The long-term outcomes associated with Key Stage 4 science options

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Executive summary

1.1 Methodology

- This report is divided into two main parts: a descriptive analysis of the uptake of the various Key Stage 4 science options between 2006 and 2019, and an analysis of the association between those options and a set of long-term outcomes.
- The descriptive analysis is based on data from the National Pupil Database and includes pupils in state-funded mainstream schools in England.
- We describe the uptake of the various options and how that has changed over time, before categorizing schools based on the proportion of their pupils entered for triple science.
- The analysis of long-term outcomes uses regression models to show the relationship between studying triple science and going on to study science post-16, controlling for prior attainment, pupil demographics and school characteristics.
- We also examine whether this relationship varies by the schools' triple science offer, and by gender.

1.2 Main findings

- Selective schools, schools with sixth forms, those with high levels of average prior attainment and those with low levels of disadvantage entered a higher proportion of their pupils for triple science.
- Schools in the South East were more likely to enter a high proportion of their pupils to triple science; 10% of schools in the region entered 75% or more in 2019 compared to 5% nationally.
- Sponsored academies and free schools tended to be more likely to enter no pupils to triple science than other school types. On the other hand, the small number of university technical colleges were more likely to enter a high proportion of pupils to triple science.
- Pupils who took triple science were more likely to go on to study science post-16 than those who took double science. For pupils who completed KS4 in 2017, the odds of a triple science pupil going on to take A-Level chemistry were 4.4 times higher than for a double science pupil, while for biology they were 3.6 times higher and for physics 2.9 times higher.
- The association between triple science and going on to study science post-16 grew stronger in the more recent years covered, appearing to increase as the proportion of pupils studying triple science increased.
- We found some indications that the association between triple science and studying science post-16 varies depends on school science curriculum offer, but these were tentative. The indications suggested that the association may be weaker for pupils who attended a school in which most pupils took triple science than for pupils who attended in school in which a minority did so.
- There were some indications that the association between triple science and going on to study science post-16 varies by gender; it is slightly stronger for female pupils.

1.3 Limitations

- During the period covered by this report, various policy changes affected the uptake of Key Stage 4 science qualifications, and the content, structure and grading of the qualifications.

- The results we present on long-term outcomes are correlational; they do not imply a causal relationship between Key Stage 4 science options and going on to study science post-16.
- Our modeling necessarily excludes pupils for whom data on the outcomes and / or controls is unavailable. They will include pupils who left the English state-school system after Key Stage 4, or those for whom prior attainment data is unavailable because they were not part of the system during Key Stage 2.
- We control for differences in prior attainment at Key Stage 2, but it is possible that selection effects remain. It may be that pupils who go on to study triple science have higher levels of motivation and general attainment than their KS2 attainment would suggest. We try to account for this by also controlling for attainment in KS4 maths and English.

1. Introduction

Since the introduction of the National Curriculum in 1988, it has been compulsory for pupils in state-funded schools in England to study science up until the end of Key Stage 4. However, there are several options available, which have varied considerably in popularity over the last fifteen years. These include triple science GCSE, comprised of three separate GCSEs in science subjects, other GCSE options that result in either one or two GCSEs (usually referred to as double or single science GCSE) and various applied qualifications, most notably BTECs. Generally, it is up to schools to decide which of these options they offer to which pupils. Some options may not be offered at all in some schools.

Triple science GCSE is seen as the most academically demanding option and, although entry requirements vary, as the most appropriate precursor to studying science at A-Level. Indeed, previous research[1] has shown that pupils who study triple science GCSE are more likely to go on to take a science A-Level. However, in a 2016 study, Archer et al found that a majority of pupils reported that they did not choose their own route in KS4 science; instead, it was decided for them by their school.[2] This raises the question of how far a school's policy on triple science GCSE affects their pupils' long term prospects of pursuing science at A-Level and beyond.

In this report, we will begin by presenting a descriptive analysis, providing background information on the popularity of Key Stage 4 science options over the period 2006-19, and how that varied between schools. This will include an analysis of how the options offered by schools varied by school characteristics, including average attainment, levels of disadvantage, admissions policy and school type. We will go on to look the association between Key Stage 4 science options and long-term outcomes, considering both pupils' individual choices and the curriculum offer of their school. This will include a range of long-term outcomes, including whether the pupil goes on to complete any Level 3 qualifications, an A-Level in a science subject, or a STEM degree.

[1] Institute of Physics (2018). *Why not physics? A snapshot of girls' uptake at A-level.*

[2] Archer, L., Moote J., Francis, B., DeWitt, J., & Yeomans, L. (2016). *Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to 'Triple Science' at Key Stage 4 in England.*

2. Methodology

This report consists of two main parts: a descriptive analysis of the popularity of Key Stage 4 science options over the period 2006-19, and an analysis of how Key Stage 4 science options affect long-term outcomes.

3.1 Descriptive analysis

This analysis will use observational data available from the National Pupil Database (NPD) linked to a range of datasets containing the longer-term outcomes of individuals such as A-level attainment, higher education enrolment and attainment and earnings and employment.

Firstly, we will use NPD to classify pupils according to the science qualifications they enter at the end of Key Stage 4. This will cover a thirteen year period from 2006 to 2019.

Having classified pupils according to their Key Stage 4 science qualifications, we will classify and describe the curriculum offers of schools and how they have changed over time. We will divide schools into categories based on the proportion of their pupils who entered triple science in any one year.

Having classified schools according to their different curriculum offers in science, we will examine how they are associated with a range of school characteristics such as governance, disadvantage, performance and geography.

3.2 Long-term outcomes

Having classified both pupils and schools according to their science curriculum offer, we will examine how both are related to longer-term outcomes.

This will include the following outcomes:

- Achievement of at least one A-Level in any of the three main science subjects by age 19
- Achievement of A-Level biology, chemistry or physics by age 19
- Achievement of any A-Level by age 19
- Achievement of any Level 3 qualification by age 19
- Enrolment on a course at NQF Level 6 or above (bachelor's degree or above) in a STEM subject by age 20
- Enrolment on a course at NQF Level 6 or above (bachelor's degree or above) in any subject by age 20
- Achievement of a degree in a STEM subject by age 22

The outcomes above can be derived from the National Pupil Database (NPD) linked to the Higher Education Statistics Agency (HESA) Student Record. In addition, a small amount of higher education takes place in the further education sector which can be observed in the Individualised Learner Record (ILR).

Having calculated a range of longer term outcomes for pupils who completed Key Stage 4 between 2006 and 2019 where possible, we will examine how they are associated with a) the individual KS4 science qualifications they achieved at 16 and b) the science curriculum offer of their school. We will do so using logistic regression models, controlling for a range of pupil characteristics (prior attainment (Key Stage 2 APS), attainment in English and maths at KS4,

ethnicity, gender, disadvantage) and school characteristics (geography, governance, selectivity).

Outcomes will be binary (0,1), with 1 indicating whether a pupil went on to complete or enrol on the relevant qualification.

The models will be of the form:

$$\log\left(\frac{p(z_{ijk})}{1-p(z_{ijk})}\right) = \boldsymbol{\gamma w}_{ijk} + \boldsymbol{\beta x}_{ijk}$$

where *p(z)* is the probability that the outcome is 1 for the ith pupil in the jth school in the kth outcome year, γ are the associations between KS4 science qualification and the outcome, *w* is an indicator variable for the KS4 science qualification taken[3], beta are the effects of the control variables on the outcome measures, and *x* are the control variables.

Models will be fitted to data related to pupils who completed KS4 in each academic year from 2006 – 17; a separate model will be fitted for each outcome and each academic year.

[3] The eligible qualifications are: triple science GCSE, double science GCSE, single science GCSE, Applied Level 2 or no L2 qualification. See section 4.2 for more details.

3. Data and definitions

4.1 National Pupil Database and HESA Student Record

The National Pupil Database (NPD) is an administrative data resource maintained by the Department for Education and provides a history of enrolments, attendance, exclusions and attainment in national tests and public examinations (e.g. GCSE and A-level) for all pupils who have been in state-funded education since 2002. For this project, we used data on entries to GCSE and A-Level, as well as prior attainment during Key Stage 2. We also used some additional demographic variables.

The Higher Education Statistics Agency (HESA) Student Record is a data resource maintained by HESA which provides individualised data about students at UK higher education providers, including the student's entry profile and personal characteristics, module and course level data, funding information and qualifications awarded. For this project, we used data on courses entered and qualifications awarded, linked to data from the NPD.

For data protection reasons, suppression has been applied to data where appropriate based on NPD and HESA guidelines.

4.2 Classifying science curriculum offers

Throughout this report, we will be discussing different Key Stage 4 science curriculum offers. However, over the period covered by the report, a wide range of options have been available to schools and pupils at KS4. In the interests of making our analysis more streamlined, we have grouped these options into the following categories: triple GCSE, double GCSE, single GCSE, applied Level 2, and no Level 2 qualification. We have counted iGCSEs and equivalent Level 1 / 2 certificates as GCSEs.

The table below shows the qualifications that we included in each category.

Table 1: Qualification categories by individual qualifications included

Qualification	Includes
Triple GCSE	Three science GCSEs: either biology, chemistry and physics, or two of these and computer science, or core, additional and further additional science
Double GCSE	Double Award science *OR* core and additional science *OR* two science GCSEs
Single GCSE	Core science *OR* one science GCSE
Applied Level 2	Level 2 BTEC *AND / OR* OCR Cambridge Technicals *AND / OR* iGNVQ
No Level 2 qualification	Did not complete any science GSCSE or other Level 2 science qualification

To complicate matters further, it is possible for pupils to take qualifications from more than one category. For example, a pupil might take a BTEC and a single science GCSE. In these cases, we have allocated pupils to categories based on a hierarchy, running from triple GCSE to double GCSE to single GCSE to applied Level 2. This means that, for example, any pupil

who took triple GCSE would be allocated to that category, even if they also took other qualifications. Similarly, any pupil who took double GCSE would be allocated to that category unless they also took triple GCSE.

The sheer number of available options and combinations is striking. Before categorisation, we found 53 different combinations.

5. Descriptive analysis: Key Stage 4 science curriculum offers

In this section, we will begin by giving an overview of the popularity of the various KS4 science options during the period 2006-19, both at the pupil and school level. We'll then go on to explore how the school level offers vary by school characteristics.

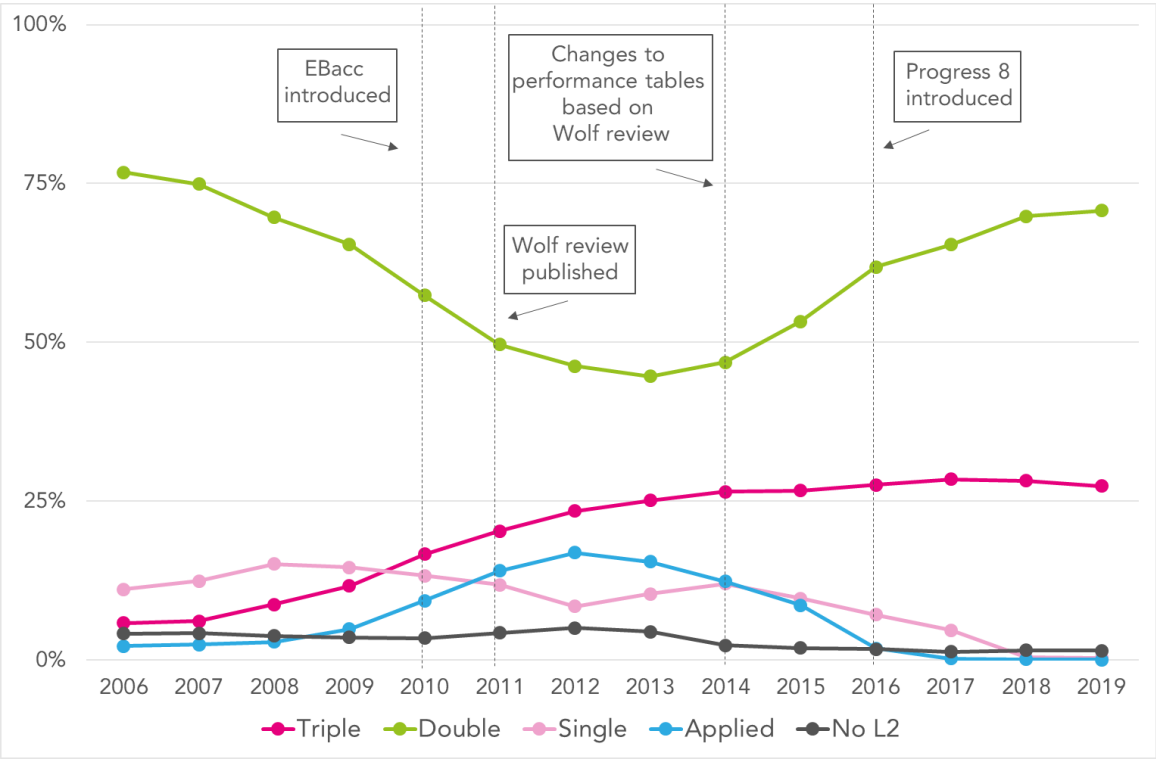
In the main body of the report below, we summarise the results of our analysis in the form of charts and brief tables. Full results are included in the appendix.

5.1 Overview

5.1.1 Pupil level

The number of entries to each KS4 science option from 2006-19 are shown in figure 1.

Figure 1: Proportion of Key Stage 4 pupils entering science qualifications, 2006-19



Double science GCSE was the most popular option in every year, although entry numbers did fall between 2007 and 2013. This coincided with an increase in entries to triple science and to applied level 2 qualifications, although entries to the latter have since tailed off dramatically following the introduction of new policies and reviews, including the English Baccalaureate, the Wolf review and Progress 8. Triple science GCSE, however, remained far more popular in 2019 than in 2006; just 6% of pupils took triple science in 2006 compared to 27% in 2019.

5.1.2 School level

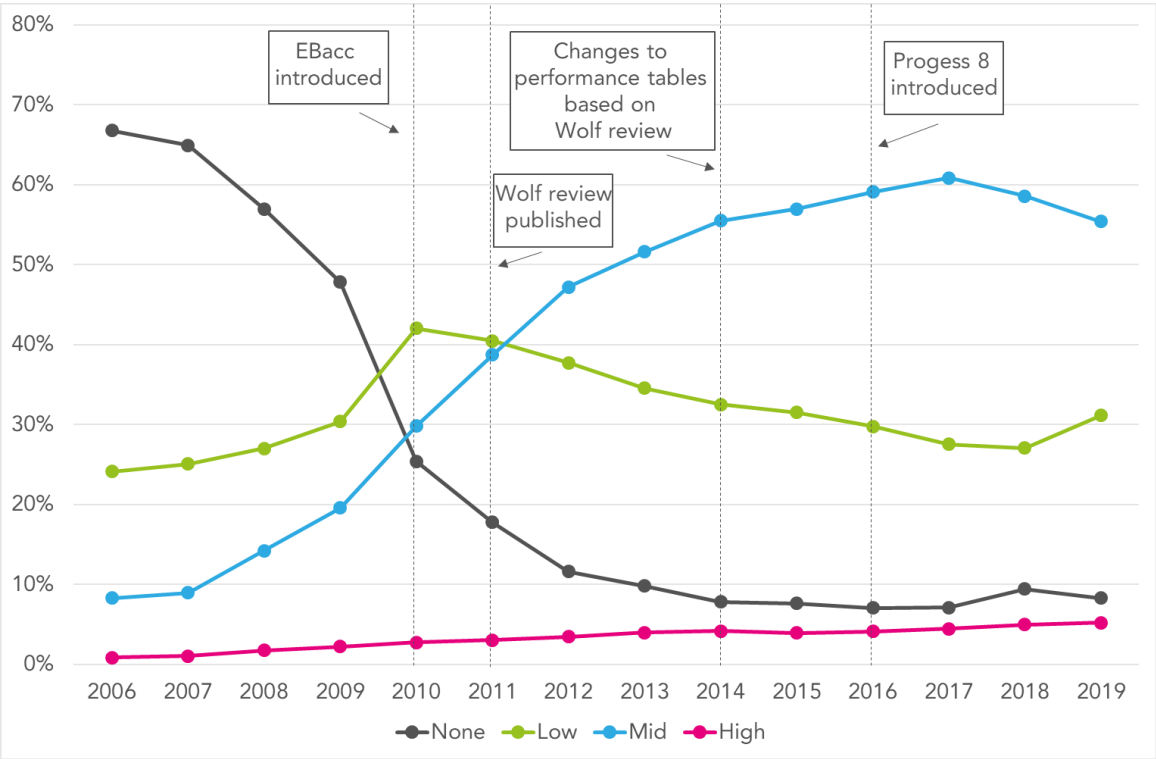
We categorised schools according to their KS4 science curriculum offer. As we were particularly interested in the proportion of pupils who studied triple science GCSE, our categories are based on this measure. The categories are described in the table below.

Table 2: Triple science bands by proportion of pupils entered

Triple science band	% pupils entered for triple science
None	0%
Low	Between 0% and 20%
Mid	Between 20% and 75%
High	Above 75%

The number of schools that fall into each band is shown in figure 2.

Figure 2: State-funded schools in England by triple science band, 2006-19



Until 2010, the most common group was those that did not have any pupils taking triple science GCSE at all, with two thirds of schools (67%) falling into this band. However, the number of schools in this band has fallen dramatically since 2006. By 2019, the most common band was *mid*, which includes schools in which at least 20%, and up to three-quarters of pupils are entering triple science. A substantial number of schools entered a smaller proportion of pupils for triple science; in 2019, 31% fell into the *low* band, entering fewer than 20% of their pupils. We believe these schools are likely to follow a policy of entering only their high attaining pupils to triple science. Finally, the proportion of schools in the *high* band, which entered at least 75% of their pupils for triple science, stood at 5% in 2019, an increase from just 1% in 2006.

5.2 Curriculum offer and school characteristics

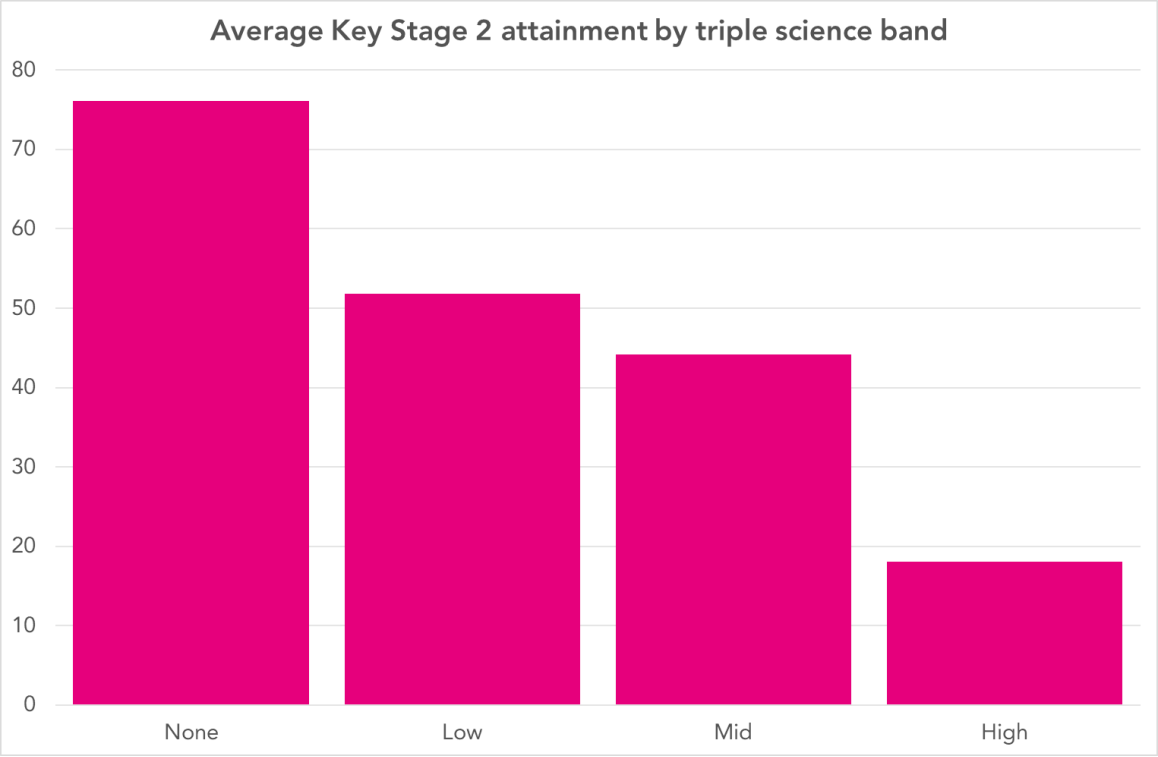
5.2.1 Attainment

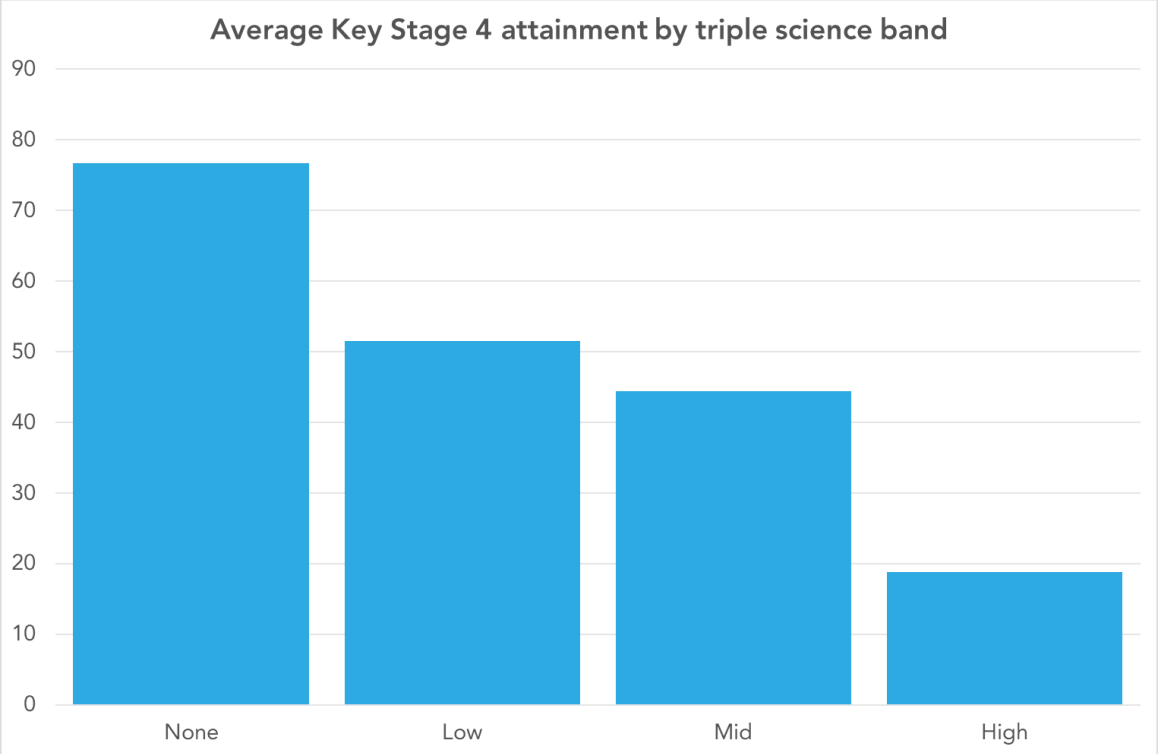
Perhaps the most striking difference between schools with different triple science offers is attainment.

The measures of attainment that we have used are based on average points scores in KS2 tests, and attainment in GCSE English and maths. In order to allow for easy comparison, we present these as percentiles from 100-1. A school in the 100th percentile has a very low level of attainment relative to other schools, while a school in the first has a very high level of attainment.

Figure 3 shows the mean school-level attainment in each of the triple science bands in 2019.

Figure 3: Average attainment by school triple science band, 2019





Broadly speaking, the higher the average level of attainment in school, the higher the proportion of pupils taking triple science. The majority of schools with no pupils taking triple science had low levels of attainment, while schools in which most pupils took triple science tended to have very high levels of attainment, both at KS2 and KS4.

5.2.2 Admissions policy

Unsurprisingly, given the differences in triple science by attainment discussed above, selective schools were far more likely to offer triple science than other schools. In 2019, around 70% of selective schools fell into the highest of our triple science bands, compared to just 2% of other schools.

Unfortunately, because of the relatively low number of selective schools, and the low proportion of these schools that fall into the lower triple science bands, data protection restrictions not do allow us to publish the exact number or proportion of selective schools that fall into each triple science band for the majority of years covered by this analysis.

5.2.3 School type

During the period covered by the analysis, there have been considerable changes in the governance of schools in England. Many schools academised during this period, and several new school types, including free schools, university technical colleges and studio schools, were introduced. In 2006, just 24 of the schools included in our analysis, less than 1%, were academies. By 2019, 68% of the 3,186 schools included were academies and 5% were free schools.

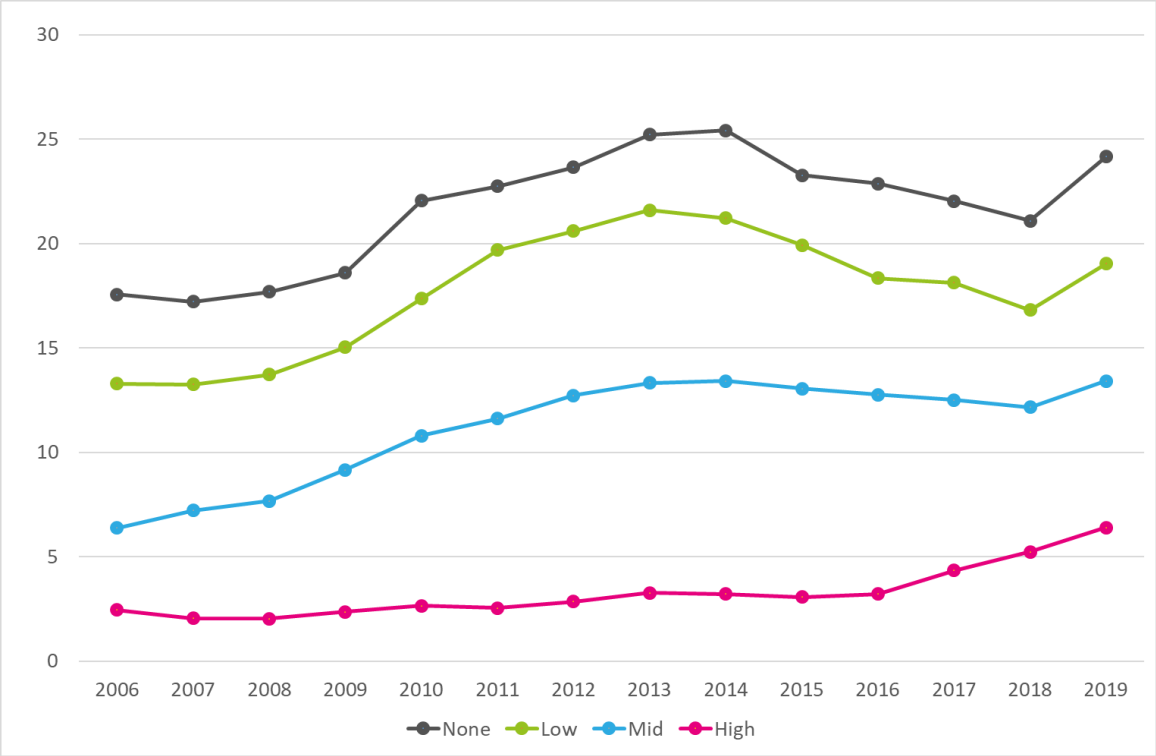
Once again, because of the relatively low numbers of some school types, we are not able to publish the exact number and proportion of schools that fall into each triple science band for several of the years and school types covered.

However, there are some differences between school types on which we can comment. Sponsored academies and free schools tended to be more likely to fall into the lowest triple science band than other school types. In 2019, around 15% of sponsored academies and free schools did so compared to 8% of schools overall. University technical colleges were most likely to fall into the *high* band; around 20% did so in 2019 compared to 5% of schools overall. Academy converters were also more likely than other school types to fall into the *high* band; 8% did so in 2019.

5.2.4 Disadvantage

Schools with a high proportion of pupils who were eligible for free school meals were less likely to fall into the higher triple science bands. In 2019, the average proportion of disadvantaged pupils in schools in the highest band was 6%, compared to 24% in the lowest band.

Figure 4: Average proportion of FSM pupils by triple science band



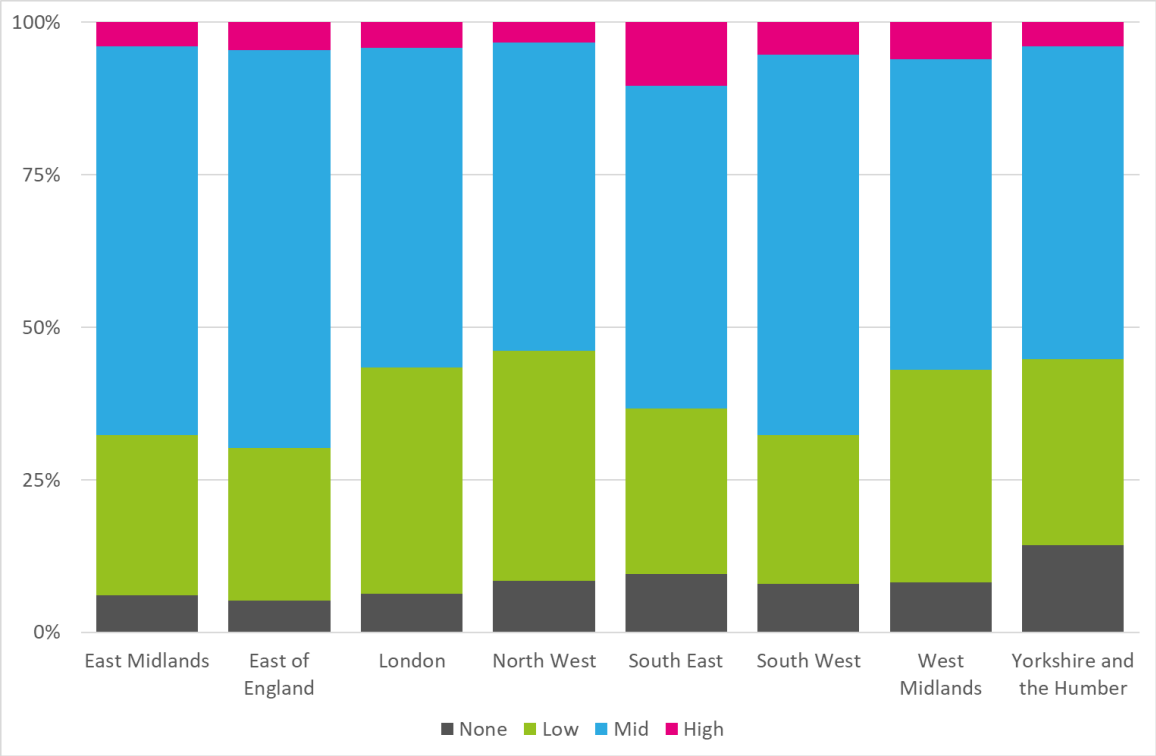
These differences by school level of disadvantage were fairly consistent throughout the period from 2006-19, although in the earlier years the difference between those schools in the *mid* and *high* bands was less marked. In 2006, the average proportion of disadvantaged pupils in a school in the *mid* band was 6%, compared to 2% in the top band. But in 2019, the average proportion in the *mid* band was 13% compared to 6% in the top band.

5.2.5 Region

The South East tended to have a higher proportion of schools in the top band than other regions, with 10% of schools in the region falling into this band in 2019 compared to 5% nationally. This is likely to be at least partly a reflection of the high number of grammar schools in the South East.

Unfortunately, because of the relatively low number of schools in the region, and the low proportion of these schools that fall into the *none* and *high* bands, data protection restrictions not do allow us to publish the exact proportion of schools in the North East that fell into each band in 2019.

Figure 5: Proportion of schools in triple science band, by region (excluding NE)



5.2.6 Sixth form

Schools with a sixth form tended to have a higher proportion of pupils studying triple science. In 2019, 8% of schools with a sixth form fell into the highest triple science band, compared with 1% of schools without. Just 6% of schools with a sixth form had no pupils entered for triple science, compared to 11% of other schools.

Again, because of the relatively low number of schools without a sixth form included in our analysis, data protection restrictions not do allow us to publish the exact proportion of schools without sixth forms that fell into each band in the majority of the years covered.

6. Long-term outcomes

6.1 Overview

In this section, we examine the association between triple science GCSE, school triple science offer and long-term outcomes, including:

- Achievement of at least one A-Level in any of the three main science subjects by age 19
- Achievement of A-Level biology, chemistry or physics by age 19
- Achievement of any A-Level by age 19
- Achievement of any Level 3 qualification by age 19
- Enrolment on a course at NQF Level 6 or above (bachelor's degree or above) in a STEM subject by age 20
- Enrolment on a course at NQF Level 6 or above (bachelor's degree or above) in any subject by age 20
- Achievement of a degree in a STEM subject by age 22

We do so by fitting logistic regression models, controlling for pupil and school level characteristics. In order to examine the impact on male and female students, we also fit models separately for each gender.

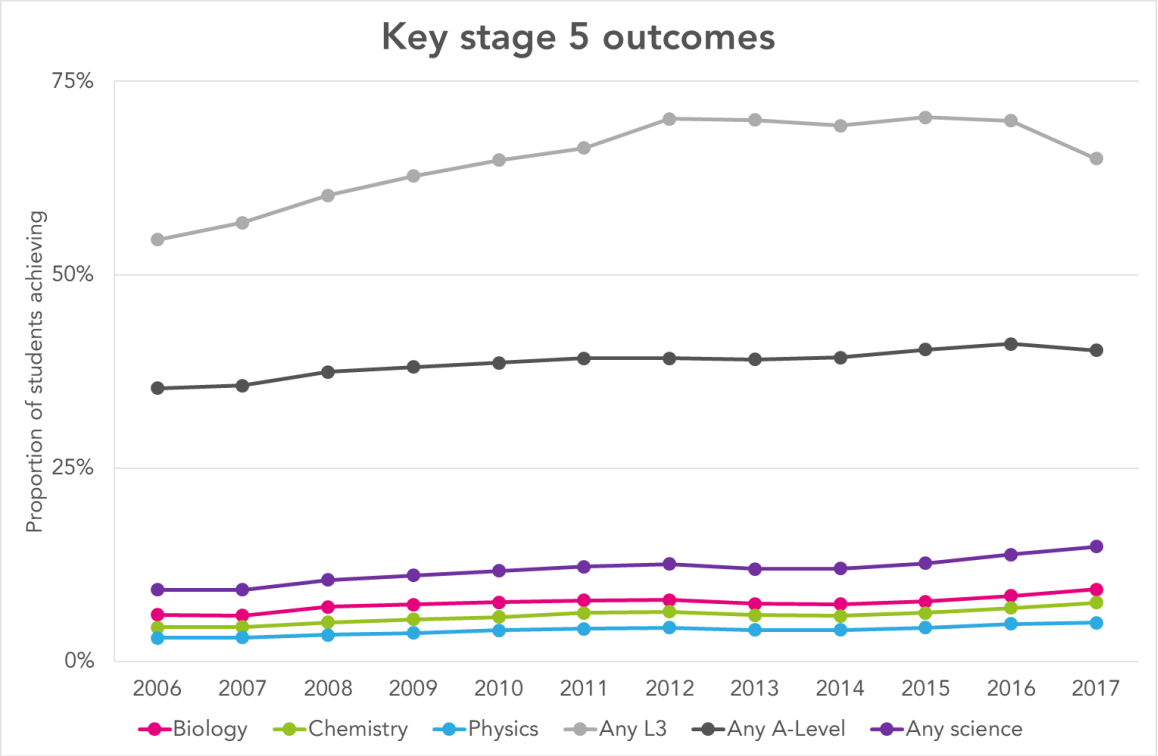
The results in this section are summarised in the body of the report in the form of charts. Full results are also included in the appendix.

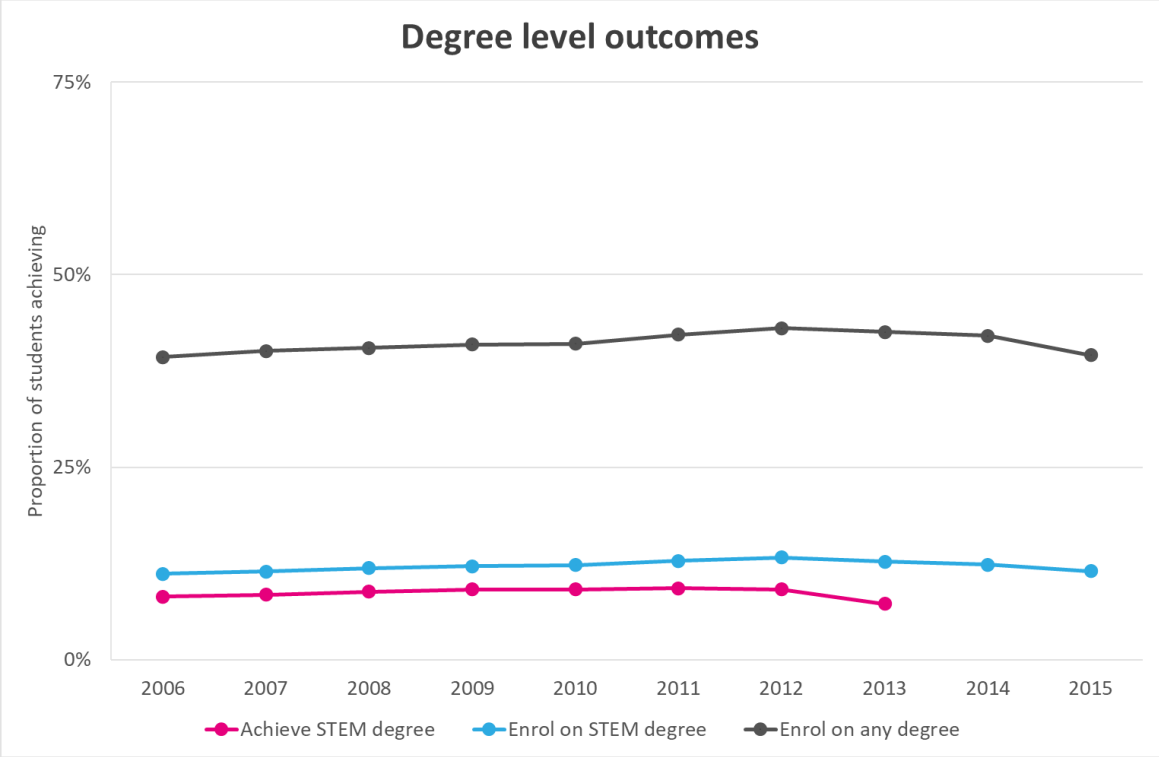
The charts in figure 6 below show the proportion of Key stage 4 pupils who went on to achieve each outcome. The years shown in the chart are the years in which pupils completed Key Stage 4.

The proportion of pupils going on to complete Level 3 qualifications of any sort has increased during the period covered, from 55% of pupils who completed KS4 in 2006 to 65% in 2017. The proportion completing A-Levels in any subject has also increased, from 35% in 2006 to 40% in 2017. A-Levels in at least one of the three main science subjects have become more popular, with just 9% completing this outcome in 2006 compared to 15% in 2017. The increase in pupils taking science A-Levels was particular steep from 2014 onwards. During the whole period, biology was the most popular of the three science A-Levels, with chemistry second and physics least popular.

Despite this, the proportion of pupils going on to enrol on a degree in any subject was fairly flat during the period covered; it stood at around 39% of pupils who completed KS4 in 2006, and 40% of those who completed KS4 in 2015. The proportion enrolling in a STEM degree was similarly flat, at 11% in 2006 and 12% in 2015, as was the proportion who went on the complete a STEM degree.

Figure 6: Overview of outcomes, 2006-17





6.2 Individual KS4 science options

In this section, we look at the association between triple science GCSE and long-term outcomes. Results are presented in the form of odds ratios and marginal effects.

Odds ratios tell us the relative odds of a student achieving the outcome, depending on whether they took triple or double science. An odds ratio of one would mean that a triple science student had exactly the same odds of achieving the outcome as a double science students. An odds ratio above one means that a triple science student is more likely to achieve the outcome, and an odds ratio of below one means that they are less likely.

Marginal effects describe the average effect of changes in a variable on an outcome. In this case, the variable of interest is pupils' Key Stage 4 science option, and we are interested in comparing the effect of taking double science GCSE with the effect of taking triple science. Marginal effects are usually easier to interpret than odds ratios, which is why we include them here.

The results presented in this section show:

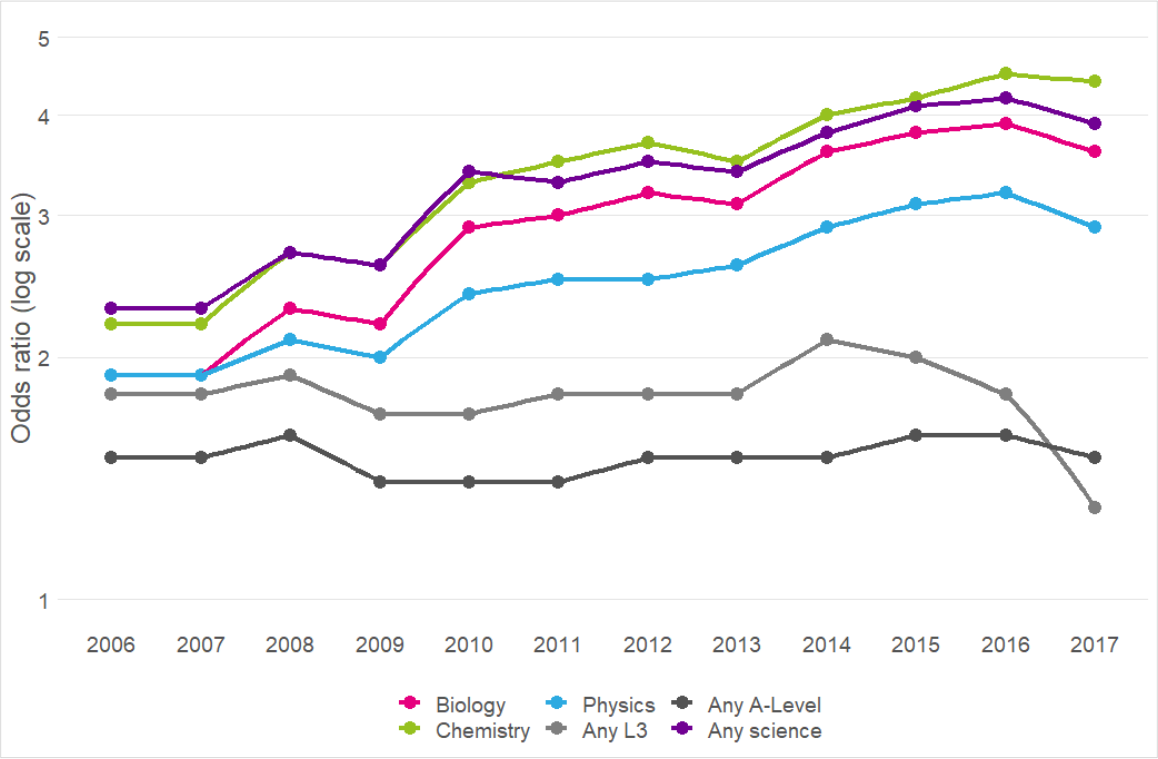
- odds ratios comparing the odds of pupils who took triple science GCSE going on to complete the relevant long-term outcome, to those of pupils who took the most common option, which is double science GCSE
- marginal effects showing the difference between triple science pupils' actual outcomes and their predicted probability of achieving the outcome, had they taken double science.

6.2.1 Key Stage 5 outcomes

All pupils

Figure 7 shows the odds ratios of triple science GCSE pupils going on to complete Level 3 qualifications, as compared to double science GCSE pupils. The years shown on this chart are the years in which pupils completed Key Stage 4.

Figure 7: Odds ratios for triple vs double science pupils completing Key Stage 5 outcomes, 2006-17



These results suggest that, even controlling for differences in attainment, pupil and school characteristics, pupils who take triple science are more likely to go on complete all of the Key Stage 5 outcomes considered here. However, the association is particularly strong for science subjects.

For pupils who completed KS4 in 2017, for example, the odds of a pupil who took triple science going on to take an A-Level in one of the three main science subjects were 3.9 times higher than for a pupil who took double science. In comparison, the odds of a pupil who took triple science going on to take an A-Level in any subject were just 1.5 times higher than for a pupil who took double science.

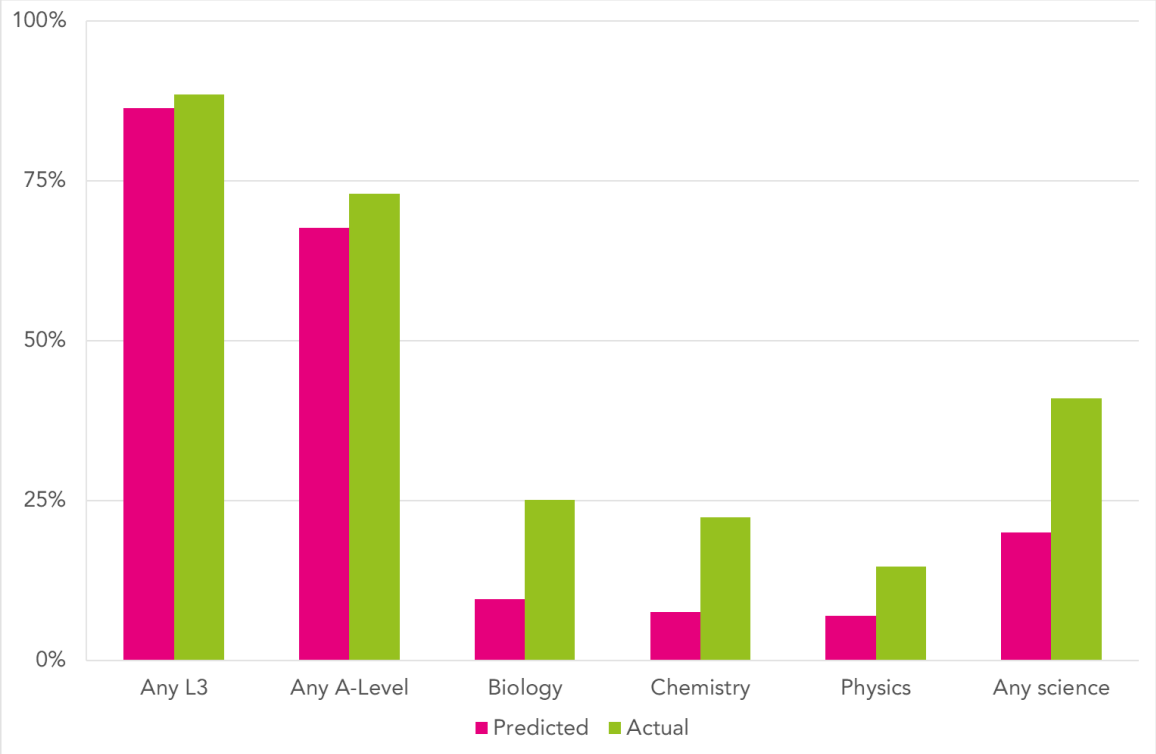
The association between triple science and completing A-Levels in chemistry and biology was consistently stronger than for physics. For pupils who completed KS4 in 2017, the odds of going on to take A-Level chemistry were 4.4 times higher than for a double science pupil, while for biology they were 3.6 times higher and physics just 2.9 times higher.

Generally speaking, the association between triple science and studying a science A-Level increased during the period covered by this report.

Looking at the marginal effects gives us some insight into how to interpret these odds ratios. As shown in figure 8, the actual proportion of triple science pupils who went on to take an A-Level in one of the three main science subjects, was 41%, and the average probability predicted by our model, had they instead taken double science, was 20%. This is a difference of 21 percentage points. In comparison, the predicted probability of triple science pupils

going on to take an A-Level in any subject had they taken double science was 68%, and 73% actually did so, a difference of just five percentage points.

Figure 8: Marginal effects, triple vs double science, 2017

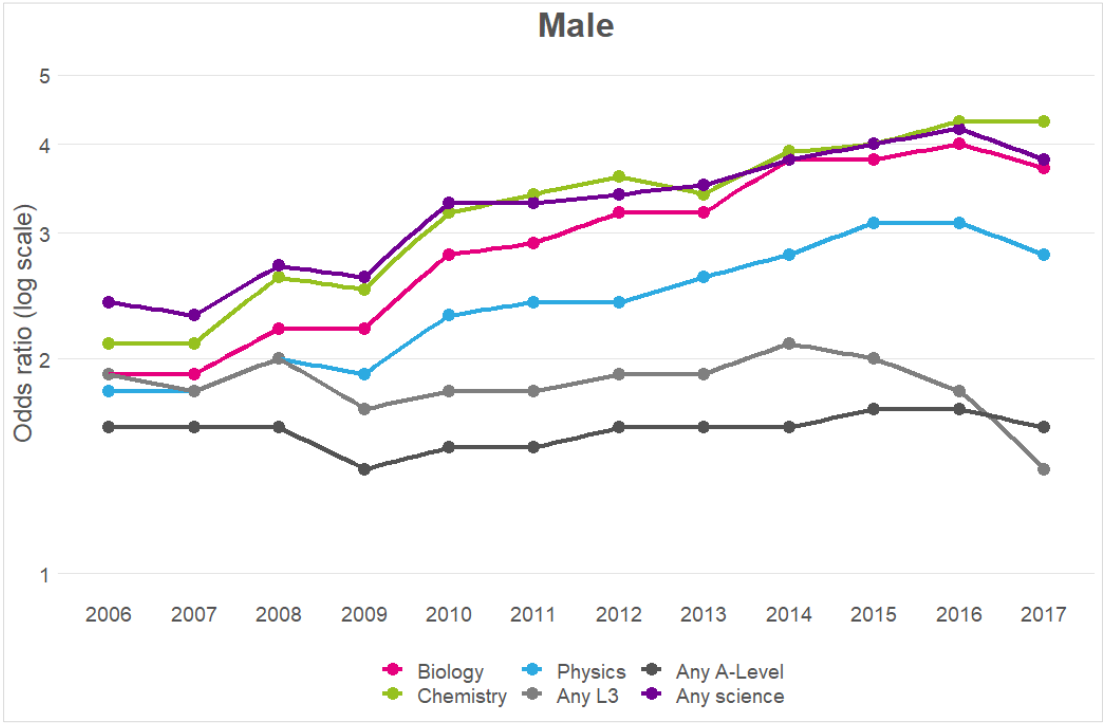


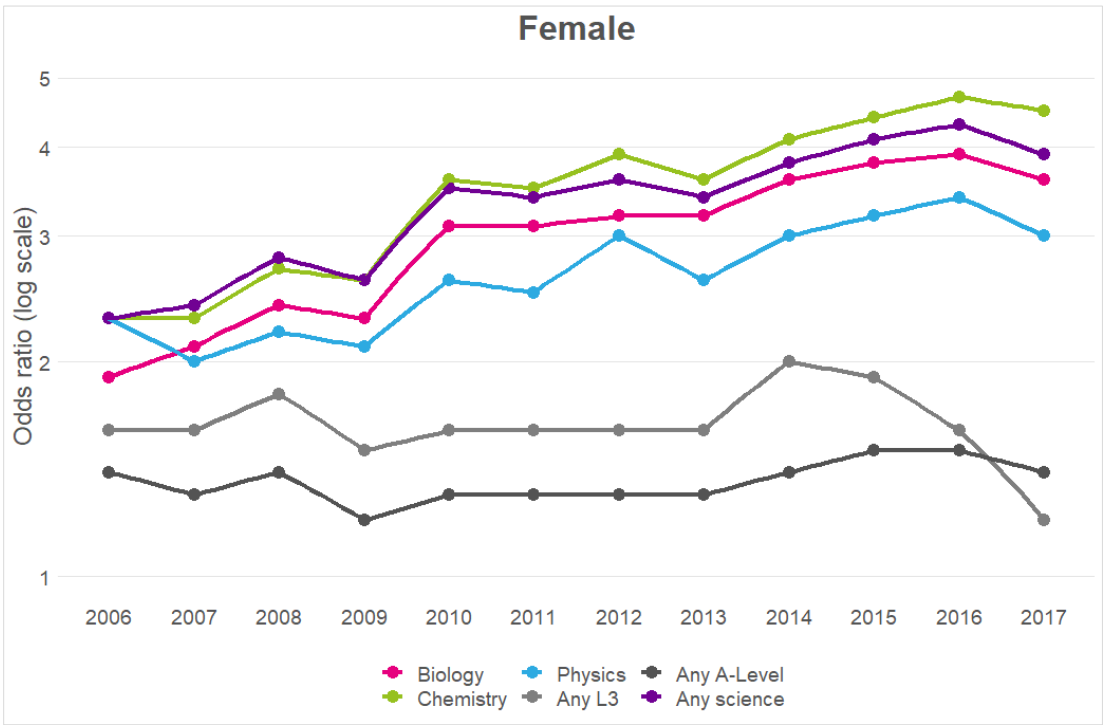
The average predicted probability of pupils who took triple science in 2017 going on to complete an A-Level in biology, had they done double science instead, was 10%. For chemistry, it was 8% and for physics 7%. The actual proportion going on to complete A-Level was 25% in biology, 22% in chemistry and just 15% in physics.

Male and female pupils

Figure 9 shows the odds ratios of male and female triple science GCSE pupils going on to complete Level 3 qualifications, as compared to double science GCSE pupils of the same gender. The years shown on this chart are the years in which pupils completed Key Stage 4.

Figure 9: Odds ratios for triple vs double science pupils completing Key Stage 5 outcomes by gender, 2006-17





These results suggest that, even controlling for differences in attainment, pupil and school characteristics, both male and female pupils who take triple science are more likely to go on complete all of the Key Stage 5 outcomes considered here. However, for female pupils, the

association between triple science and going on to complete any L3 qualification or an A-Level in any subject is weaker than for male pupils, while the association with going on to study a science A-Level is similar or in some cases stronger.

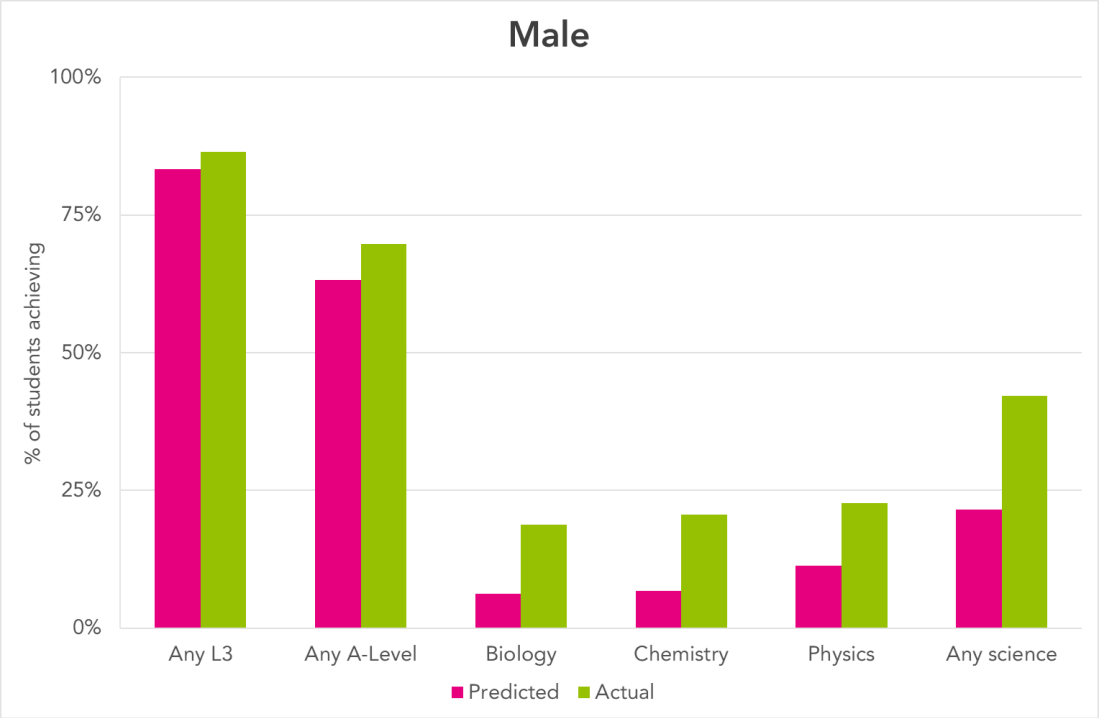
For pupils who completed KS4 in 2017, for example, the odds of a male pupil who took triple science going on to take an A-Level in one of the three main science subjects were 3.8 times higher than for a male pupil who took double science, and for a female pupil 3.9 times higher. In comparison, the odds of a male pupil who took triple science going on to take an A-Level in any subject were 1.6 times higher than for a male pupil who took double science, and 1.4 times higher for a female pupil.

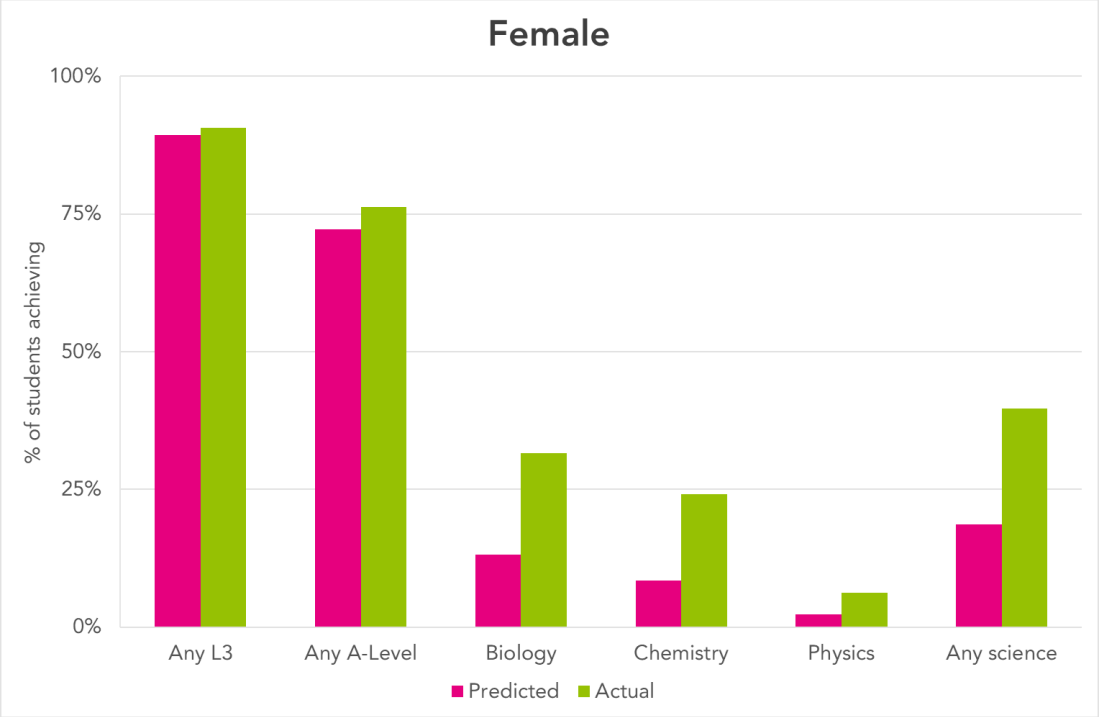
For both male and female pupils, the association between triple science and completing A-Levels in chemistry and biology was consistently stronger than for physics. In more recent years, the association between triple science and A-Level biology has been particularly strong for male pupils.

The marginal effects also illustrate these differences. As shown in figure 9, the actual proportion of male triple science pupils who went on to take an A-Level in one of the three main science subjects was 42%, and the average probability predicted by our model, had they instead taken double science, was 22%. This is a difference of 20 percentage points. In comparison, the predicted probability of triple science pupils going on to take an A-Level in any subject had they taken double science was 63%, and 70% actually did so, a difference of seven percentage points.

While for female triple science pupils, the actual proportion of who went on to take a science A-Level was 40%, and the average predicted probability, had they instead taken double science, was 19% - a difference of 21 percentage points. In comparison, the predicted probability of female triple science pupils going on to take an A-Level in any subject had they taken double science was 72%, and 76% actually did so, a difference of four percentage points.

Figure 10: Marginal effects, triple vs double science, 2017



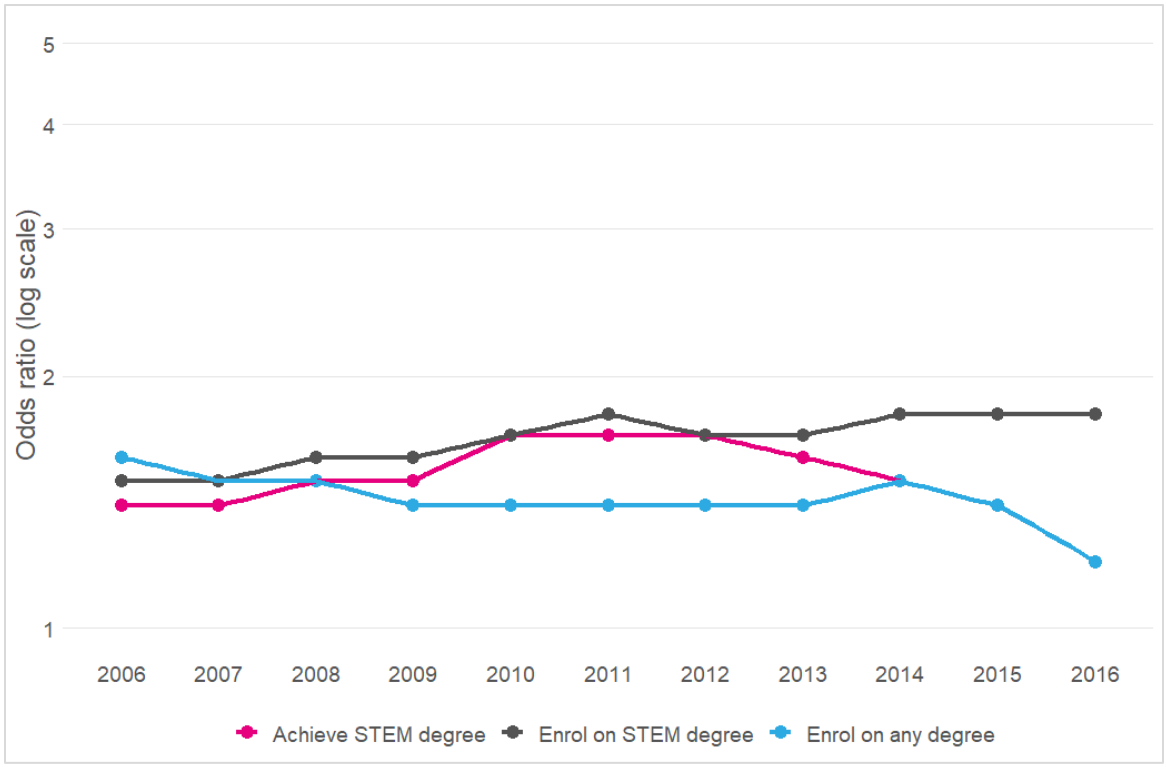


6.2.2 Degree level outcomes

All pupils

Figure 11 shows the odds ratios of triple science GCSE pupils going on to complete degree level qualifications (NQ6 level 6 or above), as compared to double science GCSE pupils. The years shown on this chart are the years in which pupils completed Key Stage 4.

Figure 11: Odds ratios for degree level outcomes, 2006-15



These results suggest that, even controlling for differences in attainment, pupil and school characteristics, pupils who take triple science are somewhat more likely to go on complete all of the outcomes considered here. The association between triple science GCSE and these degree level outcomes is weaker than the association with KS5 outcomes shown above.

In the first few years covered by this analysis, there was little difference between the odds ratios for going on to study a science subject and going on to study any subject at degree level. For pupils who completed KS4 in 2007, for example, the odds of a triple science pupil going on to study a science subject at degree level were 1.5 times higher than for a double science pupil. The odds of a triple science pupil going on to study any subject at degree level were also 1.5 times higher.

However, from 2009 onwards, there is a difference in the odds ratios for science subjects and any subjects at degree level. For pupils who completed KS4 in 2015, the odds of a triple science pupil going on to study a science subject at degree level were 1.8 times higher than for a double science pupil. In comparison, the odds of a triple science pupil going on to study any subject at degree level were just 1.2 times higher.

Again, looking at the marginal effects, as shown in figure 12, gives us some insight into how to interpret these odds ratios.

Figure 12: Marginal effects, triple vs double science, most recent year

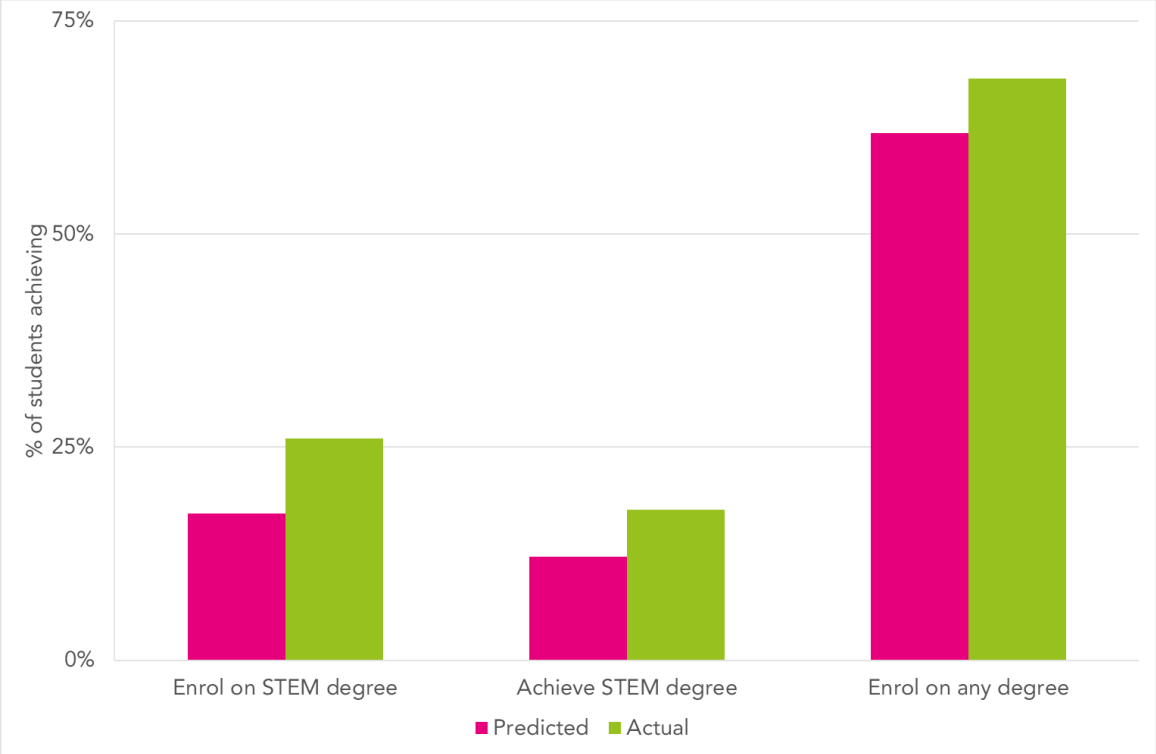


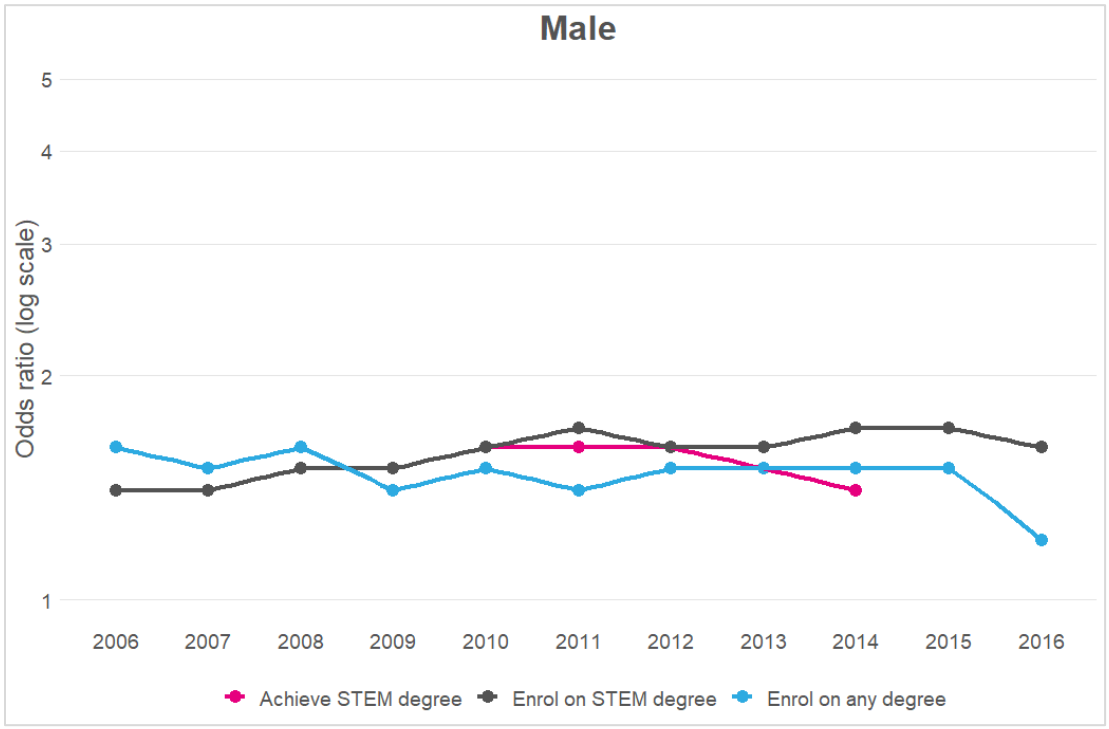
Figure 12 shows the figures for the most recent year available; that is, for the 'achieve STEM degree' outcome, for pupils who completed KS4 in 2013, and for the other outcomes, for pupils who completed KS4 in 2015.

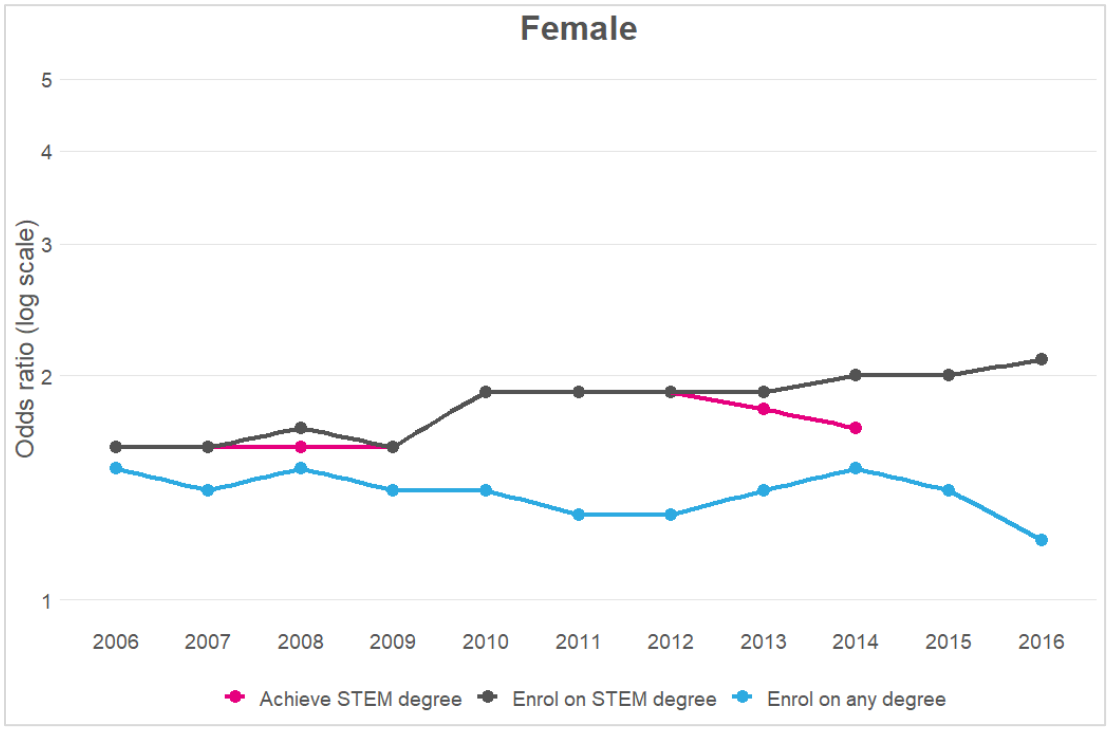
The average predicted probability of triple science pupils going on to enrol on a STEM degree, had they instead done double science, was 17%. 26% actually did so, a difference of 9 percentage points. In comparison, the average predicted probability of triple science pupils going on to enrol on any degree, had they instead done double science, was 62%. 68% actually did so, a difference of just 6 percentage points.

Male and female pupils

Figure 13 shows the odds ratios of male and female triple science GCSE pupils going on to complete degree level qualifications (NQ6 level 6 or above), as compared to double science GCSE pupils of the same gender. The years shown on this chart are the years in which pupils completed Key Stage 4.

Figure 13: Odds ratios for degree level outcomes, 2006-15





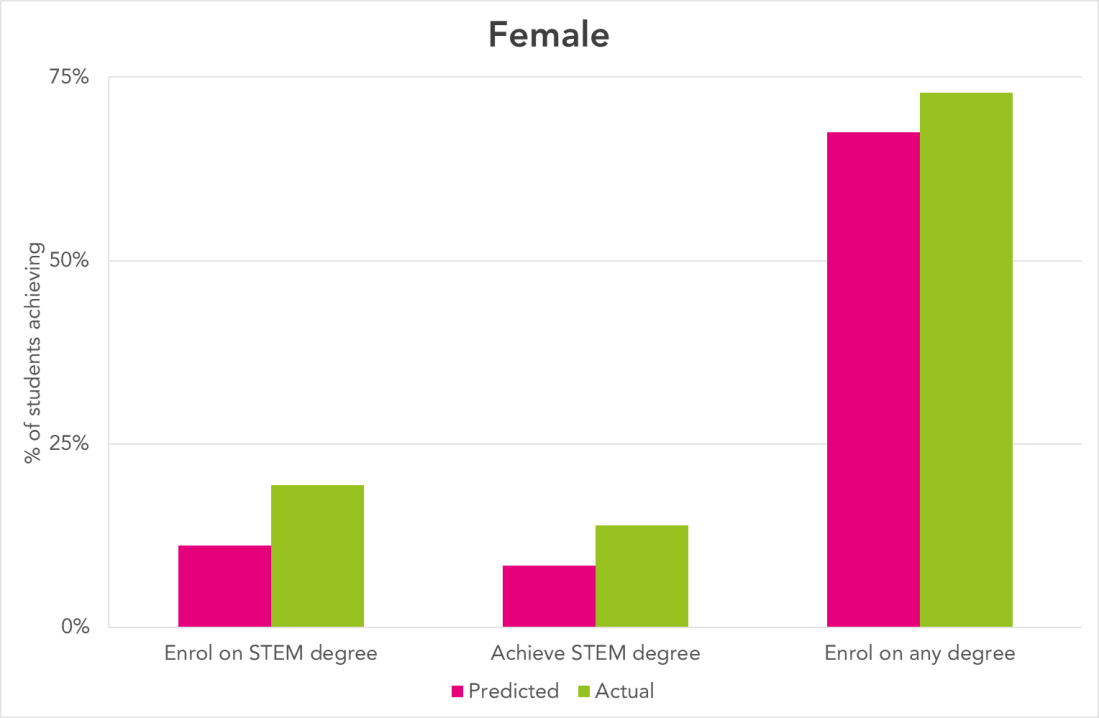
These results suggest that, even controlling for differences in attainment, pupil and school characteristics, both male and female pupils who take triple science are somewhat more likely to go on complete all of the outcomes considered here. However, for female pupils the association between going on to enrol on or complete a STEM degree is stronger than that

with enrolling on a degree in any subject in every year covered by this analysis. For male pupils, the differences are smaller and are even negative in 2006-08.

For pupils who completed KS4 in 2015, the odds of a male triple science pupil going on to study a science subject at degree level were 1.7 times higher than for a male double science pupil, and the odds of enrolling on any degree 1.5 times higher. But for a female triple science pupil, the odds of enrolling on a science degree were 2.0 times higher, and the odds of enrolling on any degree just 1.4 times higher.

Turning to the marginal effects, as shown in figure 14, gives us some insight into how to interpret these odds ratios.

Figure 14: Marginal effects, triple vs double science by gender, most recent year



The average predicted probability of a male triple science pupil going on to enrol on a STEM degree, had they instead done double science, was 23%, and 32% actually did so, a difference of 10 percentage points (allowing for rounding). In comparison, the difference for female triple science pupils was 8 percentage points.

The difference in the average predicted and actual proportion of male triple science pupils going on to enroll on a degree in any subject was 7 percentage points, while for female pupils it was 5 percentage point.

As we might expect, both the predicted and actual proportion of female triple science pupils going on to study a STEM degree was lower than for male pupils, while the predicted and actual proportion going on to study any degree was higher.

6.3 Science curriculum offer

In this section, we look at whether the association between triple science GCSE and long-term outcomes varies by school triple science offer. We have defined schools' triple science offers according to the proportion of pupils in the school who studied triple science GCSE, with four bands: none, low, mid and high (see section 4.2 for more details). Differences between the bands give some indication of the effectiveness of different approaches to entering pupils for triple science on encouraging them to go on to study science post-16.

We do this by examining the *residuals* for pupils who attended schools in each band. By residuals, we mean the difference between a pupil's actual outcome and the predicted probability of that pupil achieving the outcome, obtained from the regression models used in section 6.2.

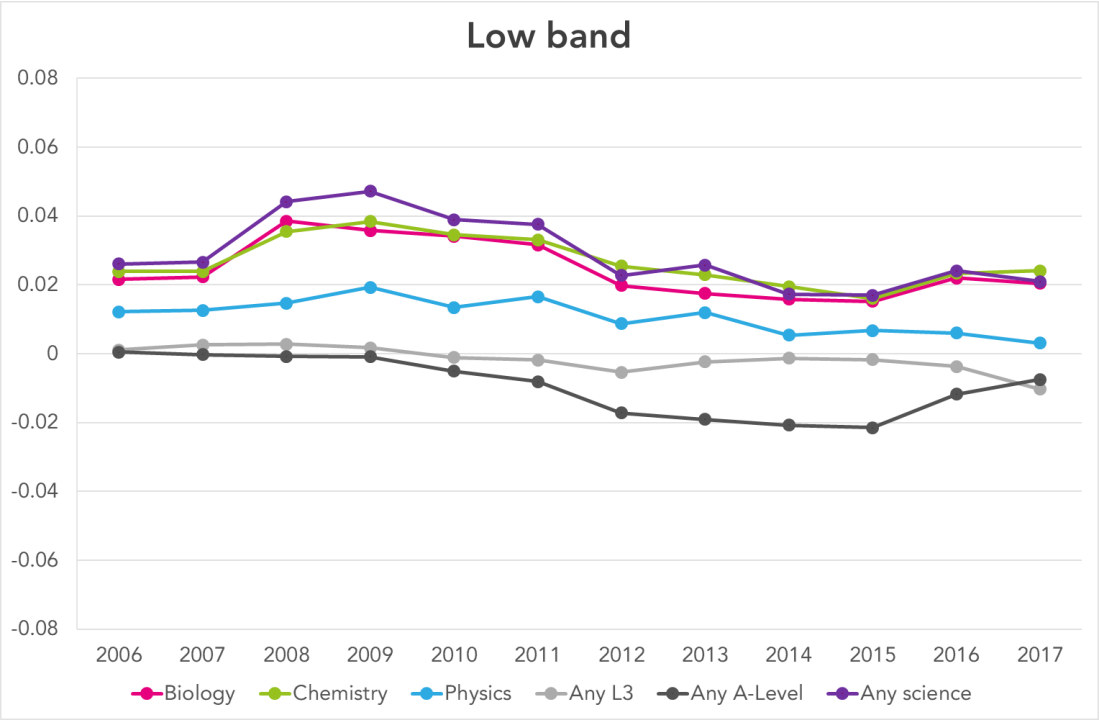
A negative average residual suggests that, on average, pupils who attended a school in the relevant band was less likely to go to complete the relevant outcome than predicted by their Key Stage 4 science option, prior attainment, demographics and school characteristics. A positive average residual suggests that, on average, they were more likely.

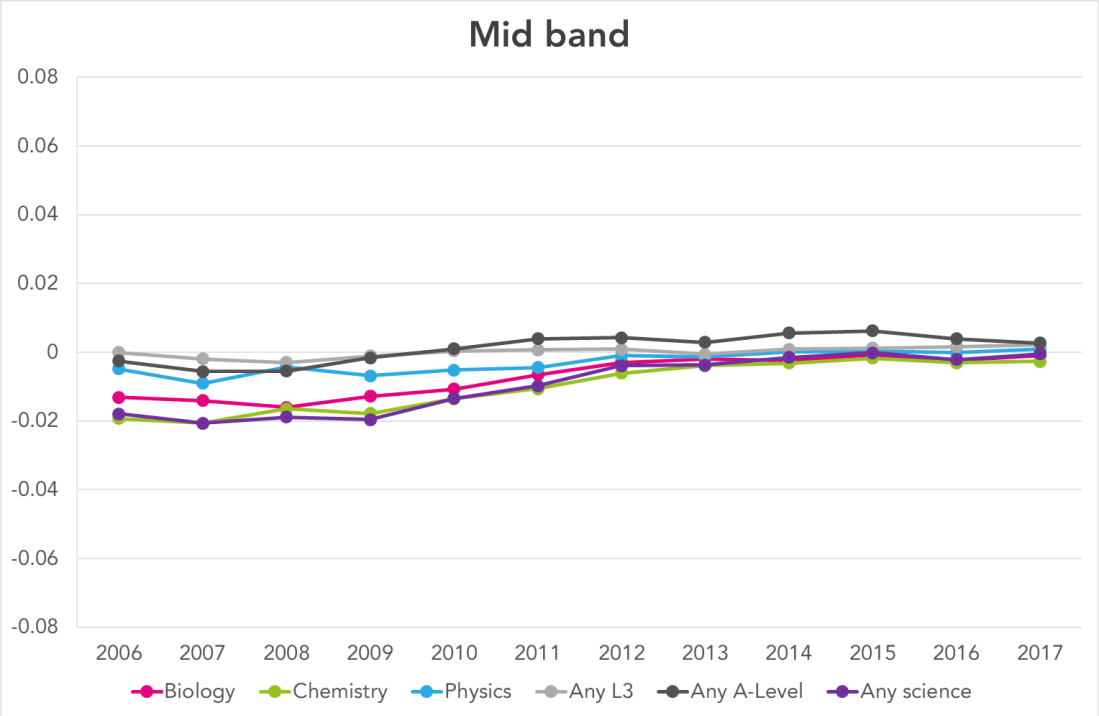
6.3.1 Key Stage 5 outcomes

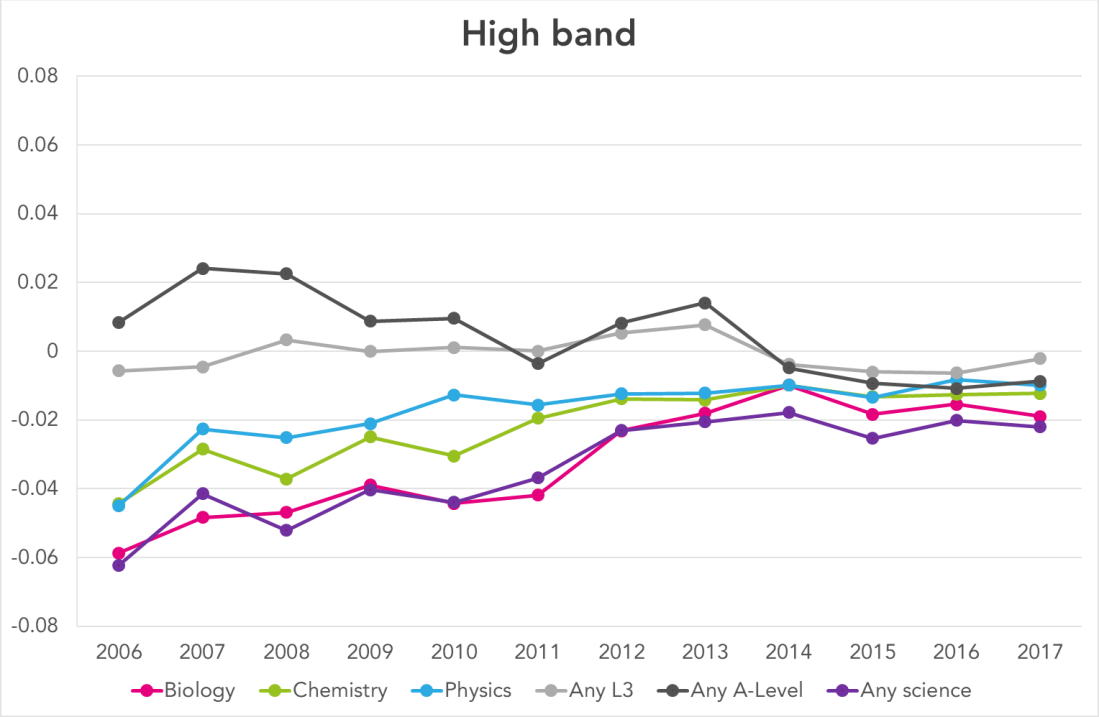
All pupils

We would consider residuals of +-0.05, to be large enough to suggest a substantial difference between bands. This represents a difference of +- 5 percentage points in the actual outcomes and the predicated probability. Figure 15 shows the residuals for each outcome and band. The years shown on these charts are the years in which pupils completed Key Stage 4.

Figure 15: Residuals by school triple science band, 2006-17







These results suggest that triple science pupils who attended schools in the mid and particularly high bands were somewhat less likely to go on to study science at A-Level than predicted, while those who attended a school in the low band were slightly more likely to do so. There is little to suggest any great difference in the likelihood of going on to study any Level 3 qualification or any A-Level subject; the difference does seem to be specific to science.

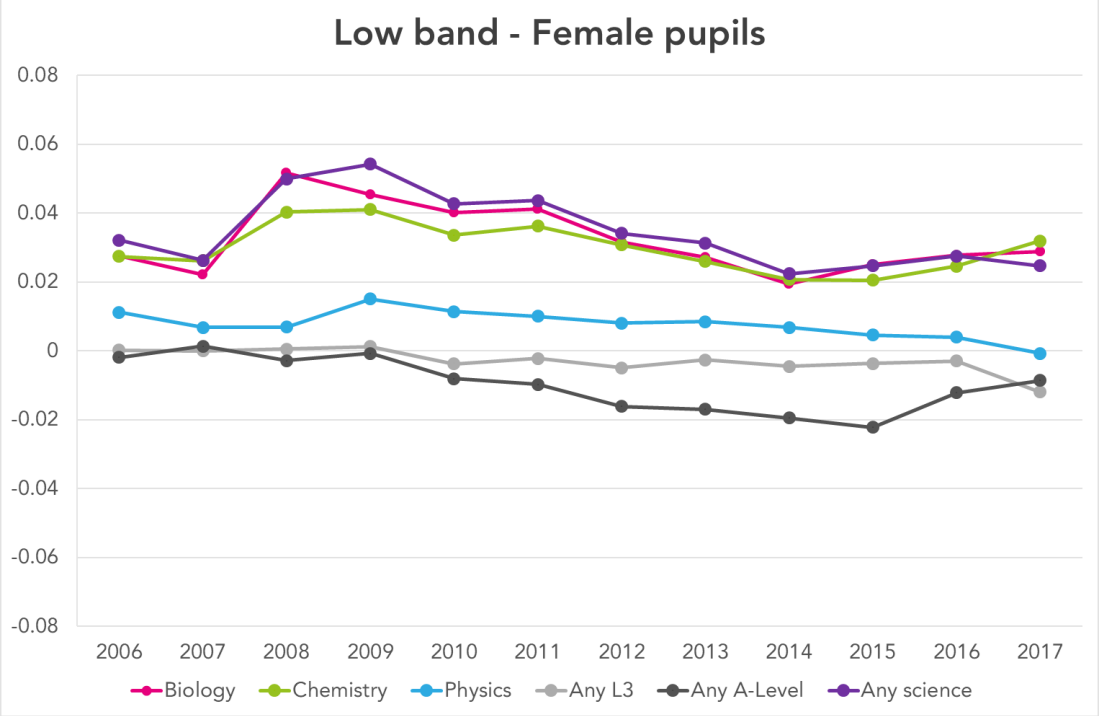
However, the residuals observed are small and mostly fall below the +-0.05 threshold that we would consider indicates a substantial difference.

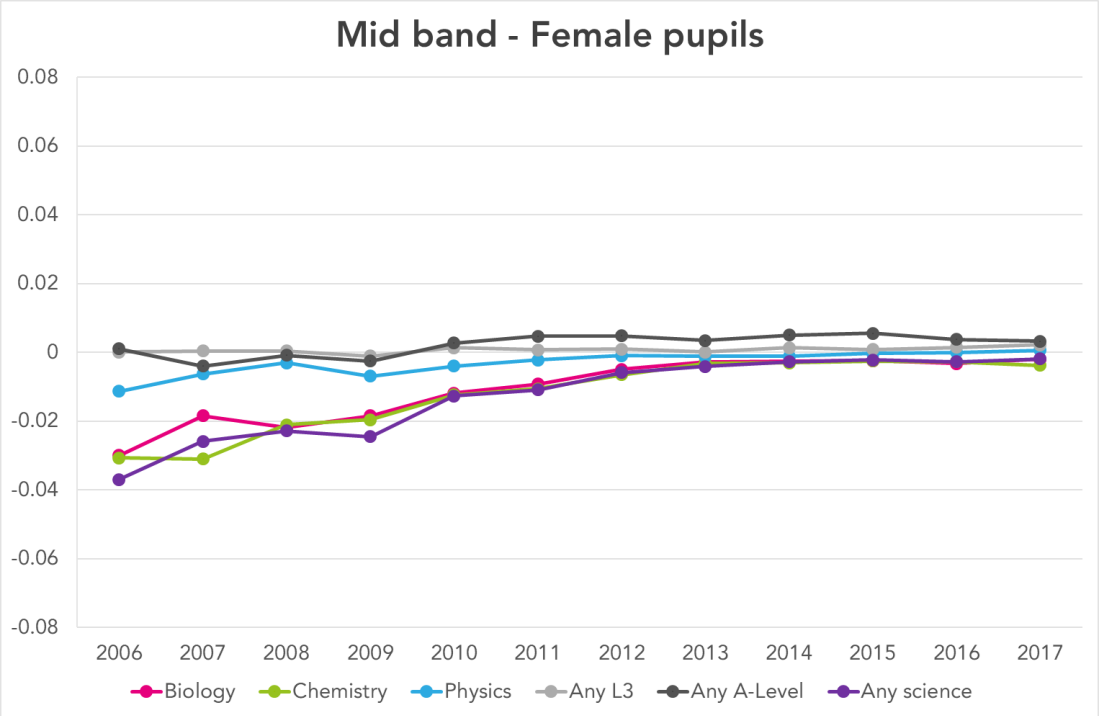
The difference between bands was larger in first few years of the period covered, and tended to decrease until around 2014 when they levelled off. For pupils who completed KS4 in 2017, there were no residuals above +-0.03, suggesting that the variation of the association of triple science with the outcomes by school band was minimal. The decrease in the residuals corresponds with an increase in the number of pupils studying triple science during the same period.

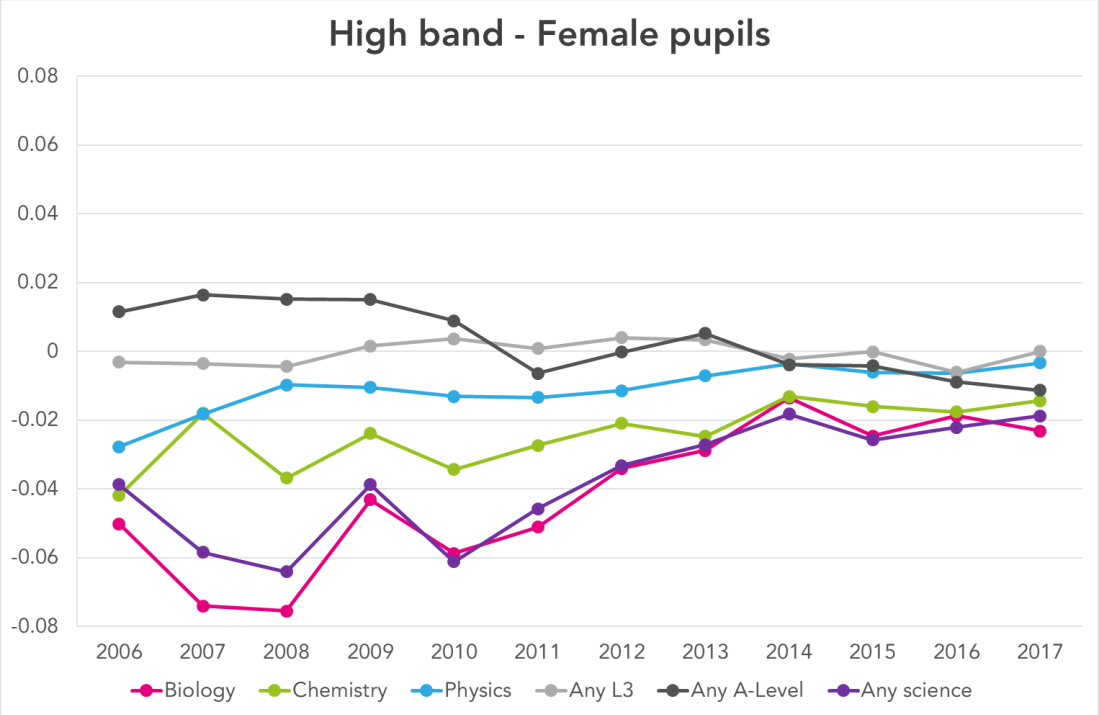
Male and female pupils

The charts below show the residuals by band for female pupils. Charts for both male and female pupils are included in Appendix 3.

Figure 16: Residuals by school triple science band, female pupils, 2006-17







The results for both male and female pupils follow the same pattern as that seen for all pupils; triple science pupils who attended schools in the mid and particularly high bands were somewhat less likely to go on to study science at A-Level than predicted, while those who attended a school in the low band were slightly more likely to do so.

However, the residuals for female pupils tended to be larger than for male, suggesting a stronger association between triple science band and going on to study science A-Levels for

females. This is particularly noticeable for triple science pupils who went to a school in the highest band. The difference here is largely driven by a stronger negative association between attending a school in the high band and going on to study biology for female pupils than for male; there is little difference between the genders in the association between the highest band and going on to study physics.

The residuals observed for female pupils are in some cases above the +-0.05 threshold that we would consider indicates a substantial difference, particularly in the first few years of the period covered. In more recent years, none fall above this threshold. The residuals observed for male pupils almost all fall below the threshold.

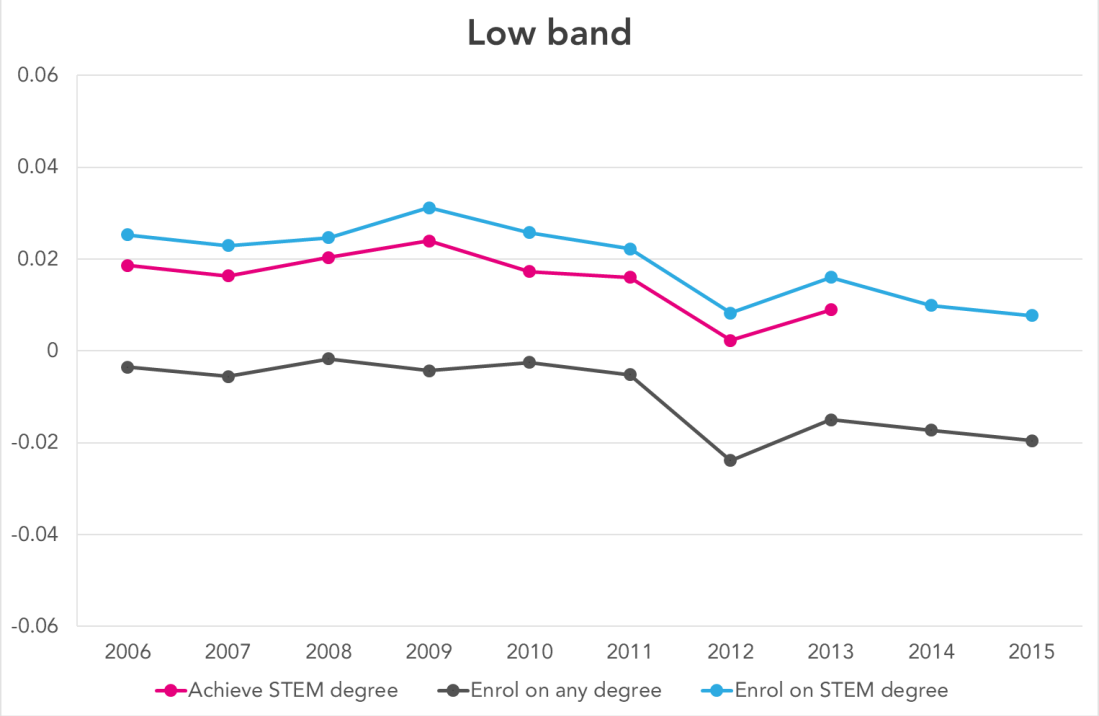
For pupils who completed KS4 in 2017, there were no residuals above +-0.04, suggesting that the variation of the association of triple science with the outcomes by school band was minimal, for both male and female pupils.

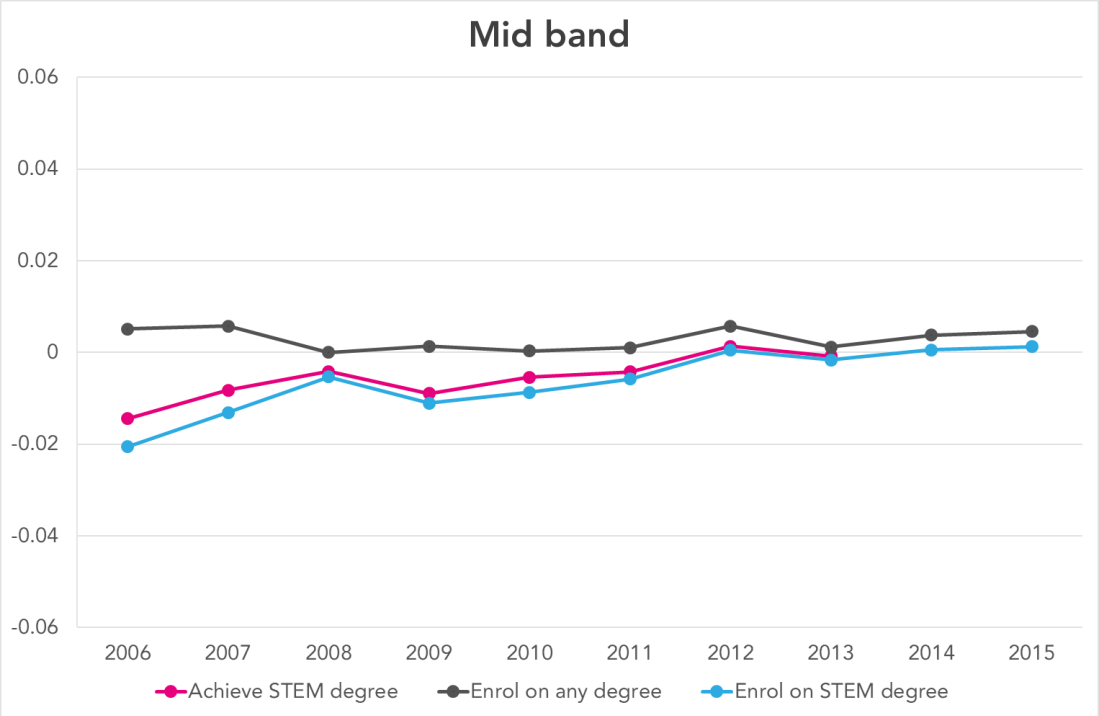
6.3.2 Degree level outcomes

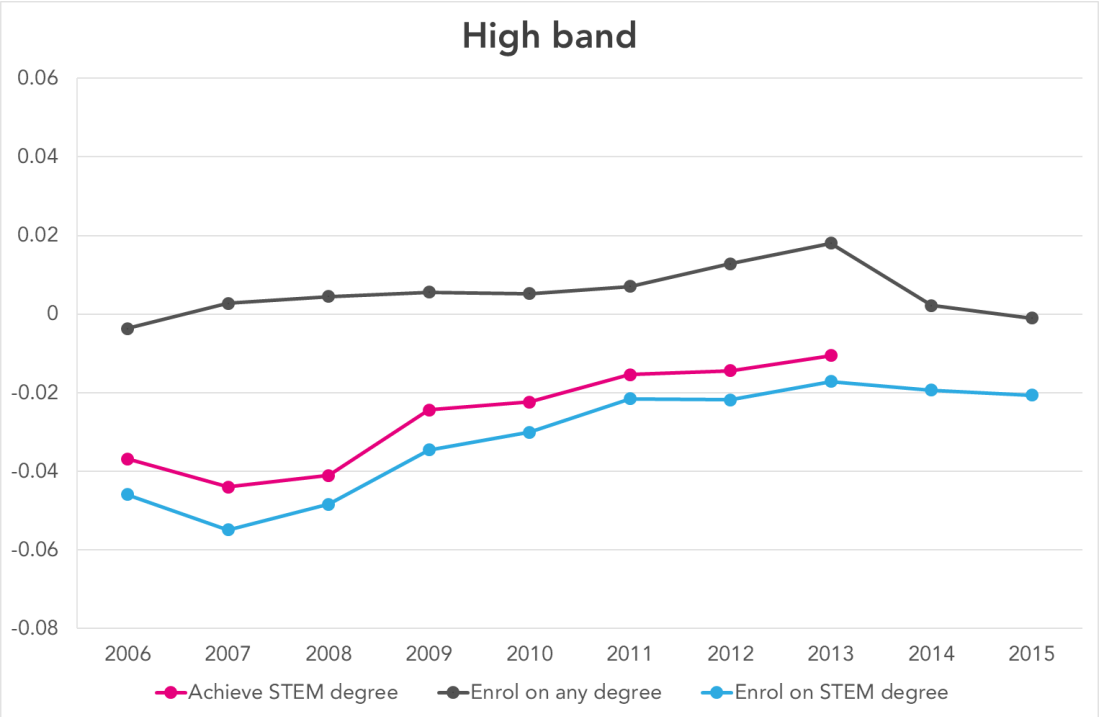
All pupils

We would consider residuals of +-0.05 to be large enough to suggest a substantial difference between bands. Figure 17 shows the residuals for each outcome and band. The years shown on these charts are the years in which pupils completed Key Stage 4.

Figure 17: Residuals by school triple science band, 2006-15







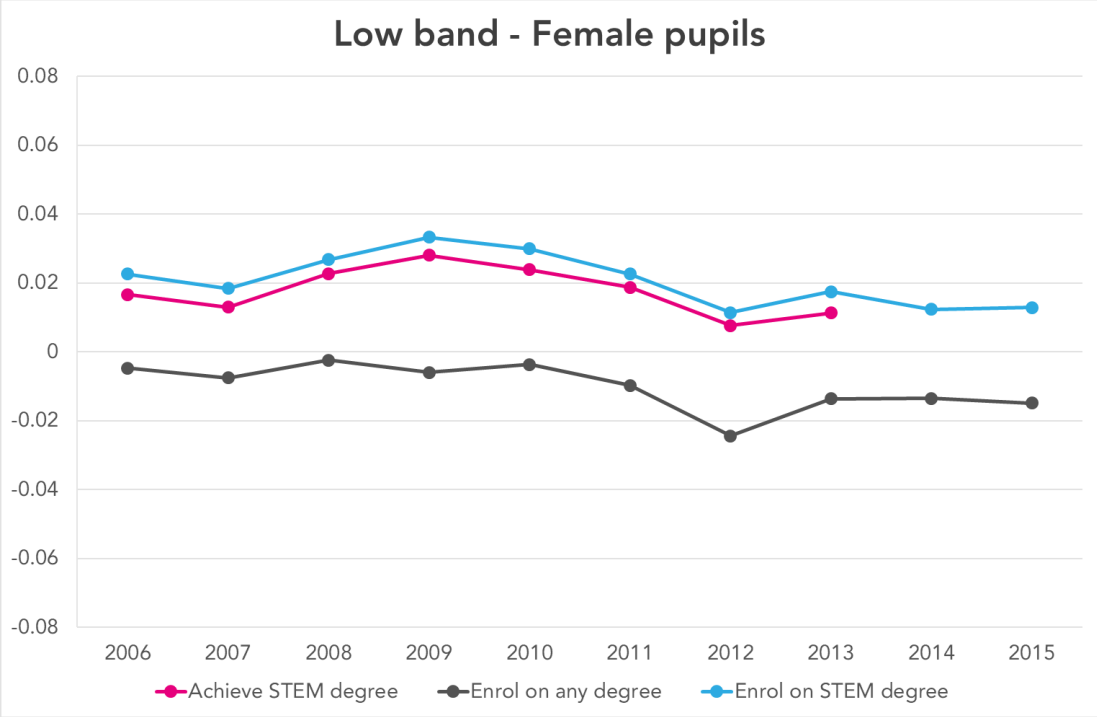
These results follow a very similar pattern to those for Key Stage 5 outcomes. They suggest that triple science pupils who attended schools in the mid and particularly high bands were somewhat less likely to go on to study STEM at degree level than predicted, but the residuals observed were small and mostly fell below our +-0.05 threshold. We also observed some positive residuals for pupils who attended a school in the low band, indicating that they were slightly more likely to go on to take a STEM degree.

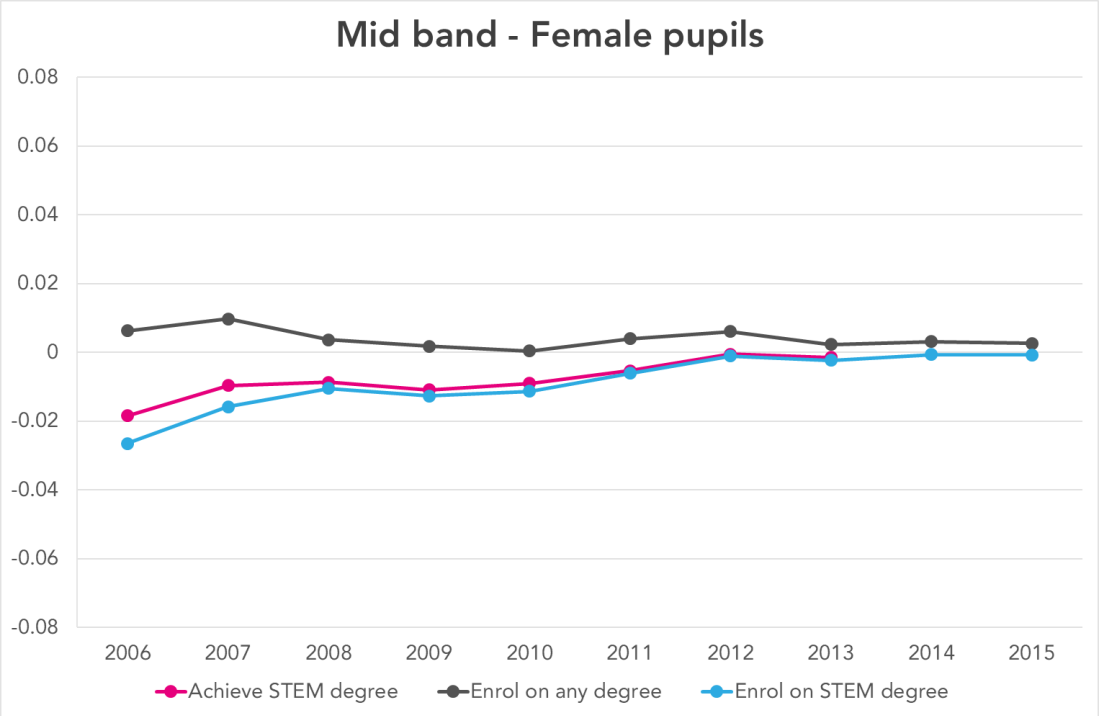
As with the Key Stage 5 outcomes, the residuals were higher in the first few years covered between levelling off at a very low level from around 2012.

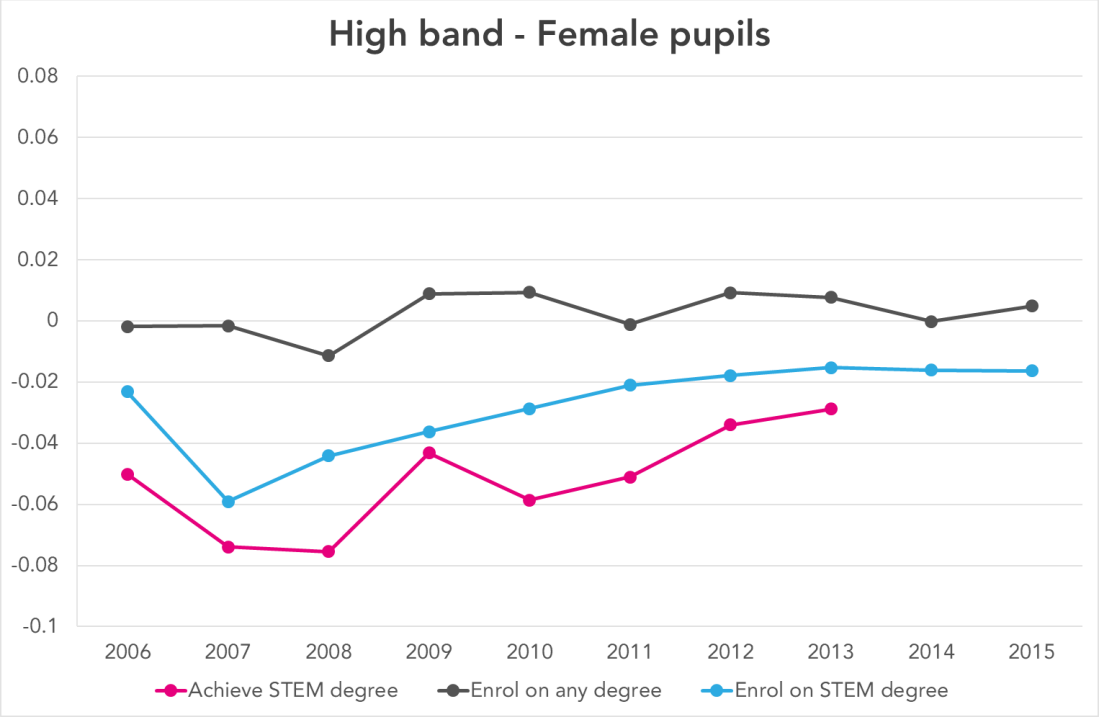
Male and female pupils

The charts below show the residuals by band for female pupils. Charts for both male and female pupils are included in Appendix 3.

Figure 18: Residuals by school triple science band, female pupils, 2006-15







The results for both male and female pupils follow the same pattern as that seen for all pupils; triple science pupils who attended schools in the mid and particularly high bands were less likely to go on to study STEM at degree-level than predicted, while those who attended a school in the low band were more likely to do so.

However, the association between school band and going on to study degree-level science was somewhat stronger for female pupils than for male. All of the residuals observed for male

pupils were below the +-0.05 threshold, but some of those for female pupils in the high band were above the threshold.

For both genders, the residuals were higher in the first few years covered between levelling off at a very low level from around 2012.

7. Discussion and conclusions

The descriptive analysis showed the rise in the popularity of triple science during the period covered, both at the pupil and school level. It also showed the rise in the number to entries applied level 2 qualifications between 2008 and 2012, followed by a dramatic fall in numbers following the government reforms, including the introduction of the English Baccalaureate and Progress 8.

We found that some types of schools were far more likely to enter a high proportion of their pupils to triple science GCSE than others. Selective schools, schools with sixth forms, those with high levels of average prior attainment and those with low levels of disadvantage entered a higher proportion. University technical colleges were more likely to enter a high proportion than other school types, while sponsored academies and free schools were most likely not to enter any pupils to triple science at all.

There were also some differences by region. Schools in the South East were most likely to enter a high proportion of their pupils to triple science; 10% of schools in the region entered 75% or more in 2019 compared to 5% nationally. School in the North West were least likely, with just 3% entering 75% or more to triple science in 2019.

The modelling of long-term outcomes shows that pupils who study triple science GCSE are more likely to go on to study science post-16, even when controlling for differences in prior attainment, pupil and school characteristics. The association between triple science and completing A-Levels in chemistry and biology was consistently stronger than for physics. There were some indications that the association between triple science GCSE and going on to study science post-16 varies by gender; for female pupils, the association between triple science and going on to complete any L3 qualification or an A-Level in any subject is weaker than for male pupils, while the association with going on to study a science A-Level is similar or in some cases stronger.

Generally speaking, the association between triple science and studying science post-16 increased during the period covered by this report. This increase coincides with an increase in the proportion of pupils studying triple science. They may be because in the earlier part of the period, pupils who were highly motivated and high attaining in science may not have had the option to take triple science. In later years, when triple science was a more common option in schools, more of these pupils would have taken triple rather than double. As this group of pupils more likely to go on to take science post-16, we might expect to see an increase in the association between triple science and studying science post-16 as more of them take triple.

We should note that these findings are correlational; they do not imply a causal relationship between Key Stage 4 science options and going on to study science post-16 (although of course they do not rule this out).

We also found some differences in long-term outcomes by school Key Stage 4 curriculum offer. Pupils who studied triple science in a school in the lowest triple science band were more likely to go on to study science post-16 than those who attended schools in the mid and high bands, although these differences were small and became smaller during the period covered by this report. Again, there were some indications that this association varied by gender; the differences between bands were larger for female pupils than for male, although they followed the same pattern.

These differences may indicate that pupils who studied triple science in schools in the lowest band were more motivated or interested in science than those in schools in the higher bands. The differences decreased during the same period that triple science entries increased, perhaps reflecting that the increase in numbers was largely due to changes in school policy rather than in pupils' own choice.

8. Appendices

This report is accompanied by three Excel workbooks. Appendix 1 contains all of the statistics on which the descriptive analysis is based. Appendix 2 contains the full results from the analysis of long-term outcomes, and Appendix 3 the results by gender.