Breaking Barriers or Reinforcing Gaps? Scientific Education and Gendered Academic Choices*

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Abstract

This paper studies the impact of an increase in the scientific content of high school curriculum on students' educational choices by examining the Italian *PNI* program, which introduced additional instruction in mathematics and physics in selected high schools. I find modest average effects on university STEM enrollment and no impact on dropout or first-year performance. While boys respond positively to the program, the effect on girls is negligible on average. However, using a proxy for local gender norms based on support for the 1981 abortion referendum, I show that there is an additional layer of heterogeneity. For girls from areas with more traditional gender attitudes, attending a school offering the *PNI* program significantly increases the probability of choosing a STEM major. These findings highlight the potential for curricular interventions to counteract restrictive gender norms and reduce disparities in STEM participation.

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1 Introduction

The rising importance of sectors of the economy relying on science, technology, engineering, and mathematics (STEM) brought many advanced countries to implement policies to increase the pool of workers with adequate skills in those fields. It is generally recognized that a shortage of STEM skills exists, particularly in advanced economies (Directorate General for Employment, 2023; Nicholson, 2020; Salesforce, 2020), and the reasons are not fully understood.[1] But increasing the number of STEM graduates goes beyond merely meeting rising workforce demands; it also drives long-term economic growth and fosters innovation (Iaria et al., 2018; Waldinger, 2016; Moser et al., 2014). By boosting the pool of STEM talent, nations not only fill current skill gaps but also create a foundation for sustained advancement in technology and productivity.

I study whether additional exposure to and training in scientific disciplines during secondary school (specifically, mathematics and physics) affects the probability of applying for a STEM degree. High schools are the stepping stones for a student's higher education choices (Deming et al., 2014; Altonji et al., 2012). In the Italian context, that is the first time students can choose a school curriculum based on the subjects they want to focus on. Moreover, there is a high degree of unexplained and unobservable heterogeneity in how secondary school can develop useful skills to pursue a career in STEM (Ellison and Swanson, 2016).

I exploit a program available to Italian high school students enrolled in *Liceo Scientifico*, the academic track focused on scientific disciplines. The program was known as *Piano Nazionale Informatico*, which translates to National Plan for Informatics (henceforth *PNI*). It involved extra weekly hours of mathematics and physics. At the end of the full course of study, *PNI* students would have attended roughly 40% more hours of mathematics and 75% more hours of physics. The syllabus of both subjects would also be more advanced. In the time window I focus on, 50% of *Liceo Scientifico* in the country offered the *PNI* program.

I use data from the *Anagrafe Nazionale Studenti Universitari*, covering students who completed high school and enrolled in university between the academic years 2010/2011 and 2014/2015. The data allow me to identify the information provided by the student at the time of university enrollment and track their career throughout higher education. I can determine where they went to high school, what they studied, their score in the final high school exam, and their municipality of residence. I observe which university they attended, their degree course, and their achievements until graduation/dropout. Thanks to additional data provided by the Ministry of Education, I can distinguish scientific high schools offering the *PNI* program from the others.

Estimating the causal effect of attending a school offering the *PNI* program presents two main challenges. First, schools that implement the *PNI* track may differ systematically from those that do not, potentially biasing comparisons. Second, students are not randomly assigned to schools, raising concerns about self-selection. The first issue is mitigated by institutional features of the Italian

[1] Evidence of STEM graduate shortages is well-documents across advanced economies. The demand for computer and information science professionals is especially high. The U.S. Bureau of Labor Statistics predicts STEM occupations will grow faster than overall employment, especially in computer-related fields, where growth is anticipated to outpace the average by over threefold (Nicholson, 2020). In Europe, by 2020, there were an estimated 756,000 unfilled roles in the ICT sector alone, underlining the magnitude of the demand for these specialized skills (Salesforce, 2020). The Employment and Social Developments in Europe (ESDE) 2023 report by the European Commission (Directorate General for Employment, 2023) highlights persistent STEM worker shortages in the EU, emphasizes that this gap is expected to grow with demographic shifts and as the green and digital transitions advance. It focuses on how the education and training systems struggle to meet the demand for more specialized skills. It points to the lack of STEM graduates as the primary cause of these shortages.

education system that make program adoption unlikely to reflect school quality or a deliberate attempt to attract a particular student profile. The second is addressed through an instrumental variable approach that leverages geographic variation in program availability within commuting distance from students' place of residence.

If schools offering the *PNI* program systematically differ from traditional-only schools — particularly in unobservable ways such as teacher motivation or ability — estimates may conflate the program's effects with broader school-level differences. I discuss how this potential issue is mitigated by the fact that teacher assignment in Italy follows a centralized process based on national rankings, in which placement is determined by seniority and performance on a standardized national exam (Testo Unico Istruzione, 1994). Appointments are made strictly in order of these rankings, minimizing scope for strategic hiring. As a result, the composition of teaching staff is largely shaped by institutional rules rather than school-specific preferences or quality. This quasi-random allocation is especially relevant given that the decision to adopt the *PNI* program was taken internally by the school principal and teaching staff. Since schools do not choose their teachers, it is unlikely that the decision to implement the program reflects unobserved academic advantages.

Descriptive evidence supports the idea that offering the *PNI* program reflects structural conditions rather than unobserved school quality. Because schools could choose to adopt the program in a portion of their classes, implementation was more feasible in larger institutions — likely because it allowed them to introduce *PNI* without requiring the teaching staff to fully abandon the traditional curriculum. Consequently, schools offering the program tend to be larger on average. They are also more commonly located in urban—but not necessarily metropolitan—areas, where a single high school often serves the entire local student population. In contrast, traditional-only schools are more often found in metropolitan settings, where educational supply is fragmented, or in rural areas, where low student numbers make it difficult to support multiple programs. Importantly, there is meaningful overlap in school size across the two groups, with many traditional-only schools falling within the size range of those offering *PNI*.

To address concerns of student self-selection into schools offering the *PNI* program — particularly the possibility that more motivated or higher-ability students might disproportionately enroll in *PNI* schools — I adopt an instrumental variable approach that leverages geographical variation in access to schools offering the program. I construct the instrument as the share of scientific high schools offering *PNI* among those accessible from a student's municipality of residence, where accessibility is defined as requiring a commute of less than one hour. This design reflects the highly localized nature of school choice in Italy: students rarely move away from home to attend high school, and commute times are generally short (11 minutes on average, 10 at the median). Importantly, the availability of the program does not follow Italy's well-known North-South divide, further supporting the view that access is shaped by local school structure rather than broader regional disparities.

The instrument shows a strong first-stage relationship with treatment and varies substantially across municipalities. To assess whether it meets the key condition of independence — that is, whether it is unrelated to unobserved determinants of student outcomes aside from program access — I test its association with a broad set of local characteristics. Conditional on province fixed effects and population size, the instrument is not statistically significantly correlated with labor force participation, employment rates, migrant share, or prevailing gender norms of the students' municipalities of residence. Where statistical significance occurs, the estimated effects are economically negligible, suggesting that the instrument does not proxy for other contextual factors that confound

estimates of the program's effect.

One potential concern is that the availability of the *PNI* program may have influenced students' decision to enroll in the scientific track (*Liceo Scientifico*) in the first place. Since my analysis is restricted to students who attended a *Liceo Scientifico*, any effect of the instrument on track choice would introduce selection into the sample, thus violating the exclusion restriction. To address this, I test whether the share of *PNI* schools accessible from a student's municipality is associated with enrollment in the *Liceo Scientifico*. I find no evidence of such a relationship, supporting the assumption that program availability does not distort the sample's composition.

A second concern is that students attending a *PNI* school may have a higher propensity to pursue higher education, potentially introducing selection bias, as my sample is limited to those who make this transition. To assess whether this issue might compromise the validity of my estimates, I test for differences in high school performance — specifically, final diploma marks and the probability of repeating a year — using the instrumental variable approach. The results, for both the overall sample and when disaggregated by gender, indicate no significant differences between treated and untreated students, supporting the assumption that program availability does not distort the sample's composition.

Overall, results for the full sample point to a small and statistically insignificant effect of the *PNI* program on the probability of enrolling in a STEM degree. I also find no evidence of an impact on university performance, measured by the number of credits earned during the first year. However, attending a school offering the program causes a statistically significant reduction in the probability of dropping out of higher education — about 4% relative to the baseline, significant at the 10% level. These aggregate findings conceal important gender differences. For boys, the likelihood of enrolling in a STEM major increases by roughly 8% relative to the baseline and is statistically significant at the 10% level. No significant effects emerge for boys' university performance or dropout. By contrast, I find no significant impact on any of the outcomes considered among girls. Importantly, these estimates capture intention-to-treat effects, reflecting exposure to schools offering the program rather than actual enrollment in the *PNI* program — making the observed magnitudes particularly noteworthy.

The impact of STEM-promoting educational policies often varies by gender, with recent studies suggesting that cultural and socioeconomic context plays a key role in shaping this heterogeneity. In more traditional settings, where social norms may discourage female participation in technical fields, girls often appear less responsive to such interventions — potentially due to differences in preferences or perceived barriers (De Philippis, 2023; Wiswall and Zafar, 2017; Reuben et al., 2017; Zafar, 2013). By contrast, evidence from more egalitarian societies indicates that removing these cultural barriers can substantially increase the effectiveness of STEM-promoting policies for girls (Joensen and Nielsen, 2016). Given Italy's marked socioeconomic and cultural diversity, it provides an ideal context for testing whether increasing exposure to scientific disciplines interacts with existing social norms to either widen or narrow gender disparities in educational choices.

To study how local gender norms shape the impact of the policy, I construct a measure based on voting outcomes from the 1981 abortion referendum in Italy. The referendum proposed a substantial rollback of the abortion rights established in 1978, and while it was ultimately rejected nationally, the support for the conservative reform varied widely across municipalities. I argue it provides a historically grounded and geographically specific measure of cultural attitudes. Drawing on a well-established literature showing that gender norms are highly persistent over time (Alesina

et al., 2013; Fernández, 2007), this approach captures the normative environment in which students were socialized. Recent studies have adopted a similar strategy in Switzerland, showing that historical referendum outcomes continue to predict gendered behaviors in occupation choices and entrepreneurship decades later (Kaiser and Mata, 2025; Arni et al., 2024). Consistent with these findings, I show that support for the abortion restrictions in 1981 strongly predicts women-to-men labor force participation ratio and women's involvement in local politics 30 years later. However, compared to labor force-based indicators measured at the time of the intervention — which may conflate cultural attitudes with structural labor market conditions or reflect post-schooling migration — the referendum-based measure offers a more stable and locally anchored proxy for prevailing gender norms.

I divide municipalities into quartiles based on the gender norms index and estimate the treatment effect separately for girls across these groups. The results reveal a striking pattern: girls from the most conservative municipalities experience a significant increase in STEM enrollment when attending a school offering the *PNI* program. The estimated effect represents roughly a 30% increase relative to the baseline — comparable in magnitude to the most successful interventions in the literature. For instance, De Philippis (2023) finds an effect of 7% of the baseline in the general population, but much larger effects among top students, whose probability of enrolling in medicine or engineering increases by 27% and 17%, respectively. Similarly, large effects are found in experiments exposing girls to successful and charismatic role models (Breda et al., 2023; Porter and Serra, 2020). I show that these coefficients are not driven by small or imbalanced comparison groups, nor are they explained by geographic concentration alone. Rather, they appear to reflect meaningful variation in how students respond to the program in different normative contexts. In areas with more traditional gender norms, both boys and girls who pursue university studies tend to be positively selected, as evidenced by the greater number of credits earned in their first year of university. Among boys, the effect of the program is relatively stable across the gender norm distribution, indicating that their academic trajectories are less sensitive to local cultural context. For girls from these more conservative municipalities, however, exposure to enhanced scientific education leads to a substantial increase in STEM enrollment. This suggests that academic reinforcement can be particularly impactful in overcoming cultural barriers, providing a critical push for capable students in environments where traditional expectations might otherwise constrain their choices.

This paper contributes to the growing literature on university field-of-study choice (see Altonji et al. (2016) for a review) by examining how curricular exposure during secondary school — specifically through the enhanced scientific training of the *PNI* program — influences students' decisions to pursue STEM degrees. By focusing on students' major choices rather than general attainment, this work complements existing studies on the long-term effects of high school curricula on educational outcomes (e.g., Altonji et al. (2012); Levine and Zimmerman (1995); Altonji (1995)).

Several recent studies have exploited quasi-natural experiments to evaluate how additional exposure to mathematics and science shapes students' academic and career trajectories. Goodman (2019) examines changes to minimum high school math requirements in the United States, finding modest increases in STEM enrollment. Cortes et al. (2015) study a policy that doubled algebra instruction for low-performing ninth-grade students in Chicago, while Görlitz and Gravert (2018) focus on a German reform increasing instruction time in core subjects. In Denmark, Joensen and Nielsen (2016, 2009) analyze curriculum changes that reduced the cost of selecting advanced math and find long-run returns in both education and earnings. De Philippis (2023) investigates a UK

policy reform targeting high-ability students, showing strong impacts on boys' STEM enrollment. All these studies demonstrate the benefits of this additional preparation, at the very least on test scores. My study differs in several important respects. First, I examine a large-scale national policy — Italy's *PNI* program — that, unlike in Görlitz and Gravert, 2018, does not involve a deep restructuring of the schooling system or the teaching programs. Moreover, instead of expanding the available subjects (De Philippis, 2023), the *PNI* program studied here provided a clean change in overall instruction time.

Most importantly, I provide evidence on the interaction between prevailing gender norms and additional exposure to scientific teaching. While previous studies document gender heterogeneity in the effects of increased mathematics instruction — often finding, as I do, that such interventions widen the STEM gender gap (De Philippis, 2023; Morando, 2020) — a more nuanced analysis suggests that this pattern is not universal and may depend critically on the surrounding cultural context. Using a novel proxy for gender attitudes, I show that the *PNI* program can counteract the effect of traditional gender roles. Leveraging a historically grounded proxy for gender attitudes — one that is plausibly insulated from contemporaneous economic conditions — I show that the *PNI* program can mitigate the influence of traditional gender norms on educational choices, possibly with long-lasting consequences. I also contribute to a deeper understanding of when and where STEM interventions are most effective, and for whom.

2 Institutional Setting

The institutional framework provides important information for the identification strategy of this study. The first key point concerns the nature of the program itself, which did not offer any formal academic or certification advantage. As such, it was not a prerequisite for pursuing STEM studies in higher education. The second important aspect is the process through which schools adopted the program — a decision shaped by the teaching staff, whose assignment is quasi-random and largely independent of school quality. This institutional structure ensures that variation in access to the program is not systematically driven by school-specific characteristics, supporting the credibility of the identification strategy.

2.1 The Italian Secondary School System and Access to Higher Education

At age 14, after completing a common national curriculum through primary and lower secondary school, Italian students face their first major academic choice: they must decide what type of high school to attend, effectively selecting the track and subjects they will focus on for the remainder of their secondary education. Figure 1 shows students can choose three different educational paths: academic, technical, or professional. Completing the full cycle of education (five years) in any of these schools formally grants access to higher education.

I focus on the students of a specific academic track program, the *Liceo Scientifico*. This type of school emphasizes scientific subjects such as mathematics, physics, and chemistry while maintaining its humanities-focused core.[2] It is the most selected by those who want to pursue higher education,

[2]Other academic track curricula are: *Liceo Classico* focusing on humanities with subjects like Latin, Greek, and philosophy; *Liceo Linguistico* specializing in foreign languages; *Liceo Pedagogico* focusing on social sciences and psychology. Alternatively, students might attend a technical school (*Istituto Tecnico*) or a vocational school (*Istituto Professionale*). The former provides specialized training in areas such as business, technology, and engineering. The

accounting for 60% of all academic track students (Associazione Almadiploma, 2013). One reason is undoubtedly the versatility of the curriculum, which leaves students' future options open to any higher education path.

Until the 2009/2010 academic year, students enrolling in the Liceo Scientifico could opt for an alternative track to the standard curriculum — the *PNI* program — which offered additional instruction in mathematics and physics. The program remained in place for cohorts graduating up to 2013/2014 and offered students additional training in mathematics and physics, strengthening the scientific focus of the curriculum. It was widely available across the country, with approximately half of all the schools offering the program, making it a significant feature of Italy's secondary education landscape during that period.

2.2 History and Structure of the *Piano Nazionale Informatica*

The *Piano Nazionale Informatica* (the National Plan for Informatics), or *PNI*, was introduced in the 60s and 70s as part of a broader educational modernization effort. Recognizing the growing importance of computer science, it aimed to teach some of its basics in schools. Throughout the '80s and '90s, *PNI* saw revisions with two key features persisting: teacher training in using computer science for teaching and the intention to deploy an experimental program, offered as an alternative to the traditional track. Schools began adopting the program in 1993. It increased the focus on mathematics and incorporated some programming elements.[3] A review of the history up until the end of the 20th century was published by Unione Matematica Italiana (2003).

As Table 1 shows, the *PNI* program involved more hours of mathematics (highlighted in red) and physics (highlighted in green) compared to the other available. At the end of the five years, a *PNI* student would have attended 875 hours of mathematics and 490 hours of physics, versus the 630 and 280 hours of a student attending the traditional path. That amounts to 40% more hours of mathematics and 75% more hours of physics. The programs also covered a wider range of topics. A key feature of the program is that the additional hours were not replacing other subjects, but were added to the traditional schedule.

The "Gelmini Reform" cancelled the *PNI* in 2010. The main rationale of the reform was to standardize the curricula at the national level. The reform's goal of streamlining high school curricula resulted in a new *Liceo Scientifico* syllabus, closely resembling the one of the *PNI* program.

2.3 Schools' Adoption of the *PNI* Program

Teachers and principals influenced a school's decision to offer the *PNI* program. According to professors and school principals I interviewed, who were working in *PNI* schools at the time, offering the program depended on a joint decision of the principal and the assembly of the teachers working at the schools (*Collegio dei Docenti*), following a proposal from one of its members.[4] Schools had the flexibility to implement *PNI* across all classes or only in a subset (depending on the number of students choosing that), making it more feasible for larger schools. This structural advantage

latter teaches skills geared toward immediate employment in fields like healthcare, hospitality, or manufacturing, emphasizing hands-on learning and direct skills training.

[3] Overall computer science integration remained limited: it fundamentally involved more weekly hours of mathematics and physics.

[4] I contacted several principals (current and former) of different Italian schools offering the *PNI* program. I had phone calls with three of them, who provided all the same explanation on the procedural steps required to adopt the program.

naturally increased the likelihood of *PNI* adoption in larger schools, where offering it in just a portion of classes was a more practical option.[5]

2.4 On Teachers' Hiring

The hiring process for high school teachers in Italian public schools is heavily regulated. It follows a rigid, centralized structure that leads to a quasi-random allocation of teachers across the country. The system is primarily based on competitive examinations (*concorsi*) and national rankings (Eurydice - European Commission, 2024).

Secondary school teachers must go through academic qualifying programs to acquire specific competencies in addition to a master's degree in one of the subjects taught at the secondary level. A sizeable portion of these programs involve direct and indirect traineeship activities. They end with a final exam testing their writing and oral skills. Passing the final test grants the teaching qualification, allowing access to the national ranking from which schools recruit teachers. Passing the examination allows one to be hired with a permanent contract and start the one-year induction period in their assigned school. The final job placement is hence dictated by the availability of positions rather than personal choice, leading teachers to schools far from their preferred locations. Moreover, seniority is crucial in determining the teachers' position in the ranking (Articles 399 and 400 of the Testo Unico Istruzione (1994)).

Transfers are difficult and governed by a points-based system that prioritizes tenure and seniority. As a result, new teachers often spend years in schools that were not their first choice, further reinforcing the quasi-random nature of initial placements. Moreover, because competitive exams are irregular, and hiring is slow, many teachers remain in limbo for years, cycling through short-term contracts in multiple regions before securing a stable position (Education International, 2023).

3 Data and Sample Description

3.1 Data Sources

The main data source for student outcomes is individual-level administrative data provided by the Italian Ministry of Education, which includes detailed information on high school and university performance but lacks comprehensive background characteristics. To address this limitation, I supplement this dataset with municipality-level data from the 2011 Census, the 2011 Registry of Local Administrators, and the outcomes of the 1981 abortion referendum, which provide a richer description of local characteristics.

Administrative Student-Level Data. In the "Anagrafe Nazionale Studenti Universitari" the Ministry of Education of Italy records all students enrolled at Italian universities. It provides demographic information collected at the time of their enrollment into higher education and details on their chosen degree course, progression, and outcomes. Importantly, demographic information is collected when students apply to university, generally during their final year of high school. That allows me to identify the students' municipality of residence at the time of high school and the high school they attended.

[5] See discussion in subsection 4.2.

School-Level Data. Formally, no registry indicates whether the *PNI* program was available in a certain school. To identify which *Liceo Scientifico* offered the program, I exploit the communications between the Ministry of Education and the school. The mathematics test of the "Esame di Maturità" (a 4-part exam that needs to be passed to be awarded a high school diploma, with the first two portions set at the national level) was different for *PNI* students. High schools needed to request a copy of the test to the Ministry of Education so their students could take the exam. The government recorded which schools requested the test each academic year, allowing me to identify the schools that offered the *PNI* program. A limitation of the data is that they allow the identification of *PNI* schools, but not of *PNI* students. A school offering the *PNI* program could provide both programs (traditional and *PNI*), or the latter only. I collected additional information about the 585 *PNI* schools in my sample by contacting their administrative offices. Roughly 1/3 of them responded to this survey. Overall, around 15% of them provided only the *PNI* program, while the remainder had both. Because of that, I will take an intention-to-treat approach, assuming all schools offer both programs.

Municipality-Level Data. To describe the municipalities in my data I exploit information from the 2011 Italian Census provided by the Italian National Institute of Statistics (*ISTAT*). It contains information on the socioeconomic characteristics of the residents of each municipality. I also use data from the Ministry of the Interior's Registry of Local and Regional Administrators, which provides detailed information on elected officials at the local level. This source allows me to characterize local administrations — particularly, by the gender composition of their elected representatives.

Gender Stereotypes. To measure gender stereotypes at the municipality level, I use the support rate for the 1981 referendum, called to repeal a 1978 which legalized and regulated access to abortion. The vote was called by Catholic and right-wing organizations seeking to substantially restrict the right to abortion, effectively aiming to eliminate access except in cases of severe medical necessity. The proposal was rejected by a wide margin, with only 32% of voters supporting the repeal. Despite the national result, support for the conservative proposal varied widely across municipalities (from 4 to 80 percent of the voters). I will discuss using this variable as a proxy for local gender norms in subsection 6.2.

3.2 Defining STEM Degrees

Defining STEM Degrees. Similarly to Chise et al. (2021), I define STEM disciplines using the definition provided in Eurostat's Classification of Fields of Education and Training (1999). This relies on the 2013 revision of the International Standard Classification of Education (ISCED 1997), which focuses on fields of education and training, ISCED-F. The equivalent STEM field of study can be classified into three categories. (i) Natural sciences, mathematics, and statistics; (ii) Information and Communication Technologies; (iii) Engineering, manufacturing, and construction. Consistent with the European Union's framework, I do not include either architecture or health studies (such as medical or nursing schools).

3.3 Sample Description

I focus on the cohorts of students graduating from *Liceo Scientifico* who achieved their diplomas between 2009/2010 and 2013/2014. I observe only those who, following the end of high school, enter

higher education. Finally, I remove all students from schools located in the provinces of *Aosta* and *Alto-Adige*.[6] Schools in *Alto-Adige* are granted special autonomy to teach in German and Italian, introducing differences in the programs offered. In the province *Aosta* the special autonomy of the local administration makes the data on high school students transitioning to higher education unreliable. Because of changes in the administrative boundaries established in 2016, I am unable to link students living in different provinces of *Sardegna* (*Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*) to their residency information. I exclude from the sample students who did not enroll in university right after the end of high school and students who repeated one or more years (whether that happened in high school or previously).

4 Descriptive Statistics

4.1 Sample Description: Students

Over the decades, and especially after the liberalization of access to university in 1969, *Liceo Scientifico* became the predominant academic track choice among Italian students (La Repubblica, 2010). Among the reasons were its greater flexibility and the growing awareness of the increasing importance of scientific disciplines. I show a breakdown of the students enrolled in higher education by cohort and their type of diploma in Table 2. Roughly 42% of the students starting their degree over that period studied at the *Liceo Scientifico*.[7]

Table 3 shows that *Liceo Scientifico* curriculum is unique in that it maintains a balanced gender composition, whereas other academic tracks tend to have a significantly higher proportion of female students. As expected, graduates from this track are more likely to enroll in STEM programs compared to their peers. However, despite their strong orientation toward science and mathematics, they do not exhibit superior academic performance in high school — however, this metric is largely school-specific and difficult to compare across curricula.[8] Similarly, university performance during the first year does not differ based on students' background.[9] Even in terms of dropout rates from university, *Liceo Scientifico* graduates do not fare better than others.

In Table 4 I focus on the differences between students who attended a school offering the *PNI* program and those graduating from a school offering the traditional program only. The difference in gender balance is small but statistically significant, with *PNI* schools enrolling a slightly higher share of girls. *PNI* students also tend to enroll more frequently in STEM degrees, to finish high

[6] In Italy, the hierarchy of administrative units below the State consists of 3 layers. The 20 regions contain each from 1 to 12 provinces (the median is 5), totaling 106. Within each province are located the municipalities, for a total above 7900 in the entire country. Their number per province varies between 6 and 309 (the median is 95).

[7] I include only students who never failed a year and started their degree right after finishing high school.

[8] The Italian high school diploma exam (*Esame di Stato*) is a comprehensive final assessment taken at the end of upper secondary education. The exam structure combines both nationally standardized and school-specific components. Typically, it includes two written tests — centrally prepared by the Ministry of Education and aligned with the student's curriculum (e.g., scientific, classical), and another designed at the school level — followed by an oral exam. While the exam content partially varies depending on the high school track and school, the evaluation process is conducted locally, by a committee composed of internal and external teachers. Despite periodic reforms, the core structure has consistently aimed to assess a broad set of competencies and serves as a necessary qualification for university admission. The outcome ranges between 60 (pass) and 100*cum laude*.

[9] I measure first-year performance using the number of credits acquired during the first year of higher education. The European Credit Transfer System (ECTS) is a system used all over Europe and enables you to easily compare study programs and transfer your academic qualifications from one educational institution to another. Passing a university exam grants you ECTS corresponding to the expected workload required for that exam (1 ECTS roughly amounts to 25 to 30 hours). Degrees are structured such that each academic year students are required to earn 60 ECTS.

school with better grades, and to do better during their first year of higher education. The most striking difference lies in the dropout rate, with students from the traditional program being almost 5 percentage points more likely to drop out of university. In general, *PNI* students seem to do better once they enroll in university.

4.2 Sample Description: Schools

Table 5 highlights two key features of the setting. As discussed in subsection 2.3, the rules governing *PNI* adoption made it more feasible for larger schools to implement the program in just a subset of classes, which helps explain why these schools tend to be larger on average. Mean cohort sizes in *PNI* schools are more than double those of traditional-only schools (97 vs. 43), with a similar contrast in medians (88 vs. 31). Yet, the variation in school size among traditional-only schools is substantial, with a standard deviation of nearly 40 — almost as large as the mean — compared to 56 in *PNI* schools. This dispersion is meaningful: 10% of traditional-only schools have a cohort size above the mean size of *PNI* schools, and 33% fall within one standard deviation of the *PNI* schools' mean. Conversely, almost 18% of *PNI* schools are smaller than the mean size of traditional-only schools, and 45% fall within one standard deviation of that mean. Figure 2 offers a visual representation of the overlap in school size across both groups. These patterns indicate that program adoption is not mechanically tied to school size. They also highlight that the identification strategy rests on the presence of substantial common support, avoiding the need for strong out-of-sample extrapolation.

The second key characteristic concerns the demographic context of *PNI* school locations. On average, *PNI* schools are situated in less populated and less densely populated municipalities than their traditional-only counterparts. Specifically, the mean population of municipalities with *PNI* schools is approximately 232,000, compared to 335,000 for those hosting only the traditional track. To further explore this pattern, I classify municipalities into rural, urban, and metropolitan categories based on population thresholds used in Italian administrative practice.[10] This classification reveals that traditional-only schools are disproportionately more represented in metropolitan municipalities, which have an average population of 1.2 million (median: 962,003), than in urban municipalities, which are much smaller on average (mean: 50,000; median: 28,563). The percentage of *PNI* schools located in rural municipalities (population mean: 1,939; median: 1,641) is nearly identical to that of traditional-only schools. The resulting pattern suggests that the *PNI* program was more commonly adopted in small-to-medium-sized urban areas, where one or a few schools typically serve the entire student population. In these settings, schools are more likely to be large enough to implement the program selectively across classes. By contrast, traditional-only schools are more frequently found in large metropolitan centers, where educational supply is fragmented across many smaller institutions, or in rural areas, where limited student numbers make offering multiple curricular tracks more difficult. These dynamics indicate that a municipality's demographic profile indirectly shapes program availability by influencing school size and the structure of local enrollment.

A defining feature of the Italian context is the longstanding North-South divide, which cuts across a wide range of economic and social dimensions. For example, Lombardy's GDP per capita

[10] Following a long-standing benchmark in national legislation (e.g., Law 311/2004) and recent academic contributions such as Cattivelli (2021), I define rural municipalities as those with fewer than 5,000 residents, and urban ones as those above that threshold. Metropolitan municipalities are instead identified according to national law establishing the 14 official metropolitan cities (*città metropolitane*), which include major urban centers in the country. Law 56/2014 formally established the metropolitan cities and includes the 14 largest urban areas in Italy: Bari, Bologna, Cagliari, Catania, Florence, Genoa, Messina, Milan, Naples, Palermo, Reggio Calabria, Rome, Turin, and Venice. This classification reflects not only population size but also administrative and institutional status.

reaches 127% of the EU average, while Calabria's stands at just 56%, reflecting persistent regional disparities in development and opportunity (Fernández-Villaverde et al., 2023; Giuntella, 2022). However, when studying the availability of the *PNI* program, this familiar territorial pattern does not appear to hold. I assess the regional presence of *PNI* schools and the share of students who attend them in Table 6.[11] The larger size of *PNI* schools is particularly evident in regions like *Trentino* and *Abruzzo*, where the share of schools offering *PNI* is well below the national average, yet the proportion of students enrolled in *PNI* programs is significantly higher. In contrast, Central Italy stands out for having a high share of *PNI* schools. However, the distribution of *PNI* availability appears relatively uniform across most regions. *Basilicata* emerges as an exception, being the only region where *PNI* and Traditional schools have a similar size profile. More broadly, apart from specific cases such as *Sardegna* and *Trentino*, there are no major regional gaps in access, suggesting that the *PNI* program was widely available across the country, suggesting that other factors — such as local school structure and demographic conditions — played a more influential role in shaping access to the program.

5 Empirical Strategy

To estimate the impact of differential exposure to scientific subjects for student i who attended school s on outcomes Y, I consider the following linear model:

$$Y_{is} = \beta_0 + \beta_1 T_{is} + \beta_2 G_{is} + \beta_3 S_s + \beta_4 P_{im} + \lambda_{cp} + \epsilon_{is} \tag{1}$$

The outcomes are the probability of enrolling in a STEM degree, performance during the first year in higher education (proxied by the number of ECTS attained), and probability of dropout. T_{is} represents a binary indicator of treatment status, i.e. a student attended a school offering the *PNI* program. The objective is to obtain an unbiased estimate of β_1.

A key concern in identifying the causal effect of the *PNI* program is the possibility that schools offering it differ systematically from those that do not in ways that are unobservable but correlate with student outcomes. For instance, if *PNI* schools had stronger leadership, more motivated teachers, or a generally better academic environment, failing to account for this could lead to a biased estimate of the program's true effect. However, the Italian institutional framework helps to address these identification challenges. As I explained in subsection 2.3 and subsection 2.4, teacher assignments are quasi-random, and the decision to implement the *PNI* program was based on a collective agreement between the principal and teaching staff, rather than a targeted policy for high-performing schools.

One remaining issue is that the *PNI* program is generally offered by larger schools, as they could implement it in only a subset of classes. Since school size may be associated with other factors — such as access to resources or broader peer networks — that influence students' outcomes, controlling for school size or incorporating it into the identification strategy is essential to isolate the program's

[11] I employ the classification of the Italian National Institute of Statistics (ISTAT) to group the regions. ISTAT divides Italy into geographical macro-areas to facilitate regional analysis and comparisons. This division allows for a more nuanced understanding of Italy's economic, social, and demographic characteristics, recognizing the diversity between different parts of the country. The macro-areas—typically Northwest (*Val d'Aosta, Piemonte, Liguria, Lombardia*), Northeast (*Friuli Venezia Giulia, Trentino Alto-Adige, Veneto, Emilia Romagna*), Center (*Toscana, Umbria, Marche, Lazio*), and South and Islands (*Campania, Abruzzo, Molise, Basilicata, Puglia, Calabria, Sicilia, Sardegna*). The classification reflects historical, economic, and cultural differences that affect various aspects of life, such as income distribution, employment, education, and healthcare access.

effect. I do this by including in Equation 1 S_s, a categorical variable controlling for the tercile of the number of students enrolled. To capture time-varying differences across schools' geographical areas, I include λ_{pc}, a set of dummy variables accounting for the combination of the school's province and the students' cohorts. I interact the cohort indicator with the province, which is the second layer in Italy's administrative hierarchy above the municipality (below the regions).

Endogeneity at the student level poses an additional identification challenge, as students who enroll in the *PNI* program may differ systematically from those who do not — particularly in terms of unobserved motivation, ability, or family support, all of which may also influence their likelihood of pursuing a STEM degree. To account for observable heterogeneity, I include controls for gender G_{is} and for whether the municipality where the student resides is categorized as rural, urban, or metropolitan P_{im}. As I explained in subsection 4.2, this classification follows the Italian administrative practice. Rural municipalities are defined as those below 5,000 residents (Law 311/2004), while metropolitan areas are the major urban centers in the country, which are granted special institutional status (Law 56/2014). While the student-level dataset does not offer a wide set of individual-level characteristics, these variables help capture important differences in both student background and local schooling context. In particular, accounting for the municipality population is essential: *PNI* programs were more likely to be offered in urban but not necessarily metropolitan areas, where school size tends to be large enough to support partial program implementation. By contrast, large cities often host a fragmented network of smaller schools, many of which did not adopt *PNI*. Moreover, small towns may only have one school, which might or might not offer the program, regardless of size. Controlling for population size thus helps account for variability in school availability and structure, reducing the risk that local context drives both program exposure and academic outcomes.

Nonetheless, these controls alone cannot fully address students freely sorting to different schools. To isolate a plausibly exogenous variation in school choice, I instrument T_{is} with the share of available schools offering the *PNI* program to students living in a given municipality. The identification strategy is valid if (i) the instrument is as good as randomly assigned (instrumental independence), (ii) it affects the outcome only through its effect on the probability of choosing a *PNI* school (exclusion), (iii) it has a non-zero relationship with the treatment (relevance). I provide evidence for these assumptions in the next sections.

5.1 Instrumental Variable

The logic behind my instrument is intuitive. Geographical proximity is an important determinant of the education institution of choice in many contexts (Mandic et al., 2023; Laverde, 2022; Agarwal and Somaini, 2019). The same holds in Italy, where students rarely leave their parental home, especially before finishing secondary education. Boarding schools are rare, as only 8 exist in the country (as of 2024). In my sample, the median commute time for a student to reach their school is less than 9 minutes.[12] Figure 3 shows, for each *Liceo Scientifico* in the country, the share of students who commute for less than a certain time. Each school is represented by the share of students traveling less than - in the case of the blue short-dashed line - 15 minutes every day. The graph provides a key insight: in the vast majority of the schools, the share of students commuting for less than 30 minutes to attend is above 90%.

[12] I use the API services provided by Google Maps to calculate the commute time. I estimate the duration by assuming the students are traveling by car.

Establishing the importance of distance supports the construction of an instrument based on school availability. I use the ratio between the number of high schools that offered the *PNI* program and the total number of high schools (of the *Liceo Scientifico* type) available to the residents of a given municipality. I exploit a data-inspired approach to define the catchment area, observing all the possible combinations of the students' municipality of residence and their high school of choice. Those allow me to infer which schools are in the feasible catchment area. The underlying assumption is that all the schools "available" to the residents of a given municipality were attended by at least one student (which is why I use all the data of students graduating from a *Liceo Scientifico*). The school's location is defined using the street address, while the students' residence is defined using the centroid of the municipality of residence (reported at the time they enrolled at the university). I refine the instrument by removing from the set of available schools those for which the commute lasted longer than 60 minutes. I plot the instrument on the map of Italian municipalities in Figure 4.[13] The distribution of the instrument across municipalities does not reveal any immediately recognizable geographic pattern, suggesting that access to *PNI* schools is not systematically clustered in specific areas.

My instrument is therefore defined at the municipality level (with 7,042 observations, one for each municipality in the sample). On average, around 50% of the accessible schools offered the *PNI* program (the standard deviation is 0.34). I plot the share for each municipality in Figure 5. The distribution of the instrument is not uniform, showing peaks around 0, 0.5, and 1, meaning that municipalities cluster into three distinct groups: those with no access, partial access, and full access to the program. This suggests that in municipalities where no schools offer the program (instrument = 0), the probability of treatment is substantially lower, while in municipalities where all schools offer it (instrument = 1), treatment probability is much higher. For municipalities around the middle peak (instrument $\simeq 0.5$), treatment assignment remains partial, meaning access to the program is available but not universal. Importantly, the instrument shows considerable variation. 60% of the municipalities are covered just partially. Even without considering those with no access to *PNI* schools, roughly 25% fare below the 0.5 threshold.

A strong relationship between the instrument and the endogenous variable is essential for a successful identification strategy, as it eliminates possible issues that can arise under weak instruments. To address the relevance of the instrument, I estimate the following first stage:

$$T_{is} = \gamma_0 + \gamma_1 Z_m + \gamma_2 G_{is} + \gamma_3 S_s + \gamma_4 P_{im} + \lambda_{cp} + \varepsilon_{is} \tag{2}$$

Where *PNI* choice T_{is} is predicted by the instrument Z_m, the availability of *PNI* schools for the students living in a given municipality.

5.2 Evaluating Instrumental Validity

As previously discussed, potential threats to identification in this setting arise from two key sources: systematic differences between schools that offer the *PNI* program and students' selection into the program. Understanding the mechanisms determining which schools implemented the *PNI* track is thus critical. In this regard, I showed how features of the Italian institutional framework, especially

[13] As mentioned in subsection 3.3, the municipalities located in the provinces of *Aosta* and *Alto-Adige* are excluded, while those located in the provinces of *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio* are not available.

related to teachers' hiring, make staff composition quasi-random and reduce the possibility that *PNI* adoption reflected underlying school quality.

More broadly, the Italian education system is designed to promote equal access, as Article 34 of the Italian Constitution states. Universal education and equal opportunity are established as fundamental rights (Italian Parliament, 1948). Following this principles, 94% of high schools are state-funded, and follow a standardized syllabus. Part of the final national exam also consists of a test prepared by the Ministry of Education, and that is common across all schools in the country. The location and endowment of schools are planned based on demographic needs, as determined through agreements between regional authorities, the Ministry of Education, and the Ministry of Finance (Article 53(1) of the Testo Unico Istruzione (1994)). This institutional design makes it unlikely that external factors, such as local labor market demand for STEM workers, systematically influenced the adoption of the *PNI* program.

Nevertheless, while the institutional framework of the Italian school system helps mitigate concerns of endogenous program placement, it is important to acknowledge that observable differences between *PNI* and non-*PNI* schools do exist. I argue that these differences are not arbitrary but stem directly from the process required to implement the *PNI* program (outlined in subsection 2.3), which was highly dependent on student enrollment numbers. In larger schools, it was more feasible to offer the program in just a subset of classes, making adoption more likely. By contrast, smaller schools, which are common both in metropolitan areas — where school size varies considerably — and in more rural communities, were often less equipped to accommodate the additional specialization. In medium-sized cities, a single school often served the entire area, resulting in larger student bodies and thus a higher probability of offering the program. For this reason, school size is an important confounder, and I explicitly account for it in my main specification to ensure that differences in access are not simply reflecting underlying variation in school scale.

Given that school size — and thus *PNI* availability — is strongly related to the local context, it is crucial to ensure that the instrumental variation in *PNI* access is not driven by underlying differences across municipalities. In particular, if the share of *PNI* schools within a municipality is systematically associated with observable characteristics such as labor market factors or prevailing gender norms, then the estimated effects of the program could be confounded by local conditions, rather than capturing the causal impact of program exposure. To address this concern, I test whether the instrument behaves as good as randomly assigned by examining its relationship with a rich set of municipality-level characteristics. While random assignment is not strictly necessary for identification, demonstrating that any residual correlations are economically negligible helps support the validity of the exclusion restriction and the robustness of the identification strategy. I estimate the following equation:

$$W_m = \alpha_0 + \alpha_1 Z_m + \alpha_2 P_m + \lambda_p + \zeta_m \tag{3}$$

Where W_m describes different socio-economic characteristics of the municipalities.[14] P_m is a categorical variable representing whether the municipality is classified as rural, urban, or metropolitan. λ_p accounts for time-invariant factors determined by a student's province of residence.[15]

[14] These variables are: labor force participation and employment, for both the overall population and females; the share of foreign-born residents; the share of members of the municipality executive committee who are women as of 2011; the support for restricting access to abortion during the 1981 abortion referendum, as a measure of gender norms at the municipality level.

[15] I do not include cohort-by-province fixed effects as in the main specification because municipality characteristics

In the two panels of Table 7, columns (1), (5), and (7), present estimates of the relationship between the instrument and key municipality-level characteristics, such as labor force participation (both overall and female-only) and the share of foreign-born residents, controlling for province fixed effects. While the coefficients are statistically significant, their economic relevance is minimal. A change in the instrument from 0% to 100% is associated with changes of less than one percentage point in these outcomes — corresponding to less than 10% of a standard deviation, or just above that in the case of female labor force participation. Similarly, column (15) shows that the relationship between the instrument and support for abortion restrictions corresponds to a change of roughly 13% of a standard deviation — again, modest in magnitude.

When I additionally control for whether a municipality is classified as rural, urban, or metropolitan, only the relationship between the instrument and support for abortion restrictions remains statistically significant. However, its magnitude becomes economically negligible. Even in the most extreme case — comparing two otherwise similar municipalities within the same province and classification (e.g., both urban), where one has no *PNI* schools and the other has full coverage — the implied change in support for abortion restrictions is just 7% of a standard deviation, or 2% of the mean. Furthermore, I find no significant association between the instrument and the share of women appointed by the mayor to the municipal executive council. This supports the interpretation that the instrument is not systematically related to gender norms, alleviating concerns about potential bias.

Having examined the factors driving which schools offered the *PNI* program, I now turn to the question of who enrolled in it — that is, whether student selection into *PNI* schools could introduce endogeneity in estimating the program's effects.

A necessary condition for the validity of the empirical design is that the more demanding scientific syllabus of the *PNI* program does not systematically change enrollment to *Liceo Scientifico*. If the availability of the program alters students' decision to enter the scientific curriculum — particularly by deterring those with lower academic confidence — then my estimation sample would be selectively composed, and the model would be misspecified, as it only includes students enrolled in the *Liceo Scientifico*. More critically, this would violate the exclusion restriction, as the instrument would affect the outcome not solely through treatment exposure (i.e., attending the *PNI*), but also by shaping curriculum selection itself. I do not expect that to be the case, as the treatment is defined at the school level, which assumes all students enrolling in a *PNI* school received the treatment. In reality, the vast majority (85%) of the schools offering the program allowed their students to choose between the two options, and constructed the classes accordingly. This suggests minimal displacement effects, as opting for the traditional program was possible in most cases. I also provide evidence of that by estimating the following equation:

$$W_{is} = \alpha_0 + \alpha_1 Z_m + \lambda_{cp} + \zeta_{is} \tag{4}$$

Where I regress the dummy variable W_{is} - indicating whether a student chooses *Liceo Scientifico* over a different academic-track school - on the instrument Z_i and cohort-by-province fixed effects λ_{cp}. This serves as a reduced-form check on whether the program's presence affected the composition of students selecting into the scientific curriculum.[16] Table 8 shows that the relationship is absent

are measured only at one point in time (2011), and therefore do not vary by cohort.

[16]This test is grounded on the notion that transition rates from academic-track schools to tertiary education were the same (Associazione Almadiploma, 2013). Because of that, my estimates do not represent the probability of

whether or not I include the province of residence, cohort, or province of residence-by-cohort fixed effects.

While I cannot observe students who do not enroll in university — limiting my ability to directly test whether *PNI* and non-*PNI* schools differ in terms of transition rates — I can assess potential selection by examining whether students who attend the *PNI* program differ in key academic outcomes during high school. These checks offer indirect evidence on whether systematic differences in ability or performance may bias the estimates. Using Equation 3, I estimate the relationship between high school-related outcomes and attending a school offering the *PNI* program. These are high school graduation mark and whether a student had to repeat at least one year.

I present the results in Table 9. The findings indicate that while OLS estimates suggest statistically significant differences — *PNI* attendance is associated with modestly higher high school grades and a substantially lower probability of repeating a year — these effects vanish under 2SLS estimation, becoming statistically insignificant across all specifications. This divergence between OLS and 2SLS results is likely attributable to selection into treatment. The first-stage relationship between the instrument and treatment remains strong, with consistently large coefficients and robust F-statistics. Overall, the evidence indicates that any systematic differences between *PNI* and non-*PNI* students are small and effectively addressed through the instrumental variable approach. This holds both in the full sample and in gender-specific estimates.

Moreover, as discussed earlier, differences in school quality are difficult to exploit strategically in the Italian context. The scope for meaningful differentiation in curricular content or staffing quality is narrow: teacher assignments are governed by centralized, quasi-random procedures, and all schools follow a nationally consistent syllabus. While a school's reputation could, in principle, influence family decisions, such factors are unlikely to cause a violation of the exclusion restriction here. When students in my sample chose their high school, no public ranking or systematic performance comparison existed to guide them. The first national tool enabling comparisons across schools — *Eduscopio*, an initiative by *Fondazione Agnelli* — was launched only in 2014, several years after the students in this study had already enrolled (Fondazione Agnelli, 2024).

Another potential source of bias relates to residential sorting — when families strategically choose to live in municipalities with greater access to *PNI* schools, anticipating academic advantages. Such behavior would represent a violation of the exclusion restriction, as the instrument could affect outcomes not only through increased treatment exposure but also through selection into municipalities based on unobserved preferences for STEM education. However, this concern appears limited in the Italian context. Students typically choose their high school after completing lower secondary education, around age 13–14, and internal mobility at this stage is uncommon. Unlike in other countries, boarding or distance high schools are virtually nonexistent in Italy — as of 2024, only eight operate nationwide. Existing research on internal migration patterns highlights that family moves are primarily driven by economic and employment opportunities, not by proximity to specific schools (Bonifazi and Heins, 2000; Bonifazi, 2013). Moreover, the Italian National Institute of Statistics (*ISTAT*) reports that migration mainly involves individuals aged 15–39, suggesting that moves often occur after high school decision (ISTAT, 2018).

It is important to note that, given the nature of the identification strategy, the estimated coefficients should be interpreted as intention-to-treat (ITT) effects — capturing the impact of program availability, rather than actual enrollment. This reflects the average effect of being exposed to

attending a *Liceo Scientifico* conditional on going to university and the other controls.

a higher probability of attending a *PNI* program, rather than the treatment effect on compliers specifically.

6 Results

I start by estimating the effect of attending a *Liceo Scientifico* offering the *PNI* program on major choice, looking specifically at the probability of enrolling in a STEM degree. I then show the impact of the treatment on second-order effects, such as the probability of dropping out of university and performance during the first year of higher education (expressed by the logarithmic transformation of the number of credits - ECTS - attained during the first year of enrollment, as more credits imply the completion of more exams). I exploit a linear 2SLS model to estimate the β_1 coefficient.

I estimate the effect of attending a *PNI* school in Table 10. The OLS estimates (shown in the odd-numbered columns) suggest no relationship between program exposure and the probability of enrolling in a STEM degree, but indicate a negative association with university dropout and a positive one with first-year performance. The first-stage relationship is strong across all specifications, with a coefficient of approximately 0.57. This implies that moving from a municipality with no schools offering the *PNI* program to one where all schools do increases the probability of treatment by nearly 60 percentage points. Given that the instrument has a mean of 0.52 and a standard deviation of 0.34, a one-standard-deviation increase corresponds to a 17 percentage point rise in treatment probability. The size of the first-stage F-statistic — 170 for STEM and dropout, and 160 for performance — consistently exceeds conventional thresholds, mitigating concerns about weak instruments.

Turning to the 2SLS estimates (even-numbered columns), I find a positive but statistically insignificant effect on both STEM enrollment and first-year academic performance. However, there is a small negative effect on the probability of dropping out of university, significant at the 10% level, suggesting that students exposed to the *PNI* program are somewhat less likely to leave higher education prematurely. Notably, the estimation of performance effects relies on a slightly reduced sample, as first-year credit data is often missing for students who drop out. Specifically, while only about 1% of non-dropout students have missing credits, the figure rises to 19% among those who drop out. This selective attrition could partially mask a potential positive impact of the *PNI* program on academic performance, as students who might have exited the system without this early preparation remain enrolled longer.

6.1 Gender Heterogeneity and Policy Implications

The interaction between the program and students' gender has important policy implications. Due to stereotypes about male-dominated careers, girls often choose majors leading to less paid jobs (Zafar, 2013). I estimate the impact of *PNI* separately for boys and girls and present the results in Table 11.

It is immediately evident how the results for the overall sample masked a substantial gender heterogeneity. For boys, the probability of enrolling in a STEM major increases by roughly 2 percentage points, representing a nearly 8% variation relative to the sample mean — statistically significant at the 10% level. I do not find any effect on the probability of dropout from higher education or performance in the first year of studies. I do not observe effects for girls across any

of the outcomes, as the coefficients remain both economically and statistically insignificant. This suggests that while the *PNI* program may have influenced boys' educational trajectories, it did not generate measurable changes for female students. I show in Appendix C.1 that these results are robust to changes in the definition of school-cohort size (using quintiles instead of terciles), municipality population size (using terciles of the municipality population instead of separating between rural, urban, or metropolitan), and the inclusion of students who repeated at least one year of high school. Just like in the study by De Philippis (2023), the program effectively widens the gender gap in STEM enrollment.

A growing body of research suggests that the effectiveness of policies aimed at strengthening math and science education — and the gender heterogeneity in their effects — depends crucially on prevailing gender norms. In more traditional environments, such policies tend to benefit boys disproportionately. For example, De Philippis (2023), studying the UK, attributes the lack of an effect on girls to persistent gender differences in preferences, consistent with the findings of Reuben et al. (2017), Wiswall and Zafar (2017), and Zafar (2013) which document systematic differences in preferences as one of the key reasons of the STEM gender gap. By contrast, in more gender-equal societies, such as Denmark, Joensen and Nielsen (2016) document positive effects of increased exposure to mathematics on both boys and girls, suggesting that cultural norms can either constrain or enable girls' responsiveness to STEM-related interventions. The Italian setting — marked by persistent and traditional gender norms — provides an ideal case to test whether increasing exposure to scientific disciplines can be effective in narrowing gender disparities where they are most entrenched.

6.2 The Interplay between Attending a *PNI* School and Local Gender Norms

Italy has long been marked by persistent economic disparities linked to geographical location (Giuntella, 2022). According to ISTAT (2018), regional differences also extend to attitudes toward traditional gender roles and the acceptance of gender-based violence. These differences are especially relevant when studying educational and career choices, which are shaped by the social context in which students are raised. To capture local variation in gender norms, I rely on the results of the 1981 Italian abortion referendum, where citizens voted on a proposal to significantly restrict access to abortion rights granted just a few years earlier. Although the proposal was ultimately rejected, support varied widely across municipalities, reflecting persistent geographic differences in attitudes toward gender roles. This historical measure provides a geographically and culturally anchored proxy for traditional gender norms — one that is especially relevant in the Italian context, where high school choice is highly localized and adolescent migration is rare. This choice is grounded in the literature on the persistence of cultural traits across generations and their influence on contemporary behavior (Becker et al., 2016; Alesina et al., 2013; Fernández, 2007), as well as recent studies set in Switzerland that employ referendum outcomes to measure local gender attitudes (Kaiser and Mata, 2025; Arni et al., 2024).

Compared to commonly used indicators such as the female-to-male labor force participation ratio (Meluzzi, 2024; Jayachandran, 2015; Fogli and Veldkamp, 2011; Fernández and Fogli, 2009; Fortin, 2005), the referendum-based measure offers two key advantages: it is not mechanically linked to local labor market conditions that may directly influence STEM enrollment, and it provides a more stable reflection of the cultural environment in which students were socialized. I validate the measure (in Appendix C.2, where I provide a more comprehensive discussion) by showing it

is negatively and significantly associated with female labor force participation and share of women elected in city councils (and subsequently nominated in administrative positions) 30 years later, even after accounting for municipality size and province fixed effects — supporting its interpretation as a distinct and meaningful proxy for gender norms.

Finally, I estimate the impact of the treatment on girls by level of gender attitudes. To do so, I split the sample into quartiles — calculated at the municipality level. The association between the local support for increasing abortion restrictions and the municipality population that existed in 1981 remains evident and is displayed in the number of observations decreasing when moving from the second to the third and fourth quartiles. The results in Table 12 reveal a highly significant effect on STEM enrollment among girls in the most conservative municipalities, where exposure to the *PNI* program appears to have a substantial impact. In these areas, the effect size reaches almost 7 percentage points, a striking increase of 32% of the baseline. For boys, except those in the third quartile of gender norms, the estimated STEM responses across gender-norm quartiles are of similar size. They range from 2.5 to 3.6 percentage points, but are much less precise. Moreover, unlike for girls, there is no clear pattern in the relationship between boys' outcomes and the local normative environment.

The magnitude of my estimated ITT effect — roughly a 30% increase over the baseline STEM enrollment rate for girls in conservative areas — stands out relative to the existing literature. For example, Goodman (2019) evaluates a broad policy shift in high school math requirements and finds a much smaller ITT effect, approximately 3.5% of the baseline - likely reflecting the fact that the policy was not specifically targeted at high-achieving students. Similarly, De Philippis (2023) finds an ITT effect of 7% of the general population's baseline. However, the effect is far more pronounced among top students, whose probability of choosing a medicine or engineering degree increases by 27% and 17% relative to the baseline, respectively. The literature on exposure to role models reports substantially larger effects. Following targeted exposure to inspirational or relatable figures, Porter and Serra (2020) and Breda et al. (2023) find an increase in economics and STEM enrollment of around 27% and 28% over the baseline, respectively. Taken together, these comparisons suggest that the size of my estimated effect, while large, is plausible given the context and the specific subgroup it affects.

I also examine the variation behind the magnitude of this effect. I begin by geographically locating girls in the top quartile of conservative gender norms. While over half come from *Lombardia* or *Veneto*, *Trentino Alto-Adige* also contributes disproportionately relative to its national share of the female student population. Several regions from the South are sizeably represented too, such as *Campania*, *Puglia*, *Calabria*, and *Sicilia*. Since identification is based on within-cohort-by-province comparisons, I analyze patterns of STEM enrollment at that level. A potential concern is that some cohort-by-province cells may include very few students or feature strong imbalances between treatment and control groups. To address this, I conduct robustness checks restricting the sample to cells with at least 10 girls and with treatment-to-control ratios no lower than 0.25 and 0.35, respectively. While these restrictions substantially reduce the sample size, the magnitude of the estimated effects remains relatively stable, dropping to roughly 23% of the baseline probability of choosing a STEM degree and statistically significant only at the 10% level, when I look at the most restrictive comparison - where the sample size is reduced by a factor of 3. This suggests that the results are not driven by a small number of extreme or poorly balanced comparisons. A detailed analysis of this robustness exercise is provided in Appendix C.3.

The persistence of the effect across northern and southern regions complicates a purely economic interpretation. While labor market opportunities may play a role in regions like *Lombardia*, *Veneto*, and *Trentino*, the presence of similarly large effects in *Campania* and (especially) *Calabria* suggests another dynamic at play. One hypothesis is that girls from these more traditional areas — who may face stronger barriers to university participation — are positively selected when they do enroll in higher education. Among them, exposure to the enhanced math and science curriculum of the *PNI* program may act as a critical nudge toward choosing a STEM major. This interpretation is supported by baseline outcomes, as girls from municipalities with the most conservative gender norms perform well during their first year of higher education and exhibit low dropout rates — reinforcing the idea of positive selection. A similar pattern holds for boys: those from more traditional areas also show slightly better baseline outcomes. However, unlike for girls, there is no clear relationship between boys' outcomes and the prevailing gender attitudes in their municipality.

7 Conclusion

This paper studies the effect of strengthened scientific instruction on students' educational trajectories by examining the Italian *PNI* program, which introduced more advanced mathematics and physics coursework in a subset of high schools. The program had a modest average effect on the likelihood of enrolling in a STEM degree, with no measurable impact on dropout or first-year academic performance. I document that the program contributes to widening the gender gap in STEM enrollment: while male students respond positively to the treatment, female students, on average, do not. However, this pattern masks an additional, crucial, layer of heterogeneity.

The central contribution of the paper lies in identifying the role of prevailing gender norms in shaping the policy's effectiveness. To do so, I construct a novel proxy for local gender attitudes, based on municipality-level support for the 1981 abortion referendum — a historically rooted measure grounded in the documented persistence of cultural norms over time (Kaiser and Mata, 2025; Arni et al., 2024; Alesina et al., 2013; Fernández, 2007). I show that, although both boys and girls from more traditional municipalities appear positively selected into university, the effect of the *PNI* program on girls is particularly pronounced in these settings. The estimates suggest that greater exposure to scientific curricula significantly increases the probability that girls from more conservative backgrounds choose a STEM major — pointing to the potential of curricular interventions to mitigate the influence of restrictive cultural attitudes.

These findings suggest that policies aimed at strengthening scientific education can do more than broaden access to STEM fields: they can actively challenge gendered expectations and promote more equitable academic choices. While the average effect on female students is negligible, I show that in contexts where traditional norms are more deeply entrenched, such interventions can have transformative effects. The magnitude of the impact is comparable to that of those highly successful interventions involving exposure to female role models (Breda et al., 2023; Porter and Serra, 2020), underscoring the value of early, curriculum-based strategies. Conversely, the absence of an effect in less traditional areas — where gender gaps are already narrower — suggests that other factors, such as individual preferences or institutional constraints, may play a more central role in those contexts.

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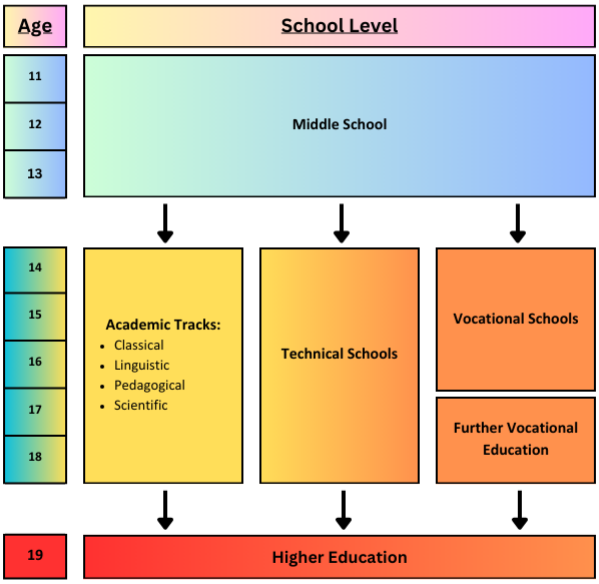
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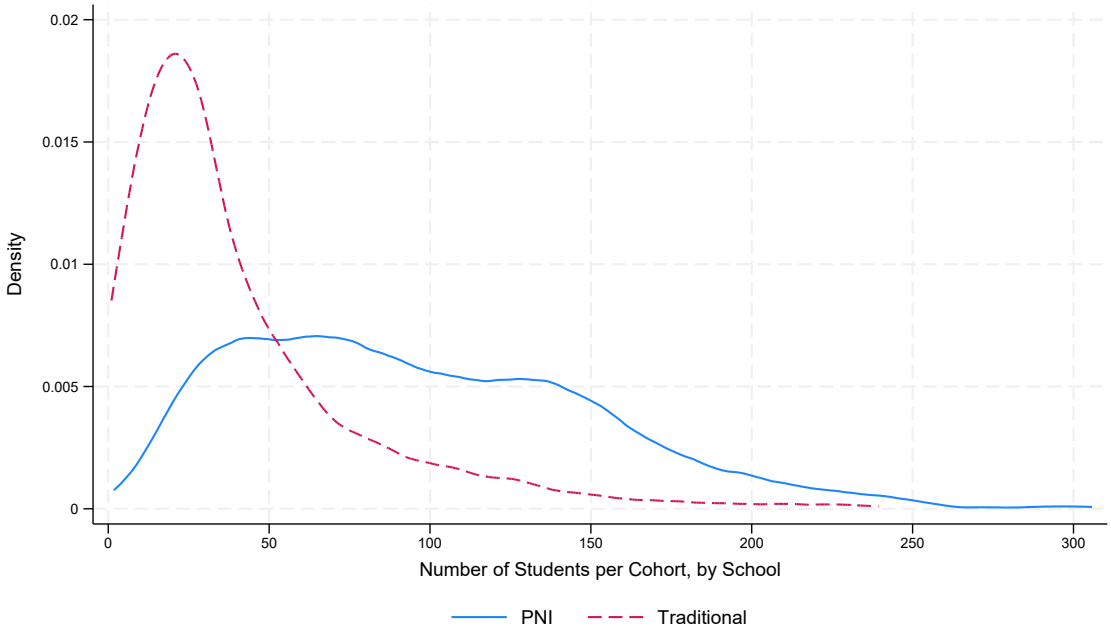
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Figure 1: School Progression in Italy



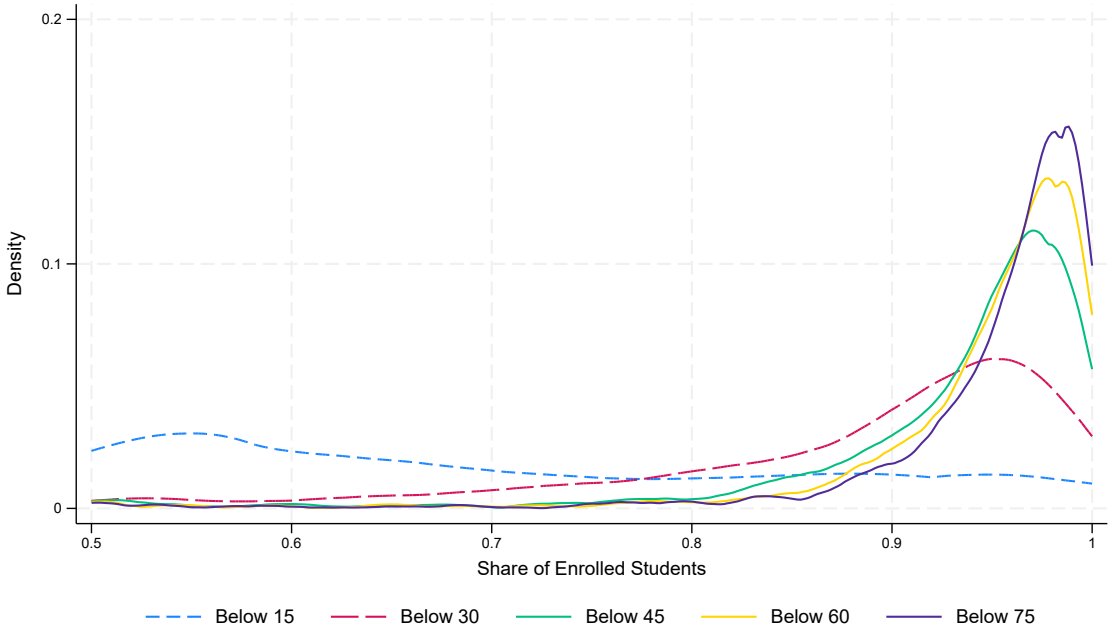
Notes: The figure illustrates Italian students' potential (higher) secondary education choices. The focus is on the options available to students who choose the academic track. These were the options available before the *Gelmini* Reform, which entered into force in the academic year 2010/2011. My sample focuses on students who enrolled in the previous five academic years and therefore were exposed to this set of choices.

Figure 2: Distribution of School-Cohort Size: *PNI* vs. Traditional Schools



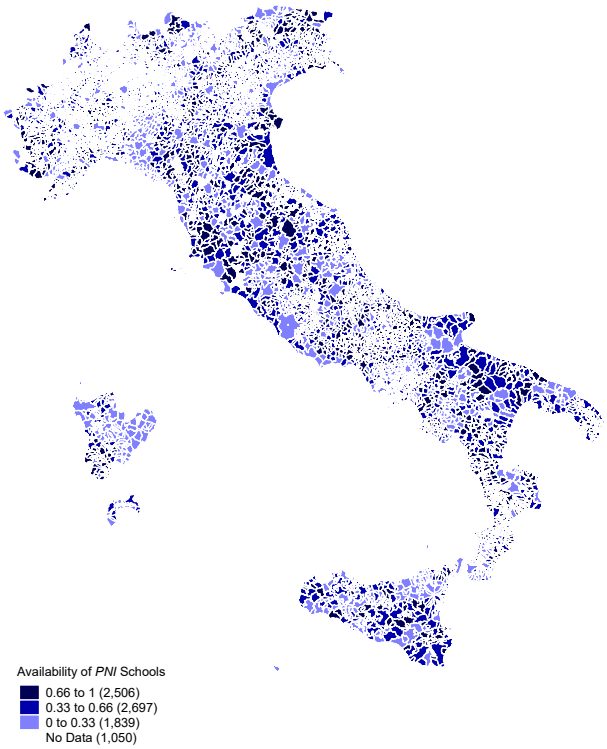
Notes: The graph shows the distribution of school-cohort size - as in, the number of students who, in a given academic year and from a given school, enroll in higher education - by school, separating between schools offering the *PNI* program and those offering only the Traditional one. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included in the cohorts. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The sample size is of 1,152 schools.

Figure 3: Share of Students of each *Liceo Scientifico* by Duration of their Commute



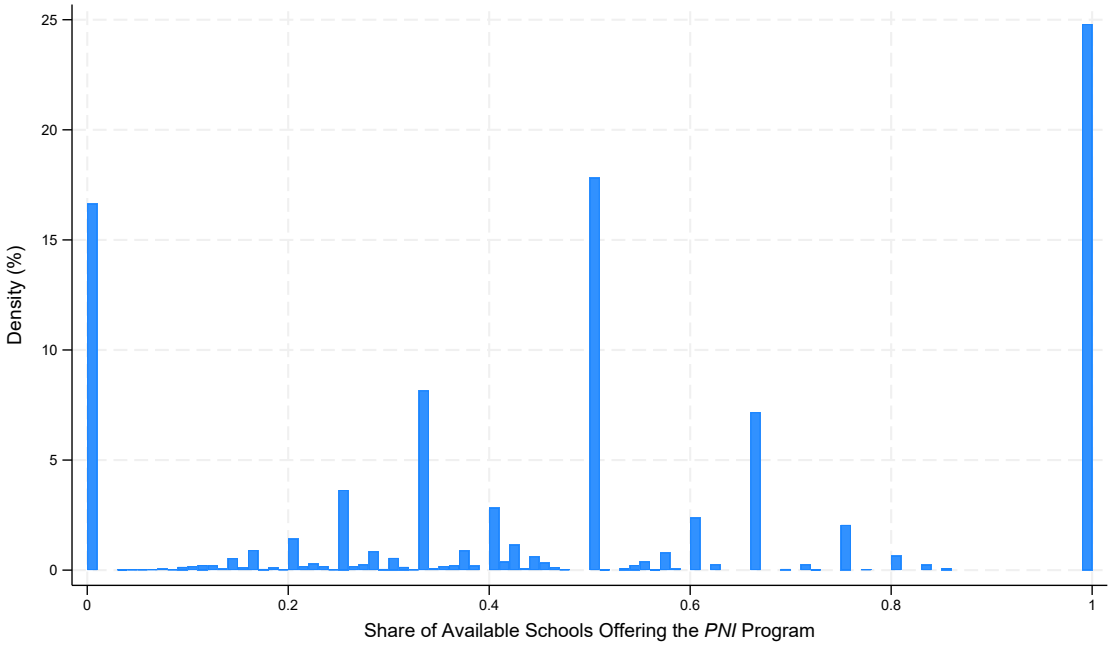
Notes: The graph shows the share of students enrolled in all the academic track scientific high schools in Italy by the duration of their commute to school. Commute time is calculated using the Google Maps API, simulating a trip by car. I include the students who achieve a diploma at *Liceo Scientifico* (the scientific curriculum of the academic-track high schools) and then enroll in higher education. I exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The sample size is 1,152.

Figure 4: The Instrumental Variable: Map of the Availability of *PNI* Schools



Notes: The graph maps the between-municipalities variation of the instrumental variable, the share of schools offering a *PNI* program available to residents of a certain municipality. It is calculated by linking each school to all the municipalities of residence of the students enrolled, excluding those with a commute longer than 60 minutes (estimated using Google Maps API as the time required to drive from the student municipality of residence to the street address of the school). The number of observations per category is reported in parenthesis. I exclude all municipalities and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The sample size is 7,042 municipalities. That does not include the 692 for which there are no data (189 of those located in the provinces I exclude).

Figure 5: The Instrumental Variable: Availability of *PNI* Schools



Notes: The graph shows the distribution of the instrumental variable, the share of schools offering a *PNI* program available to residents of a certain municipality. The numerator of this variable is the number of *PNI* schools to which students could have enrolled, depending on their municipality of residence. The denominator consists of the total number of academic track scientific high schools available to residents of that same municipality. Only schools requiring a commute below 60 minutes are included in the numerator and denominator. I exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The sample size is 7,042.

Table 1: Timetables for Traditional and *PNI Liceo Scientifico*

	Traditional					PNI				
Subjects	I	II	III	IV	V	I	II	III	IV	V
Italian	4	4	4	3	4	4	4	4	3	4
Latin	4	5	4	4	3	4	5	4	4	3
Ancient Greek	-	-	-	-	-	-	-	-	-	-
Mathematics	5	4	3	3	3	5	5	5	5	5
Physics	-	-	2	3	3	2	3	3	3	3
Natural Sciences, Chemistry, and Geography	2	2	3	3	2	2	2	3	3	2
Foreign Language and Literature	3	4	3	3	4	3	4	3	3	4
History	3	2	2	2	3	3	2	2	2	3
Philosophy	-	-	2	3	3	-	-	2	3	3
Art History	2	2	2	2	2	2	2	2	2	2
Physical Education	2	2	2	2	2	2	2	2	2	2
Religion	1	1	1	1	1	1	1	1	1	1
Total	25	27	28	29	30	28	31	31	31	32

Notes: The table shows the differences in weekly timetable between the Traditional and the *PNI* program of *Liceo Scientifico*, for each of the 5 years of secondary education.

Table 2: University Students by Diploma Type and Academic Year

Academic Year	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Total
Scientific Studies	0.410	0.418	0.418	0.411	0.408	0.413
Classical Studies	0.176	0.175	0.174	0.165	0.162	0.170
Linguistic Studies	0.061	0.060	0.059	0.060	0.065	0.061
Pedagogical Studies	0.071	0.073	0.071	0.076	0.072	0.073
Non-Academic Tracks	0.282	0.274	0.279	0.288	0.284	0.283
Number of Students	200,909	197,100	191,946	190,248	191,978	972,181

Notes: The table shows the share of students graduating from high school who enroll in higher education, by academic year and type of high school. I separate between each of the academic-track high schools(*Liceo Scientifico*, *Liceo Classico*, *Liceo Linguistico*, and *Liceo Pedagogico*) and technical or vocational curricula. Students who failed one year or more are excluded, as well as those who do not immediately enter higher education after achieving their diploma.

Table 3: University Students' Characteristics by Diploma Type

	High School Curriculum				
Variables	Scientific	Classical	Linguistic	Pedagogical	Non-Academic
Percentage of Girls	0.496	0.706	0.867	0.911	0.467
	(0.500)	(0.456)	(0.340)	(0.285)	(0.499)
High School Mark	80.245	82.080	80.984	79.617	79.343
	(11.802)	(11.900)	(11.379)	(11.287)	(11.469)
STEM Enrollment	0.244	0.144	0.073	0.083	0.177
	(0.430)	(0.351)	(0.261)	(0.276)	(0.382)
First Year ECTS	41.783	42.573	44.147	41.032	38.290
	(17.734)	(18.608)	(18.714)	(18.396)	(18.937)
Dropout Rate	0.452	0.443	0.430	0.494	0.572
	(0.498)	(0.497)	(0.495)	(0.500)	(0.495)
Number of Students	401,536	165,596	59,175	70,540	275,334

Notes: The table shows student characteristics by the type of high school attended for students who enrolled in higher education between 2010/2011 and 2014/2015. I separate between each of the academic-track high schools(*Liceo Scientifico*, *Liceo Classico*, *Liceo Linguistico*, and *Liceo Pedagogico*) and technical or vocational curricula. Students who failed one year or more are excluded, as well as those who do not immediately enter higher education after achieving their diploma. High School Mark is expressed on a scale from 60 to 100 (a score below 60 implies failing to pass the exam). ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year. I consider dropouts students who officially abandon their degree and those who remain enrolled but have not concluded their studies as of the academic year 2022/2023. The total number of observations is 978,754. Standard deviations are in parentheses.

Table 4: Characteristics of *Liceo Scientifico* Graduates, by *PNI* Status

	Liceo Scientifico		
Variables	Traditional	*PNI*	P-value of the Difference
Share of Girls	0.488	0.499	0.000
	(0.500)	(0.500)	
Diploma Score	79.757	80.474	0.000
	(11.955)	(11.724)	
STEM Enrollment	0.233	0.249	0.000
	(0.423)	(0.433)	
First Year ECTS	40.539	42.346	0.000
	(18.040)	(17.565)	
Dropout Rate	0.484	0.438	0.000
	(0.500)	(0.496)	
Number of Students	118,191	279,928	

Notes: The table shows student characteristics by the type of high school attended for students who enrolled in higher education between 2010/2011 and 2014/2015. I separate between students who graduated from a *Liceo Scientifico* offering the *PNI* program or the traditional program only. I perform a t-test to assess the difference, with the null hypothesis stating that the means are equal. Students who failed one year or more are excluded, as well as those who do not immediately enter higher education after achieving their diploma. High School Mark is expressed on a scale from 60 to 100 (a score below 60 implies failing to pass the exam). ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year. I consider dropouts students who officially abandon their degree and those who remain enrolled but have not concluded their studies as of the academic year 2022/2023. I exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The total number of observations is 400,420. Standard deviations are in parentheses.

Table 5: Characteristics of the High Schools, by *PNI* Status

Variables	*Liceo Scientifico* Traditional	*PNI*	P-value of the Difference
Characteristics of the High Schools			
Average Number of Students (by cohort)	43	97	0.000
Median Number of Students (by cohort)	31	88	
	(39.241)	(56.223)	
Average Commute Time (in minutes)	11	9	0.000
Median Commute Time (in minutes)	10	8	
	(8.114)	(7.284)	
Demographic Characteristics of the Schools' Municipalities			
Average Population	334,758	231,882	0.000
Median Population	42,602	33,669	
	(671,256)	(580,884)	
Average Population (residents per square KM)	1,794	1,268	0.000
Median Population (residents per square KM)	893	591	
	(2,178)	(1,776)	
Percentage in Rural Municipality	3.33	3.49	0.864
	(17.89)	(18.31)	
Percentage in Urban Municipality	72.50	81.61	0.000
	(44.68)	(38.75)	
Percentage in Metropolitan Municipality	24.17	14.90	0.000
	(42.85)	(35.64)	
Number of Schools	575	577	

Notes: The table shows the characteristics of the *Liceo Scientifico* high schools in the sample and the municipalities where they are located, over the academic years 2010/2011 and 2014/2015. I also provide the percentage of schools by type of municipality (along the rural, urban, and metropolitan categories). I compare the high schools offering the *PNI* program and those offering only the traditional program. I perform a t-test to assess the difference, with the null hypothesis stating that the means are equal. Standard deviations are in parentheses.

Table 6: Regional Distribution of *PNI* Schools and *PNI* Students

	PNI Schools			*PNI* Students		
Region	Traditional	*PNI*	Total	Traditional	*PNI*	Total
Piemonte	53.85	46.15	78	32.96	67.04	24,417
Lombardia	54.02	45.98	174	30.10	69.90	51,759
Trentino Alto-Adige	75.00	25.00	12	50.23	49.77	2,652
Veneto	54.76	45.24	84	32.76	67.24	27,777
Friuli Venezia Giulia	38.10	61.90	21	18.92	81.08	7,396
Liguria	43.48	56.52	23	21.52	78.48	8,874
Emilia Romagna	46.03	53.97	63	25.98	74.02	22,856
Toscana	37.31	62.69	67	17.52	82.48	22,017
Umbria	25.00	75.00	16	21.82	78.18	5,995
Marche	35.48	64.52	31	22.07	77.93	10,073
Lazio	48.72	51.28	117	24.94	75.06	40,947
Abruzzo	60.00	40.00	30	26.63	73.37	11,192
Molise	30.00	70.00	10	17.13	82.87	2,849
Campania	60.00	40.00	150	40.35	59.65	57,493
Puglia	44.71	55.29	85	28.89	71.11	34,651
Basilicata	45.00	55.00	20	43.63	56.37	5,139
Calabria	32.69	67.31	52	24.04	75.96	17,638
Sicilia	54.05	45.95	111	28.17	71.83	38,219
Sardegna	71.43	28.57	21	57.38	42.62	6,175
Total	575	577	1,152	118,191	279,928	398,119
Percent	50.57	49.43	100	29.69	70.31	100

Notes: The table shows the percentage of the high schools offering the *PNI* program and the number of students attending them, by region. I include only students who graduated from a *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, who did not fail one year or more years, and who did not immediately enter higher education after achieving their diploma. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*.

Table 7: Balance Checks: *PNI* Availability and Municipality Characteristics

Outcome Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Labor Force Participation		Employment		Foreign-Born Residents	
Share of Available *PNI*	-0.005**	0.0003	0.001	-0.001	-0.004***	-0.002
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Mean of the Outcome	0.50	0.50	0.89	0.89	0.06	0.06
SD of the Outcome	0.06	0.06	0.06	0.06	0.04	0.04
Observations	7,042	7,042	7,042	7,042	7,042	7,042
Province Fixed Effects	X	X	X	X	X	X
Municipality Type		X		X		X

Outcome Variable	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Women's LFP		Women's Employment		Women in ECs		Abortion Restrictions	
Share of Available *PNI*	-0.008***	-0.003	-0.001	-0.003	0.009	0.006	0.015***	0.008**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.003)	(0.003)
Mean of the Outcome	0.40	0.40	0.87	0.87	0.17	0.17	0.34	0.34
SD of the Outcome	0.07	0.07	0.08	0.08	0.19	0.19	0.11	0.11
Observations	7,042	7,042	7,042	7,042	6,926	6,926	7,018	7,018
Province Fixed Effects	X	X	X	X	X	X	X	X
Municipality Type		X		X		X		X

Notes: I estimate the relationship between the characteristics of the municipalities of residence of the students in my sample and the share of available schools offering the *PNI* program (Equation 3). The share of available *PNI* is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. The dependent variables showed in the top panel are: the share of residents (above 15 years of age) who are in the labor force; the share of residents in the labor force who are employed; the share of foreign-born residents (of any age). The dependent variables showed in the bottom panel are: the share of female residents (above 15 years of age) who are in the labor force; the share of female residents in the labor force who are employed; the share of elected women administrators in the municipality executive committee (ECs), which is appointed by the elected major and carries out day-to-day governance; and the share of voters in the municipality who supported the restricting access to abortion in the 1981 abortion referendum. I control for province fixed effects and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. I exclude all municipalities from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the municipality level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: Relationship Between *PNI* Availability and Alternative Academic Track Choices

Outcome Variable	(1)	(2)	(3)
	Probability of Choosing *Liceo Scientifico*		
Share of Available *PNI*	0.027	0.030	0.030
	(0.029)	(0.024)	(0.024)
Mean of the Outcome	0.59	0.59	0.59
SD of the Outcome	0.49	0.49	0.49
Observations	704,150	704,149	704,146
Province Fixed Effects		X	X
Cohort Fixed Effects		X	X
Cohort-Province Fixed Effects			X

Notes: I estimate the relationship between the probability of choosing to attend a *Liceo Scientifico* and the share of available schools offering the *PNI* program (Equation 4). The share of available *PNI* is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I progressively add categorical variables controlling for province and cohort fixed effects (column (2)), and then for their interaction (column (3)). The association is estimated at the student level, including all students enrolled in academic track schools (*Liceo Classico*, *Liceo Linguistico*, *Liceo Pedagogico*, and *Liceo Scientifico*). I include students who graduated between the academic years 2010/2011 and 2014/2015, did not repeat one or more years of high school, and enrolled immediately in higher education. I exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9: 2SLS Estimates: High School Outcomes

	(1)	(2)	(3)	(4)
Outcome Variable	Log of High School Mark		Probability of Repeating a Year	
Specification	OLS	2SLS	OLS	2SLS
PNI	0.005***	0.006	-0.022***	0.002
	(0.002)	(0.005)	(0.005)	(0.008)
First-Stage	-	0.570***	-	0.567***
	-	(0.038)	-	(0.035)
F-statistic	-	172.14	-	189.31
Mean of the Outcome	80.30	80.30	0.10	0.10
SD of the Outcome	11.80	11.80	0.30	0.30
Observations	398,119	398,119	441,786	441,786
Cohort-Province Fixed Effects	X	X	X	X
Gender	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X
Type of Municipality	X	X	X	X

I estimate the relationship between the logarithmic transformation of the final high school mark (which is received after completing the final high school exam and ranges between 60 and 101), whether a student repeated at least one year in high school, and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1. I use an OLS estimator in the odd-numbered columns and a 2SLS estimator in the even-numbered ones. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, gender, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico* and graduated between the academic years 2010/2011 and 2014/2015 are included. Additionally, when I estimate the effect on high school mark I consider only those who did not repeat one or more years and who enrolled immediately in higher education; when I estimate the effect on the probability of repeating one year, I only include students who enrolled immediately in higher education. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10: 2SLS Estimates: Probability of Choosing a STEM Degree

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome Variable	STEM		Dropout		Performance	
Specification	OLS	2SLS	OLS	2SLS	OLS	2SLS
PNI	0.005	0.010	-0.021***	-0.019*	0.031***	0.007
	(0.004)	(0.008)	(0.004)	(0.010)	(0.005)	(0.014)
First-Stage	-	0.570***	-	0.570***	-	0.566***
	-	(0.038)	-	(0.038)	-	(0.038)
F-statistic	-	172.14	-	172.14	-	160.32
Mean of the Outcome	0.25	0.25	0.45	0.45	41.86	41.86
SD of the Outcome	0.43	0.43	0.50	0.50	17.70	17.70
Observations	398,119	398,119	398,119	398,119	360,970	360,970
Cohort-Province Fixed Effects	X	X	X	X	X	X
Gender	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X

Notes: I estimate the relationship between the outcomes of interest and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1. The outcomes are: probability of choosing a STEM degree ("STEM"), the probability of dropping out from higher education ("Dropout") and students' performance during their first year of university ("Performance", which is proxied by the number of credits, ECTS, acquired during the first academic year. ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year). I use an OLS estimator in the odd-numbered columns and a 2SLS estimator in the even-numbered ones. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, gender, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 11: 2SLS Estimates: Heterogeneity by Gender

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome Variable	STEM		Dropout		Performance	
Subsample	Boys	Girls	Boys	Girls	Boys	Girls
PNI	0.021*	0.003	-0.022	-0.017	0.009	0.005
	(0.012)	(0.010)	(0.014)	(0.012)	(0.020)	(0.015)
First-Stage	0.561***	0.578***	0.561***	0.578***	0.555***	0.574***
	(0.039)	(0.038)	(0.039)	(0.038)	(0.039)	(0.038)
F-statistic	225.62	179.11	225.62	179.11	208.90	170.00
Mean of the Outcome	0.26	0.23	0.48	0.42	40.68	43.01
SD of the Outcome	0.44	0.42	0.50	0.49	18.03	17.29
Observations	201,055	197,058	201,055	197,058	178,840	182,227
Cohort-Province Fixed Effects	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X

Notes: I estimate the relationship between the outcomes of interest and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1, for boys and girls separately. The outcomes are: probability of choosing a STEM degree ("STEM"), the probability of dropping out from higher education ("Dropout") and students' performance during their first year of university ("Performance", which is proxied by the number of credits, ECTS, acquired during the first academic year. ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year). I use a 2SLS estimator in all columns. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 12: 2SLS Estimates: *PNI* and Local Gender Norms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome Variable	STEM		Dropout		Performance		STEM		Dropout		Performance	
Subsample	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
	1st Quartile of Conservative Gender Norms (Approval Rate: 21%)						2nd Quartile of Conservative Gender Norms (Approval Rate: 29%)					
PNI	0.030	-0.027	-0.037	-0.019	0.011	-0.009	0.036*	0.002	-0.027	-0.024	0.010	-0.010
	(0.026)	(0.022)	(0.029)	(0.024)	(0.044)	(0.035)	(0.020)	(0.017)	(0.025)	(0.020)	(0.031)	(0.026)
First-Stage	0.453***	0.471***	0.453***	0.471***	0.445***	0.470***	0.590***	0.622***	0.590***	0.622***	0.583***	0.613***
	(0.061)	(0.058)	(0.061)	(0.058)	(0.061)	(0.058)	(0.070)	(0.065)	(0.070)	(0.065)	(0.069)	(0.065)
F-statistic	108.85	84.24	108.85	84.24	96.27	78.72	129.23	95.67	129.23	95.67	117.19	88.04
Mean of the Outcome	0.26	0.24	0.47	0.42	41.38	43.65	0.26	0.24	0.49	0.43	39.04	41.24
SD of the Outcome	0.44	0.42	0.50	0.49	17.86	17.20	0.44	0.43	0.50	0.50	17.95	17.19
Observations	61,260	60,029	61,260	60,029	54,992	55,545	75,567	70,400	75,567	70,400	66,177	64,520
Cohort-Province Fixed Effects	X	X	X	X	X	X	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X	X	X	X	X	X	X

	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Outcome Variable	STEM		Dropout		Performance		STEM		Dropout		Performance	
Subsample	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
	3rd Quartile of Conservative Gender Norms (Approval Rate: 36%)						4th Quartile of Conservative Gender Norms (Approval Rate: 49%)					
PNI	-0.001	-0.010	-0.002	-0.010	0.014	-0.0003	0.025	0.067***	-0.009	-0.015	-0.022	0.023
	(0.021)	(0.019)	(0.024)	(0.021)	(0.037)	(0.026)	(0.026)	(0.023)	(0.032)	(0.027)	(0.043)	(0.031)
First-Stage	0.612***	0.624***	0.612***	0.624***	0.610***	0.622***	0.622***	0.582***	0.622***	0.582***	0.592***	0.574***
	(0.070)	(0.067)	(0.070)	(0.067)	(0.070)	(0.066)	(0.066)	(0.065)	(0.066)	(0.065)	(0.060)	(0.065)
F-statistic	62.47	52.27	62.47	52.27	60.47	50.91	86.44	81.07	86.44	81.07	84.29	78.55
Mean of the Outcome	0.27	0.23	0.47	0.42	41.09	43.32	0.26	0.21	0.44	0.39	43.66	46.22
SD of the Outcome	0.44	0.42	0.50	0.49	18.18	17.42	0.44	0.41	0.50	0.49	17.94	16.99
Observations	42,475	43,378	42,475	43,378	37,915	40,356	20,997	22,425	20,997	22,425	19,002	21,047
Cohort-Province Fixed Effects	X	X	X	X	X	X	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X	X	X	X	X	X	X

Notes: I estimate the relationship between the outcomes of interest and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1, for boys and girls separately, based on the quartile of the distribution of conservative gender norms of their municipality of residence. Gender norms are calculated using the share of votes in favor of the conservative norm in the 1981 abortion referendum. The outcomes are: probability of choosing a STEM degree ("STEM"), the probability of dropping out from higher education ("Dropout") and students' performance during their first year of university ("Performance", which is proxied by the number of credits, ECTS, acquired during the first academic year. ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year). I use a 2SLS estimator in all columns. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix A: Robustness Exercises

To ensure that the gender-specific estimates are not driven by specific modeling choices, I perform a set of robustness checks altering key control variables and sample restrictions. While my baseline model includes controls for municipality type (rural, urban, or metropolitan) and school size terciles, I test whether the results are robust to alternative classifications — specifically, school-cohort size quintiles and terciles of municipality population. Additionally, I examine whether excluding students who repeated a year in high school affects the findings.

Alternative Controls for School-Cohort Size and Municipality Population

The results of these alternative specifications are reported in columns (3) to (6) of Table A1. Across all alternative categorizations, the estimated effects of attending a *PNI* school on STEM enrollment remain consistent with those obtained from the baseline specification shown in columns (1) and (2). Both the size and significance of the coefficients are stable, suggesting that the original findings are not sensitive to how school or municipality characteristics are defined. These robustness checks help validate that the estimated gender heterogeneity in treatment effects is not an artifact of the specific control variables included.

Including Students Who Repeated One Year of High School

In a second robustness exercise, presented in Table A2, I re-estimate the model including students who repeated one or more years in high school. The results confirm that the impact on STEM enrollment remains effectively unchanged for both boys and girls. Interestingly, the inclusion of these students increases the precision of the estimates on dropout, which become statistically significant for both genders. This result may reflect a broader effect of the *PNI* program on academic preparation during high school, potentially equipping even less academically successful students with the skills needed to persist in higher education.

Table A1: Robustness Exercise: Alternative Controls for School-Cohort Size and Municipality Population

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome Variable	STEM					
Subsample	Boys	Girls	Boys	Girls	Boys	Girls
PNI	0.021*	0.003	0.021*	0.003	0.020*	-0.003
	(0.012)	(0.010)	(0.012)	(0.010)	(0.022)	(0.011)
First-Stage	0.561***	0.578***	0.562***	0.578***	0.498***	0.525***
	(0.039)	(0.038)	(0.038)	(0.037)	(0.036)	(0.035)
F-statistic	225.62	179.11	214.09	154.49	216.64	173.43
Mean of the Outcome	0.26	0.23	0.26	0.23	0.26	0.23
SD of the Outcome	0.44	0.42	0.44	0.42	0.44	0.42
Observations	201,055	197,058	201,055	197,058	201,055	197,058
Cohort-Province Fixed Effects	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	-	-	X	X
Quintile of School-Cohort Size	-	-	X	X	-	-
Type of Municipality	X	X	X	X	-	-
Tercile of Municipality Population	-	-	-	-	X	X

Notes: I estimate the relationship between the probability of choosing a STEM degree ("STEM") and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program, for boys and girls separately. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I always control for cohort-by-province fixed effects. In columns (1) and (2), I estimate Equation 1, which includes a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. In columns (3) and (4), I instead include a categorical variable representing the quintile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. In columns (5) and (6), I instead include a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable representing the tercile of municipality population. I show the coefficient of the first-stage regression and the relative F-statistic, modifying Equation 2 accordingly. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: Robustness Exercise: Including Students Who Repeat One Year in High School

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome Variable	STEM		Dropout		Performance	
Subsample	Boys	Girls	Boys	Girls	Boys	Girls
PNI	0.021*	0.008	-0.031**	-0.019*	0.025	0.007
	(0.011)	(0.010)	(0.014)	(0.011)	(0.021)	(0.016)
First-Stage	0.556***	0.576***	0.556***	0.576***	0.551***	0.573***
	(0.039)	(0.038)	(0.039)	(0.038)	(0.039)	(0.038)
F-statistic	249.55	191.83	249.55	191.83	229.96	180.95
Mean of the Outcome	0.25	0.22	0.50	0.43	39.85	42.52
SD of the Outcome	0.43	0.42	0.50	0.50	18.25	17.46
Observations	228,590	213,194	228,590	213,194	199,577	195,517
Cohort-Province Fixed Effects	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X

Notes: I estimate the relationship between the outcomes of interest and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1, for boys and girls separately. The outcomes are: probability of choosing a STEM degree ("STEM"), the probability of dropping out from higher education ("Dropout") and students' performance during their first year of university ("Performance", which is proxied by the number of credits, ECTS, acquired during the first academic year. ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year). I use a 2SLS estimator in all columns. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico* and who enrolled in higher education between the academic years 2010/2011 and 2014/2015 immediately after finishing high school are included. I also exclude all students and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix B: Gender Attitudes and the 1981 Referendum on Abortion

In this section, I provide a more extensive discussion to support the choice of using a historically rooted proxy for gender norms: the outcome of the 1981 abortion referendum in Italy. In that referendum, citizens were asked to vote on a conservative proposal that sought to significantly restrict access to abortion, effectively undoing many of the rights granted by a 1978 law. While the proposal was ultimately rejected at the national level, participation was high, and the results revealed substantial variation in attitudes. Support for the policy ranged widely across municipalities, from less than 4% in the more progressive to over 80% in the more conservative.

Support for restrictive abortion laws — like the one proposed in the 1981 referendum — reflects a broader endorsement of traditional gender roles, particularly those that assign women a primary role in the private sphere as caregivers and mothers. Such views are often associated with resistance to women's full participation in public life, including both the labor market and political institutions.[17]

Municipalities with higher support for the conservative proposal are likely to have harbored more traditional attitudes toward gender roles at the time — attitudes that may continue to shape local norms and behaviors today through cultural persistence and intergenerational transmission. A large body of research shows that cultural traits, including gender norms, are remarkably persistent. Becker et al. (2016) show that long-gone institutional environments continue to influence present-day civic attitudes and trust in public administration. On gender-specific dimensions, Alesina et al. (2013) find that regions with historically rigid gender divisions of labor, rooted in practices as far back as the Neolithic era, exhibit lower gender equality today. Similarly, Fernández (2007) documents the intergenerational transmission of gender norms, emphasizing their stability over time and their enduring influence on female labor market participation and educational choices. Stronger evidence comes from two recent studies that apply a similar approach to mine (Kaiser and Mata, 2025; Arni et al., 2024). Both examine the 1981 Swiss referendum, in which voters were asked to confirm a law granting equal rights to men and women in family, work, and social life. The level of support for the law is shown to predict both the likelihood of men applying to traditionally male-dominated occupations and the ratio of female-to-male-founded startups across regions more than 40 years later.

On the other hand, the literature has made extensive use of indicators based on labor market outcomes — most notably, the ratio between women's and men's labor force participation — to proxy for gender norms (Meluzzi, 2024; Jayachandran, 2015; Fogli and Veldkamp, 2011; Fernández and Fogli, 2009; Fortin, 2005). While informative, these measures can easily conflate cultural and structural economic factors, making it difficult to disentangle norms from labor market conditions or policy constraints. However, using local preferences for the suppression of the abortion law also has potential drawbacks. Attitudes may have evolved since 1981, and referenda often reflect issue-specific beliefs, which may not perfectly align with broader views on gender roles. Moreover, the literature that exploits public votes to proxy for prevailing gender norms is still relatively underdeveloped, with only two studies set in Switzerland adopting a similar strategy to mine (Kaiser and Mata,

[17] Several studies link opposition to abortion rights with broader adherence to traditional gender roles. Deckman and McTague (2015) show that support for restrictive abortion policies correlates with conservative views about women's participation in the workforce and politics in the United States. Similarly, Norris et al. (2021) argue that abortion attitudes are a reliable indicator of value systems that resist gender equality. Most directly, Fröhlich and Ruedin (2023) provide cross-national evidence that abortion preferences are not only shaped by individual ideology, but also reflect deeply rooted cultural gender norms that affect both public opinion and women's political representation.

2025; Arni et al., 2024).

Still, in the context of my study, the referendum-based measure offers clear advantages. Since I am examining educational choices — especially the decision to pursue a STEM degree — using labor force participation rates as a proxy of gender attitudes presents a risk of conflating cultural attitudes with labor market incentives. A high female-to-male labor force participation ratio might reflect more progressive gender norms, but it might also be the result of economic necessity, job availability, or public childcare provision. As such, relying on labor market indicators to proxy cultural norms may blur the distinction between norms as constraints and economic conditions as drivers of behavior. By contrast, the referendum offers a more stable and meaningful measure of the cultural attitudes that shape educational trajectories. Although it took place roughly a decade before the students in my sample were born, it captures the normative environment in which their parents and local institutions were socialized — and which likely continued to influence expectations around gender roles during the students' childhood. Moreover, since high school choice in Italy is highly localized — students typically attend schools close to home — young people are especially likely to be exposed to the prevailing cultural norms of their municipality of residence. Referendum outcomes, being fixed in time and tied to place, provide a geographically and historically grounded proxy for those norms, avoiding the confounding influence of more mobile, contemporary labor market indicators.

In Table B1, I provide evidence on the validity of using the 1981 referendum results as a proxy for prevailing gender norms by estimating their relationship with women's participation in local labor markets and political institutions. Specifically, I examine three municipality-level indicators as of 2011: the ratio of female to male labor force participation, obtained from the Population Census; and the share of women among elected officials in city councils and executive committees, sourced from the Ministry of the Interior's Registry of Local and Regional Administrators.[18] All three outcomes display a strong and statistically significant negative association with support for the restriction of abortion rights.

The size of the effects is economically meaningful. A one-unit increase in support for the conservative proposal — which ranges from 0 to 1, with a mean of 0.34 and standard deviation of 0.112 — is associated with a 9.6 percentage point decline in the labor force participation ratio (13% of the mean, over one standard deviation), and a 3.3 to 5.9 percentage point reduction in the share of women in city councils. The strongest relationship emerges with women's representation in executive committees, where the association reaches 9.3 percentage points (over half a standard deviation). While the coefficient for labor force participation remains stable when adding controls for province fixed effects and municipality type (rural, urban, metropolitan), the estimates for women in political office become stronger, likely reflecting the fact that gender representation in politics is more sensitive to institutional and structural characteristics across municipal contexts. These results lend empirical support to interpreting the referendum outcome as a valid and historically grounded proxy for deeply rooted gender norms. They echo earlier findings in the literature documenting the intergenerational persistence of cultural attitudes, including those shaping women's roles in labor markets and political life (Alesina et al., 2013; Fernández, 2007).

[18] In Italian municipalities, the *consiglio comunale* (city council) is the elected legislative body responsible for approving budgets, regulations, and local policies. The *giunta comunale* (executive committee), by contrast, is appointed by the mayor and is responsible for implementing council decisions and managing daily administrative functions.

Table B1: Relationship Between Gender Norms Measures

	(1)	(2)	(3)	(4)	(5)	(6)
			Share of Women Elected in:			
Outcome Variable	Women-to-Men LFP		City Councils		City Executive Committees	
Support for Abortion Limitations	-0.096***	-0.084***	-0.033**	-0.060***	-0.078***	-0.093***
	(0.010)	(0.010)	(0.015)	(0.015)	(0.029)	(0.029)
Mean of the Outcome	0.67	0.67	0.15	0.15	0.17	0.17
SD of the Outcome	0.09	0.09	0.11	0.11	0.19	0.19
Observations	7,018	7,018	6,902	6,902	6,904	6,904
Province Fixed Effects	X	X	X	X	X	X
Type of Municipality		X		X		X

Notes: I estimate the relationship between the municipality-level support for the conservative abortion reform during the 1981 abortion referendum and three different dependent variables. One is the municipality-level ratio of women-to-men labor force participation as of 2011 (LFP), measured during the Italian National Census. The others are the municipality-level share of elected women administrators in the city council and the executive committee as of 2011, calculated using the Ministry of the Interior's Registry of Local and Regional Administrators. While the council functions as the local legislature, the executive committee is appointed by the mayor and carries out day-to-day governance. I control for province fixed effects (columns (1), (3), and (5)), and then for whether a municipality is considered rural, urban, or metropolitan (columns (2), (4), and (6)). I also exclude all municipalities from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the municipality level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix C: Breaking Down Results for Gender Norms

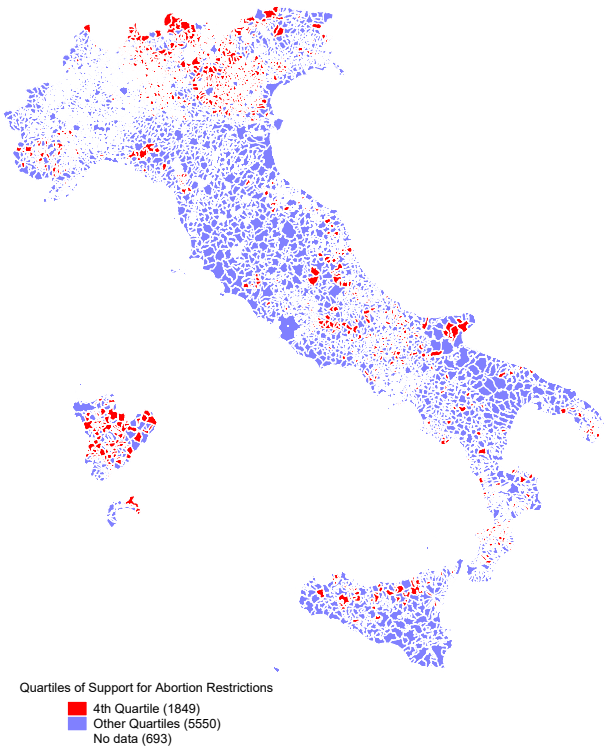
In this section, I provide a more elaborate breakdown of the variation behind the coefficients estimated using 2SLS, for girls in the 4th Quartile of Conservative Gender Norms - in other words, living in those municipalities that had the highest share of votes to restrict access to abortion during the 1981 referendum.

Figure C1 maps the municipalities in the top quartile of conservative gender norms across the national territory. A clear concentration emerges in the North-Eastern regions, particularly in *Veneto*, *Trentino Alto-Adige*, and the eastern part of *Lombardia*. However, their overall distribution does not align with a traditional North–South divide. Beyond simple geographical location, I assess in Table C1 how much each region contributes to the total number of girls living in these municipalities. As shown in column (2), more than 60% are located in *Lombardia* and *Veneto*, where their percentages are 3.5 and 4 times higher than their respective shares in the overall sample, reported in column (1). While *Trentino Alto-Adige* contributes less in absolute terms, it still displays a disproportionately high concentration relative to its national weight. Southern regions such as *Campania*, *Puglia*, *Calabria*, and *Sicilia* account for most of the remaining one-third of the subsample.

Because my identification strategy essentially relies on comparisons between treated and control students within cohort-by-province groups, I examine the data at that same level to better understand the source of the estimated effects. Due to the sample restriction to girls living in municipalities with the most conservative gender norms, these cohort-by-province cells are sometimes small or highly imbalanced. Roughly 5% of the cells contain fewer than 10 girls, and in about 20% of them, the number of students in one cell is less than 20% of the other. To assess whether these imbalances might be driving the results, I re-estimate the model under two increasingly restrictive sample criteria: the first requires each cell to include at least 10 girls and a treatment-to-control ratio no lower than 0.25; the second tightens the ratio threshold to 0.35. These checks allow me to test the robustness of the results to exclude highly imbalanced comparisons.

I present the results of these robustness checks in Table C2. The most immediate consequence of the restrictions is a substantial drop in sample size, as many of the more imbalanced cohort-by-province cells are excluded. While this reduction naturally affects both the size of the estimates, the magnitude of the effects remains relatively stable across specifications. In both restricted samples, the estimated coefficients are approximately 20% of the baseline probability of choosing a STEM degree. Their persistence under stricter sample criteria shows that they are not driven by a handful of highly imbalanced comparisons.

Figure C1: Location of the Municipalities with the Most Conservative Gender Norms



Notes: The graph highlights the municipalities belonging to the top quartile of conservative gender norms (in red) and those belonging to all other quartiles (in blue), separately. The quartiles of conservative gender norms are calculated using the percentage of votes received by the policy issuing restrictions on abortion during the 1981 referendum. The number of observations per category is reported in parenthesis. I exclude all municipalities in the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. The sample size is 7,634 municipalities. That does not include the 692 for which there are no data (189 of those located in the provinces I exclude).

Table C1: Regional Distribution of Girls Residents in Municipalities with Conservative Gender Norms

	(1)	(2)
	Percentage of Girls by Region within:	
Region	Girls' Population	4th Quartile of CGN
Piemonte	6.25	1.89
Lombardia	12.38	33.46
Trentino Alto-Adige	0.76	3.56
Veneto	6.90	28.01
Friuli Venezia Giulia	1.97	0.47
Liguria	2.15	0.08
Emilia Romagna	5.65	0.32
Toscana	5.67	0.47
Umbria	1.46	0.10
Marche	2.71	1.45
Lazio	9.28	1.01
Abruzzo	2.98	1.31
Molise	0.79	0.89
Campania	14.34	6.48
Puglia	8.92	7.98
Basilicata	1.51	0.35
Calabria	5.15	4.57
Sicilia	9.51	5.10
Sardegna	1.62	2.50
Total (%)	100	100
Number of Girls	197,058	22,425

Notes: The table breaks down regional differences in the percentage of girls who enroll in higher education (column (1)) and those who live in a municipality belonging to the 4th quartile of the conservative gender norms ("CGN") distribution (column (2)), based on the share of votes in favor of more restrictive abortion laws in the 1981 referendum. I include girls who graduated from a *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, who did not fail one year or more years, and who did not immediately enter higher education after achieving their diploma. I also exclude all girls and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*.

Table C2: Robustness Check: PNI and Local Gender Norms - Girls

	(1)	(2)	(3)	(4)	(5)	(6)
		Restriction #1			Restriction #2	
Outcome Variable	STEM	Dropout	Performance	STEM	Dropout	Performance
PNI	0.064**	0.037	0.020	0.048*	0.039	-0.039
	(0.026)	(0.030)	(0.034)	(0.028)	(0.039)	(0.037)
First-Stage	0.699***	0.699***	0.701***	0.783***	0.783***	0.787***
	(0.084)	(0.084)	(0.085)	(0.108)	(0.108)	(0.110)
F-statistic	73.12	73.12	73.16	70.92	70.92	71.97
Mean of the Outcome	0.22	0.40	46.03	0.21	0.39	45.99
SD of the Outcome	0.41	0.49	17.09	0.41	0.49	17.38
Observations	12,427	12,427	11,701	7,373	7,373	6,923
Cohort-Province Fixed Effects	X	X	X	X	X	X
Tercile of School-Cohort Size	X	X	X	X	X	X
Type of Municipality	X	X	X	X	X	X

Notes: I estimate the relationship between the outcomes of interest and attending an academic track scientific high school (*Liceo Scientifico*) offering the *PNI* program using Equation 1 for girls in the top quartile of the conservative gender norms distribution. Gender norms are calculated using the share of votes in favor of the conservative norm in the 1981 abortion referendum. I apply 2 different restrictions to the sample. Restriction #1 limits the sample to girls in cohort-by-province cells where both the treatment and control groups include at least 10 individuals, and where the ratio of treated to control girls (or vice versa) is no lower than 0.25. Restriction #2 limits the sample to girls in cohort-by-province cells where both the treatment and control groups include at least 10 individuals, and where the ratio of treated to control girls (or vice versa) is no lower than 0.35. The outcomes are: probability of choosing a STEM degree ("STEM"), the probability of dropping out from higher education ("Dropout") and students' performance during their first year of university ("Performance", which is proxied by the number of credits, ECTS, acquired during the first academic year. ECTS are granted upon exam completion, and students can acquire a maximum of 60 during each academic year). I use a 2SLS estimator in all columns. I instrument *PNI* assignment using the share of available *PNI*, which is the ratio between the number of *Liceo Scientifico* schools offering the *PNI* option and the number of *Liceo Scientifico* schools within a 60-minute commute from the municipality of residence of the student. I show the coefficient of the first-stage Equation 2 regression and the relative F-statistic. I control for cohort-by-province fixed effects, a categorical variable representing the tercile number of students in the school-cohort group, and a categorical variable indicating whether a municipality is considered rural, urban, or metropolitan. Only students who attended *Liceo Scientifico*, who enrolled in higher education between the academic years 2010/2011 and 2014/2015, did not repeat one or more years, and enrolled immediately in higher education are included. I also exclude all girls and schools from the provinces of *Aosta*, *Alto-Adige*, *Carbonia-Iglesias*, *Medio Campidano*, *Ogliastra*, and *Olbia-Tempio*. Standard errors are clustered at the school level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.