earlier phase of the immigration wave, inflows were dominated by migrants from neighboring countries—most notably Peru—who constituted the largest immigrant group for much of the period prior to the late 2010s. More recently, this pattern shifted sharply, with Venezuelan migrants becoming the predominant group, reflecting the large-scale humanitarian crisis in Venezuela. Detailed evidence on the evolution of immigration by country of origin is reported in Online Appendix Figure B.II.

At the same time, immigrant students and their families display relatively high educational resources and aspirations. Immigrant students are more likely to have mothers with higher educational attainment and parents who expect them to reach higher education, indicating positive educational selection despite the challenges associated with migration. Additional descriptive evidence on parental education and educational expectations is presented in Online Appendix Figure B.III.

Collectively, these patterns highlight a sharp increase in immigrant presence in Chilean schools, a gradual shift in countries of origin, and the arrival of families with relatively strong educational aspirations

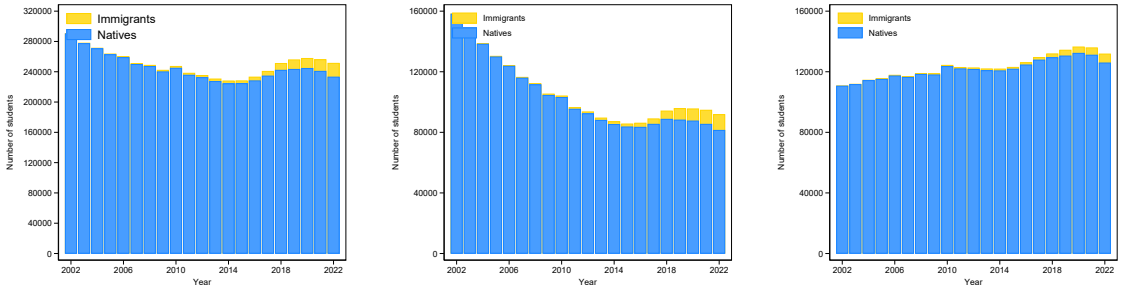
2.2 K–12 School System in Chile

The Chilean school system is roughly organized into two cycles: primary education (grades 1–8) and secondary education (grades 9–12). Education is provided by three types of schools. Public and *voucher* schools together serve 93% of students and are funded through a voucher system that provides both regular and targeted subsidies based on student characteristics and school location. Private schools, which serve the remaining 7% of students, are funded exclusively through tuition fees. An important feature of the Chilean system is that both native and immigrant students are eligible to receive funding, ensuring universal access to subsidized education, regardless to the citizenship status.

The scope for student selection in subsidized schools has been progressively limited over the past two decades. In 2006, the General Education Law (*Ley General de Educación*) prohibited elementary schools receiving vouchers from selecting students based on parental background, socioeconomic status, or academic performance. However, enforcing these restrictions was challenging, and schools may have continued to engage in some selection practices (Carrasco et al., 2017). A more comprehensive reform was introduced in 2016 with the School Inclusion Law (*Ley de Inclusión*), which began implementation that year and was fully in place by 2019. This reform prohibited voucher schools from charging additional fees on top of the voucher and moved admissions to a fully centralized system using a deferred acceptance algorithm. The priorities in this system include siblings, disadvantaged students—15% of seats can be reserved for them—, children of school workers, and former students. Importantly, there is no formal priority for native students over immigrants. While most students in our sample began school before this reform, its implementation signals the direction of policy changes during our study period. Moreover, data from 2024 show that only 11% of schools were oversubscribed, suggesting that the scope for selection remains limited even after the immigration shock.

Enrollment trends in elementary schools provide important context for understanding how the Chilean education system absorbed the recent immigration shock. Figure 2 shows that enrollment among native students declined steadily throughout the 2000s and early 2010s, reflecting a sharp and persistent fall in fertility rates. Chile's current fertility rate—around 1.2 children per woman—is well below replacement and substantially lower than that of the United States, leading to a contraction in the size of native cohorts entering elementary school and generating excess capacity within the system. This decline

was particularly pronounced in public schools, as many families shifted toward voucher schools, which experienced a slight increase in enrollment. (Campos and Kearns, 2024). Against this backdrop of declining native enrollment, immigrant student enrollment increased rapidly in the late 2010s. As a result, the inflow of immigrant students occurred in a context of slack capacity—especially in the public sector—helping to stabilize cohort sizes rather than placing pressure on an already congested school system.



(a) Overall enrollment (b) Public schools (c) Voucher schools

Figure 2: Enrollment evolution

Notes: The figure shows the evolution of enrollment for native students (blue) and immigrant students (yellow). Panel (a) reports enrollment trends for the full school system, Panel (b) focuses on public schools, and Panel (c) focuses on voucher schools.

3 Data and Sample Construction

This project combines student-level administrative records from multiple Chilean education agencies using a unique student identifier. We draw on longitudinal enrollment data from the Ministry of Education, which cover the universe of students enrolled in Chile's K–12 system—public, voucher, and private schools—and include detailed information on students and schools. These records are linked to standardized test data from the Education Quality Agency, which administers nationwide assessments annually in grade four and on a regular basis in other grades, as well as to data from the Department of Educational Measurement (DEMRE), which administers the national university admission exam. Together, these sources allow us to follow students across educational stages, from primary school through the transition to higher education.

These data are unusually rich, as standardized exams in Chile are accompanied by detailed background questionnaires administered to students, parents, and teachers. These surveys provide information on dimensions that have been less explored in the literature, including cognitive and non-cognitive skills, parental expectations, teaching practices, and

the school environment. This breadth of information allows us to go beyond academic achievement and examine potential mechanisms underlying our results. Overall, the combination of universal coverage, consistent identifiers, and high-quality survey data makes this setting particularly well suited for studying the effects of immigrant exposure in schools.

We use family-link administrative records from Altmejd et al. (2021); Barrios-Fernández (2022); Barrios Fernández et al. (2024) to identify siblings. These data are essential for our empirical strategy, as they allow us to track siblings across cohorts and schools and to construct family fixed effects. They also form the basis of the instrumental variable approach developed in Section 4, which exploits variation in immigrant exposure across siblings within the same family.

Table 1 presents summary statistics for several relevant samples, including all students in the same entry cohorts, immigrant students, and the overall native population. It also reports statistics for the subsample of native students with at least two siblings, which is central to our instrumental variable strategy based on older siblings' school histories and family fixed effects. Native students in the sibling-based sample are broadly comparable to the overall native population but are slightly negatively selected, exhibiting higher public school attendance, lower average socioeconomic status, and somewhat weaker academic performance. Immigrant students differ more markedly from natives overall, but these differences narrow substantially when immigrants are compared to natives in the sibling sample.

When examining mid- and long-term outcomes, it is important to note that immigrant shares are highly persistent across grades (see Online Appendix D.I). Because most students remain in the same school through grade eight and typically switch schools only at the transition to high school, estimated effects on later outcomes should be interpreted as reflecting continued and cumulative exposure to immigrant peers rather than exposure limited to a single grade.

Table 1: Summary Statistics

	All students (1)	Immigrant students (2)	Native students (3)	Native students with siblings (4)
A. Demographic characteristics				
Female = 1	0.488	0.450	0.489	0.490
Age in grade 1	9.246	9.363	9.244	9.312
B. Socioeconomic background				
Public school = 1	0.411	0.584	0.407	0.472
Voucher school = 1	0.508	0.339	0.511	0.442
School SES = Low	0.405	0.370	0.406	0.477
School SES = Mid	0.344	0.410	0.343	0.307
School SES = High	0.250	0.219	0.250	0.214
Mother education: less than high school	0.266	0.273	0.266	0.283
Mother education: completed high school	0.490	0.445	0.491	0.483
Mother education: higher education	0.243	0.282	0.243	0.234
Books at home: less than 10	0.379	0.439	0.379	0.376
Books at home: 10–50	0.420	0.360	0.421	0.405
Books at home: 50–100	0.118	0.104	0.118	0.123
Books at home: more than 100	0.082	0.097	0.082	0.096
C. Academic performance				
Grade four GPA	5.878	5.676	5.882	5.752
Grade four attendance	92.429	87.159	92.538	92.445
Spanish score (σ_n)	264.522	264.059	264.529	258.768
Math score (σ_n)	255.343	251.670	255.399	250.921
Has repeated a grade = 1	0.026	0.069	0.025	0.034

Notes: This table presents summary statistics for fourth-grade students. Column (1) reports averages for the full sample. Column (2) restricts to immigrant students, defined as those not born in Chile. Column (3) reports averages for native students. Column (4) corresponds to native students with at least two older sibling observed in the data. School SES refers to the socioeconomic classification assigned by the Education Quality Agency.

4 Empirical Strategy

4.1 Identification Challenges

We are interested in estimating the effect of exposure to immigrant peers on native students' educational outcomes. Formally, we consider the following relationship:

$$Y_{ist} = \beta_0 + \beta_1 I_{st} + \varepsilon_{ist}, \tag{1}$$

where Y_{ist} denotes an educational outcome of native student i attending school s in cohort t, and I_{st} is the share of immigrant students in the same school–cohort.

A key challenge is that exposure to immigrant peers is not randomly assigned. Both immigrants and native students sort non-randomly across schools, and this sorting may generate spurious correlations between immigrant exposure and student outcomes. We discuss below the two main sources of selection that motivate our empirical strategy.

Immigrant sorting A first source of selection arises from the non-random sorting of immigrant students across schools. In Chile, immigrant students are more likely to enroll in public schools and in schools with lower average test scores and parental education, implying that schools with higher immigrant shares differ systematically along dimensions that independently affect student achievement. Figure D.II in the Online Appendix documents these patterns by comparing observable characteristics of schools attended by immigrant and native students. To address this concern, our empirical strategy relies on specifications that compare students within narrowly defined sets of schools and cohorts, thereby controlling for time-invariant differences in school quality and student composition.

Native sorting A second and distinct identification challenge arises from endogenous responses by native families. Native students may react to changes in immigrant shares by changing schools, generating non-random mobility across institutions that can bias estimates relying solely on school fixed effects. Potentially, bias may persist even in specifications that include family fixed effects if families reallocate children across schools. School mobility among native students is non-negligible in our setting (see Online Appendix Figure D.III). While a large literature has emphasized the non-random sorting of immigrant students across schools, considerably less attention has been paid to endogenous native responses to immigration. An important exception is Figlio et al. (2024), who show that U.S.-born students—particularly those from higher socioeconomic backgrounds—systematically sort into and out of schools in response to immigrant concentration, with meaningful implications for estimated peer effects. Motivated by this evidence, our empirical strategy explicitly accounts for both immigrant sorting across schools and endogenous school mobility among native families.

4.2 Estimation Framework

To address these identification challenges, we adopt an instrumental variables strategy that exploits within-family variation in immigrant exposure across siblings. Our main estimating equation is:

$$Y_{ist} = \beta_0 + \beta_1 I_{ist} + \mu_{f(i)} + \phi_t + \varepsilon_{ist}, \tag{2}$$

where $\mu_{f(i)}$ denotes family fixed effects and ϕ_t cohort fixed effects.

Actual exposure to immigrant peers is instrumented using the immigrant share that student i would have faced had she attended the school where her eldest sibling began schooling. The corresponding first-stage equation is:

$$I_{ist} = \pi_0 + \pi_1 I_{s'(i)t} + \mu_{f(i)} + \phi_t + \upsilon_{ist}, \tag{3}$$

where $s'(i)$ denotes the school attended by the eldest sibling of student i.

This design focuses on families with three or more children, allowing us to include family fixed effects and compare siblings within the same household. The identifying variation arises from differences in the timing of school entry across siblings combined with the rapid expansion of immigration to Chile. Intuitively, younger siblings in the same family may face different immigrant shares simply because immigration increased between the time the eldest and younger children entered school.

If all siblings attended the same school, this approach would be equivalent to a school fixed-effects design, as in Hoxby (2000). In practice, however, a substantial fraction of families change schools across siblings, accounting for approximately 35% of the sample. Instrumenting actual exposure with the immigrant share the younger sibling would encounter at their older sibling's school allows us to isolate variation in exposure that is independent of endogenous school choice. Standard errors are clustered at the level of the eldest sibling's school.

4.3 Instrument Validity

The validity of our approach rests on three key assumptions, which we discuss in turn: a strong first stage, independence and the exclusion restriction, and monotonicity. Additional details are provided in Online Appendix D.

First stage. The first-stage relationship is examined in Figure D.IV. The estimated coefficient π_1 is approximately 0.3, and the Kleibergen–Paap rk Wald F-statistic exceeds 300, indicating a strong first stage.

Independence and exclusion restriction. The exclusion restriction in our setting requires that, conditional on the fixed effects included in specification (2), predicted immigrant exposure at the eldest sibling's school affects native students' outcomes only through actual immigrant exposure in their own school.

A possible concern is that the instrument could affect outcomes by altering the composition of native peers at the eldest sibling's school. To assess this possibility, we examine whether predicted immigrant exposure is related to predetermined characteristics of native students, finding no systematic relationship, as shown in Online Appendix Figure D.Va. Another concern is that the instrument may capture pre-existing differences in school quality. We address this by testing whether predicted immigrant exposure is associated with differential pre-trends in average test scores at the eldest sibling's school prior to the entry of the cohorts under study. Consistent with this concern being unlikely, we find no evidence of such trends, as illustrated in Online Appendix Figure D.Vb. Finally, the instrument could reflect broader neighborhood-level immigration patterns rather than school-level exposure. To explore this, we compare estimates for students living closer to versus farther from the eldest sibling's school, and obtain similar results across groups, suggesting no systematic differences, as shown in Online Appendix Figure D.Vc. Taken together, these findings suggest that the exclusion restriction is unlikely to be violated in our setting.

Monotonicity. Interpreting our IV estimates as a local average treatment effect requires that higher predicted immigrant exposure at the eldest sibling's school weakly increases the immigrant share a student actually experiences.

A potential concern is that families might respond to higher predicted exposure by reallocating children across schools, breaking this monotonic relationship. We assess this by examining whether the relationship between predicted and actual exposure varies across observable subsamples and find a stable first-stage relationship across groups, as shown in Online Appendix Figure D.VIa. Another concern is that families could selectively move younger siblings to different schools in response to higher predicted exposure. We examine

this possibility by testing whether predicted immigrant exposure affects the probability that siblings attend the same school and find no evidence of systematic school switching, as illustrated in Online Appendix Figure D.VIb. Finally, we assess whether higher predicted exposure induces compensatory sorting into schools with different peer composition, baseline achievement, or pre-existing trends. As shown in the three panels of Online Appendix Figure D.VII, we find no such patterns. Together, these results indicate that variation in predicted exposure translates smoothly into variation in actual exposure, supporting the monotonicity assumption required for a LATE interpretation of our IV estimates.

5 Immigrant Exposure and Native Students' Educational Outcomes

Figure 3 summarizes our main estimates of the effect of exposure to immigrant peers on native students' fourth-grade language and mathematics test scores. Each bar corresponds to a different specification, ordered from simpler models to more demanding designs that progressively address selection across schools and families. Table 2 reports the corresponding estimates and additional details.

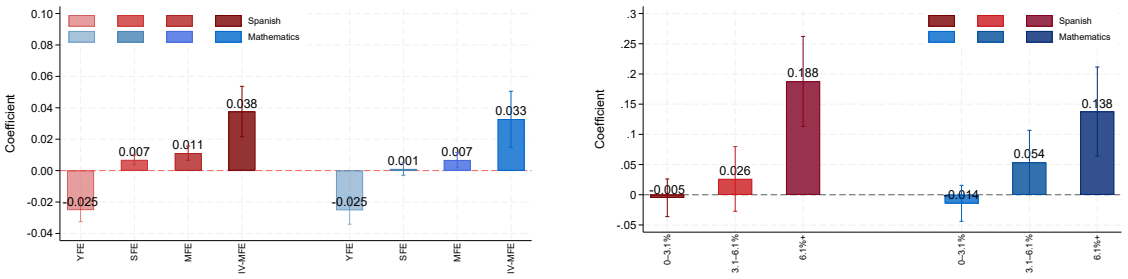
The first set of bars shows estimates from a naive specification that controls only for year fixed effects. These coefficients display a negative and statistically significant association between immigrant exposure and test scores in both subjects. At the mean of the data, an increase of 3.1 percentage points in the immigrant share—roughly equivalent to one additional immigrant student per classroom—is associated with a decline of about 0.025 standard deviations in language and mathematics scores. This pattern is consistent with negative selection into schools with higher immigrant shares.

Once we account for sorting across schools by introducing school fixed effects, the estimated effects become positive. Figure 3 shows a clear reversal relative to the naive specification, indicating that the negative association is driven by differences across schools rather than by within-school peer effects. Adding mother fixed effects further strengthens this pattern, yielding positive and statistically significant estimates in both subjects. These results highlight the importance of controlling for unobserved family-level sorting and endogenous school choice, which bias simpler specifications downward.

The largest effects emerge in the instrumental variables specification with mother fixed

effects, which addresses remaining concerns related to endogenous native mobility across schools. As shown in Figure 3, a 3.1 percentage point increase in immigrant exposure in early grades raises fourth-grade language scores by approximately 0.038 standard deviations and mathematics scores by about 0.033 standard deviations. These estimates are economically meaningful and substantially larger than the corresponding OLS estimates, suggesting that selection by native families attenuates reduced-form effects. The first-stage relationship underlying these estimates is strong, with Kleibergen–Paap F-statistics well above conventional thresholds (see Table 2).

The right panel of Figure 3 explores nonlinearities in the IV specification by allowing the effect of immigrant exposure to vary across bins. The results reveal substantial heterogeneity: effects are small and statistically indistinguishable from zero at low levels of exposure, but become large and significant—particularly for language scores—once immigrant shares exceed approximately 6 percentage points. This pattern indicates that the average positive effects observed in the linear IV model are driven primarily by schools experiencing larger immigrant inflows.



(a) Main effects

(b) Non-linear specification

Figure 3: Effects of immigrant exposure on SIMCE outcomes

Notes: Panel (a) reports estimated effects on spanish and mathematics test scores under alternative specifications. Estimates are shown for a naive model including only year fixed effects, a specification with school fixed effects, a specification with mother fixed effects, and the preferred IV specification with mother fixed effects. Panel (b) reports results from a non-linear specification, estimating the effects of immigrant exposure for schools with immigrant shares between 0–3.1%, 3.1–6.1%, and above 6.1%.

To benchmark the magnitude of our IV–MFE estimates, it is useful to compare them to effects documented in the education literature for other well-studied inputs. For instance, Chetty et al. (2014) estimate that a one standard deviation improvement in teacher value added raises reading achievement by about 0.10 standard deviations, while Rivkin et al. (2005) find that a one standard deviation increase in average teacher quality raises achieve-

ment by at least 0.11 standard deviations in mathematics and 0.095 in reading. At the classroom level, Carrell et al. (2018) show that exposure to one additional disruptive student in a class of 25 throughout elementary school lowers later math and reading test scores by roughly 0.02 standard deviations. Other policy-relevant interventions generate effects of similar order of magnitude: Angrist and Lavy (1999) report gains of 0.017–0.019 standard deviations from a one-student reduction in class size, Krueger and Whitmore (2001) find effects of around 0.05 standard deviations from comparable reductions, and Barrios-Fernández and Bovini (2021) document reading score gains of about 0.024 standard deviations from an additional year of full-school-day exposure. Using a closely related identification strategy, Figlio et al. (2024) also finds test score gains of approximately 0.02–0.03 standard deviations from higher exposure to immigrant peers. Taken together, these comparisons suggest that the gains associated with immigrant exposure in our setting are comparable in size to those generated by widely studied educational policies, underscoring their potential relevance for student achievement.

Table 2: Effects of Immigrant Exposure on Test Scores

	NAIVE	School FE	School+Mother FE	IV MFE	IV MFE Non-linear
	(1)	(2)	(3)	(4)	(5)
			Panel A: SIMCE Language		
Share of Immigrants (σ)	-0.0251***	0.0068***	0.0111***	0.0376***	
	(0.0038)	(0.0016)	(0.0023)	(0.0082)	
Immigrant share bin: $(0, 0.031]$					-0.0050
					(0.0159)
Immigrant share bin: $(0.031, 0.061]$					0.0262
					(0.0273)
Immigrant share bin: $(0.061, \infty)$					0.1877***
					(0.0380)
Reduced form				0.0107***	
				(0.0024)	
First stage				0.2839***	
				(0.0139)	
Observations	2945567	2945488	1154756	260907	260907
Outcome mean	0.0177	0.0177	0.0274	-0.0751	-0.0751
R^2	0.0020	0.1621	0.6521		
Kleibergen–Paap F				601.20	388.87
			Panel B: SIMCE Mathematics		
Share of Immigrants (σ)	-0.0253***	0.0010	0.0067***	0.0327***	
	(0.0045)	(0.0020)	(0.0025)	(0.0091)	
Immigrant share bin: $(0, 0.031]$					-0.0141
					(0.0152)
Immigrant share bin: $(0.031, 0.061]$					0.0535**
					(0.0271)
Immigrant share bin: $(0.061, \infty)$					0.1378***
					(0.0376)
Reduced form				0.0092***	
				(0.0026)	
First stage				0.2818***	
				(0.0142)	
Observations	2949415	2949340	1157158	261465	261465
Outcome mean	0.0189	0.0189	0.0497	-0.0301	-0.0301
R^2	0.0019	0.2240	0.6895		
Kleibergen–Paap F				619.23	404.62
Year FE	X	X	X	X	X
School FE		X	X		
Mother FE			X	X	X

Notes: Each cell reports coefficients; standard errors in parentheses. Column (4) reports 2SLS estimates; reports the coefficient of the instrument in the outcome regression and reports the coefficient of the instrument in the first-stage regression. In the nonlinear IV column, coefficients correspond to immigrant-share bins $(0, 0.031]$, $(0.031, 0.061]$, and $(0.061, \infty)$, with the omitted category being $\sigma = 0$.

A natural concern in instrumental variables settings is whether the IV estimates primarily reflect causal effects for a narrow or atypical subpopulation of *compliers*, rather than correcting for endogenous selection more broadly. To address this issue, we explicitly characterize the population of compliers underlying our IV estimates.

We follow the approach proposed by Hull (2025), which provides a transparent way to describe the effective population contributing to design-based estimands in settings with continuous treatments and instruments. The method consists of interacting predetermined characteristics with treatment intensity and re-estimating the IV specification, allowing us to recover weighted averages of baseline characteristics for the complier population without imposing parametric assumptions.

Figure 4 compares baseline characteristics across three groups: the complier population implied by the IV with mother fixed effects, the sibling sample, and the overall population of native students. Across a wide range of demographic, socioeconomic, and academic characteristics—including gender, age at school entry, parental education, school socioeconomic status, and home educational resources—the complier population closely resembles both the sibling sample and the full native student population.

The main systematic difference is that compliers are somewhat more likely to come from families whose eldest sibling attends a public or low-SES school, reflecting that school assignment margins are more relevant for this group. Importantly, however, compliers do not differ meaningfully in baseline academic performance or family background.

As a robustness check, we examine whether estimates obtained from a mother fixed-effects specification, but estimated on samples that more closely resemble the IV complier population, yield results comparable to the IV estimates. If the IV results were primarily driven by the composition of the complier sample rather than by correcting for endogenous selection, one would expect these fixed-effects estimates to be similar in magnitude to the IV. Figure E.I shows that this is not the case. Estimates obtained from complier-like subsamples are substantially smaller than the IV estimates. This pattern indicates that the IV results are not explained by sample composition but instead reflect the correction of selection bias that remains even after conditioning on mother fixed effects.

Taken together, this evidence indicates that our IV strategy corrects for endogenous sorting across schools rather than shifting the estimand toward a substantively different or highly selected population, supporting the interpretation of our estimates as informative

about the impact of immigrant exposure for a broadly representative population of native students in Chile.

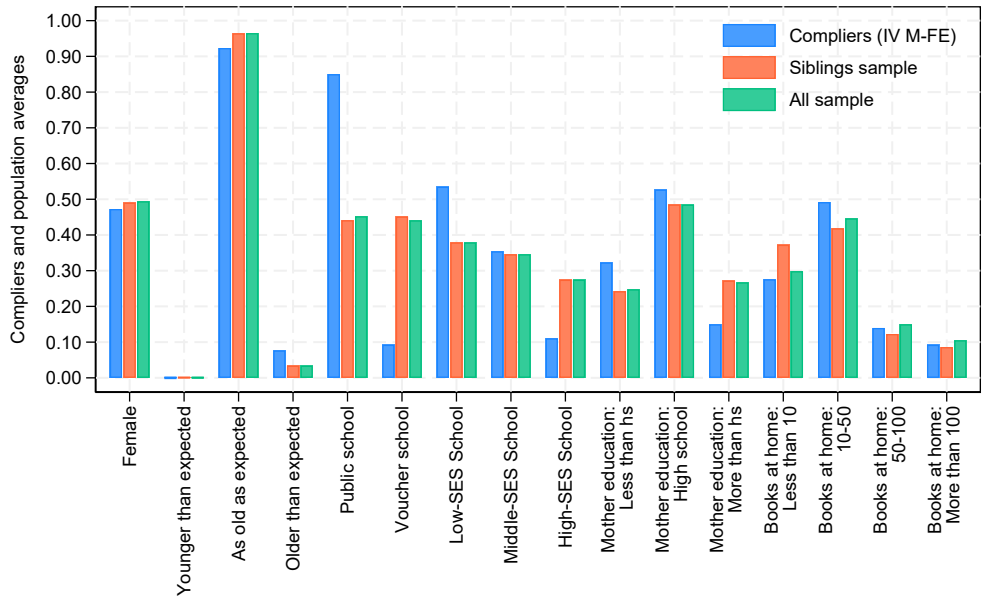


Figure 4: Compliers

Notes: Figure 4 compares baseline characteristics across three groups: the complier population implied by the IV specification with mother fixed effects, the sibling sample, and the overall population of native students. Compliers are characterized following the approach in Hull (2025).

We next explore whether the effects of immigrant exposure differ by gender and whether they persist beyond elementary school. We find little evidence of meaningful heterogeneity across boys and girls. Estimated effects are positive and statistically similar for both groups, although point estimates tend to be slightly larger for male students. These differences, however, are modest and not statistically distinguishable, suggesting that the benefits of immigrant exposure accrue broadly across genders. Figure E.II in the Online Appendix reports the full set of estimates by gender.

We also examine whether the positive effects observed in grade four translate into improvements in longer-term educational outcomes. Figure E.III, reported in the Online Appendix, summarizes the estimated effects on later test scores and educational attainment. The results indicate that exposure to immigrant peers has persistent effects throughout the schooling trajectory. A 3.1 percentage point increase in immigrant exposure raises test scores in grades eight and ten, increases the probability of on-time high school completion by approximately 2.1 percentage points, and raises immediate post-secondary enrollment by about 1.1 percentage points. These magnitudes are economically meaningful and con-

sistent with the interpretation that early exposure to immigrant peers generates lasting academic benefits rather than short-lived gains.

Overall, these findings suggest that the positive effects of immigrant exposure are not confined to a specific subgroup nor to a single educational stage. Instead, they appear broadly shared across genders and persist into later educational transitions. Full results for medium- and long-term outcomes are reported in the Online Appendix.

6 What is changing in schools?

To study potential mechanisms, we combine administrative records with survey data from students, parents, and teachers collected by the Education Quality Agency. Because the set of survey questions varies over time, these measures are not consistently available for all cohorts, which reduces the effective sample size in some mechanism-specific analyses.

To address this limitation, we implement a modified version of our IV strategy that allows us to include families with two children in the estimation. This alternative approach replaces family fixed effects with fixed effects for the older sibling's school interacted with the year in which the older sibling enters school. The resulting estimates are very similar when restricting the sample to that used in the main IV specification, and slightly smaller when the sample is expanded (see Figure F.I).[1]

6.1 School Resources

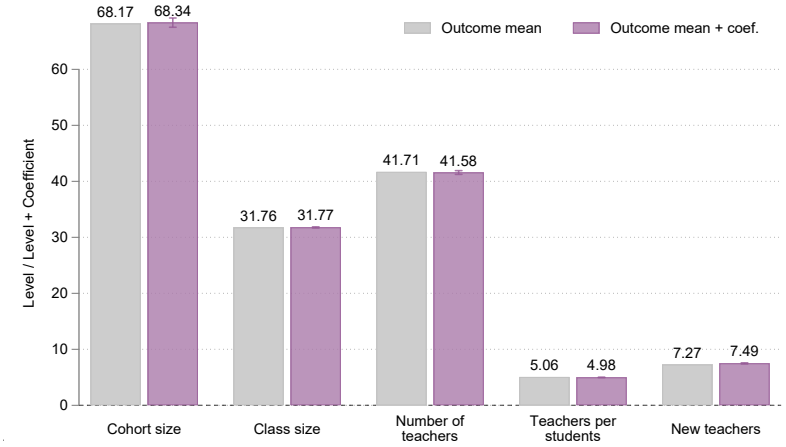
A natural first hypothesis is that schools receive additional resources following the arrival of immigrant students, indirectly benefiting native students. In Chile, the school funding formula provides additional vouchers for vulnerable students, a category that may include some immigrants. If schools experiencing larger immigrant inflows were systematically allocated more resources, such changes could account for part of the estimated effects.

Figure 5 examines whether exposure to immigrant peers is associated with changes in key school resources, using administrative records from the student enrollment registry, teacher staffing and assignment files, and teacher-level information from DEMRE, including teachers' admission test scores.

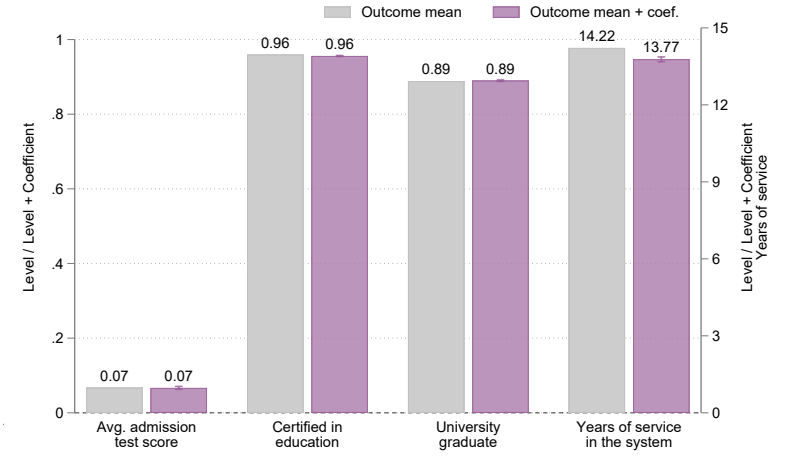
[1] Compliers in this alternative specification are similar to those identified by our main IV strategy; additional details and supporting evidence are provided in Online Appendix F.

Panel 5a shows no indication that schools expand capacity or change congestion in response to immigrant inflows. Cohort sizes remain stable, class sizes do not decrease, and teacher–student ratios show no improvement. Similarly, the number of newly hired teachers shows no meaningful adjustment. Although some estimates are statistically precise, their magnitudes are extremely small relative to baseline levels, suggesting economically negligible effects. Panel 5b further shows that immigrant exposure is not associated with changes in teacher quality. Measures such as teachers' admission test scores, certification status, university graduation, and years of experience remain virtually unchanged.

These results indicate that improvements in native students' outcomes are unlikely to be driven by systematic changes in school resources or teacher quality. Instead, the evidence points to effects operating through other channels, such as adjustments in teacher practices and changes in the school environment, rather than through increased inputs. The estimates presented here can thus be interpreted as "precise zeros" with respect to school resources and teacher quality.



(a) School inputs



(b) Teacher quality

Figure 5: School resources

Notes: Panel (a) reports results for outcomes related to school inputs, while Panel (b) reports results for measures of teacher quality. In both panels, gray bars display the mean value of each outcome, and purple bars display the mean plus the estimated coefficient obtained from the alternative IV specification.

6.2 Teacher Practices

Figure 6 examines the effects of exposure to immigrant peers on a set of teacher practices, measured using information from student, teacher and parent surveys. Across a wide range of indicators, we find consistent evidence that higher immigrant exposure is associated with changes in teachers' instructional behavior.

Specifically, an increase in the share of immigrant students is associated with greater teacher attention to low-performing students, a higher likelihood of congratulating stu-

dents who improve, and more frequent use of practices aimed at checking understanding, such as asking questions or correcting misbehavior in class. We also find positive effects on practices related to classroom cooperation and behavioral support. While individual coefficients are modest in magnitude, the pattern is remarkably consistent across outcomes.

Turning to teachers' own reports, however, we find little evidence of meaningful changes in instructional practices. Figure F.IV shows that the estimated effects on teacher-reported practices are generally small and statistically insignificant across all measures. This contrasts with the positive patterns observed in students' and, to some extent, parents' reports.

These results suggest that the changes documented in previous figures are primarily driven by how teaching practices are perceived rather than by substantial shifts in teachers' self-reported behavior. One possible interpretation is that improvements in classroom environment and student behavior make existing practices more effective or more salient to students, leading them to report higher exposure to these practices. In this sense, immigrant exposure may enhance the effectiveness of teaching without necessarily altering the frequency with which teachers report implementing these practices.

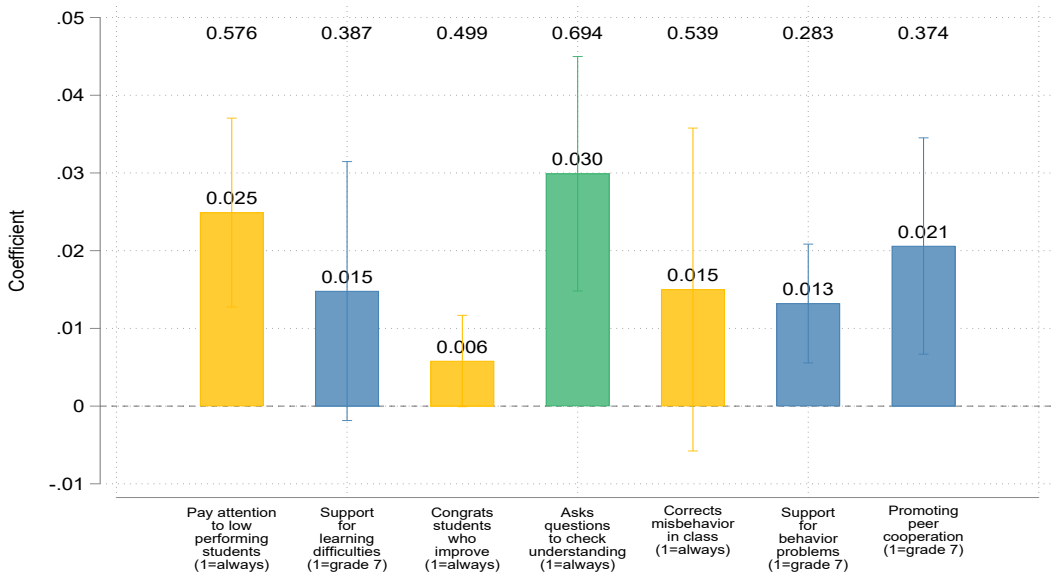


Figure 6: Teacher practices

Notes: Bars show estimated coefficients of immigrant exposure on teacher practices. Vertical lines indicate 95% confidence intervals. Colors correspond to the source of information: student questionnaires (yellow), teacher questionnaires (green), and parent questionnaires (blue). Values reported at the top of each bar correspond to the mean of the dependent variable.

6.3 School Environment

Figure 7 examines the relationship between immigrant exposure and several dimensions of the school environment, including classroom disruptions, discipline, peer relations, mutual respect, and overall school climate. These variables come from student, teacher, and parent surveys. The results point to systematic improvements in the school environment as immigrant share increases.

In particular, higher immigrant exposure is associated with fewer classroom interruptions and behavioral disruptions, better peer relations among students, and more respectful interactions within the school. We also observe positive effects on broader perceptions of school friendliness and mutual respect between students and teachers. Although some estimates are imprecisely estimated, the direction of the effects is overwhelmingly positive.

As with teacher practices, these improvements are consistently observed across all three respondent groups—students, teachers, and parents—each reporting a better school climate in contexts with higher immigrant presence. This consistency across respondents suggests that the documented improvements are not merely perceptual or source-specific, but instead reflect broader changes in the school environment.

Overall, these results suggest that exposure to immigrant peers affects more than native students' academic learning. Higher immigrant presence is associated with broader changes in the school environment, shaping classroom interactions, social relationships, and perceptions of respect and order. In this sense, immigration appears to influence the school as a community, with effects that extend beyond individual academic outcomes to the social and institutional context in which learning takes place.

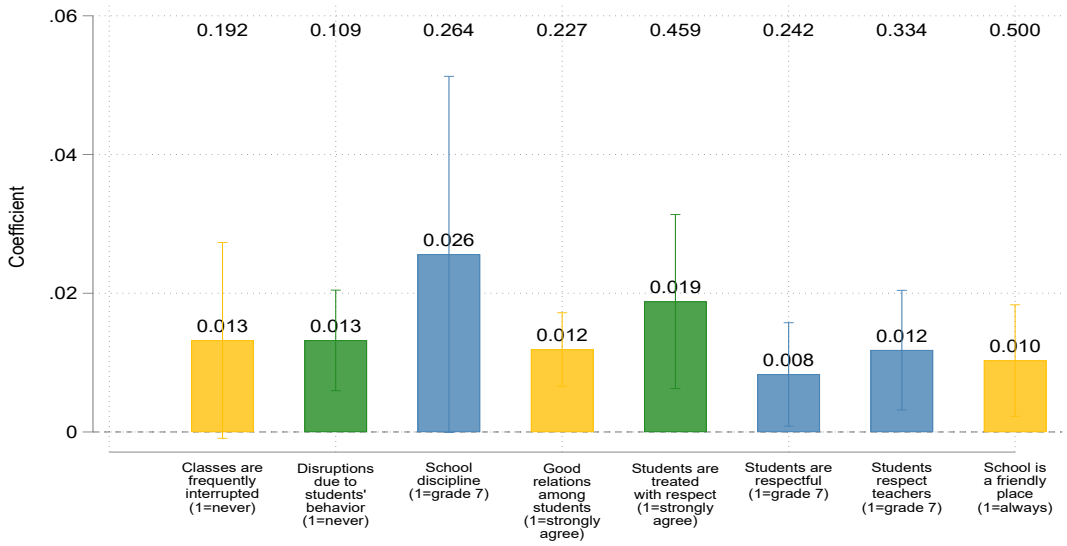


Figure 7: School environment

Notes: Bars show estimated coefficients of immigrant exposure on school environment. Vertical lines indicate 95% confidence intervals. Colors correspond to the source of information: student questionnaires (yellow), teacher questionnaires (green), and parent questionnaires (blue). Values reported at the top of each bar correspond to the mean of the dependent variable.

6.4 Peers

Immigrant students differ from native students along several academic and demographic dimensions. To characterize these differences, we begin by comparing immigrant and native students in the overall student population. In particular, we estimate the following specification:

$$y_{it} = \beta_0 + \beta_1 I_i + \mu_t + \varepsilon_{it}, \tag{4}$$

where I_i is an indicator for immigrant status and μ_t denotes year fixed effects. This specification captures average differences between immigrant and native students within the same cohort.

Figure 8 reports the estimated differences across a range of academic and demographic outcomes. The figure shows that, relative to the overall student population, immigrant students have lower test scores in mathematics and spanish and are older when they reach fourth grade. These patterns are consistent with the presence of language barriers and adjustment costs associated with entering a new educational system.

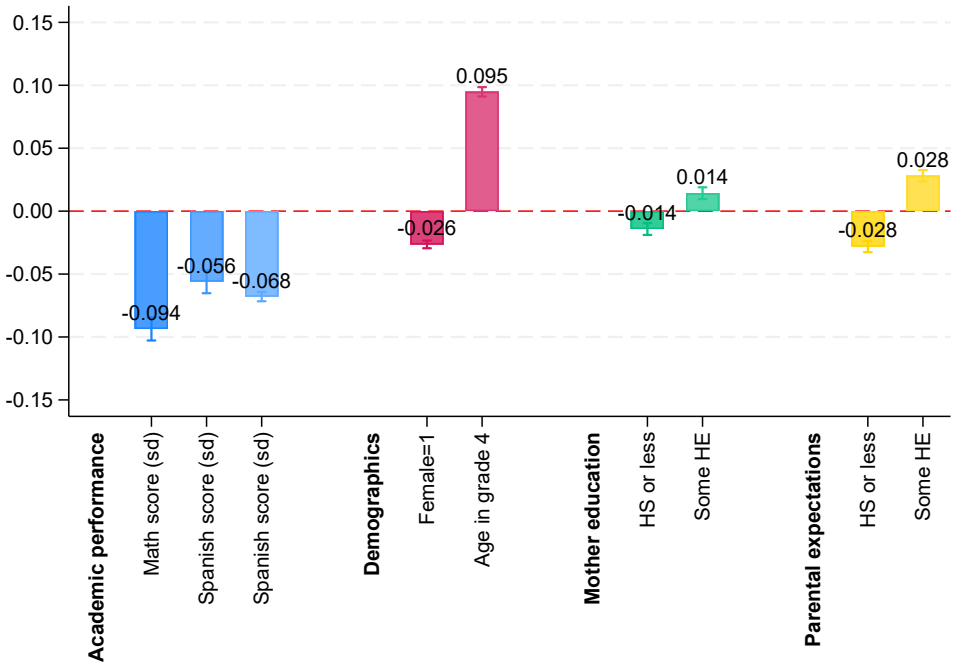


Figure 8: Immigrants' characteristics relative to the overall student population

Notes: The figure reports estimated differences between immigrant and native students across academic and demographic outcomes in the overall student population. Estimates are obtained from a regression of each outcome on an indicator for immigrant status and year fixed effects.

Aggregate comparisons, however, may conceal substantial sorting of immigrant students across schools. To isolate differences between immigrant and native students within the same educational environment, we next compare students who belong to the same school and year. We estimate:

$$y_{ist} = \beta_0 + \beta_1 I_i + \mu_s \times \mu_t + \varepsilon_{ist}, \tag{5}$$

where $\mu_s \times \mu_t$ denotes school-by-year fixed effects, absorbing all differences across schools and across cohorts within schools.

Figure 9 presents the corresponding within-school estimates. Once comparisons are restricted to students within the same school cohort, the pattern reverses. Immigrant students tend to have higher test scores than their native classmates, are nearly the same age when reaching fourth grade, and come from households with more educated parents and higher educational expectations.

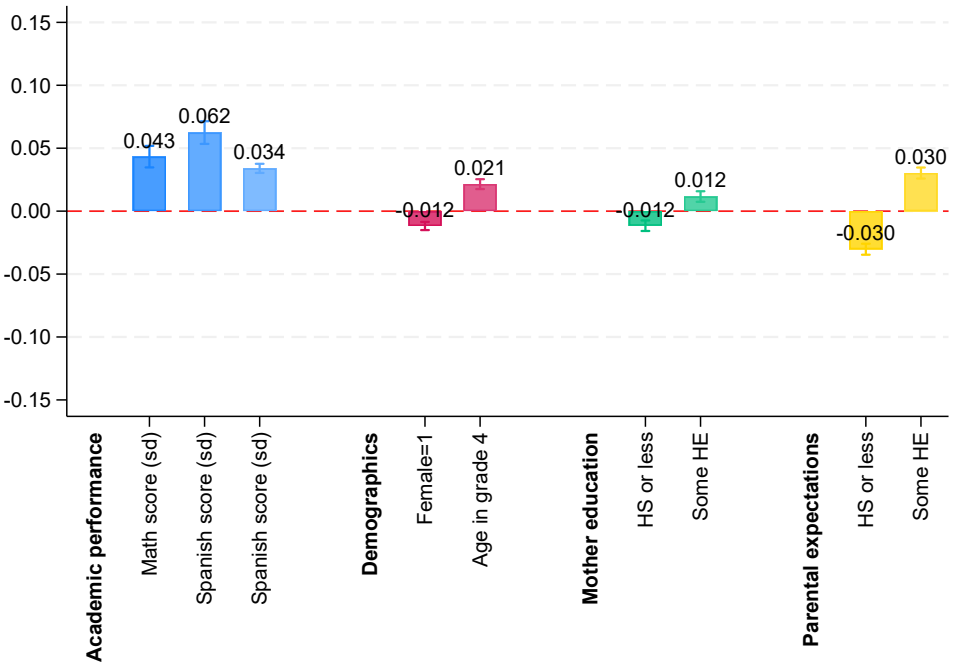


Figure 9: Immigrants' characteristics relative to their school cohort

Notes: The figure reports estimated differences between immigrant and native students within the same school cohort. Estimates are obtained from regressions that include school-by-year fixed effects, absorbing all differences across schools and across cohorts within schools.

Beyond academic and demographic characteristics, immigrant students also differ from their native peers along a wide range of non-cognitive dimensions that are closely related to motivation, effort, and attitudes toward learning. These dimensions are measured using student survey. Figure 10 reports estimates from the same within-school cohort specification described in equation 5, comparing immigrant and native students who attend the same school and belong to the same cohort.

The figure shows that immigrant students systematically exhibit more favorable characteristics across a wide range of non-cognitive outcomes, which can be broadly grouped into two related domains. The first set of dimensions is closely related to conscientiousness and motivation and can be interpreted as capturing a measure of grit. Along these dimensions, immigrant students display higher levels of effort and perseverance, being more likely to try hard across subjects and to persist when facing challenging tasks. In addition, they report more positive attitudes toward learning, being more likely to enjoy studying and reading and to consider grades important. Together, these patterns point to stronger academic engagement and sustained effort in the learning process.

A second set of dimensions is related to self-confidence and perceived learning ability and can be interpreted as capturing a measure of self-efficacy. Relative to their native classmates, immigrant students report higher self-assessed learning ability, state that they learn more easily and faster, and are more likely to believe they can successfully complete the school year. They are also more likely to report completing homework despite difficulties, consistent with stronger beliefs in their ability to overcome academic challenges. In addition, they report greater confidence in their future goals and a stronger belief that they will achieve them. These measures capture differences in students' confidence about their own academic skills and expectations, which may shape how they approach learning tasks and respond to challenges in the classroom.

These results indicate that immigrant students constitute particularly strong peers along multiple non-cognitive dimensions that are known to influence classroom dynamics and peer interactions. Their higher levels of motivation, effort, and self-confidence may affect the learning environment experienced by native students, providing a plausible peer-based channel through which exposure to immigrant classmates may shape native students' academic outcomes.

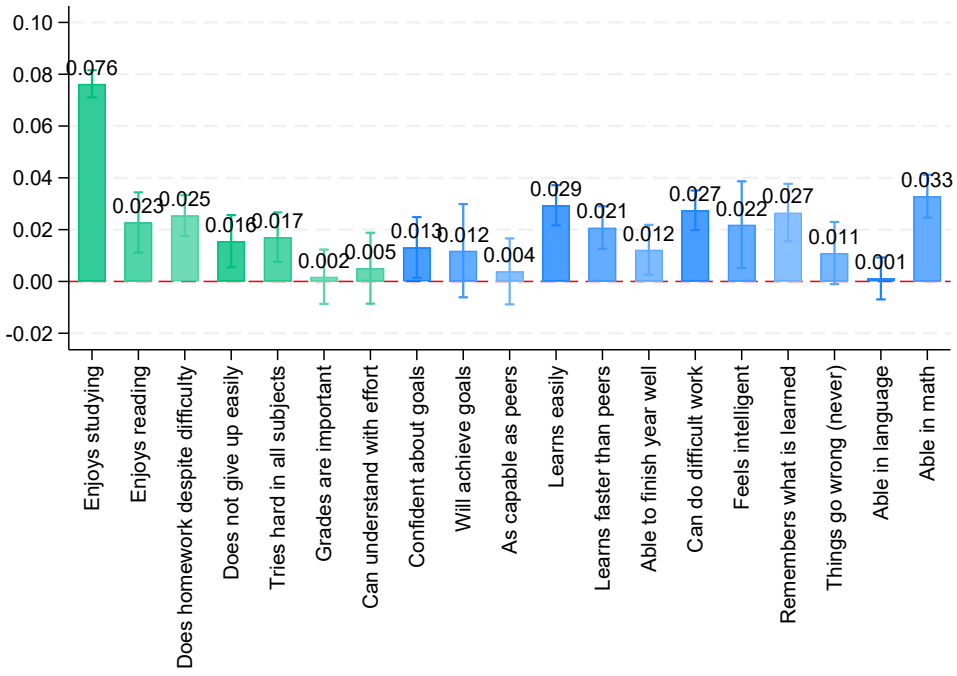


Figure 10: Immigrant students' cognitive and non-cognitive characteristics

Notes: The figure shows differences in cognitive and non-cognitive characteristics between immigrant and native students within the same cohort. Non-cognitive variables are grouped into two categories: those related to grit (shown in green) and those related to self-efficacy (shown in blue).

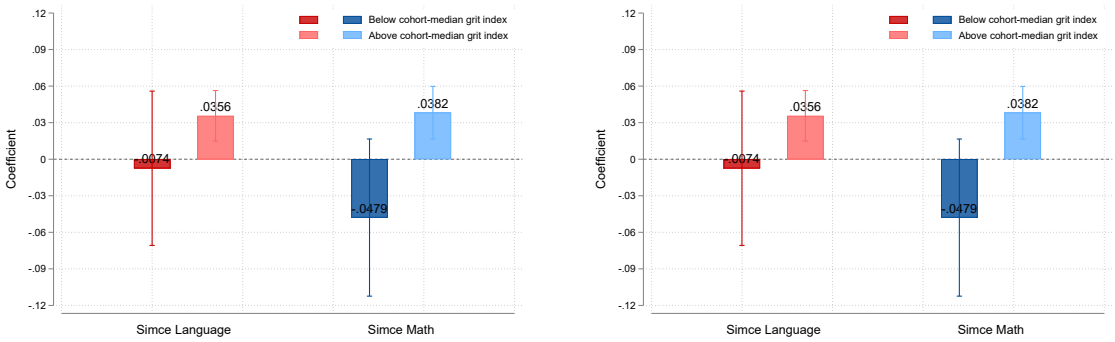
Figure 11 provides additional evidence on the role of non-cognitive traits by examining heterogeneity in peer effects according to an effort index constructed from students' non-cognitive characteristics.

Specifically, we construct an effort index as the average of the non-cognitive variables related to effort and engagement available in the SIMCE questionnaires. Since the set of available variables varies across years, the index is computed using all relevant measures observed in each cohort. We then split exposure to immigrant peers based on whether immigrant classmates are above or below the cohort-specific median of this effort index.

The results show that the gains from exposure to immigrant peers are primarily driven by cohorts in which immigrant classmates report above-median values of the effort index. In contrast, exposure to immigrants with lower-than-median of the effort index is associated with negative or statistically insignificant effects. This heterogeneity underscores that the impact of immigrant exposure depends not only on the presence of immigrant peers, but also on their non-cognitive characteristics, highlighting that the type of immigrant peer matters for generating positive peer influences.

Panel (a) reports effects on fourth-grade test scores, where the grit index is measured contemporaneously and thus reflects associations at the same point in time. Panel (b) examines effects on later academic performance, measured in eighth or tenth grade depending on data availability. In this case, the grit index reported in fourth grade can be interpreted as a baseline non-cognitive characteristic, measured prior to the later outcomes.

These findings emphasize that the peer effects associated with immigrant exposure are shaped by immigrants' non-cognitive traits, particularly effort as reflected in motivation and engagement. Rather than reflecting a uniform effect of immigrant presence, the results indicate that the academic influence of immigrant peers depends on the type of immigrant students to which natives are exposed, highlighting the role of peer composition in generating positive spillovers.



(a) Fourth-grade test scores

(b) Eighth- or tenth-grade test scores

Figure 11: Effects of immigrant exposure by grit index

Notes: Panel (a) reports results for fourth-grade test scores, while Panel (b) reports results for eighth- or tenth-grade test scores, depending on data availability.

As an additional exercise, we replicate this analysis using exposure to native peers, splitting cohorts based on whether native classmates are above or below the cohort-specific median of the same effort index (see Online Appendix Figure F.III). This provides a benchmark pure peer effect, allowing us to assess whether the patterns documented above are driven by peer characteristics more generally or are specific to immigrant peers. While the estimates for native peers are qualitatively similar in direction, their magnitude is substantially smaller. This suggests that the effects identified in the main analysis are not solely driven by exposure to high-effort peers per se, but rather reflect characteristics that are more strongly associated with immigrant peers, highlighting a distinct role for immigrant peer composition in shaping academic outcomes.

7 Conclusion

This paper studies how exposure to immigrant classmates affects native students' educational outcomes in Chile, exploiting a large and unexpected immigration shock that transformed the country's K–12 school system between 2010 and 2020. Using population-wide administrative records linked to survey data, and a design that simultaneously addresses immigrant sorting across schools and endogenous native responses, we find that immigrant exposure has positive and persistent effects on native outcomes. Fourth-grade test scores rise, and these gains extend into longer educational trajectories, increasing on-time high school completion and post-secondary enrollment. The mechanism evidence points away from resource congestion—school inputs remain broadly stable as immigrant shares rise—

and toward peer channels. Positive effects are driven by exposure to immigrants with high academic motivation and grit, alongside improvements in classroom climate and learning conditions; exposure to immigrants with lower non-cognitive endowments, by contrast, seems to worsen native outcomes. The picture that emerges is one in which the effects of immigration in schools are real, persistent, and traceable to the attributes that immigrants bring to the classroom.

Our findings speak to a tension that animates the broader public debate on immigration. In Chile, as in many receiving countries, public attitudes toward immigrants in schools turned increasingly negative over the period we study. Our results show that, along the educational dimension, this perception diverges sharply from the evidence: the actual effects of immigrant exposure on native students' learning and long-run trajectories are positive. The mechanisms we uncover explain why effects are positive in this setting—immigrants' positive selection strengthens peer quality for native students—but they underscore that aggregate narratives about immigration flows do not necessarily carry reliable information about the actual consequences of immigration.

These findings apply most directly to settings that share two features of the Chilean context: positive immigrant selection relative to local peers, and school systems with sufficient capacity to absorb immigrant inflows without straining resources. In settings where either condition fails—immigrants are negatively selected or schools are genuinely congested—effects may differ or reverse. Importantly, the immigrant selection and sorting we document are not unique to Chile. Figlio et al. (2024) attributes positive effects of immigrants on native students in Florida to similar selection-and-sorting dynamics, and studies of labor market effects document analogous neighborhood sorting in Germany, the United Kingdom, and the United States (Dustmann et al., 2024; Card, 2001; Saiz, 2007; Glitz, 2014). We view our findings as an existence result: under the conditions we document, immigration can generate sustained educational gains for native students, and the mechanisms that produce them appear to be operative in other settings as well.

The policy implications follow from the mechanism. The positive peer effects we document arise because immigrants sort into schools where they compare favorably to local peers. A policy that redistributes immigrants toward higher-quality schools—motivated by concern for immigrant students' own outcomes—could weaken this mechanism: as immigrants are matched with stronger peers, their relative advantage diminishes and so do

the peer gains for natives. This creates a genuine trade-off between improving immigrant students' access to higher-quality learning environments and preserving the peer benefits that accrue to native students under the current sorting pattern. Characterizing that trade-off, and designing assignment policies that navigate it efficiently, is an important avenue for future research.

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Immigrant Exposure and Native Students' Educational Outcomes

Online Appendix

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March 26, 2026

Latest Version

Contents

A Discrimination **1**

B Immigrants **2**

C Data and Sample Construction **4**

D Validity and Interpretation of the IV **7**

D.1 Interpretation 7
D.2 Sorting 7
D.3 First stage 9
D.4 Independence and Exclusion restriction 9
D.5 Monotonicity 10

E Additional Results **13**

F Drivers **15**

G Robustness Checks **18**

A Discrimination

Immigration has also affected school environments through changes in social interactions and perceptions. Figure A.I documents reported discrimination within school cohorts. Immigrant students are more likely to report experiences of discrimination, highlighting that peer composition may affect not only academic outcomes but also social dynamics within schools.

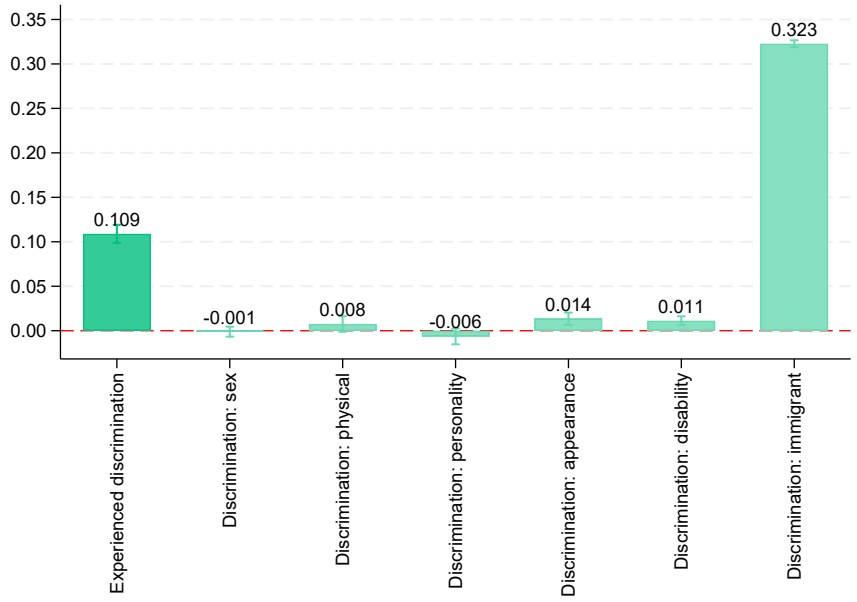
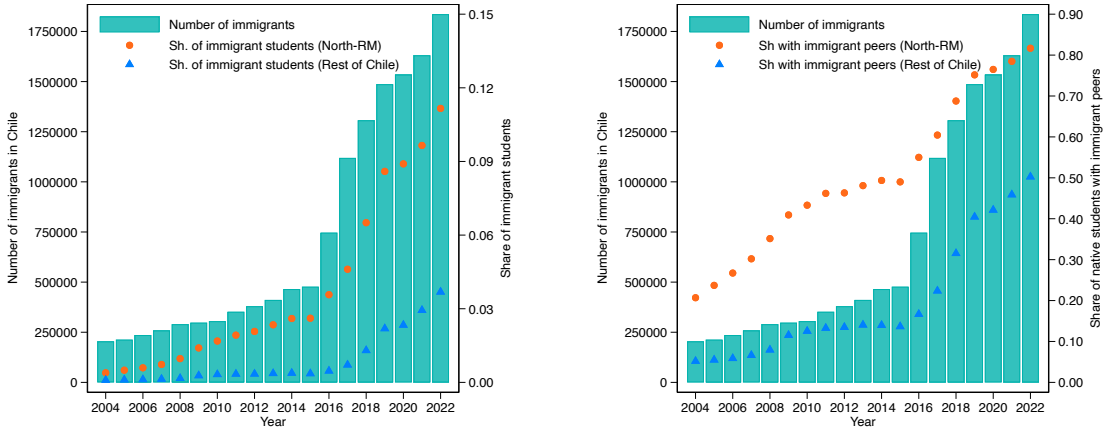


Figure A.I: Discrimination

Notes: The figure reports differences in reported discrimination between immigrant and native students. Each coefficient is obtained from a regression where the dependent variable is a dummy equal to one if the student reports the corresponding type of discrimination. The main explanatory variable is a dummy equal to one if the student is an immigrant. All regressions include school and year fixed effects.

B Immigrants



(a) Immigrant Share Evolution

(b) Native Exposure to Immigrants

Figure B.I: Immigration trends and native exposure at regional levels

Notes: Panel (a) shows the evolution of the share of immigrant students by region. Panel (b) reports average native students' exposure to immigrant peers at the regional level. Immigration status is defined based on students' country of birth. All measures are constructed using administrative enrollment records covering the universe of K–12 students.

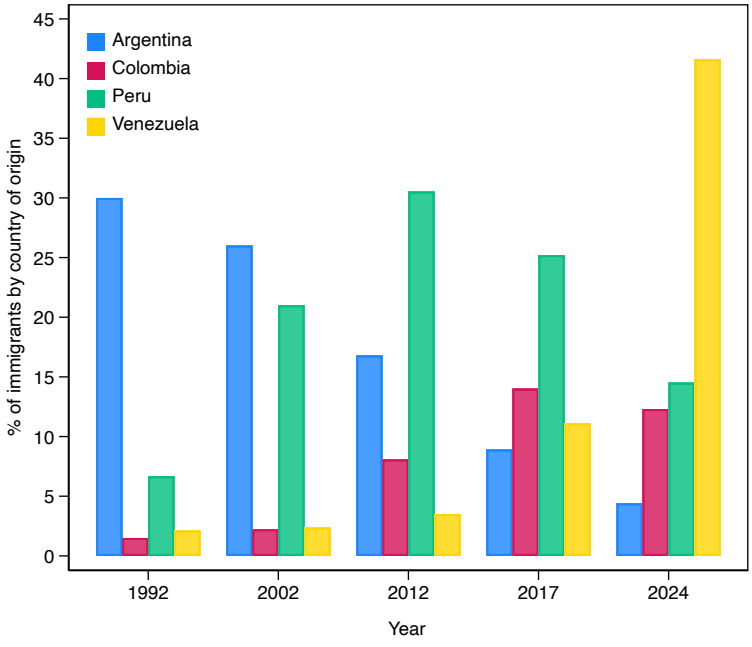
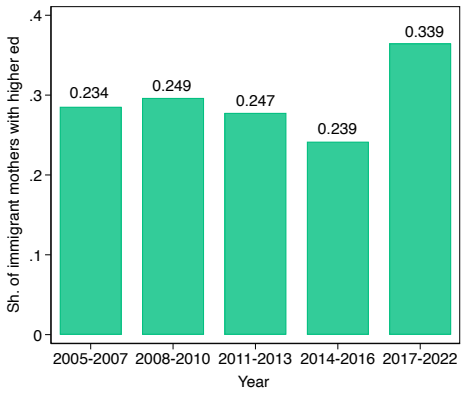
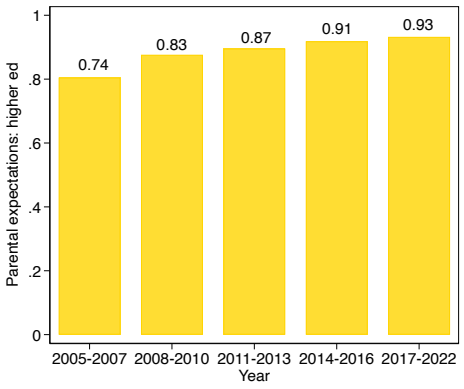


Figure B.II: Evolution of immigration to Chile by country of origin

Notes: The figure shows the evolution of the number of immigrant students by country of origin. Immigrant status and country of origin are defined using administrative enrollment records. The sample includes all immigrant students enrolled in the Chilean K–12 school system during the period of analysis.



(a) Share of immigrant students with mothers with higher education



(b) Share of immigrant students with parents expecting them to reach higher education

Figure B.III: Parental background of immigrant students

Notes: Panel (a) reports the share of immigrant students whose mothers have completed higher education. Panel (b) shows the share of immigrant students whose parents report expecting them to attain higher education. Parental education and expectations are measured using parent surveys administered by the Education Quality Agency. The sample is restricted to immigrant students with non-missing survey information.

C Data and Sample Construction

This project combines administrative records from the Ministry of Education, the Education Quality Agency, and the Department of Educational Measurement (DEMRE), which administers the national university admission exam.

From the Ministry of Education, we obtain longitudinal records covering the universe of students enrolled in Chile's K–12 school system, including public, voucher, and private schools. These registers contain detailed information on schools—such as identifiers, administrative dependence, and location—and on students—such as identifiers, gender, age, grade, class section, attendance, GPA, and grade completion status.

We link these records to data on standardized exams from the Education Quality Agency using a consistent student identifier. Standardized exams have been administered annually in grade four since 2005, and regularly in grades eight and ten since 2004. In addition, a few cohorts—2012 to 2015—were also tested in grade two.

A distinctive feature of the Chilean system is that, together with these standardized exams, rich background surveys are administered to students, their parents, and teachers. These surveys collect detailed information on household characteristics—such as parental education, expectations, and books at home—as well as on study habits, teaching practices, and the school environment. We use these data to characterize and compare immigrant and native students beyond academic performance and to explore potential mechanisms underlying our main effects.

We complement these data with DEMRE records on the national university admission exam, which allow us to study whether exposure to immigrant peers affects the likelihood of taking the exam and native students' performance on it. In addition, we merge data from the Ministry of Education on higher education enrollment to examine whether immigrant exposure influences postsecondary attendance.

The Ministry of Education also provides detailed information on teachers, including their education, university admission exam scores, demographics, and years of experience, which we link to schools. These data allow us to investigate whether larger immigrant concentrations affect both the number and the composition of teachers within schools.

In the K–12 enrollment data, we observe whether each student was born in Chile or abroad. Since nationality of origin is available only from 2016 onwards, we define immigrant status solely based on the foreign-born indicator.

When analyzing test scores, we standardize them using the mean and standard deviation of the native student population. Most analyses focus on grade four, the level with the most consistent testing. We define exposure to immigrants as the share of immigrant students in a student's school cohort in grade four. We also conduct complementary analyses for outcomes observed in grades eight and ten, defining exposure as the immigrant share in grades eight and ten, respectively.

We use family-link administrative records from Altmejd et al. (2021); Barrios-Fernández (2022); Barrios Fernández et al. (2024) to identify siblings. These data are essential for our empirical strategy, as they allow us to track siblings across cohorts and schools and to construct family fixed effects. They also form the basis of the instrumental variable

approach developed in Section 4, which exploits variation in immigrant exposure across siblings within the same family.

Our main sample consists of native students who started first grade between 2005 and 2015 and who have at least one older sibling who entered the school system after 2000—the first year for which school records are available. These students are expected to reach fourth grade between 2008 and 2018. Table 1 reports summary statistics for this sample and compares them with several relevant groups: (i) all students entering school in the same cohort, (ii) immigrant students, and (iii) native students overall. Column (iv) focuses on the subsample of native students with at least two siblings. This subsample is particularly relevant for our instrumental variable strategy, which requires information on older siblings' school histories and the inclusion of family fixed effects.

Native students in our main analysis sample—those with siblings, shown in column (4) of Table 1—are broadly comparable to the overall native student population, but they exhibit slightly less favorable socioeconomic and academic characteristics on average. Relative to native students as a whole, students in the sibling sample are more likely to attend public schools (47.2% versus 40.7%), are more concentrated in low-SES schools, and come from households with marginally lower maternal education. They also display somewhat lower academic performance, with lower standardized test scores and a higher probability of grade repetition.

These differences suggest that the sibling-based sample used for the instrumental variable analysis is, if anything, slightly negatively selected relative to the full native population. This pattern is consistent with the sorting mechanisms discussed in Section 2.1, whereby more socioeconomically disadvantaged families are more likely to remain in, or be exposed to, schools with higher immigrant concentration. Importantly, this comparison underscores that our IV estimates are not driven by a positively selected subsample of native students.

Immigrant students, reported in column (2), differ systematically from native students in several dimensions. Relative to native students overall (column 3), immigrants are substantially more likely to attend public schools, exhibit lower average academic performance, and face greater schooling challenges. They have lower grade four GPA, markedly lower attendance rates, lower standardized test scores, and a higher probability of grade repetition. Immigrant students are also slightly older when entering school.

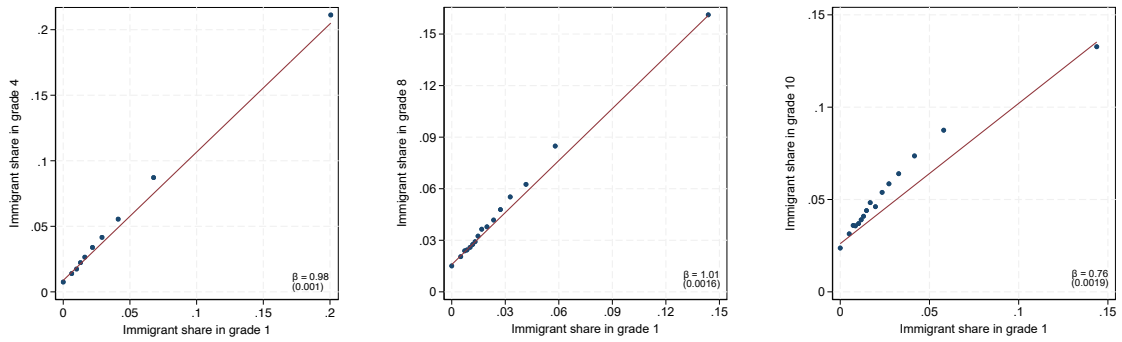
However, these differences are less pronounced when immigrants are compared to native students in the sibling sample (column 4). In terms of school type, socioeconomic background, and academic outcomes, immigrants more closely resemble natives with at least two older siblings than the native population as a whole. This reflects the fact that the sibling-based sample is somewhat negatively selected relative to all natives, with higher public school attendance, lower school SES, and weaker average academic performance. Overall, these patterns highlight the importance of accounting for non-random sorting across schools and families when assessing the effects of immigrant exposure.

When examining mid- and long-term outcomes—such as later test scores, high school graduation, university admission exam performance, and higher education enrollment—it

is important to note that immigrant shares are highly persistent across grades. A regression of immigrant shares in grades 4, 8, or 10 on those in grade 1 yields coefficients of 0.98, 1.01, and 0.76, respectively (see Online Appendix D.I for further details). The lower correlation between grades 1 and 10 reflects the fact that most students in Chile attend the same school through grade 8 but typically switch schools for high school. As a result, estimated effects on later outcomes should be interpreted as reflecting continued exposure to immigrant peers rather than exposure limited to a single grade. Similarly, immigrant exposure in grades eight or ten is likely to capture cumulative exposure during earlier schooling years.

D Validity and Interpretation of the IV

D.1 Interpretation



(a) 1st vs 4th grade (b) 1st vs 8th grade (c) 1st vs 10th grade

Figure D.I: Immigrant shares correlation

Notes: Each panel plots the correlation between immigrant shares measured in 1st grade and later grades within the same school. Panels (a), (b), and (c) compare immigrant shares in 1st grade with those in 4th, 8th, and 10th grade, respectively. Immigrant shares are computed using administrative enrollment records covering the universe of K–12 students. The strong correlations across grades indicate substantial persistence in immigrant exposure over time.

D.2 Sorting

This section provides descriptive evidence on sorting patterns that motivate our empirical strategy. We first document non-random sorting of immigrant students across schools by comparing observable characteristics of schools attended by immigrant and native students. Consistent with the discussion in the main text, immigrant students are more likely to enroll in public schools and in schools with lower parental education. Immigrant students also have lower test scores on average. Figure D.II illustrates these systematic differences in school characteristics by students' immigration status.

We then examine sorting responses among native students. Figure D.III shows that both the observable characteristics of native students and the characteristics of the schools they attend vary systematically with immigrant share. These patterns indicate that native students are not randomly distributed across schools as immigrant concentration changes, providing descriptive evidence of endogenous native sorting. Together, these figures underscore the importance of accounting for both immigrant sorting across schools and native sorting responses when estimating the effects of immigrant peer exposure.

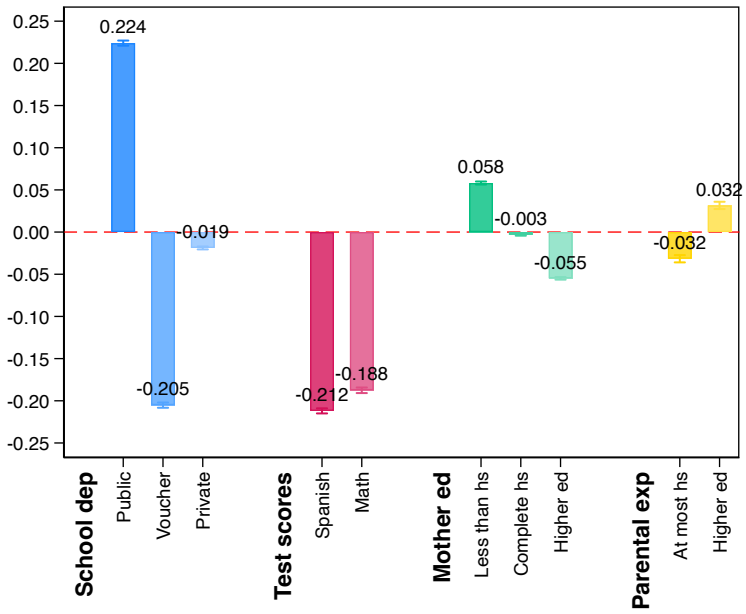


Figure D.II: Immigrant sorting

Notes: Each bar reports the coefficient from a regression where the dependent variable is the characteristic shown on the horizontal axis and the explanatory variable is a dummy equal to one if the student is an immigrant.

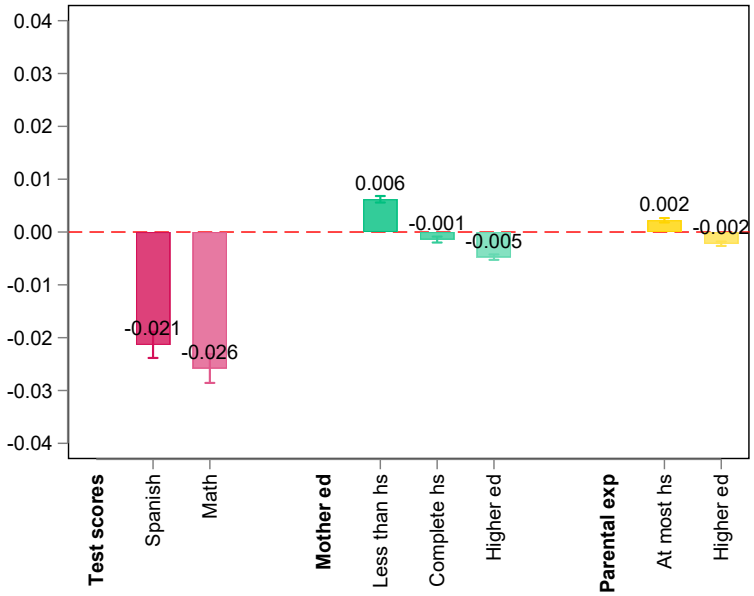


Figure D.III: Native sorting

Notes: Each bar reports the coefficient from a regression where the dependent variable is the characteristic shown on the horizontal axis and the explanatory variable is the share of immigrant students in the cohort. The sample is restricted to native students.

D.3 First stage

Figure D.IV illustrates the first stage by plotting predicted versus actual immigrant exposure after partialling out fixed effects. The estimated coefficient π_1 is approximately 0.3, and the Kleibergen–Paap rk Wald F-statistic exceeds 300, indicating a strong first stage.

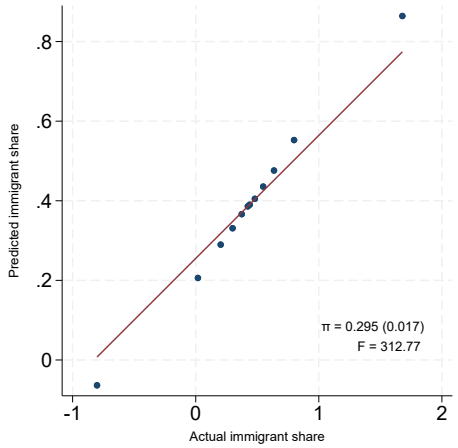


Figure D.IV: Predicted versus actual exposure to immigrants

Notes: The figure plots binned averages of actual immigrant exposure against predicted exposure from the instrumental variable after partialling out school and year fixed effects. Each point represents the average within a bin of the predicted exposure variable. The solid line shows the fitted linear relationship.

D.4 Independence and Exclusion restriction

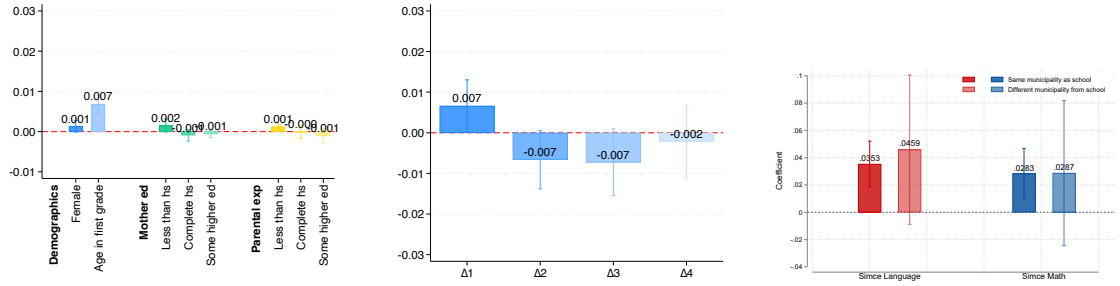
In our setting, the exclusion restriction requires that—conditional on the fixed effects included in specification (2)—the share of immigrants that native students *would have faced* in their eldest sibling's school affects their outcomes only through the share of immigrants they actually face.

We assess the plausibility of the exclusion restriction through three complementary exercises, summarized in Figure D.V. Panel (a) examines whether the instrument predicts changes in the composition of native peers at the eldest sibling's school. Specifically, we estimate reduced-form regressions in which predetermined characteristics of native students—such as parental education and socioeconomic composition—are regressed on the instrument. The estimates show no systematic relationship, indicating that variation in predicted immigrant exposure is not associated with shifts in native peer characteristics at the school attended by the eldest sibling.

Panel (b) evaluates whether the instrument is correlated with pre-existing trends in school quality. We test this by regressing changes in average test scores at the eldest sibling's school in the years prior to the entry of the cohorts under study on the instrument. The absence of differential pre-trends in test scores suggests that schools with higher predicted immigrant exposure were not on systematically different achievement trajectories before younger siblings entered school.

Finally, Panel (c) explores whether the estimated effects reflect broader neighborhood-level immigration patterns rather than school-level exposure. We compare estimates for

students whose families lived in the same municipality as the school with those living in a different municipality at the time the eldest sibling began schooling. Despite differences in residential proximity, estimated effects are similar across the two groups, suggesting that our results are driven by exposure within schools rather than by correlated changes in neighborhood composition.



(a) Native peer characteristics (b) Test score trends (c) Distance to school

Figure D.V: Assessing the exclusion restriction

Notes: The figure reports reduced-form estimates using the instrument for immigrant exposure based on the share of immigrants that students would have faced in their eldest sibling's school. Panel (a) examines whether the instrument predicts predetermined characteristics of native peers at the eldest sibling's school. Panel (b) tests whether the instrument is associated with pre-existing trends in school test scores prior to the entry of the cohorts under study. Panel (c) compares estimated effects for students living in the same municipality as the school and those living in a different municipality when the eldest sibling began schooling.

D.5 Monotonicity

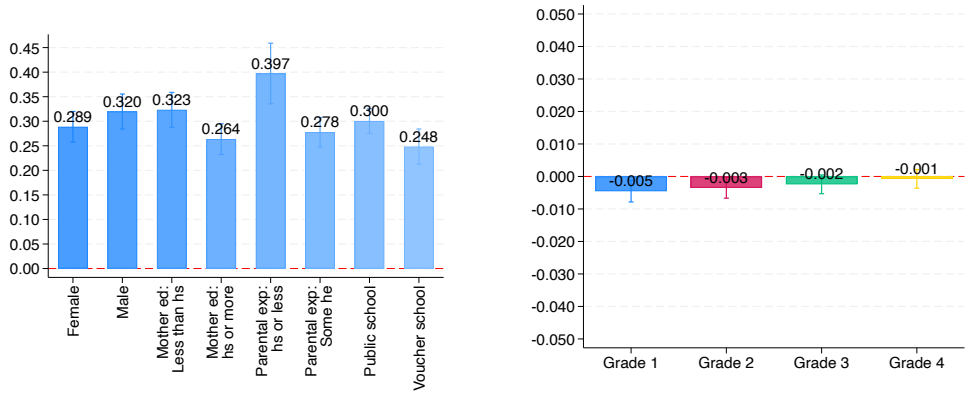
To interpret the IV estimates as the local average treatment effect (LATE), our instrument must satisfy the monotonicity assumption: an increase in the immigrant share that a student would have encountered in her eldest sibling's school should weakly increase the immigrant share she actually experiences, and a decrease should weakly reduce it.

We provide evidence in support of this assumption through a series of complementary exercises. We begin by assessing whether the relationship between actual and predicted immigrant exposure is stable across different subsamples of the data. Panel (a) of Figure D.VI, shows that the first-stage coefficient remains remarkably stable across a wide range of subsamples defined by observable characteristics, including mother education and school dependence. The absence of substantial heterogeneity in the first stage suggests that increases in predicted exposure translate into increases in actual exposure in a consistent manner across groups, which is a necessary condition for monotonicity.

Panel (b) of Figure D.VI examines whether families respond to higher potential immigrant exposure by systematically changing schools. Specifically, we estimate reduced-form regressions in which the outcome is an indicator for whether the younger sibling attends the same school as the eldest sibling. The figure plots this probability against the immigrant share that would have been encountered at the eldest sibling's school. The relationship is essentially flat, indicating that the likelihood of remaining in the same school does not vary meaningfully with predicted immigrant exposure. This finding rules out selective school switching as a primary channel through which monotonicity could be violated.

We further investigate whether monotonicity could be violated through compensatory school choices, whereby families facing higher immigrant exposure might move younger siblings to systematically higher- or lower-quality schools. Figure D.VII, addresses this concern by examining characteristics of the school actually attended by the younger sibling. Panel (a) shows that the instrument does not predict changes in native peer characteristics at the fourth-grade school, indicating that exposure to immigrants is not associated with shifts in the composition of native classmates. Panel (b) shows no relationship between the instrument and baseline test scores at the fourth-grade school, suggesting that families are not sorting into schools with systematically different prior achievement levels. Finally, Panel (c) shows that the instrument does not predict differential test score trends at the fourth-grade school prior to exposure, ruling out selective movement toward schools on distinct achievement trajectories.

Taken together, these results suggest that higher predicted immigrant exposure does not induce systematic school switching toward better or worse environments. Instead, variation in the instrument translates smoothly into variation in actual exposure, supporting the monotonicity assumption required for a LATE interpretation of our IV estimates.

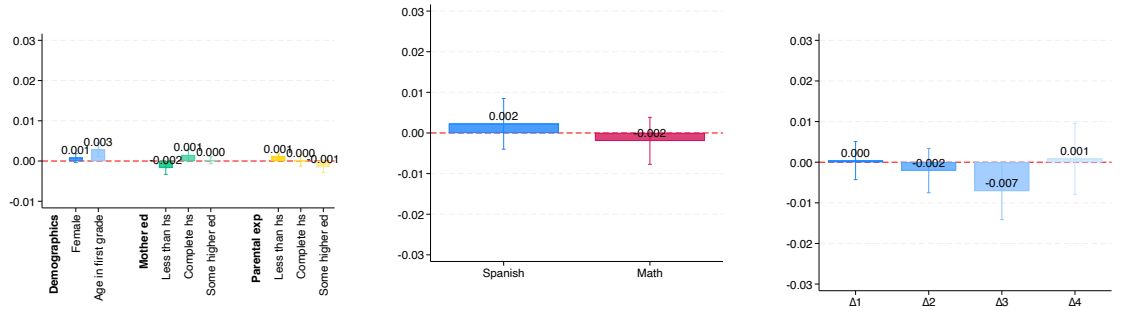


(a) First-stage across subsamples

(b) Probability of attending eldest sibling's school

Figure D.VI: Evidence on monotonicity

Notes: Panel (a) reports first-stage coefficients across subsamples defined by observable characteristics. Panel (b) reports reduced-form estimates of the probability that the younger sibling attends the same school as the eldest sibling against predicted immigrant exposure.



(a) Native peer characteristics

(b) Baseline academic performance

(c) Pre-existing test score trends

Figure D.VII: School quality and monotonicity

Notes: The figure reports reduced-form estimates. Panel (a) examines native peer characteristics at the school attended by the younger sibling. Panel (b) shows baseline test scores at that school. Panel (c) tests for pre-existing trends in school test scores prior to exposure.

E Additional Results

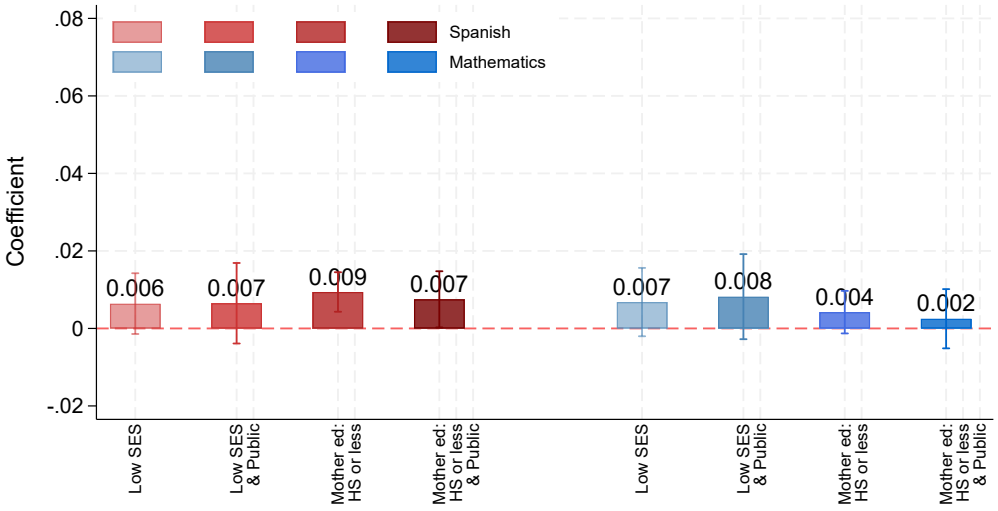


Figure E.I: Sample compliers

Notes: This figure reports estimates from a fixed-effects specification that includes year, school, and mother fixed effects. The model is estimated on subsamples designed to approximate the characteristics of IV compliers: (i) students attending low-SES schools only; (ii) students attending low-SES and public schools; (iii) students whose mothers have a high school degree or less; and (iv) students whose mothers have a high school degree or less and who attend public schools.

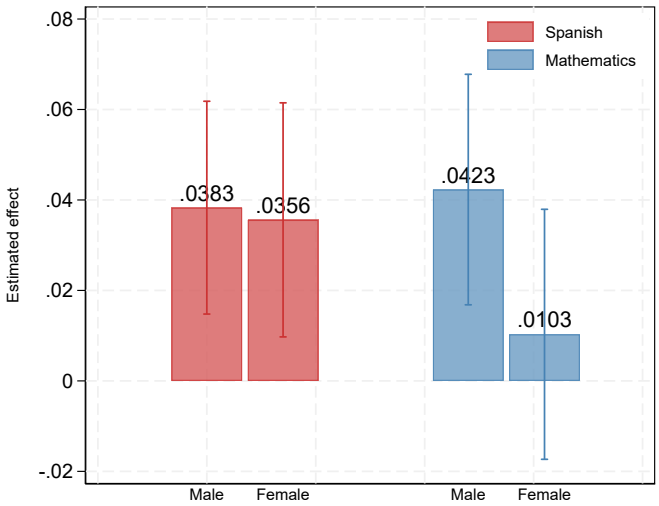


Figure E.II: Heterogeneity by gender

Notes: The figure reports IV–MFE estimates of the effect of immigrant peer exposure on native students' outcomes separately for female and male students. Point estimates are positive and of similar magnitude across genders, with differences not statistically distinguishable from each other.

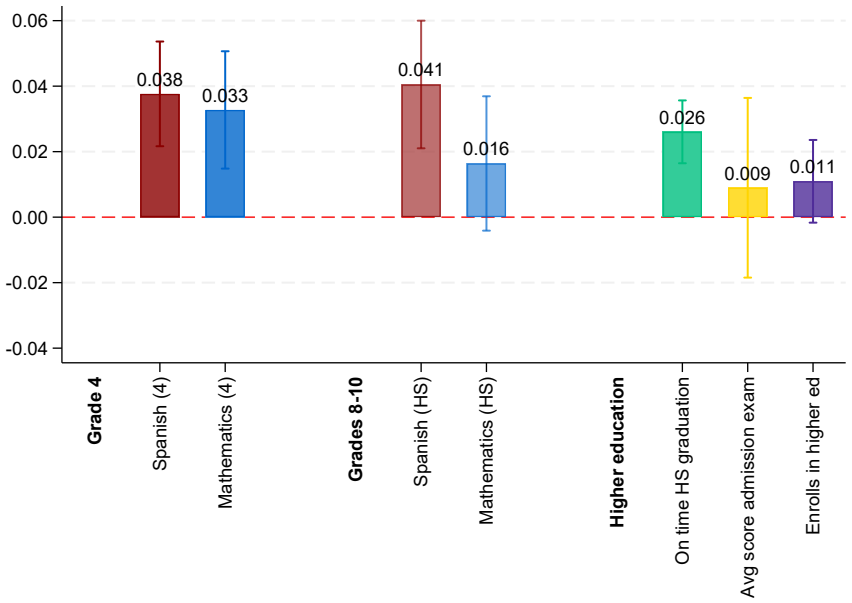


Figure E.III: Long-term educational outcomes

Notes: The figure summarizes IV–MFE estimates of the effect of immigrant peer exposure on later educational outcomes, including test scores in grades eight and ten, on-time high school completion, and immediate post-secondary enrollment. All specifications follow the baseline empirical strategy used for fourth-grade outcomes. Estimates indicate that the positive effects of immigrant exposure persist beyond elementary school.

F Drivers

Alternative IV Specification

The estimating equation for this alternative specification is:

$$y_{it} = \beta_0 + \beta_1 I_{st} + \mu_{s'\tau} + \phi_t + \upsilon_{ist},$$

where $\mu_{s'\tau}$ denotes fixed effects for the older sibling's school interacted with the year of school entry.

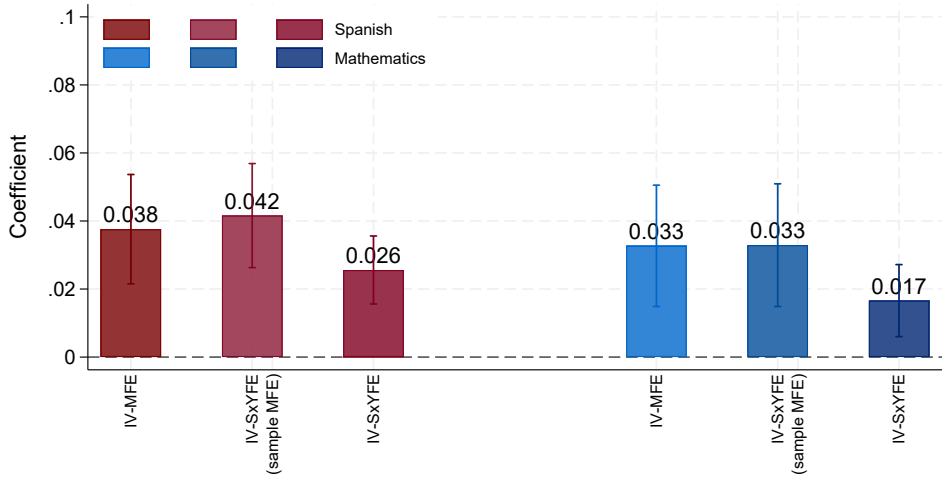


Figure F.I: Alternative IV

Notes: The figure reports IV estimates and corresponding confidence intervals for different specifications. The first bar (IV-MFE) shows the baseline IV estimate. The second bar (IV-SxYFE, sample IV-MFE) reports estimates from the alternative specification including older sibling's school-by-entry year fixed effects, estimated on the baseline IV sample. The third bar (IV-SxYFE) reports estimates from the same specification using the full sample.

Figure F.II compares the characteristics of compliers identified by the alternative IV specification with those from the sibling sample and the full sample. Compliers under the alternative IV are highly similar to those identified by the main IV strategy. In particular, differences in the shares of public schools and low–socioeconomic-status students relative to the full sample are present in both IV specifications and are not specific to the alternative design.

Across other observable dimensions, the three groups display very similar profiles, with no systematic differences that would indicate a substantively different complier population. This close alignment suggests that the alternative IV approach identifies a population comparable to that of the main IV, supporting its use for the analysis of mechanisms while allowing for a larger sample.

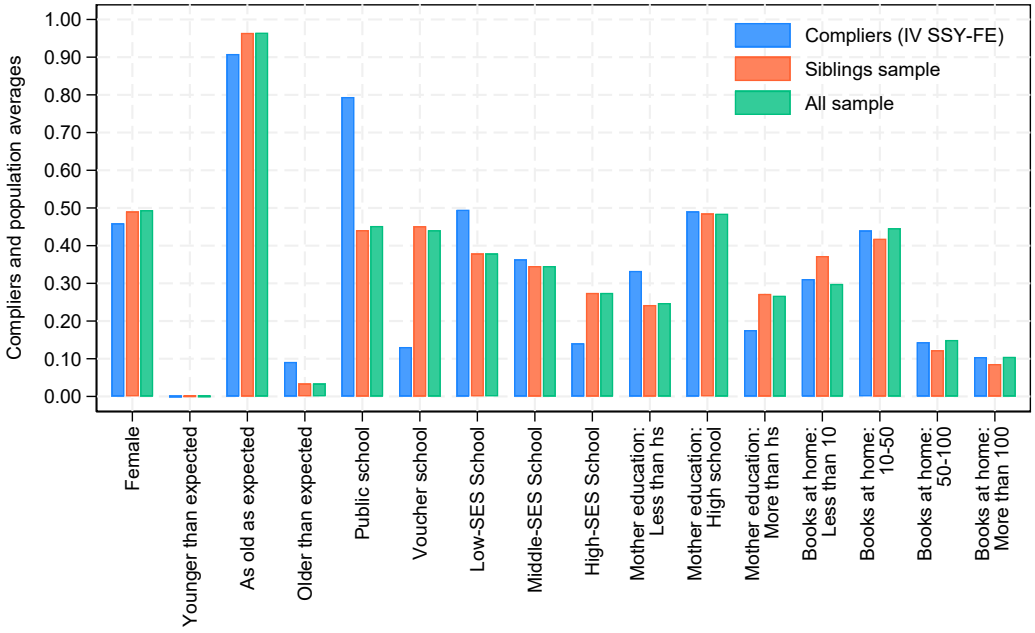
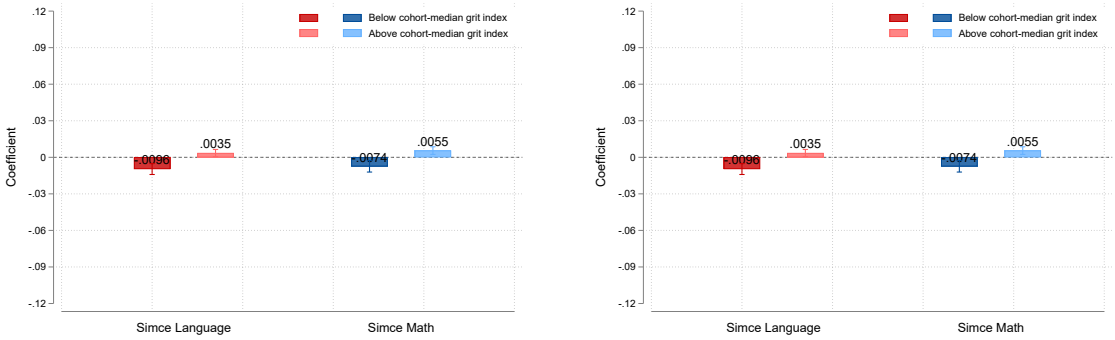


Figure F.II: Compliers IV-SSY FE

Notes: The figure compares baseline characteristics across three groups: the complier population implied by the alternative IV specification with older sibling's school-by-entry year fixed effects, the sibling sample, and the overall population of native students. Compliers are characterized following Hull (2025).



(a) Fourth-grade test scores

(b) Eighth- or tenth-grade test scores

Figure F.III: Effects of exposure to native peers by grit index

Notes: Panel (a) reports results for fourth-grade test scores, while Panel (b) reports results for eighth- or tenth-grade test scores, depending on data availability.

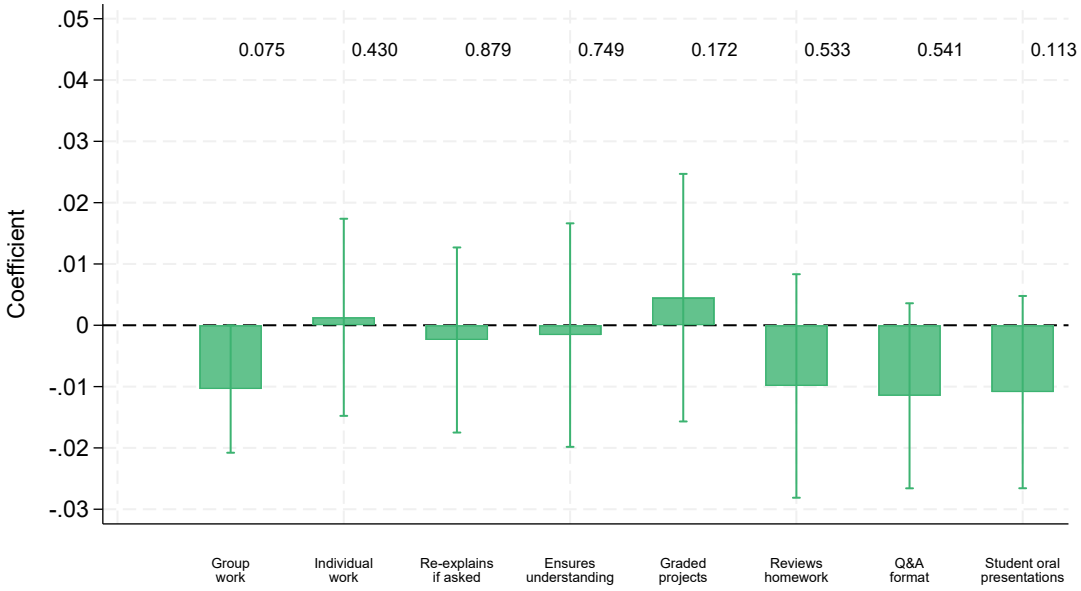
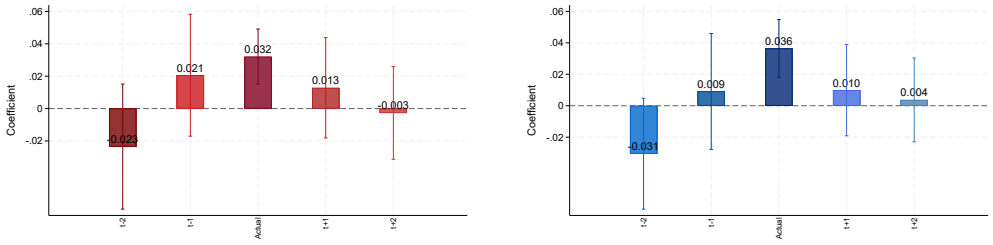


Figure F.IV: Teacher practices - teacher survey

Notes: Bars show estimated coefficients of immigrant exposure on teacher practices. Vertical lines indicate 95% confidence intervals. All outcomes are constructed from the teacher survey. Values reported at the top of each bar correspond to the mean of the dependent variable.

G Robustness Checks

As an additional validation of our identification strategy, we estimate placebo specifications using immigrant exposure in adjacent cohorts. If our results were driven by spurious correlations or persistent differences across schools, similar effects should appear when using immigrant shares from nearby cohorts. Figure G.I shows that this is not the case: coefficients for $t-2$ and $t-1$ are small and statistically indistinguishable from zero in both subjects, while the contemporaneous effect remains positive and significant. This pattern suggests that the main estimates are not driven by pre-existing trends or cross-cohort differences, but instead reflect within-cohort peer effects.



(a) Spanish Test Scores

(b) Mathematics Test Scores

Figure G.I: Placebo Estimates Using Two Adjacent Cohorts Before and After

Notes: This figure presents placebo estimates using immigrant exposure in nearby cohorts. The variables $t-2$ and $t-1$ correspond to the immigrant share in fourth grade two years before and one year before the student's own cohort, respectively. The variables $t+1$ and $t+2$ correspond to the immigrant share in fourth grade one year after and two years after the student's own cohort, respectively. The central bar corresponds to the immigrant share in the student's own fourth-grade cohort.