# Supplementary Materials

# Appendix 1 Description of the Australian education system

## ***Comprehensive education in Australia***

Australia exemplifies a comprehensive education system, where students are not streamed into different educational programs until they turn 16. The sorting of students occurs primarily through school and subject choices (Author, 2018). Since 2001 students in secondary education are not obliged to study mathematics or science subjects to be admitted to university. Although most engineering and science departments set some entry pre-requisites regarding the study of mathematics and science for entry, these prerequisites were, in the past decade, relaxed or even abandoned to attract more entrants (Law, 2018). Students have the option of doing bridging courses once admitted to university.

The university applicants who are Year 12 students at the time of application (Commonwealth Department of Education and Training, 2017) are mostly admitted based on their Australian Tertiary Admission Rank (ATAR), which reflects each student’s overall achievement relative to their peers in the country (Nicholas, Poladian, Mack, & Wilson, 2015). While upper secondary education is organized by state-specific boards of education and students study many different subjects, that vary in terms of title and content, their results are scaled into one national rank by the Universities Admissions Centre (UAC) to moderate the differences between courses, schools and states. Each student who completes the required courses in Years 11 and 12 receives a percentile rank known as the ATAR that ranges from 0 to 99.95 with increments of 0.05. A student with an ATAR of 65.00, for instance, performed better than 65% of their reference cohort.

School science subjects and mathematics subjects differ by state and student cohort. Law (2018) provides an account of mathematics courses in Australia available three years before the time at which the LSAY 2006 students studied in Years 11 and 12. Some 21% of students do not study any mathematics courses with many more females (nearly 30%) than males contributing to this overall proportion. Many students (about 48%) do not study any science. In each state the most basic mathematics course does not involve any elements of calculus and is specifically marketed to students whose further study will not require strong quantitative skills. In contrast, the advanced course is marketed to students with aptitude for mathematics and a special interest in it. The course is considered as preparation for the study of the most mathematically intensive fields at tertiary level. In each state there is also one or two mathematics subject in-between which is marketed to students whose later career path is likely to require some quantitative skills.

## ***School sectors in Australia***

Australia has three school sectors: the government, the Independent and the Catholic schools. About two-thirds of secondary students attend government schools, where priority is given to children living in local catchment areas (Campbell, Proctor, & Sherington, 2009). Parents who can pay tuition fees can opt for a Catholic or Independent school that charges fees which can vary from very modest to tens of thousands of dollars each year. Most students in Catholic schools are not Catholic themselves but their families value the Catholic credo as part of their children’s education. Year 11 and 12 science and mathematics subjects are identical for all students within the same state, regardless of their school sector, but elite schools have more qualified teachers and often advanced subjects are more easily accessible there while all of them might not be available in some government schools, particularly in rural areas. In principle, the students can travel elsewhere to do their Year 12 mathematics or science, or do them online, but lack of access to these courses within the local school is a barrier (Perry & Southwell, 2014).

# Appendix 2 Attrition in LSAY 2006

Appendix Table 2.1 LSAY 2006 cohort: Respondents by wave

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| YearWaveAge (mode)School year (mode) | 2006Wave 115 yrs 9mYear 10 | 2007Wave 216 yrs 9mYear 11 | 2008Wave 317 yrs 9mYear 12 | 2009Wave 418 yrs 9m | 2010Wave 519 yrs 9m |  |
| Respondents | **14,170** | 9,353 | 8,380 | 7,299 | 6,316 |  |
| Attrition from Wave 1 | **n.a.** | 34% | 32% | 38% | 45% |  |
| YearWaveAge (mode) | 2011Wave 620 yrs 9m | 2012Wave 721 yrs 9m | 2013Wave 822 yrs 9m | 2014Wave 923 yrs 9m | 2015Wave 1024 yrs 9m | 2016Wave 1125 yrs 9m |
| Respondents | 5,420 | 4,670 | **4,223** | 3,839 | 3,563 | **3,343** |
| Attrition from Wave 1 | 58% | 62% | **67%** | 70% | 73% | **76%** |

Source: LSAY06

Note: Data on occupational expectations come from Waves 1, 8 and 11 (bold font). The data on Year 12 subject choices were collected between 2007 and 2009 in Waves 2,3 and 4. The data on tertiary fields of study were collected from Waves 2 through 11. The data on employment were collected from Waves 9, 10 and 11

# Appendix 3 Missing data patterns

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |   | Missing | Non-missing | % Missing |
| Female |  | 0 | 3343 | 0% |
| PISA 2006 science test score |  | 0 | 3343 | 0% |
| PISA 2006 science self-concept |  | 406 | 2937 | 12% |
| Expects BAH career 2006 |  | 501 | 2842 | 15% |
| Expects CEM career 2006 |  | 501 | 2842 | 15% |
| Expects BAH career 2013 |  | 369 | 2974 | 11% |
| Expects CEM career 2013 |  | 369 | 2974 | 11% |
| Expects BAH career 2016 |  | 360 | 2983 | 11% |
| Expects CEM career 2016 |  | 360 | 2983 | 11% |
| ESCS |  | 5 | 3338 | 0% |
| Mother not in science 2006 |  | 308 | 3035 | 9% |
| Mother BAH 2006 |  | 308 | 3035 | 9% |
| Mother CEM 2006 |  | 308 | 3035 | 9% |
| Father not in science 2006 |  | 188 | 3155 | 6% |
| Father BAH 2006 |  | 188 | 3155 | 6% |
| Father CEM 2006 |  | 188 | 3155 | 6% |
| Australian born |  | 39 | 3304 | 1% |
| Second generation migrant |  | 39 | 3304 | 1% |
| First generation migrant |  | 39 | 3304 | 1% |
| No science subjects Year 12 |  | 893 | 5599 | 14% |
| Life science subjects Year 12 |  | 893 | 5599 | 14% |
| Physics in Year 12 |  | 893 | 5599 | 14% |
| Both life science subjects and physics Year 12 | 893 | 5599 | 14% |
| No mathematics Year 12 |  | 578 | 5914 | 9% |
| Mathematics Year 12 |  | 578 | 5914 | 9% |
| Advanced mathematics Year12 |  | 578 | 5914 | 9% |
| Australian Tertiary Admission Rank ATAR | 570 | 3971 | 14% |
| BAH university degree |  | 23 | 3948 | 1% |
| CEM university degree |  | 23 | 3948 | 1% |
| Both BAH and CEM university degree | 23 | 3948 | 1% |
| BAH employment |  | 639 | 3007 | 18% |
| CEM employment |   | 639 | 3007 | 18% |

Note: if a variable was used as a dependent and independent variable, the missing data statistics are provided only for the former analysis. Other missing data statistics are available upon request.

# Appendix 4 Measurement of variables

Appendix Table 4.1 Dependent Variables

|  |  |
| --- | --- |
| Dependent variable | How it was measured (codes in parentheses) |
|  | Occupational expectations at age 16 | non-science was coded (0) BAH occupations were four-digit ISCO88 codes 22xx, 315x except 3151, 32xx except 324x were coded (1) CEM occupations were four-digit ISCO88 (ILO, 1990) codes 21xx, 1222, 1223, 1236, 213x, 31xx except for 313x but 3139 included, 314x, 3434 coded (2) All other occupations were treated as non-science |
|  | Occupational expectations at ages 23 and 26 | non-science was coded (0) BAH occupations were four-digit ANZSCO codes: 2341, 2342, 2343, 2345, 2346, 2347, 25xx coded (1)CEM occupations were four-digit ANZSCO codes (ABS, 2006): 135x, 2232, 2241, 23xx - excluding 2323, 2324, 2325, 2341, 2342, 2343, 2345, 2346, 2347- and 26xx were coded (2) All other occupations were treated as non-science |
|  | Life science subjects (coded on content not subject title) | agricultural science, biology, contemporary issues and science, environmental science, human biology, life sciences, marine and aquatic practices, marine studies, multi-strand studies, psychology, science life skills, science of natural resources, senior science were coded (1) else (0) |
|  | Physics (coded on content not subject title) | physical science, physics, physics (including electronics) were coded (1) else (0) |
|  | Advanced mathematics in Year 12 | Calculus, Introductory Calculus, Mathematics Extension, Specialist Mathematics (or Mathematics Specialized) were coded (2)  |
|  | Mathematics in Year 12 | All mathematics courses not listed above were coded (1) no mathematics was coded (0) |
|  | BAH university fields of study | non-science was coded (0) ASCED (ABS, 2001) codes 0109 biological sciences, 0199 other natural and physical sciences, 05 agriculture, environmental and related studies, 06 health, 0907 behavioral science, 090701 psychology were coded (1) |
|  | CEM university fields of study | 0101 mathematical sciences, 0103 physics and astronomy, 0105 chemical sciences, 0107 earth sciences, 02 information technology, 03 engineering and related technologies, 04 architecture and building were coded (2) |
|  | BAH employment | non-science was coded (0) ANZSCO codes as for BAH expectations at ages 23 and 26 were coded (1) |
|  | CEM employment | ANZSCO codes as for CEM expectations at ages 23 and 26 were coded (2) |

|  |
| --- |
| Appendix Table 4.2 Independent Variables  |
|  | PISA 2006 science test score | Five OECD-provided plausible values which denote a science literacy test score with a mean of 500 and a standard deviation of 100 (OECD, 2007).  |
|  | PISA 2006 science self-concept | OECD-provided attitudinal scale with known reliability (OECD, 2007). Items: "Learning advanced science topics would be easy for me", "I can usually give good answers to test questions on school science topics ", "I learn science topics quickly", "Science topics are easy for me", "When I am being taught science I can understand the concepts very well" and "The self-concept was standardized to the mean of 0 and the standard deviation of 1, with higher values denoting higher self-concept. |
|  | Father works in CEM/BAH  | Derived using the steps used of student occupational expectations at 16 (non-science 0, BAH 1, CEM 2) |
|  | Mother works in CEM/BAH | Derived using the steps used of student occupational expectations at 16 (non-science 0, BAH 1, CEM 2) |
|  | ESCS: Economic Social and Cultural Status (OECD, 2007) | An OECD-derived variable which indicates socio-economic status of student family, measured in standard deviations above or below the mean with higher scores denoting higher status.  |
|  | Student migration status | 1. Australian born students (students and both parents born in Australia)
2. first-generation students (students born in Australia and at least one parent is born overseas)
3. second foreign-born students (both student and parents are born overseas)
 |
|  | ATAR Australian Tertiary Admission Rank |  Values from 30 to 99.95 |
|  | The details of weighting variables are in (Lim, 2011) |

# Appendix 5 Descriptive Statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Mean | SD | Min | Max | N |
| Female |  | 0.53 | 0.50 | 0 | 1 | 3343 |
| PISA 2006 science test score |  | 0.50 | 0.88 | -2.95 | 3.41 | 3343 |
| PISA 2006 science self-concept |  | 0.17 | 0.97 | -2.95 | 2.55 | 3343 |
| Non-science career 2006\* |  | 0.66 | 0.49 | 0 | 1 | 3343 |
| Expects BAH career 2006\* |  | 0.26 | 0.44 | 0 | 1 | 3343 |
| Expects CEM career 2006\* |  | 0.16 | 0.37 | 0 | 1 | 3343 |
| Non-science career 2013\* |  | 0.75 | 0.43 | 0 | 1 | 3343 |
| Expects BAH career 2013\* |  | 0.15 | 0.36 | 0 | 1 | 3343 |
| Expects CEM career 2013\* |  | 0.10 | 0.30 | 0 | 1 | 3343 |
| Non-science career 2016\* |  | 0.77 | 0.42 | 0 | 1 | 3343 |
| Expects BAH career 2016\* |  | 0.14 | 0.34 | 0 | 1 | 3343 |
| Expects CEM career 2016\* |  | 0.09 | 0.29 | 0 | 1 | 3343 |
| ESCS |  | 0.41 | 0.73 | -2.78 | 2.54 | 3343 |
| Mother not in science 2006\* |  | 0.85 | 0.36 | 0 | 1 | 3343 |
| Mother BAH 2006\* |  | 0.13 | 0.34 | 0 | 1 | 3343 |
| Mother CEM 2006\* |  | 0.02 | 0.15 | 0 | 1 | 3343 |
| Father not in science 2006\* |  | 0.82 | 0.38 | 0 | 1 | 3343 |
| Father BAH 2006\* |  | 0.06 | 0.24 | 0 | 1 | 3343 |
| Father CEM 2006\* |  | 0.12 | 0.32 | 0 | 1 | 3343 |
| Australian born\* |  | 0.61 | 0.49 | 0 | 1 | 3343 |
| Second generation migrant\* |  | 0.32 | 0.47 | 0 | 1 | 3343 |
| First generation migrant\* |  | 0.07 | 0.26 | 0 | 1 | 3343 |
| No science subjects Year 12\* |  | 0.48 | 0.50 | 0 | 1 | 6492 |
| Life science subjects Year 12\* |  | 0.35 | 0.48 | 0 | 1 | 6492 |
| Physics in Year 12\* |  | 0.14 | 0.34 | 0 | 1 | 6492 |
| Both life science subjects and physics\* | 0.04 | 0.19 | 0 | 1 | 6492 |
| No mathematics Year 12\* |  | 0.21 | 0.41 | 0 | 1 | 6492 |
| Mathematics Year 12\* |  | 0.68 | 0.47 | 0 | 1 | 6492 |
| Advanced mathematics Year12\* |  | 0.11 | 0.31 | 0 | 1 | 6492 |
| Australian Tertiary Admission Rank ATAR | 80.2 | 13.8 | 33 | 100 | 3971 |
| BAH university degree\* |  | 0.31 | 0.46 | 0 | 1 | 3971 |
| CEM university degree\* |  | 0.17 | 0.38 | 0 | 1 | 3971 |
| Both BAH and CEM university degree\* | 0.03 | 0.16 | 0 | 1 | 3971 |
| Non-science employment\* |  | 0.83 | 0.38 | 0 | 1 | 3646 |
| BAH employment\* |  | 0.10 | 0.30 | 0 | 1 | 3646 |
| CEM employment\* |  | 0.07 | 0.25 | 0 | 1 | 3646 |

Note: \*Categorical variables presented as dummies for ease of interpretation. If a variable was used both as a dependent and independent variable, descriptive statistics are provided only for the former analysis. Other descriptive statistics are available upon request. These statistics are derived from the first imputation and will be somewhat different for the other four imputed datasets.

# Appendix 6 Supplementary analyses: occupational expectations at age 16 and the uptake of mathematics subjects in Year 12

|  |
| --- |
| Table A6.1 Predictors of science career plans at age 16, multinomial logit, relative risk ratios (RRR) with standard errors (SE) |
|   | Life science career (BAH) RRR | SE | Computing / engineering career (CEM) RRR | SE |
| Reference: male | - |  | - |  |
| Female | 2.21\*\*\* | 0.32 | 0.21\*\*\* | 0.03 |
| PISA 2006 science test score | 1.52\*\*\* | 0.17 | 1.56\*\*\* | 0.17 |
| PISA 2006 science self-concept score | 2.15\*\*\* | 0.21 | 1.90\*\*\* | 0.2 |
| ESCS | 0.99 | 0.11 | 1.02 | 0.13 |
| Reference: mother not in science 2006 | - |  | - |  |
| Mother BAH 2006 | 1.42\* | 0.26 | 1.24 | 0.28 |
| Mother CEM 2006 | 0.91 | 0.49 | 0.51 | 0.28 |
| Reference: father not in science 2006 | - |  | - |  |
| Father BAH 2006 | 1.36 | 0.42 | 0.54\* | 0.18 |
| Father CEM 2006 | 1.01 | 0.19 | 1.28 | 0.28 |
| Australian born | - |  | - |  |
| Second generation migrant | 1.29\* | 0.18 | 1.84\*\*\* | 0.31 |
| First generation migrant | 2.50\*\*\* | 0.78 | 1.4 | 0.39 |
|  |  |  |  |  |
| KHB decomposition of the gender gap |  |  |  |  |
| % overall *increase/*decrease in gender gap | *33.2*% |  | 9.4% |  |
| % *increase*/decrease if all students had: |  |  |  |  |
| identical science self-concept at 16 | *33.2*% |  | 9.4% |  |
| identical science test scores at 16 | 0% |  | 0% |  |
|  |  |  |  |  |
| Observations | 3343 |  |  |  |
| Pseudo *R*2 | 0.16 |   |   |   |
| \* *p* < .10, \*\* *p* < .05, \*\*\* *p* < .01 |  |  |  |  |
| Note: The decomposition suggests that if all predictor values were equal for boys and girls (which they are not because girls in this sample have lower science self-concept than boys), the gender gap in BAH career expectations would not decrease but it would widen by 33%. This suppression effect (MacKinnon, Krull, & Lockwood, 2000) suggests that strengthening girls’ science self-concept among female students could lead to narrowing of the gender gap in CEM but potentially also to widening of the gap in BAH, as even more girls would opt for the latter (for argument that this might be the case in all PISA-participating countries see: Author, 2012). The KHB also suggests that the gender gaps in BAH and CEM expectations in Table 1 mostly do not depend on the predictors in the model (as only 33% and 9% do). |
| Table A6.2. Predictors of mathematics subject choices in Year 12, multinomial logit, relative risk ratios (RRR) with standard errors (SE) |
|   | Mathematics in Year 12 RRR | SE | Advanced mathematics in Year 12 RRR | SE |
| Reference: male |  - |  |  - |  |
| Female | 0.63\*\* | 0.05 | 0.38\*\* | 0.05 |
| Reference: expects nonscience career 2006 |  -  |  |  -  | . |
| Expects BAH career 2006 | 1.89\*\* | 0.19 | 2.84\*\* | 0.5 |
| Expects CEM career 2006 | 2.16\*\* | 0.31 | 4.91\*\* | 0.89 |
| PISA 2006 science test score | 1.12 | 0.11 | 1.86\*\* | 0.27 |
| PISA 2006 science self-concept score | 1.05 | 0.05 | 1.79\*\* | 0.14 |
| Family status (ESCS) | 0.87 | 0.07 | 0.64\*\* | 0.07 |
| Reference: mother not in science 2006 |  -  |  |  -  | . |
| Mother BAH 2006 | 1.2 | 0.16 | 1.09 | 0.22 |
| Mother CEM 2006 | 1.05 | 0.28 | 1.57 | 0.58 |
| Reference: father not in science 2006 |  -  |  |  -  | . |
| Father BAH 2006 | 0.91 | 0.17 | 0.99 | 0.26 |
| Father CEM 2006 | 1.11 | 0.16 | 1.26 | 0.25 |
| Australian born |  -  |  |  -  | . |
| Second generation migrant | 1.20\* | 0.1 | 1.97\*\* | 0.26 |
| First generation migrant | 2.16\*\* | 0.41 | 7.38\*\* | 1.77 |
|  |  |  |  |  |
| KHB decomposition  |  |  |  |  |
| % Gender gap explained  | 17.0% |  | 28.3% |  |
| % Gender gap would decrease if all had: |  |  |  |  |
| identical CEM career expectations at age 16 | 15.1% |  | 14.9% |  |
| identical science test scores at age 16 | 0.1% |  | 0.0% |  |
| identical science self-concept at age 16 | 1.8% |   | 13.4% |   |
|  |  |  |  |  |
| Observations | 6492 |  |  |  |
| Pseudo *R*2 | 0.25 |   |   |   |
| \*\* *p* < .05, \*\* *p* < .01 |  |  |  |  |

# Appendix 7 Selected KHB elements for analytical tables

|  |  |  |
| --- | --- | --- |
| Multinomial logit coefficients: KHB decomposition results |  |  |
| Table 1 | BAH | sig | CEM | sig |
| % confounding | 0.13 |  | 0.33 |  |
| Reduced (total effect) | 0.95 | 0.00 | -0.92 | 0.00 |
| Full (direct effect) | 0.83 | 0.00 | -0.62 | 0.00 |
| Difference (indirect effect) | 0.12 | 0.00 | -0.30 | 0.00 |
|  |  |  |  |  |
| Table 2 | BAH | sig | CEM | sig |
| % confounding | 0.45 |  | 0.18 |  |
| Reduced (total effect) | 1.19 | 0.00 | -0.87 | 0.00 |
| Full (direct effect) | 0.65 | 0.01 | -0.72 | 0.00 |
| Difference (indirect effect) | 0.53 | 0.00 | -0.15 | 0.00 |
|  |  |  |  |  |
| Table 3 | Life science | sig | Physics | sig |
| % confounding | 0.37 |  | 0.33 |  |
| Reduced (total effect) | 0.46 | 0.00 | -1.27 | 0.00 |
| Full (direct effect) | 0.29 | 0.00 | -0.85 | 0.00 |
| Difference (indirect effect) | 0.17 | 0.00 | -0.42 | 0.00 |
|  |  |  |  |  |
| Table 4 | BAH | sig | CEM | sig |
| % confounding | 0.56 | 0.00 | 0.51 | 0.00 |
| Reduced (total effect) | 0.73 | 0.00 | -1.13 | 0.00 |
| Full (direct effect) | 0.32 | 0.00 | -0.55 | 0.00 |
| Difference (indirect effect) | 0.41 | 0.00 | -0.57 | 0.00 |
|  |  |  |  |  |
| Table 5 | BAH | sig | CEM | sig |
| % confounding | 0.81 |  | 0.20 |  |
| Reduced (total effect) | 0.84 | 0.00 | -0.77 | 0.00 |
| Full (direct effect) | 0.16 | 0.25 | -0.54 | 0.04 |
| Difference (indirect effect) | 0.67 | 0.00 | -0.23 | 0.02 |
|  |  |  |  |  |
| Table A6.1 | BAH | sig | CEM | sig |
| % confounding | -0.33 | 0.00 | 0.09 | 0.00 |
| Reduced (total effect) | 0.59 | 0.00 | -1.71 | 0.00 |
| Full (direct effect) | 0.79 | 0.00 | -1.55 | 0.00 |
| Difference (indirect effect) | -0.20 | 0.00 | -0.16 | 0.00 |
| Table A6.2 CEM career plan at 16 | Mathematics | sig | Advanced mathematics | sig |
| % confounding | 0.19 |  | 0.18 |  |
| Reduced (total effect) | -0.58 | 0.00 | -1.19 | 0.00 |
| Full (direct effect) | -0.47 | 0.00 | -0.96 | 0.00 |
| Difference (indirect effect) | -0.11 | 0.00 | -0.23 | 0.00 |

Note: Analytical tables contain exponentiated coefficients, while this table contains adjusted multinomial logit coefficients

**References for supplementary materials**

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