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IZA DP No. 17084

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ABSTRACT

Single-Sex vs. Coeducational Schooling and STEM: Comparing Australian Students with Similar University Admission Scores*

This study investigates the impact of single-sex versus coeducational schooling on students' decisions to pursue STEM fields at the university level. Using administrative data from eight undergraduate cohorts (2012-2019) at a prominent Australian university, we compare students with similar Australian Tertiary Admissions Ranks (ATARs) who could have feasibly enrolled in either school type of comparable quality under different circumstances. We control for individual characteristics and the academic quality of the high schools attended. Our primary outcomes are the proportion of students from each school type choosing a STEM major and their weighted average marks for each year of university studies. Contrary to expectations, we find no evidence that a single-sex high school background increases STEM participation among girls at the university level. Interestingly, students from single-sex high schools show a higher propensity to choose a business major. Additionally, we find that the linear correlation between ATAR scores and first-year university grades is approximately 0.4. However, our analysis suggests that this relationship is better characterized as nonlinear rather than linear.

JEL Classification: I21, I23, J24

Keywords: single-sex schooling, coeducational, STEM, academic performance, Australia

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1. Introduction

One of the longstanding debates in educational circles revolves around the efficacy of single-sex versus coeducational high schools. The idea that boys and girls learn differently – and should therefore be placed in different learning environments – is consistent with many people's core beliefs about gender. There is a long-held view that single-sex education has advantages (especially academic) for girls, while coeducation has advantages (especially social) for boys (Jackson and Bisset, 2005). Consistent with this view, in Australia, there are more single-sex schools for girls than for boys (7% compared to 5%) and this pattern is more marked in some states than in others (Forgasz and Leder, 2020).[1]

Advocates on both sides present compelling arguments regarding the merits and drawbacks of each educational model (Lee and Bryk, 1986; Marsh, 1989; Morse, 1998; Mael et al., 2005; Pahlke and Hyde, 2016). For example, it has been argued that single-sex high schools can provide an environment free from certain distractions that might arise in coeducational settings, as well as allowing students to have increased confidence and participation in classroom discussions and extracurricular activities. On the other hand, proponents of coeducational schools point out that coeducational settings better prepare students for the realities of the world beyond school, where they will interact and collaborate with individuals of all genders in their personal and professional lives. In addition, coeducational schools have the potential to challenge and break down traditional gender stereotypes by promoting equality and mutual respect between genders.

As women remain underrepresented in STEM (Science, Technology, Engineering, and Mathematics) jobs and among STEM degree holders, a critical aspect that demands exploration is how differing school environments may influence students' decisions regarding pursuing STEM subjects at university. According to the STEM Equality Monitor for 2023, in Australia in 2021, women only made up 37% of enrollments in university STEM courses and 27% of the workforce across all STEM industries.[2] There are consequences for the gender disparity in STEM. Recent data for the US and Canada suggest that in both countries the gender gap in the likelihood of graduating with a STEM-related degree explains up to a fifth of the wage gap between younger college-educated men and women (Card and Payne, 2020).

In recent years, there has been a growing emphasis on encouraging students, particularly young women, to pursue STEM fields to address the global demand for skilled professionals in these areas.[3] As STEM skills are now required for many jobs in the world's fastest-growing industries,

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[1] The media also highlights that there is now increasing pressure for boys' schools to become coeducational, while at the same time, demand for all-girls school is increasing. For example, see: https://www.smh.com.au/national/nsw/undeniable-trend-boys-schools-feel-the-pressure-to-go-co-ed-20230208-p5cizf.html and https://www.theeducatoronline.com/k12/news/demand-for-sydney-allgirls-schools-soaring--survey/282020.

[2] See: https://www.industry.gov.au/publications/stem-equity-monitor.

[3] Data from the nationally representative Longitudinal Survey of Australian Youth (LSAY) collected from students who were 15 years of age in 2009 show that, in all schools, boys are overrepresented in physical science courses and careers, while girls are overrepresented in life science (Sikora, 2014).

in an effort to address the gender disparity in STEM, the Australian Government has introduced a range of programs and initiatives such as awarding undergraduate and postgraduate scholarships to women in STEM, developing partnerships with industry to grow the pool of future women in STEM, supporting STEM experts to become visible media and public role models, and appointing a 'Women in STEM Ambassador' whose primary role is to mobilise Australia's business leaders, educators and policymakers to increase the participation of women and girls in STEM.

It is crucially important to comprehend the impact of the educational setting during the developmental years on such decisions. Developing policies to harness the potential of women to contribute further to this vital sector requires an understanding of how gender is currently related to participation and success in STEM jobs (Noonan, 2017).

Single-sex high schools and coeducational high schools offer distinct social, academic, and psychological environments, which can significantly shape students' attitudes and interests.[4] Such differing environments can also affect confidence levels in STEM subjects. The relative comparison of one's own academic strengths and weaknesses with respect to one's classmates can affect a student's decision to select and specialize in a STEM field. Landaud et al. (2018) find that gaining admission to more selective coeducational high schools (with more highly achieving peers) in France induces a significant decrease in the probability that girls choose science and a symmetrical increase in the probability that they choose humanities one year later. In addition, performance relative to peers in STEM subjects appears to matter for females in making their choice regarding field of study in college. Buser et al. (2017) conducted an experiment among lower-secondary school students from a coeducational setting in Switzerland. They find that students who compete are significantly more likely to choose a math-intensive specialization more than one-and-a-half years later, and that the gender difference in competitiveness between boys and girls (with boys more likely to compete) can explain a significant portion of the gender difference in specialization choices. Goulas et al. (2020) find using high school data from Greece that females who are assigned to classroom peers among which they have a higher comparative STEM advantage are more likely to choose a STEM school track and apply to a STEM degree.

Hundreds of empirical studies have investigated the effects of single-sex schooling on academic outcomes as well as other outcomes such as indicators of individual student adaptation and socioemotional development. The results have been inconclusive and mixed (Pahlke et al., 2014; Robinson et al., 2021). Some studies suggest that students in single-sex schools outperform their peers in coeducational schools, whereas others suggest no difference (or even have a benefit for students in coeducational schools). However, only a few of these

[4] A recent example highlighting strong public sentiments regarding school type, which received extensive media attention, is the case of Newington College in New South Wales, Australia. Numerous former students and parents believe that the decision to transition a prestigious boys' school to a coeducational format will disrupt a cherished tradition, prompting them to publicly protest against the change. See: https://www.news.com.au/lifestyle/parenting/school-life/alumni-protest-against-newington-colleges-decision-to-go-coed/news-story/e46de1ac4e3d82e67c55dd19f37a5565.

studies focus on STEM outcomes (e.g., Thompson, 2003; Park et al., 2013; Park et al., 2018; Forgasz and Leder, 2020; Law and Sikora, 2020).

Kahn and Ginther (2017) summarize research from economics, sociology, psychology, and other disciplines which have tried to understand why women are under-represented in STEM, focusing mostly on the US context. McNally (2020) provides a review of the evidence on explanations for the STEM gap in tertiary education. She finds that the STEM gender gap in tertiary education results from factors that influence educational preparedness as well as factors that influence those who are 'STEM ready' at the point of making choices within tertiary education. These factors are often similar, such as lack of confidence among females (particularly with regard to maths ability) and lack of 'female friendliness' of educational environments even within upper secondary education.[5]

Drawing on historical administrative student data, the primary aim of this paper is to examine whether single-sex or coeducational schools are an important factor in helping girls to choose STEM as their field of study at university and to propose policy recommendations that emerge from our results. To isolate the effect of single-sex schooling, of particular interest will be comparing students of similar ability while controlling for academic quality of their high schools (based on school rankings), school sector (Catholic, independent, or public), and other individual and family characteristics. The approach of employing university administrative data to examine this issue is a novel contribution in the Australian context. Our analysis aims to go beyond the reliance on conventional survey data (e.g., Harker, 2000; Gemici et al., 2013; Law and Sikora, 2020) or high school subject enrollment statistics (Forgasz and Leder, 2020) used in prior research.

Central to this investigation is the utilization of unique administrative data from one of Australia's leading universities and STEM institutions. The data includes the academic records of undergraduate cohorts enrolled between 2012 and 2019, inclusive of details pertaining to their respective high schools and Australian Tertiary Admission Rank (ATAR) scores. Through this exploration, we seek to shed light on whether STEM preferences may be influenced by the educational setting during secondary education and provide insights that can inform educational policies and practices aimed at promoting female inclusivity in STEM fields.

This paper primarily contributes to the literature on the effects of single-sex schooling on STEM outcomes and general academic performance (Lee and Bryk, 1986; Marsh, 1989; Mael et al., 2005; Pahlke et al., 2014; Park et al., 2013; Dustmann et al., 2018; Robinson et al., 2021). In addition, by focusing on the role of gender mix in high schools in determining the field of study as well as students' university admission scores, this paper also contributes to the literature on college major choice (Altonji et al., 2016). Kahn and Ginther's (2018) review paper discusses the striking rates of gender segregation by field of study in the US. They show that with regard to STEM, female under-representation is limited to maths-intensive science

[5] One of her policy suggestions is to try experimenting with teaching high-ability students maths and science within gender-specific groupings.

fields – geosciences, engineering, maths/computer science and physical science. Using Eurostat and UNESCO data, McNally (2020) shows a similar type of gender segregation in broad STEM groupings in Europe. As students need prerequisites to enter STEM degree programs, the gender gap in STEM may result from subject choice decisions made in high school by students, their families and teachers. This is reflected in their 'educational preparedness' which could be influenced by whether or not they have a single-sex or coeducational environment in high school.

The specific research questions this study proposes to address are as follows:

- Are female students who attend single-sex schools more likely to pursue STEM majors at the university level compared to those who attend coeducational schools?
- How does the academic performance of female students at university compare between graduates of single-sex and coeducational high schools?
- Are female graduates of single-sex high schools more likely to persist in STEM majors at the university level compared to their peers from coeducational schools?
- For the above three questions, what are the corresponding findings for boys?

Section 2 provides background details on the single-sex vs coeducational schooling literature. Section 3 describes the student administrative data and school rankings data we use for our analysis. We describe the main methodological approach used for our empirical analysis in Section 4. The analysis is primarily based on binned scatterplots (Cattaneo et al, 2024) which provide a graphical representation of the conditional, nonparametric relationship between two key variables of interest. In Section 5, we present the results of the empirical analysis comparing boys and girls from single-sex and coeducational high schools in terms of the proportion majoring in STEM at university as well as their grades obtained at university. We also examine the proportion of students who choose to major in business-related studies (such as accounting, economics, finance, marketing, and management) and conduct heterogeneity analysis by school sector. Finally, section 6 concludes with some policy implications.

2. Background

Many parents seriously contemplate the implications of high school selection, whether it be private or public, single-sex or coeducational, on their children's future educational and career trajectories. This future path includes the choice of major and academic performance at university. Given the significance attributed to this decision, many parents dedicate substantial time and resources to selecting the most suitable educational environment for their children. This decision may entail relocating to specific public school catchment areas upon completion of primary education (and paying the associated housing premiums to be in school zones), paying to enrol their children at high-cost independent schools, or seeking to secure scholarships for admission to such institutions.

Pahlke et al. (2014) examined data from 184 studies comparing students in K-12 single-sex and coeducational schooling in a meta-analysis. They find that the apparently superior results of single-sex schooling in studies that do not adjust for covariates were likely the result of preexisting differences between students and schools that were unrelated to the gender composition of the classroom. Among studies that do account for covariates, they found that the performance and attitudes of single-sex and coeducational students typically did not differ. They therefore conclude that results from the highest quality studies do not support the view that single-sex schooling provides benefits compared with coeducational schooling. Robinson et al. (2021) provide a 20-year scoping review to present recent up-to-date research data related single-sex education. Based on a review of 70 relevant academic studies, they conclude that claims that suggest providing girls and/or boys with single-sex education, alone, will have positive impacts upon students' academic performance ought to be questioned.[6]

The main issue with previous studies in the literature comparing students from single-sex schools and coeducational schools is that, in general, differences between students in both types of schools are not well accounted for. Studies that merely compare the outcomes of students in single-sex and coeducational schooling may reflect preexisting differences between the students rather than effects of schooling type. For example, students in single-sex schools tend to have higher achievement levels prior to starting in the school and come from more affluent backgrounds. Moreover, many single-sex schools are private and have more resources than local coeducational public schools.[7] Studies that do not control for these differences may misidentify selection effects as effects of single-sex schooling.

In contrast to other interventions that can be analyzed in a controlled setting, such as educational methods, conducting a randomized experiment on the issue of single-sex versus coeducational schooling would require considerable resources for its design and execution. Randomly assigning individuals (students) to either treatment or control groups assumes that students can be allocated without their knowledge or consent. However, in practice, it is improbable that students would be involuntarily assigned to single-sex schools, primarily due to legal and ethical considerations. As soon as parental preference is allowed to determine assignment to school type, the possibility that the two groups will differ significantly is real (Mael et al., 2005).

Although it is very challenging to randomly assign students to single-sex or coeducational schooling in most countries, there is an exception in the context of South Korea. The fact that students in Seoul get randomly assigned to single-sex of coeducational high schools is exploited in the studies by Park et al. (2013, 2018) and Dustman et al. (2018).[8] Most relevant to our work is the study by Park et al. (2018) who analyze data from a longitudinal survey of

[6] Australian studies in this literature include Carpenter and Hayden (1987); Lumley (1992); Young and Fraser (1994); Forgasz (1998); Ainley and Daly (2002); and Law and Sikora (2020).
[7] In the Australian context, single-sex schooling is predominantly found in the fee-paying sectors of education. Within the government sector, the overwhelming majority of high schools are coeducational. The public schools which are single-sex often have selective entry based on academic achievement.
[8] Although the distribution of students into high schools may be close to a random assignment, an important caveat regarding the studies using Korean data is that he distribution of teachers is not. Many single-sex schools in Seoul are private, with a different system of teacher selection and appointment than public schools. The majority of coeducational schools, in contrast, are public.

high school seniors to assess whether single-sex schools affect actual choices of a STEM college major at university. They find that single-sex schooling exacerbates gender differences in STEM at university. Based on their investigation of the actual STEM university major, they find that all-girls schools do not make significant differences to these STEM outcomes. On the other hand, all-boys schools increase the probability of attending university with a STEM major.

A related literature has utilized variation in gender peer composition in coeducational schools to examine whether men (women) who attended high school classes with a large share of male (female) peers show higher likelihood to choose STEM college majors after high school. Exploiting random assignment of classmates in high school within school-cohort in Italy, Anelli and Peri (2019) analyze whether the gender composition of peers in high school affected their choice of college major and labour market outcomes. They find that the share of own-gender high school peers included linearly in regressions analyzing the choice of college-major is not significant for either men or women. For women, even more extreme class composition (>90%-female) did not have any impact on college-major choice. In contrast, Mouganie and Wang (2019) find that in Chinese high schools, an increase in the share of high-performing female peers increases the probability that women will choose a science track relative to men, whereas men are unaffected by the gender composition of high-ability peers. They suggest that one explanation for this finding is that girls may perceive top-performing female classmates as role models who provide them with an ability affirmation.

There are also coeducational schools with a 'parallel education' system where boys and girls might take some academic classes separately by gender.[9] Eisenkopf et al. (2015) exploit such a natural experiment at a high school in the German-speaking part of Switzerland. They study the effects of random assignment to coeducational and single-sex classes on the academic performance of female high school students who all face the same curriculum. Their results show that single-sex schooling improves the performance of female students in mathematics. This positive effect is particularly large for female students with high ex-ante ability.

There has also been related research focused on the university setting. While women's colleges in the US numbered in the hundreds in the early 1960s, most have since transitioned to coeducation. Calkins et al. (2023) leverage variation in the adoption of coeducation by US women's colleges to study how exposure to a mixed-gender collegiate environment affects women's decisions to major in STEM fields. They do so by collecting information on the timing of colleges' transitions to coeducation in the US and conducting a difference-in-difference analysis. In the long run, they find that the share of women majoring in STEM fell by around 3.0-3.5 percentage points relative to control colleges. Analyzing college major choices for women who could have chosen to attend a coeducational college or women's college also sheds light on this issue. Using data on admitted applicants to Wellesley College, an elite women's college in Massachusetts, Butcher et al. (2023) find that enrollees are significantly more likely to receive an economics degree than non-enrollees. They argue that there is a wider role for

[9] There are a handful of coeducational high schools in Victoria which have adopted a parallel education system, including Haileybury, Mentone Grammar, and Tintern Grammar.

women's colleges in increasing female participation in economics, which has implications for other STEM fields in general.

3. Data

Our sample is comprised of all domestic undergraduate students who enrolled at Monash University (a large university in Victoria, Australia) between 2012 and 2019. The student enrollment data was originally collected for helping monitor student enrollments, and student performance data are collected over time while students are pursuing their university studies. For these individuals, we have information on gender, high school, school sector, ATAR score, year finished high school, domestic/international student, year of commencement at university, field of study at university, weighted average mark for each year at university, country of birth, parental educational background, and household socioeconomic status (based on their residential postcodes).[10]

Information on high school quality will be crucial for allowing us to compare students from comparable single-sex and coeducational schools. The Victorian Certificate of Education (VCE) is the main credential available to secondary school students who successfully complete year 11 and 12 in the Australian state of Victoria.[11] Victorian year 12 students receive a VCE subject score for each subject they complete. These scores are raw marks out of 50, calculated by the Victorian Curriculum and Assessment Authority (VCAA) based on School Assessed Coursework and final exams.[12] To link our student-level data to measures of school quality, we merge it to school-level data that feature in the ranking lists of top schools. We utilize each school's median VCE subject score as well as the percentage of VCE subject scores that are over 40 as our measures of school quality. Such scores are used to produce high school rankings that are publicly known and available online.[13] In particular, the annual school rankings data are provided for the top 100 public schools, top 100 independent schools, and top 50 Catholic schools for the years 2012-2019. We also collected information on the VCE cohort size for each school to control for different school sizes. We take the 2012-2019 average of these school variables for each school and use them in our subsequent empirical analysis.[14]

The use of measures of school quality for our analysis is motivated by the educational literature on high school choice. The findings in Jackson and Bisset (2005) suggest that the reputation and exam results of the school are key features guiding parents' choices of school for their

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[10] Ethics approval was obtained from the Monash University's Human Research Ethics Committee to conduct this analysis.
[11] The other credential is the international baccalaureate (IB), which are only offered by a few Victorian high schools.
[12] The maximum study score is 50. Each year, and for every subject, the mean subject score is set at 30. A score of between 23 and 37 represents the scores for the middle range of students; a score of 38 or more indicates that a student is in the top 15%. (See: https://www.vcaa.vic.edu.au/curriculum/vce/vce-faqs/Pages/current-students.aspx).
[13] Our data on such school rankings is manually collected from https://bettereducation.com.au/results/vce.aspx.
[14] Our analysis is necessarily restricted to schools that have appeared in the ranking lists of top schools over this period. This restriction is, however, not a major constraint in our analysis as most Monash students come from these ranked high schools.

children, and that these factors are particularly important amongst parents who opt for single-sex education for their daughter(s) or son(s). West and Varlaam (1991) and Robinson and Smithers (1999) suggest that whether a school is single-sex or coeducational is less important than whether it is a 'good' school that is placed favourably in the league tables.

The measure of student ability we utilize is the ATAR score. The ATAR is a summary measure of Year 12 results that compares a student's overall academic achievement with all other final year students in all states and territories in Australia. It is used as the primary criteria to determine admission into different Australian universities and to different fields of study within those universities. In our context, this information is important as it ensures that we are able to compare students of similar calibre from single-sex and coeducational schools with each other.

In Victoria, VCE subject scores in the final year of high school are used by the Victorian Tertiary Admissions Centre (VTAC) to determine a student's scaled subject scores. These scores are then used to determine a student's final ATAR score. The ATAR score for Victorian year 12 students is a percentile ranking that shows their relative performance compared to other students in their cohort. This score ranges from 0 to 99.95, with a higher number indicating a stronger performance. For example, a score of 80 means a student placed in the top 20% of their year group. VTAC calculates these scores after students complete the VCE. No student ever receives a 00.00 rating and anyone who gets under 30.00 is just given "below 30.00."

The Australian university admissions system is very different from many developed countries where there is a system that more comprehensively evaluates students' academic and personal achievements, including the use of student admission essays, teacher recommendation letters, extracurricular activities, and leadership roles. It has been argued that the ATAR is a narrow representation of a student at the end of a 13-year journey, and that reducing students to a four-digit number does not value the learning of students and should not be used as a proxy for student quality. Recently, there have been efforts by some school principals to scrap the ATAR for a less blunt measure of year 12 achievement.[15] Nevertheless, there is evidence that important information regarding student ability is embodied in the ATAR; there is empirical evidence that ATAR scores have implications for post-university earnings outcomes. Combining income tax data from the Australian Bureau of Statistics with higher education enrollments data, Dwyer and Griselda (2023) find that university graduates with higher ATARs earn higher median salaries. Although having a higher ATAR does not guarantee a high salary, their empirical analysis reveals that at the age of 30, the median graduate with an ATAR above 98 earned $33,000 more than the median graduate with an ATAR below 70.

While the ATAR helps to streamline the university admissions process across Australian states and territories, it is worth noting that the way it is computed is not standardized at a national level. The rank is calculated slightly differently in the various states and territories. For

[15] See, for example, the following 2023 article in The Age newspaper "Principals urge education authorities to scrap ATAR: https://www.theage.com.au/national/victoria/principals-urge-education-authorities-to-scrap-atar-20230208-p5cirv.html

example, in Victoria, an aggregate ATAR score is calculated from the following: (i) the highest scaled score in one of the English subjects; (ii) the highest scaled score in each of the next three permissible studies; and (iii) 10% of the scaled score in each of the fifth and sixth permissible studies. In comparison, in the Australian Capital Territory (ACT) and New South Wales (NSW), ATAR scores take into account a student's best two English units and the best 8 units from other subjects and the AST exam (in ACT) and the HSC exam (in NSW).

Our final sample includes 32,536 individuals from 374 different high schools. In the sample, 63.1% of students are from coeducational environments, 22.2% are from all-girls schools and 14.7% are from all-boys schools. These students come from Catholic schools (23.0%), independent schools (36.8%), and public schools (40.2%).

To our knowledge, the use of university administrative data in this paper is unique in the Australian context for examining the issue of STEM outcomes at university.[16] There have been a few studies conducted based on university administrative data in other countries. In Italy, Anelli and Peri (2019) constructed a database of 30,000 individuals who graduated from college preparatory public high schools in the municipality of Milan, Italy, between 1985 and 2005, and linked this information to their college career. Based on information of the identity of their peers (classmates) in the last year of high school, they analyse whether the gender composition of peers in high school affected their choice of college major. In the US, Jiang (2020) analyses the determinants of the gender gap in college major choice and job choice between STEM and non-STEM fields and quantifies how much the gender wage gap can be explained by these choices. His analysis is based on using unique administrative data from Purdue University, one of the leading public STEM institutions in the US. It contains academic records of undergraduate students who graduated between 2007–2014. Another related example from the US is Butcher et al. (2023) who analyzed 15 cohorts of admitted applicants to Wellesley College between Fall 1999 and Fall 2013 with information on their subsequent degree and major data.

4. Method

Our method for evaluating the impact of single-sex versus coeducational schooling relies on comparing students of similar ability who, under different circumstances, might have enrolled in either type of institution of similar quality. In the context of high school selection, many parents apply to multiple schools and typically opt for the highest-ranked school their children are accepted to. Therefore, to establish a meaningful comparison, we need to consider a hypothetical scenario where a student with specific individual characteristics and attending a single-sex school would instead attend a coeducational one of similar quality, and vice versa. This necessitates having good measures of school quality in our dataset, enabling us to assess students within comparable educational environments they could potentially have experienced.

[16] This paper is related to earlier work by Lumley (1992) and can be viewed as an extension using contemporary statistical techniques to analyze the population of enrolled students at Monash University. The data used in Lumley (1992) came from a voluntary survey questionnaire administered every second year to first-year enrollees at Monash University.

More specifically, our analysis focuses on comparing girls in single-sex schools with those in coeducational schools, controlling for individual traits, school sector, and school academic quality. While our analysis is not necessarily causal, girls attending single-sex schools can be thought of as constituting the treatment group, while those in coeducational settings serve as the control group. We adopt a similar approach when examining the effect of single-sex schooling for boys.

Due to the complexity of comparing single-sex and coeducational schools, valid conclusions can only be drawn from studies which account for key characteristics of both school and student populations (Sikora, 2014). Even with ATAR scores and measures of school rankings, the comparison of students from single-sex schools and coeducational schools using regression and matching techniques to obtain causal estimates is challenging as there could remain unobserved differences between students and schools. For example, coeducational schools are often larger and have more facilities and resources dedicated to various programs, including STEM and other specialized education programs. Single-sex schools may lack these resources, making it more challenging for students to explore and excel in STEM subjects, which affects their decision to enrol in STEM at university.

The main approach in this paper is to utilize binned scatterplots to estimate the link between single-sex/coeducational schooling and STEM participation at university while controlling for individual and other relevant characteristics. Binned scatterplots provide a graphical representation of the conditional, nonparametric relationship between two variables, and allow the quick detection of nonlinearities, outliers, distributional concerns, and the best fitting functional form (Cattaneo et al., 2024). In our context, since a student's ATAR score is a single number that determines admission into various university majors, it is useful and informative to examine the field-of-study choices made by students with similar ATAR scores from single-sex and coeducational high school environments.[17]

Binned scatterplots help condense information from a regular scatterplot by partitioning the x-axis into bins and calculating the mean of y within each bin. As a result, binned scatterplots are able to reveal a more nuanced, nonlinear relationship if one exists. They can be a powerful tool to present a flexible, yet cleanly interpretable, estimate of the relationship between an outcome and a covariate of interest. Although not necessarily causal, the power of binned scatterplots lies in its ability to allow researchers to evaluate patterns are found in the data and check for the credibility of offered theories.[18]

[17] In spirit, ATAR scores are like propensity scores for individuals used in matching analyses as they both are single numbers that attempt to summarize individual characteristics.

[18] Our implementation of binned scatterplots is based on the *binsreg* command in Stata by Cattaneo et al. (2019). There exist two other user-written popular Stata commands that implement binscatter methods (*binscatter* and *binscatter2*). As noted by Cattaneo et al. (2019), both of those packages incorporate other covariates or fixed effects incorrectly and yield invalid results.

We follow the recommendation of Starr and Goldfarb (2020), who suggest that practitioners create and report a canonical binned scatterplot with confidence bands as a baseline, with the bins chosen by minimizing the integrated mean squared error. This approach allows the binned scatterplot to depict the nonparametric relationship of interest without imposing any smoothing constraints. It can reveal whether a linear or polynomial fit is most appropriate for summarizing the relationship between the outcome variables across the entire range of ATAR scores. Binned scatterplots can also easily examine heterogeneous relationships for different subgroups. For our heterogeneity analysis, we conduct the same empirical exercise by school sector (Catholic, independent, public).

Finally, as there is no universal agreed definition regarding what constitutes a STEM field, we experiment with different definitions of STEM. Delaney and Devereux (2019) report finding a smaller gender gap when we include nursing degrees in STEM, showing that the definition of STEM used is an important determinant of the conclusions reached. We therefore also use alternative definitions of STEM that include nursing degrees and other health-related majors.

5. Results

5.1 Descriptive statistics

Table 1 provides descriptive data of the sample for our analysis. Columns (1) and (2) compare the characteristics of girls from single-sex and coeducational high schools. From the raw data, some differences between students from single-sex schools and coeducational schools are clear. It is readily observable that most single-sex schools in Australia belong to the Catholic or independent sectors. These schools tend to be located in affluent metropolitan areas and attract students from families of high socioeconomic status (SES) (Law and Sikora, 2020). Such a pattern is very evident from the SES variables in the table. Girls who attend single-sex schools also tend to have higher educated parents and be more likely to have a parent with at least a college degree.

In Table 1, among girls from single-sex schooling backgrounds, only 18 percent of girls enrolled to commence undergraduate studies at Monash University come from government schools, compared to 45 percent from the Catholic sector and 37 percent from independent schools. In contrast, among girls with coeducational high school backgrounds, the majority (54 percent) of girls are from government schools. These raw descriptive data patterns are similar for the boys provided in columns (3) and (4).

Another point worth noting from Table 1 is that due to their relative scarcity, single-sex schools in Australia can afford to be more selective than coeducational schools. Consequently, it can be seen that they tend to have higher school median VCE scores for their graduating cohorts, as well as a higher percentage of students who score over 40 in their VCE subjects.[19]

[19] The distribution of school median VCE scores in our sample for single-sex and coeducational schools can be seen in Table A1 (for girls) and Table A2 (for boys) in the appendix.

5.2 Regression and matching

We examine conditional differences between students from single-sex schools and coeducational schools in terms of average STEM enrollments at university using regression and matching techniques. The analysis is conducted separately for boys and girls which allows us to focus on each counterfactual situation more directly. We control for individual and family characteristics, school sector, school quality, and VCE cohort size. The covariates controlled for include a student's ATAR score, school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification,[20] and born in Australia. Year fixed effects are included in the regression analysis.

The OLS results presented in Table 2 suggest that single-sex schooling is weakly negatively associated with STEM participation at university. For girls, single-sex schooling is associated with a 2.0 percentage point decrease in STEM programs that include the health and nursing fields (significant at the 10 percent level). For boys, single-sex schooling is associated with a 1.8 percentage point (insignificant) decrease in STEM enrollments in the first year of university. In addition, the propensity score matching estimates (using nearest neighbor matching with a caliper restriction of 0.1) suggest that there are no significant associations between single-sex schooling and STEM outcomes in the first year of university.

In Australia, two previous studies based on a sample of university undergraduates in the 1990s found no evidence that all-girls school graduates went on to pursue mathematics or science at university at higher rates than their peers in coeducational schools (Forgasz, 1998; Lumley, 1992). Using LSAY survey data, Law and Sikora (2020) observed no benefits of sex-segregated schooling for young women, in terms of increasing the likelihood of specialising in science at university. They also find that graduating from an all-boys secondary school reduces, rather than raises, the likelihood that young men will choose physical science majors.

Given the availability of ATAR scores for each student and their decision to enroll in STEM at university, an interesting question is whether students with similar ATAR scores from different gendered schooling environments make different choices regarding their field of study at university. While regression and matching techniques allow one to control for individual characteristics such as the ATAR score, they obscure any information about the distribution of this critically important independent variable. Conceptually, one would like to match on ATAR scores when comparing students from single-sex and coeducational schools as this will help create a better counterfactual. This is because the ATAR score is the primary factor in determining entry to various university majors.[21] As currently implemented, the focus of the

[20] We specify the parental education variable this way instead of using more detailed information on parent 1 and parent 2 in order to maximize our sample size. Some students only have data reported for parent 1 (e.g. single-parent families).

[21] Monash University generally requires a minimum ATAR score of 70 for general admission to the university. A list of ATAR required for entry to various degree programs (highest ATAR to receive an offer, lowest ATAR to

regression and matching analysis is to estimate the average treatment effect of single-sex schooling, assuming the conditional independence assumption is plausible.

5.3 Binned scatterplots

Binned scatterplots make plain whether the distribution of a key independent variable is driving a particular relationship. Initially, we examine STEM enrollment rates in the first year of university by ATAR rank for boys and girls separately, controlling only for year fixed effects (see Figure A1 in the appendix). This approach deliberately overlooks the inclusion of the student ability and school academic quality metrics mentioned earlier and does not address selection issues in an appropriate way. The binned scatterplots depicting this unconditional relationship suggest that there are overlapping confidence intervals and generally no significant differences between boys and girls from single-sex and coeducational schools in terms of choosing a STEM major in their first year at university.

Our main analysis focuses on examining binned scatterplots that take into account individual, family, and school characteristics. The analysis is based on non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024). In a single graph, in order to allow a side-by-side comparison, binned scatterplots are created separately for girls in single-sex schools and girls in coeducational schools.

Figure 1 presents the binned scatterplots for girls choosing a STEM field as a university major in single-sex and coeducational high schools. In the top panel, the focus is on STEM as is commonly defined in the literature.[22] Across a large range of the ATAR distribution, the data reveals that girls from single-sex schools are significantly less likely to choose a STEM major in year 1 at university (i.e. there is no overlap in the confidence intervals). However, the significant gap is reduced and disappears for most of the ATAR distribution by year 2 and year 3. There also appears to be some attrition from STEM for girls at the higher end of the ATAR distribution in years 2 and 3. This suggests that some girls do not persist with their STEM degrees over time.

The bottom panel of Figure 1 is based on a more extended definition of STEM which includes the fields of health and nursing. The gap between girls in single-sex and coeducational schools is clearly more noticeable using this alternative broader measure of STEM. We observe a

receive an offer) is published each year. See: https://www.monash.edu/study/courses/admissions-transparency/atar-offer-profile-report. For example, for 2024, the minimum ATAR to be eligible for entry to medicine is 90. However, in practice, the final ATAR to do a degree in medicine is significantly higher due to the competition of a large number of applicants for a relatively small number of places.

[22] The specific fields of study at Monash included in our STEM definition include: aerospace engineering and technology, behavioural science, biological sciences, chemical sciences, civil engineering, computer science, electrical and electronic engineering and technology, engineering and related technologies, environmental studies, information systems, information technology mathematical sciences, manufacturing engineering and technology, mechanical and industrial engineering and technology medical studies, natural and physical sciences, other information technology, other natural and physical sciences, pharmacy, process and resources engineering, radiography, and rehabilitation therapies. Our STEM definition includes students with joint majors.

significant gap between girls in single-sex and coeducational schools which persists in years 1, 2 and 3.

For boys, it can be seen in Figure 2 that boys from coeducational schools are significantly more likely than boys from all-boys schools to major in STEM across the ATAR distribution. Furthermore, most of the gaps present in year 1 remain even in years 2 and 3. The attrition in STEM over time previously seen for girls does not appear to occur for boys.

STEM fields are one of the major options students can opt for when choosing a field to specialize in at university. A major alternative field of study that many students choose in the first year of university in Australia is a business-related field, such as accounting, economics, finance, marketing, and management. Figure 3 reveals that across the ATAR distribution, students from single-sex high schools are more likely to choose a business major at university.[23] An interesting aspect to note regarding Figure 3 is that a drop-off in student numbers for business majors is clearly visible for students with ATAR scores greater than the mid-90s region. Given that ATAR entry cutoff scores for law and medicine (generally considered to be the two most prestigious fields of study at university in Australia) are in this range, the data suggests that many students with high ATAR scores are not choosing to study a business-related field at university.

It is also of interest to examine how well students from single-sex and coeducational backgrounds perform at university in terms of their grades. Therefore, we also examine how students perform in terms of their weighted average marks (WAM) for each year of their studies at university.[24] As one would expect, there is a positive relationship between ATAR scores and university grades (the linear correlation between ATAR scores and first-year university grades is approximately 0.4). However, the relationship is best described as nonlinear rather than linear. Students who score distinctions (WAM>70) and high distinctions (WAM>80) at university are much more likely to have had ATAR scores above 90. While it appears that girls from coeducational backgrounds score higher marks than girls from single-sex backgrounds (Figure 4, top panel), most of the gaps for school type across the ATAR distribution are not statistically significant for the first three years at university. On the other hand, for boys (Figure 4, bottom panel), there is a clear gap in the binned scatterplot between the two lines which indicates that boys from coeducational schools do better than boys from single-sex schools in the first year of university. Interestingly, this initial WAM gap is reduced in year 2 and gradually disappears by year 3. This pattern suggests that there might be some time needed for boys from single-sex schools to adjust to the new coeducational and social environment at university.

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[23] These results are consistent with the finding in Law and Sikora (2020) that graduates of all-boys schools are more likely to study business and economics rather than physical sciences at university, based on survey data from the 2003 Longitudinal Survey of Australian Youth (LSAY).

[24] The standard undergraduate student load is to take four units (or courses) per semester. A weighted average mark takes into consideration the credit point value of each unit.

5.4 Binned scatterplots by school sector

Delving more deeply into the gaps in STEM observed in Figures 1 and 2, we examine the heterogeneous relationship between STEM and ATAR for the different school sectors. We focus on three sectors: the Catholic school sector, the independent school sector, and the government select-entry school sector. The reason we choose to omit the larger government sector as a subgroup is because in the state of Victoria, in the government sector, there is only one single-sex boys school and only a handful of public single-sex girls schools. Examining a government school sector subgroup will be undesirable as it will necessitate the comparison of high academic achieving single-sex schools with a broader population of coeducational schools.[25]

Figure 5 reveals that the STEM gap between single-sex and coeducational boys and girls is driven by gaps that are evident in the Catholic school sector.[26] For reasons that are not immediately obvious, boys and girls from single-sex Catholic schools (and girls more so than boys) are significantly less likely than their counterparts in coeducational schools to study STEM fields in the first year of university. For the girls from Catholic schools, it may be the case that attitudes about suitable subjects for girls to study still persist at some Catholic girl schools. It might also reflect the general STEM teacher shortage issues. Victoria, for instance, has one of the highest rates of out-of-field STEM teaching at 14.9 percent.[27] This teacher shortage issue could be affecting single-sex schools in the Catholic school sector more significantly, but there is no data collected on out-of-field teaching to verify this.

It is also worth noting that in public select-entry schools, the proportion of boys and girls enrolled in STEM for students with ATAR scores above the mid-80s is quite consistent (around 0.6 for girls and 0.5 for boys). This proportion is higher than that observed for students in the Catholic or independent sectors. This suggests that select-entry schools may play a significant role in promoting the uptake of STEM at university. Students with ATAR scores above the mid-80s might be more inclined to pursue STEM if exposed to an environment that is more conducive to STEM development.

Prior research has found that gender gaps in STEM are smaller among high-achieving students and for students who go to school in more affluent areas (Delaney and Devereux, 2019). Hence, the results for the independent school sector and select-entry school sector are consistent with prior research.

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[25] The government select-entry school sector we focus on comprises of four schools, of which one is a single-sex boys school (Melbourne High School), one is a single-sex girls school (MacRobertson Girls High School), and two are coeducational schools (Nossal High School and Suzanne Cory High School).

[26] In our sample, for girls, there are 25 single-sex schools and 34 coeducational schools in the Catholic sector, and 18 single-sex schools and 89 coeducational schools in the independent sector. For boys, there are 13 single-sex schools and 32 coeducational schools in the Catholic sector, and 6 single-sex schools and 90 coeducational schools in the independent sector.

[27] See: https://www.smh.com.au/national/one-in-eight-stem-classes-taught-by-out-of-field-teacher-20200511-p54ru1.html.

Mirroring the findings in Figure 3, an analysis by school sector reveals that there is a reverse positive gap for business majors. In the Catholic school sector in particular, boys and girls from single-sex schools more likely to major in business fields as compared to boys and girls from coeducational schools (Figure 6). While there is a small gap for students for some parts of the ATAR distribution in the independent school sector, any gap is non-existent in the select-entry school sector.

Finally, Figure 7 examines how students from the different school sectors perform in terms of their weighted average marks for the first year of university. The gap in WAM seen for boys earlier in Figure 4 can be seen to be driven by differences in the performance of boys in single-sex Catholic schools and boys in coeducational Catholic schools. It will be interesting to further explore why this gap only exists for boys in the Catholic sector and not for boys in the independent school sector or public select-entry school sector.

5.5 Specialist science school students

In Victoria, the John Monash Science School (JMSS) is Victoria's first specialist high school that focuses on STEM. It opened in 2010 and accommodates up to 640 students across Years 10, 11 and 12. It is co-located on Monash University's Clayton campus in Melbourne's south-east. The school is a public select-entry school and students with a passion for science are selected for entry after analysis of written assessments, group activities and interviews. Given the school's unique positioning, it is of interest to see whether JMSS students are more likely to pursue a STEM major at university as compared to students from other public select-entry schools. If the goal is to encourage and promote more students to study STEM at university, it is useful to evaluate how effectively a STEM specialist school is achieving this objective.

Figure 8 compares STEM enrollments in years 1, 2, and 3 at university between JMSS students and students from the other select-entry schools in Victoria.[28] The results suggest the potential role that specialist science schools like JMSS can play in increasing the proportion of students who study STEM majors at university. For all three years and for both boys and girls, JMSS students are found to be more likely than other select-entry school students to choose a STEM major (although the gap is often not statistically significant). While there is certainly likely to be selection issues involved, the results do indicate for high achieving students that gain admission to select-entry schools, having more exposure to STEM subjects in the last three years of high school can have a positive influence on the likelihood of pursuing STEM at university.

It is also worth noting that at the higher end of the ATAR distribution, there is not much difference between JMSS and other select entry schools in terms of the proportion of students enrolled in STEM. Given the relatively low numbers of public select-entry schools in Victoria (currently, there are only four in Victoria compared to 42 in NSW), it is worth considering

[28] For girls, this is comparing JMSS with students from MacRobertson Girls, Nossal High and Suzanne Cory High. For boys, it is a comparison of JMSS with students from Melbourne High, Nossal High and Suzanne Cory High.

investing in public resources to expand the number of select-entry schools, including specialist science schools.[29] Furthermore, it would be valuable to replicate this study using data from universities in New South Wales, given the greater number of select-entry schools there. This would allow for testing the hypothesis that an increased presence of select-entry schools correlates with higher STEM enrollments at university.

6. Discussion

This paper uses novel administrative data from a leading Australian university to examine the link between a student's high school environment and the decision to choose a STEM major at university. Specifically, the focus is on investigating the influence of single-sex versus coeducational schooling, while accounting for school sector as well as other individual and family factors. The question at hand can be approached as a thought experiment: if two students possess similar ATAR scores but attended different types of schools – one single-sex and the other coeducational – will the former be more inclined to pursue a STEM field at university?

Our data spans eight undergraduate cohorts (2012-2019) and we have data on the degree programs students enrolled in and the weighted average marks for each student each year. With access to each student's ATAR score – a pivotal determinant for university entry and eligibility in various fields of study in Australia – we are able to provide a graphical representation of the conditional, nonparametric relationship between ATAR and the decision to pursue a STEM field at university for students in single-sex and coeducational high schools.

In terms of contributions, by examining the choice of major across the ATAR distribution, our work is novel in providing insight into the types of students who choose STEM majors as well as business majors. Our work is also the first to provide a direct link between ATAR scores and grade performance at university. Contrary to expectations, we find no evidence that a single-sex high school background increases STEM participation among girls at the university level. Interestingly, students from single-sex high schools show a higher propensity to choose a business major. Additionally, we find that the linear correlation between ATAR scores and first-year university grades is approximately 0.4. However, our analysis suggests that this relationship is better characterized as nonlinear rather than linear. Based on an analysis by school sector, the empirical finding that a lower proportion of boys and girls in single-sex Catholic schools pursue STEM at university compared to students in coeducational Catholic schools warrants further attention.

To further promote the study of STEM subjects at university, the Victorian government introduced a specialist science school in 2010, catering to students in the last three years of high school. This paper is likely the first study to evaluate whether one of its key objectives is being achieved. Our findings indicate that a larger proportion of students from the science

[29] There are 17 fully selective entry government high schools and 25 partially selective entry schools in NSW, Australia. See: https://education.nsw.gov.au/schooling/parents-and-carers/choosing-a-school-setting/selective-high-schools/choosing-a-school/selective-high-schools

school chose to major in STEM at university compared to other high-ability students from select-entry schools, who, in turn, were more likely than students from Catholic and independent schools to major in STEM. Given these positive outcomes, it is worth considering additional investments to increase the number of select-entry schools in Victoria and to expand the initiative of introducing specialist science schools. At present, Victoria is significantly behind New South Wales in terms of the number of public select-entry schools available to students. Students who obtain ATAR scores above the mid-80s might be more inclined to pursue STEM if they have more opportunities to be placed in a schooling environment that is more conducive to STEM development.

A limitation of the analysis considered in this paper is that it is based on data from one university. Future research incorporating administrative data from a broader range of universities will be invaluable in validating these findings and providing a more comprehensive understanding of the impact of single-sex schools on STEM, as well as the role of specialist science schools and select-entry schools on STEM enrollment. Such expanded research will be crucial for informing educational policy and investment decisions not only in Victoria but also across broader educational contexts.

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Table 1: Descriptive statistics

	Females		Males	
	Single-sex (1)	Coeducational (2)	Single-sex (3)	Coeducational (4)
STEM – Year 1	0.37	0.38	0.38	0.42
STEM – Year 1 (with health and nursing)	0.45	0.50	0.39	0.45
WAM – Year 1	68.55	68.28	66.67	66.80
ATAR rank	88.72	85.71	90.28	87.90
School median VCE	34.06	31.52	34.06	32.07
School VCE Subject Scores 40+	19.49	11.66	20.69	13.19
School VCE cohort size	249.91	291.40	401.66	312.11
Catholic school	0.45	0.10	0.48	0.09
Government school	0.18	0.54	0.19	0.51
Independent school	0.37	0.35	0.33	0.40
SES – high	0.62	0.34	0.66	0.43
SES – med high	0.23	0.33	0.20	0.31
SES – med low	0.10	0.22	0.10	0.18
SES – low	0.06	0.11	0.05	0.09
Any parent >= college	0.71	0.60	0.76	0.67
Parent 1 >= college	0.66	0.55	0.71	0.62
Parent 1 – VET/Dip	0.13	0.16	0.11	0.14
Parent 1 – Year 12	0.16	0.22	0.14	0.17
Parent 1 <= Year 12	0.05	0.08	0.05	0.07
Parent 2 >= college	0.49	0.38	0.55	0.44
Parent 2 – VET/Dip	0.20	0.21	0.18	0.21
Parent 2 – Year 12	0.23	0.30	0.21	0.26
Parent 2 <= Year 12	0.08	0.12	0.07	0.10
Born in Australia	0.84	0.77	0.84	0.78
Observations	7,230	10,734	4,772	9,800

Notes: Means for outcomes and characteristics are provided by subgroups. Data are for students who commenced their university studies between 2012-2019.

Table 2: OLS and matching estimates

Outcome	OLS		Propensity Score Matching	
	Girls	Boys	Girls	Boys
STEM Year 1	-0.007	-0.018	-0.022	-0104
	(0.010)	(0.012)	(0.037)	(0.145)
STEM Year 1 (with health and nursing)	-0.021*	-0.016	-0.049	-0.117
	(0.010)	(0.012)	(0.039)	(0.143)
WAM Year 1	-0.175	-0.131	-0.131	-1.969
	(0.220)	(0.292)	(0.648)	(2.196)
N	17,964	14,572	17,928	14,510

Notes: Coefficient reported is the coefficient on the single-sex dummy. For girls, the comparison is between girls in single-sex schools and girls in coeducational schools. For boys, the comparison is between boys in single-sex schools and boys in coeducational schools. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Propensity score matching is nearest neighbor matching with replacement with a caliper restriction of (0.10). The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia, as well as year fixed effects.

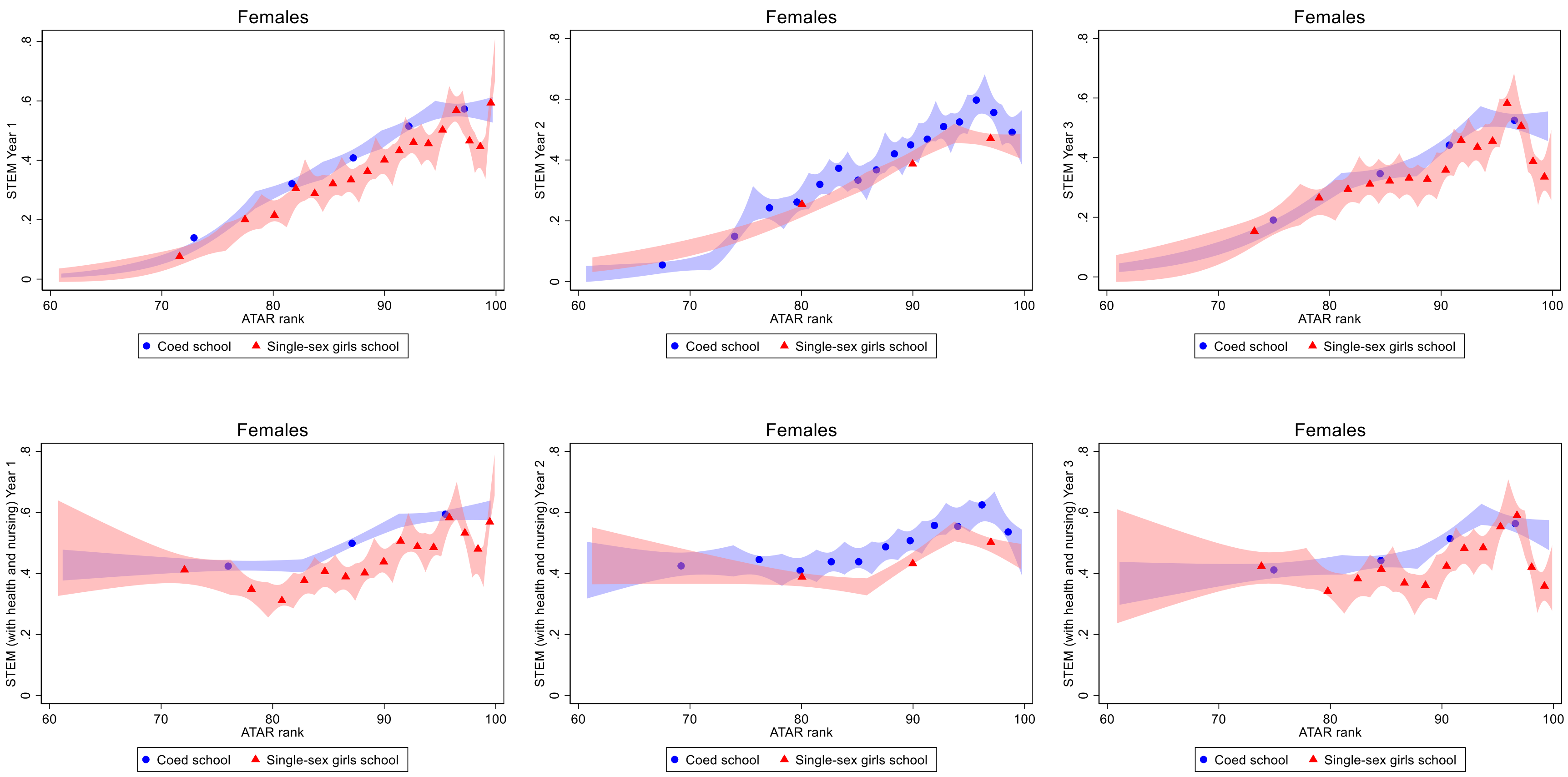

Figure 1: STEM university major for girls in single-sex and coed high schools

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for girls in single-sex schools and girls in coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

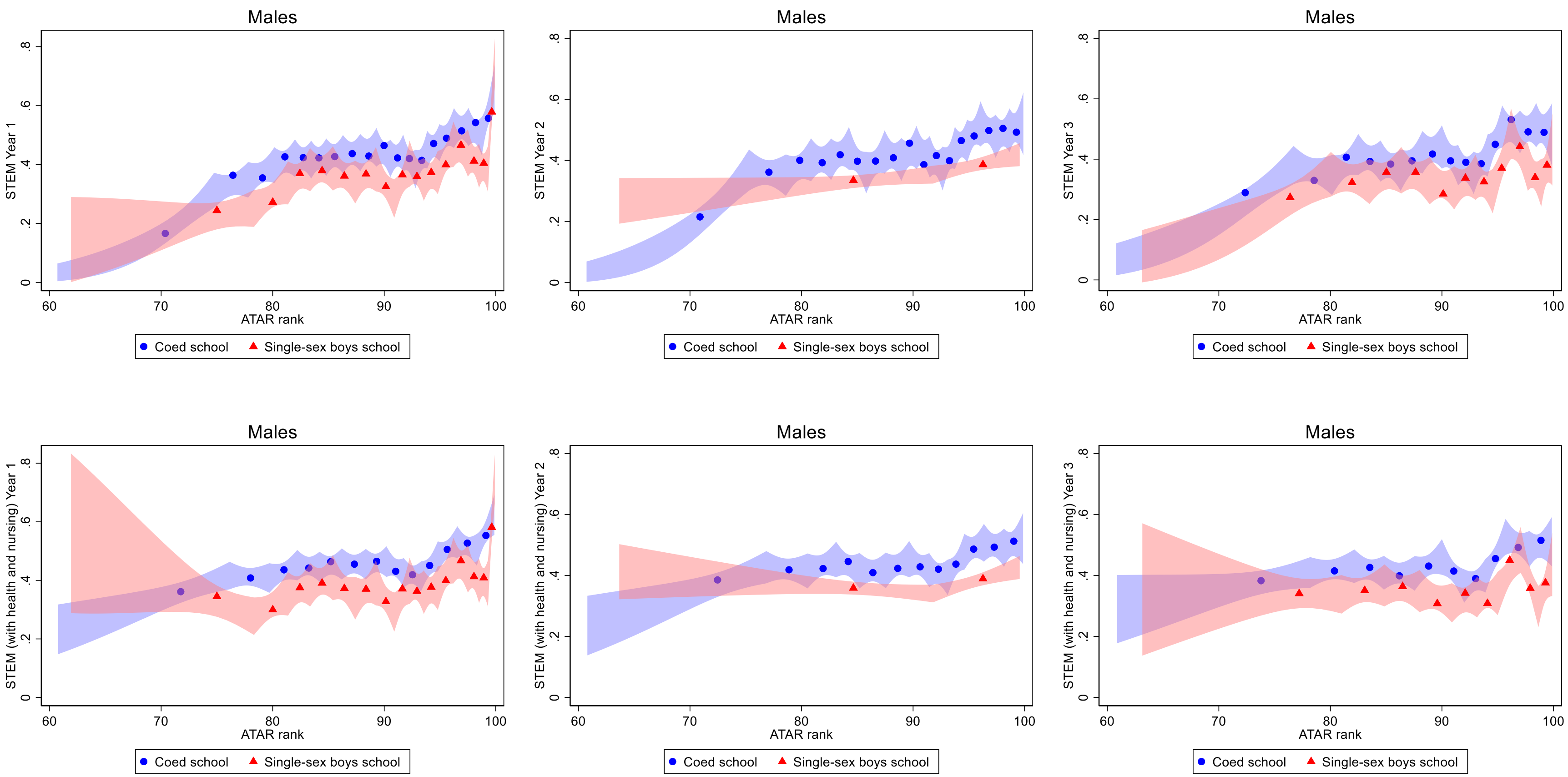

Figure 2: STEM university major for boys in single-sex and coed high schools

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys in single-sex schools and boys in coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

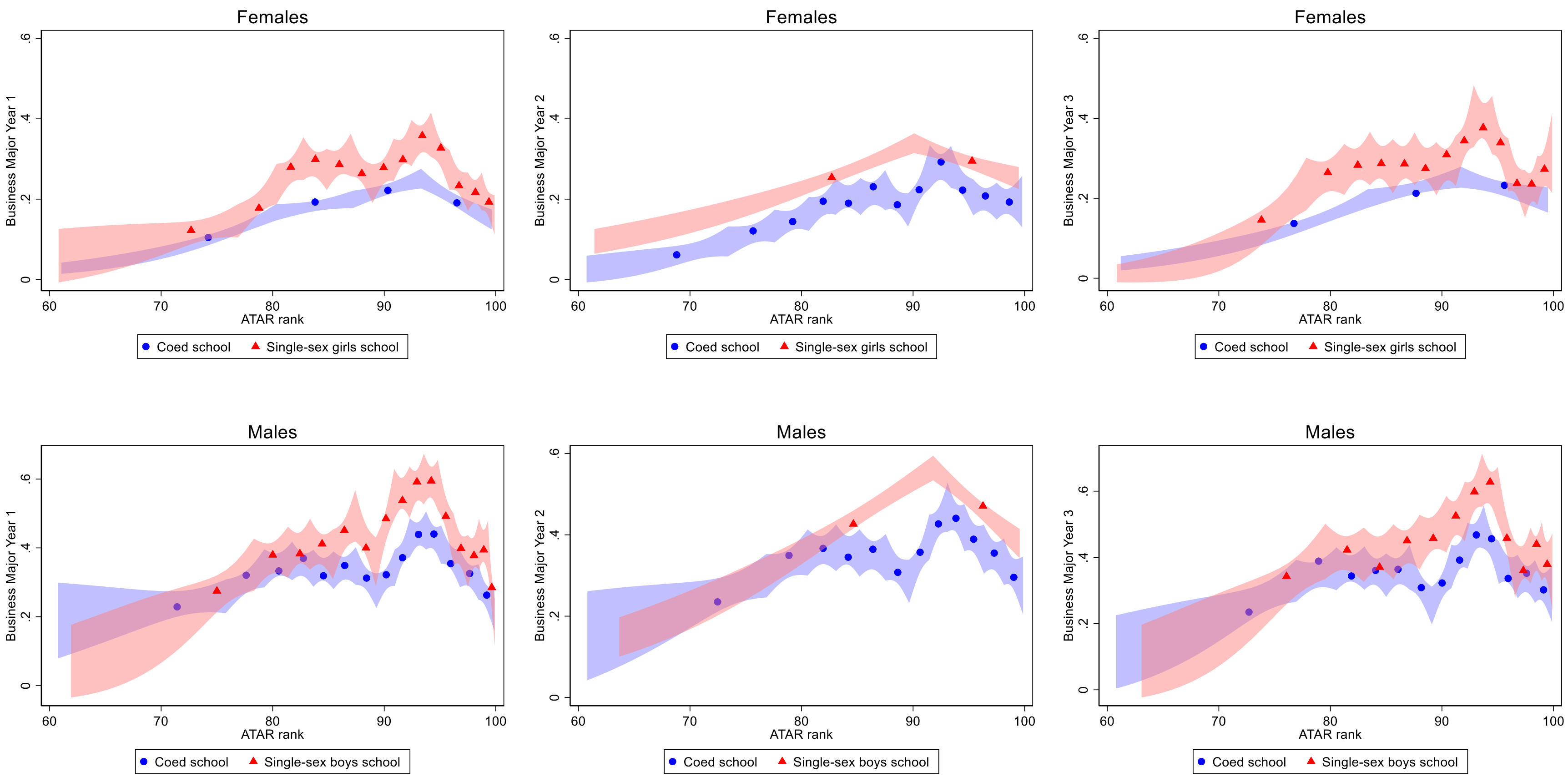

Figure 3: Business university major in single-sex and coed high schools

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

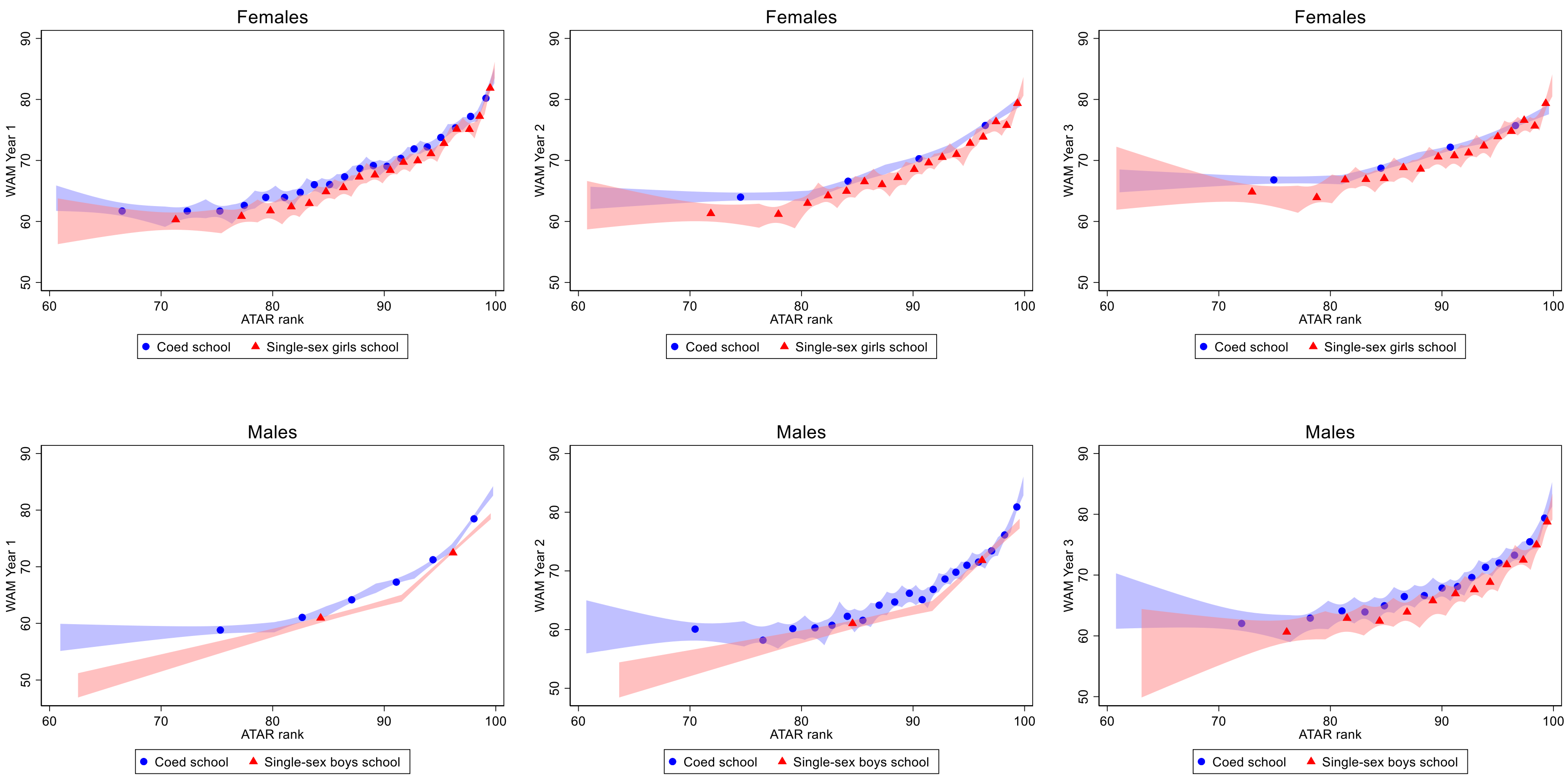

Figure 4: WAM in single-sex and coed high schools

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

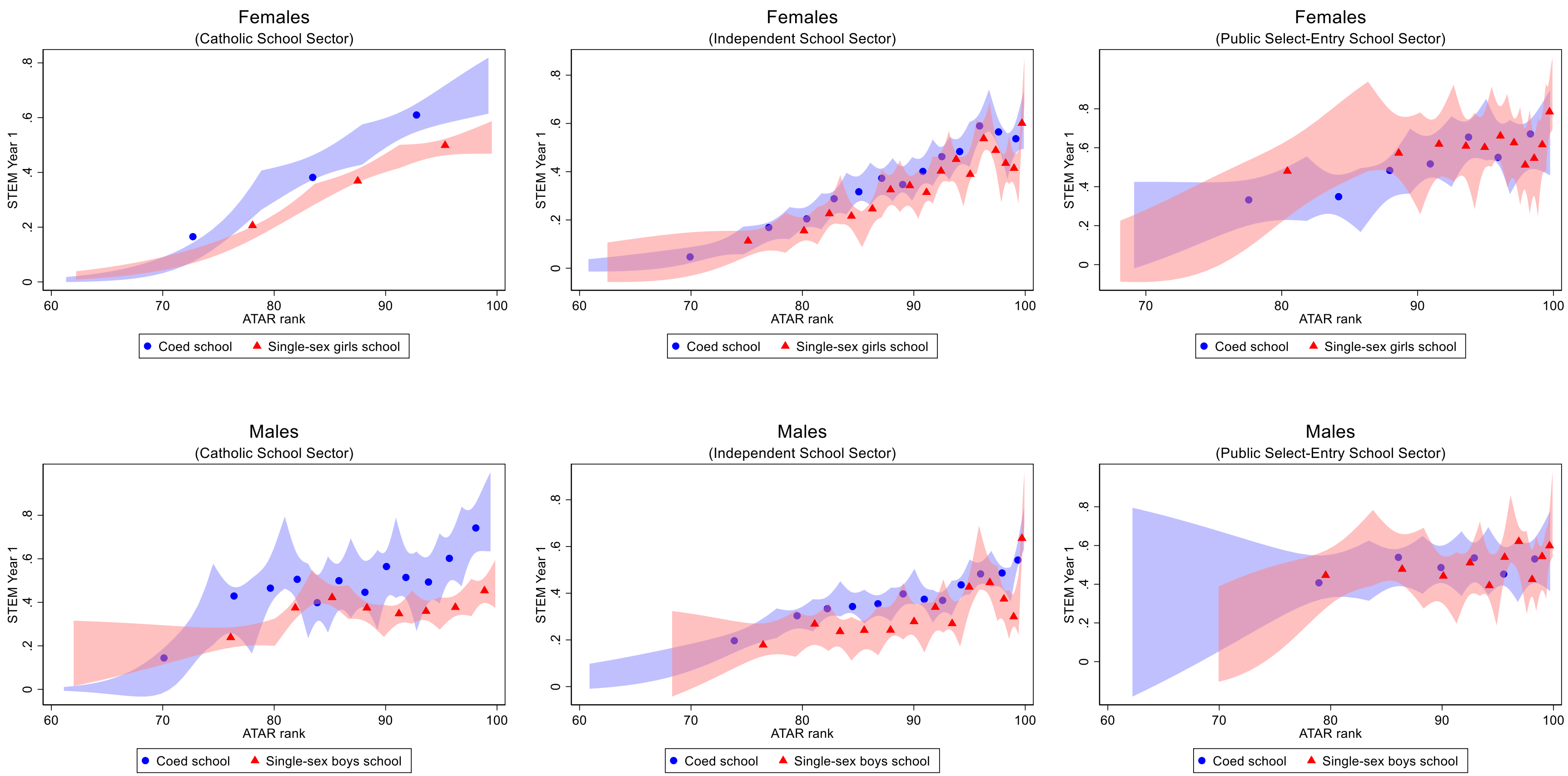

Figure 5: STEM university major in single-sex and coed high schools by school sector

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

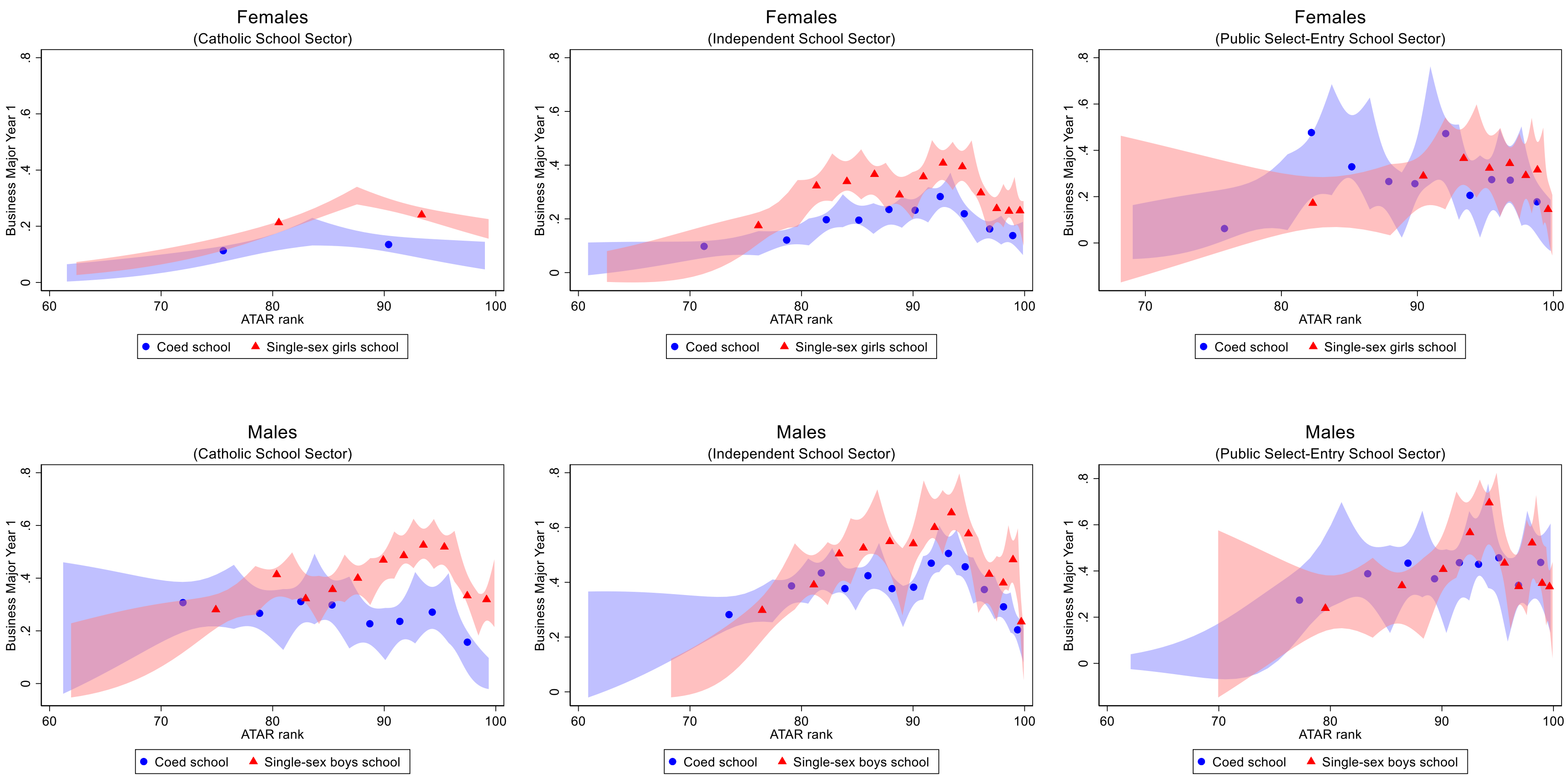

Figure 6: Business university major in single-sex and coed high schools by school sector

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

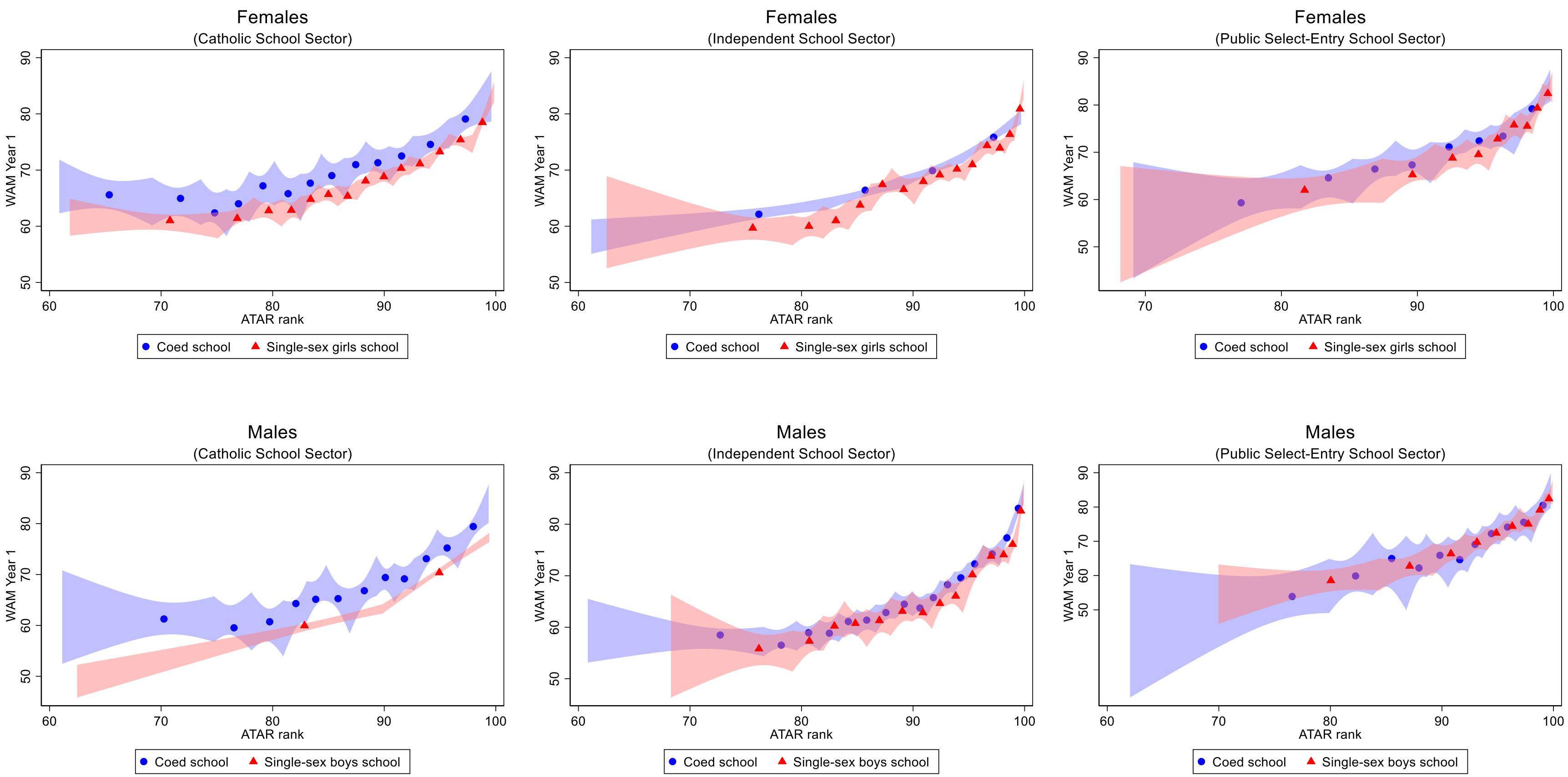

Figure 7: WAM in single-sex and coed high schools by school sector

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

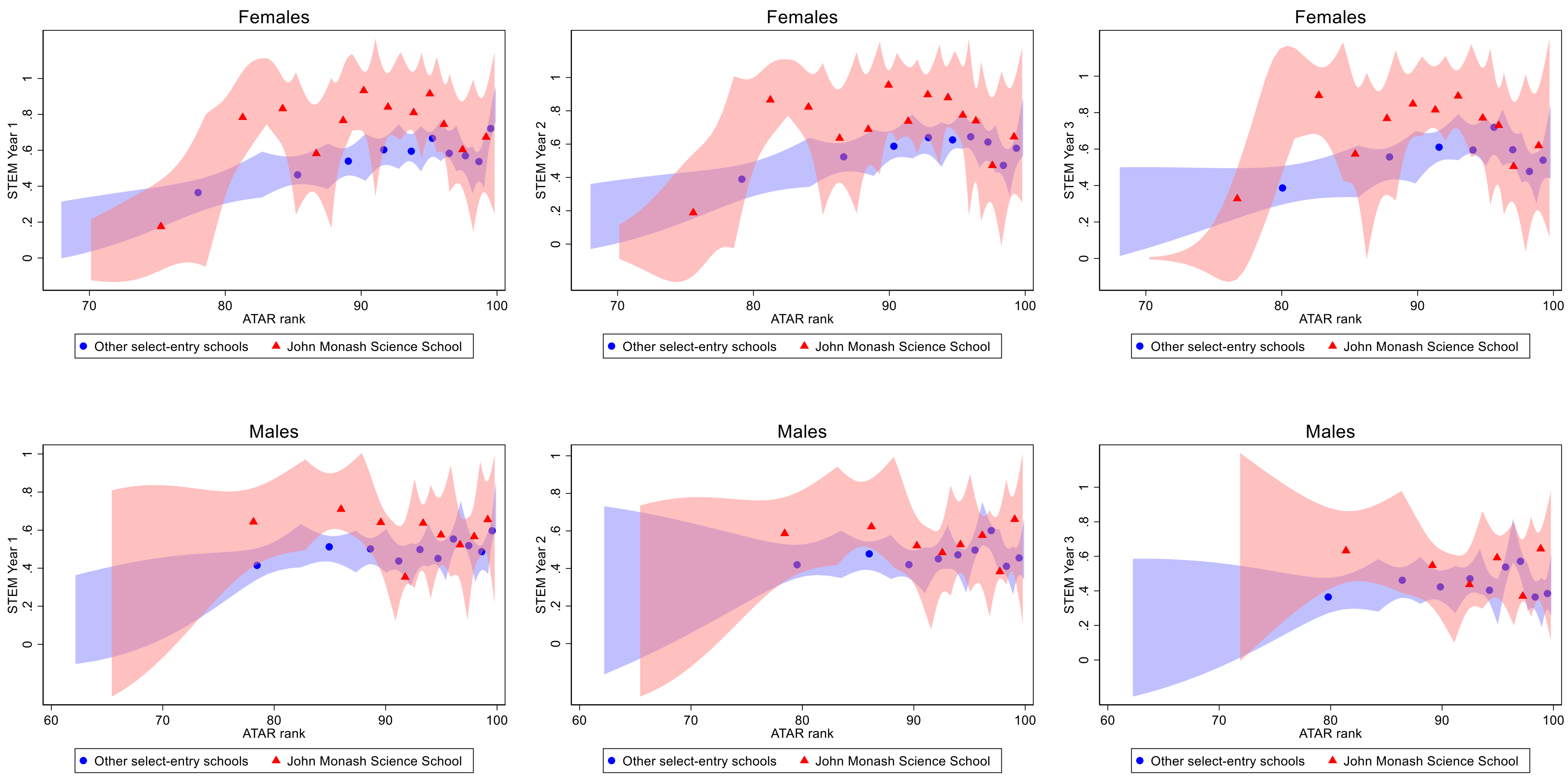

Figure 8: Role of science schools and STEM: John Monash Science School vs other select-entry schools

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls. The 95% confidence bands are shown. The covariates controlled for include school median VCE, school percentage of VCE subject scores > 40, school sector (independent, Catholic, public), socioeconomic status of home postcode in 2011 (high, medium-high, medium-low, low), any parent/guardian has a college education or postgraduate qualification, born in Australia. Year fixed effects are included.

ONLINE APPENDIX

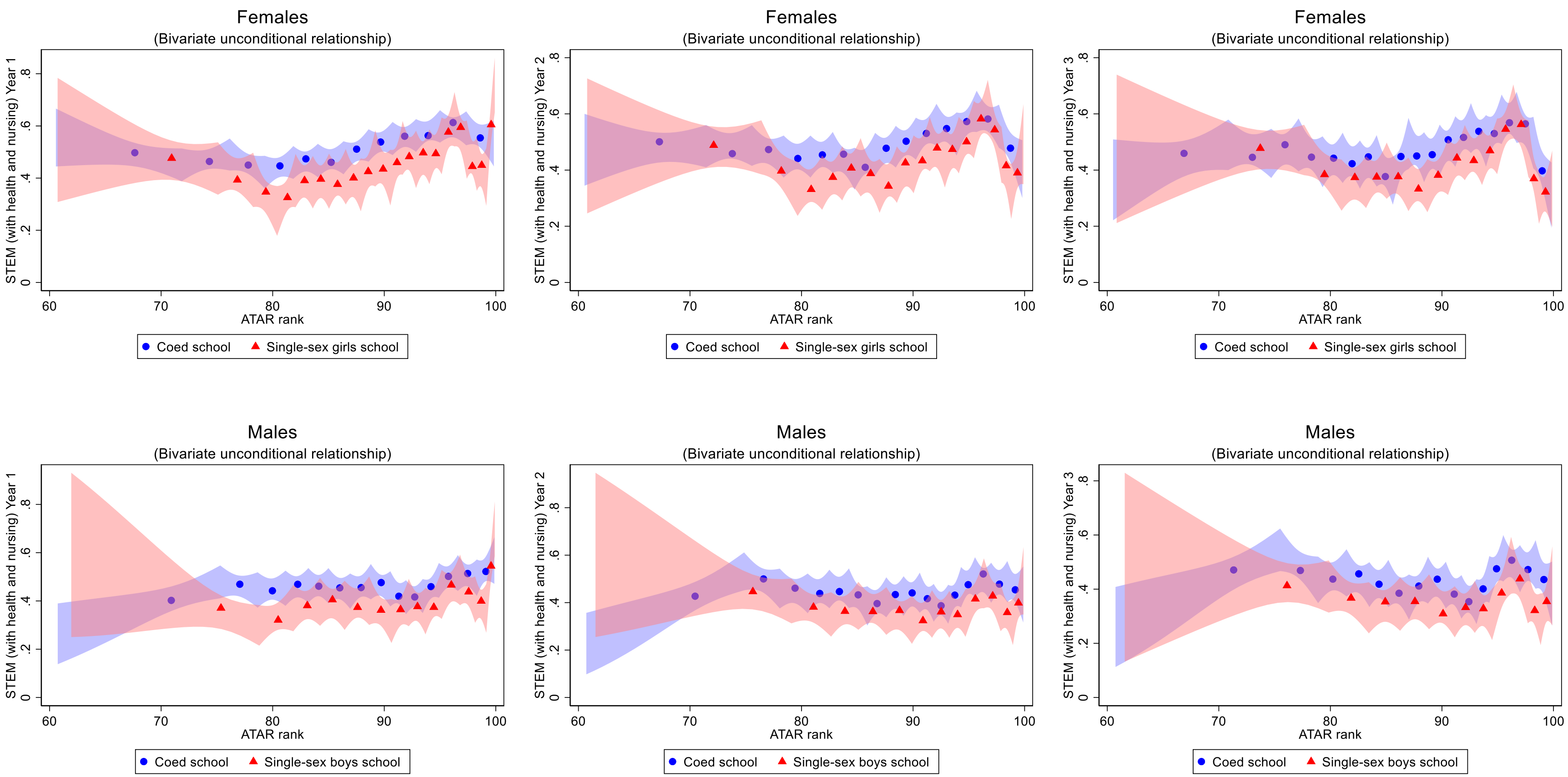

Figure A1: STEM university major for single-sex and coed high schools: unconditional relationship

Notes: This figure presents non-parametric binned scatterplots following the procedure in Cattaneo et al. (2024) separately for boys and girls in single-sex schools and coed schools. The 95% confidence bands are shown. No control variables are included in the model except for year fixed effects.

Table A1: School median VCE scores by school type – girls

School Median VCE	Coed School	All Girls School	Total
24.00	2	0	2
25.00	15	0	15
25.50	4	0	4
26.00	44	0	44
26.50	1	0	1
26.67	12	0	12
26.75	5	0	5
27.00	51	0	51
27.17	22	0	22
27.25	4	0	4
27.33	100	0	100
27.50	109	0	109
27.60	3	0	3
27.67	56	0	56
28.00	270	0	270
28.20	12	0	12
28.25	23	0	23
28.33	18	0	18
28.50	281	0	281
28.67	183	58	241
28.71	79	0	79
28.75	87	0	87
28.80	95	0	95
29.00	631	24	655
29.13	42	0	42
29.14	62	0	62
29.25	151	0	151
29.29	3	0	3
29.38	24	0	24
29.43	88	0	88
29.50	280	0	280
29.57	25	0	25
29.67	151	0	151
29.75	142	0	142
29.83	34	0	34
29.88	98	0	98
30.00	537	0	537
30.13	64	0	64
30.14	99	0	99
30.17	0	260	260
30.20	11	0	11
30.25	27	75	102

30.29	1	0	1
30.33	61	0	61
30.38	129	0	129
30.40	45	0	45
30.50	279	0	279
30.57	41	0	41
30.60	94	0	94
30.63	39	0	39
30.71	0	20	20
30.75	138	185	323
30.80	20	0	20
30.83	5	70	75
30.86	0	58	58
30.88	148	250	398
31.00	290	0	290
31.13	79	0	79
31.14	0	45	45
31.20	114	0	114
31.25	401	192	593
31.29	25	15	40
31.38	78	0	78
31.40	16	46	62
31.50	119	0	119
31.63	63	0	63
31.67	51	0	51
31.75	165	29	194
31.88	261	0	261
32.00	54	159	213
32.13	10	305	315
32.25	12	61	73
32.38	0	211	211
32.50	106	0	106
32.63	231	0	231
32.75	97	43	140
32.88	63	90	153
33.00	121	372	493
33.13	340	105	445
33.25	0	180	180
33.33	3	0	3
33.38	438	0	438
33.50	187	0	187
33.63	64	282	346
33.75	86	0	86
33.88	38	140	178

34.00	389	120	509
34.13	0	105	105
34.25	0	126	126
34.43	130	0	130
34.50	393	0	393
34.63	147	0	147
34.75	0	216	216
34.88	0	211	211
35.13	191	364	555
35.25	0	85	85
35.38	0	335	335
35.50	309	0	309
35.63	111	188	299
35.75	0	231	231
35.88	386	539	925
36.00	0	547	547
36.25	95	118	213
36.50	0	137	137
37.00	44	0	44
37.13	42	0	42
37.63	0	633	633
37.88	40	0	40
Total Students	10,734	7,230	17,964

Table A2: School median VCE scores by school type - boys

School Median VCE	Coed School	All Boys School	Total
24.00	1	0	1
25.00	15	0	15
25.50	1	0	1
26.00	41	0	41
26.67	9	0	9
26.75	5	0	5
27.00	39	0	39
27.17	26	0	26
27.25	6	0	6
27.33	57	0	57
27.50	58	0	58
27.60	8	0	8
27.67	29	0	29
28.00	203	0	203
28.20	9	0	9
28.25	17	0	17
28.33	21	0	21
28.50	144	0	144
28.67	102	0	102
28.71	38	0	38
28.75	50	0	50
28.80	72	0	72
29.00	466	0	466
29.13	39	0	39
29.14	24	0	24
29.25	103	0	103
29.38	14	0	14
29.43	49	0	49
29.50	141	0	141
29.57	14	0	14
29.67	98	0	98
29.75	66	35	101
29.80	0	29	29
29.83	22	0	22
29.88	90	0	90
30.00	380	0	380
30.13	90	0	90
30.14	65	0	65
30.20	5	0	5
30.25	29	0	29
30.33	49	75	124
30.38	81	158	239

30.40	27	0	27
30.50	221	0	221
30.57	24	0	24
30.60	73	0	73
30.63	42	71	113
30.75	92	0	92
30.80	31	0	31
30.83	3	0	3
30.88	146	561	707
31.00	205	120	325
31.13	122	0	122
31.20	65	0	65
31.25	345	0	345
31.29	15	0	15
31.38	96	0	96
31.40	14	0	14
31.50	111	51	162
31.63	73	0	73
31.67	38	0	38
31.75	153	0	153
31.83	0	34	34
31.88	294	0	294
32.00	54	0	54
32.13	8	0	8
32.25	7	374	381
32.50	101	0	101
32.63	190	0	190
32.75	136	0	136
32.88	73	0	73
33.00	155	0	155
33.13	345	0	345
33.33	3	0	3
33.38	457	349	806
33.50	254	0	254
33.63	43	223	266
33.75	158	0	158
33.88	37	0	37
34.00	510	0	510
34.43	134	0	134
34.50	404	0	404
34.63	216	0	216
34.75	0	286	286
34.88	534	322	856
35.13	255	0	255

35.38	0	251	251
35.50	341	460	801
35.63	114	0	114
35.88	16	455	471
36.25	96	0	96
36.75	0	918	918
37.00	62	0	62
37.13	72	0	72
37.88	59	0	59
Total Students	9,800	4,772	14,572