PRO BONO ECONOMICS

in partnership with

BRITISH SCIENCE ASSOCIATION

Graduate earnings and the STEM premium: a breakeven analysis of BSA’s CREST Silver Programme

Technical report prepared for British Science Association in association with Ian Moore, Sergiu Cociu and Helene Beaujet.

Disclaimer

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1 Introduction

The British Science Association (BSA) asked Pro Bono Economics to explore the economic impact of its CREST Silver Award programme. This is one of BSA's suite of CREST Awards that are designed to increase young people's interest and participation in STEM related subjects.

In a previous study, *Quantifying CREST* (PBE, 2016), we found that pupils who took part in the Silver Award do better in science subjects in GCSE exams, and are more likely to study a STEM subject at AS level. Due to the possible impact of other variables on these results, further research was recommended, which is currently being conducted by EEF.

In this study, we consider the potential impact of participation in the CREST Silver programme on the decision to study a STEM subject at university[1]. At present, there is no data available that allows us to track the progress of CREST Silver students over time, that could then be used to assess the impact of the programme on the likelihood of going on to study a STEM degree, and the subsequent societal benefit from an increase in this likelihood.

Therefore, we have to work backwards and estimate a breakeven figure for the impact of the programme. That is, given the expected benefits (higher earnings) from a STEM degree, and the known costs of the CREST Silver programme, what is the number required of additional pupils choosing STEM courses, for the expected benefits to exceed the costs.

Across the whole population, about 30% of all pupils go on to university. The demographic characteristics and general educational attainment of the CREST participants (as set out in the 2016 report) generally puts these students into a sub-population of those for whom progression to university is a "normal" pathway. We therefore choose to focus on the question of subject choice at university – STEM or non-STEM. For all undergraduates, the split is c.40% STEM and c.60% non-STEM[2]. In other words, we are interested in what happens if CREST Silver participants choose STEM at above the background rate of c.40%.

This is a conservative approach that does not include any benefits associated with other possible educational pathways, for example if CREST Silver is lifting the overall rate of progression to university.

Key findings[3]

- We estimate that on average graduates of STEM degree programmes earn £34,700 more than non-STEM graduates over the first 10 years after graduation.
- We estimate the costs of running the CREST Silver Award was around £90,000, or £70 per pupil in 2017/18. This includes BSA's own costs and an estimate for costs incurred by schools that run the programme.
- These figures imply that the expected benefits of CREST Silver exceed the costs provided the programme causes an increased uptake of STEM subjects at university and that an

[1] In the 2016 report, two definitions of STEM were used: a broad definition as agreed with the BSA and a narrower one as suggested by Department for Education; both matched to GCSE subjects. In this report, the STEM definition used is based on university courses and aligns closely to the broad definition used in the 2016 report. See Figure 8 in Appendix 2 for more details.

[2] See Higher Education Statistics Authority first year enrolment statistics, for example https://www.hesa.ac.uk/news/17-01-2019/sb252-higher-education-student-statistics/subjects

[3] Costs and benefits are expressed in 2017/18 prices unless otherwise stated.

additional 3 or more students choose STEM rather than non-STEM subjects. This is equivalent to 0.2% of the 2017/18 cohort of 1,275 CREST students.[4]

Our analysis of just one pathway suggests that CREST Silver only needs to have a relatively small effect on degree choice for societal net benefits to exceed costs. Whilst this is not implausible, further evidence is needed to track the degree subject choices of CREST Silver students (and preferably all educational pathways) to allow a fuller economic evaluation of the scheme.

Report structure

This report is structured into the following sections:

- Background to BSA CREST Silver
- Our analysis
- Key results and sensitivities

[4] Nationally the proportion of STEM graduates in each year is around 12% of each school year's population of c.750,000.

2 Background

The British Science Association (BSA) coordinates, delivers and oversees a number of different projects and programmes aimed at engaging more people with science. The CREST Awards programme is its flagship programme for young people, providing STEM enrichment activities to engage and inspire 5 to 19 year-olds. There are six different CREST Award levels aimed at children in different age groups that require increasing amounts of student and teacher time and mentor involvement (see Figure 1).

The CREST Silver programme, which is the focus of this study and the 2016 report, includes around 30 hours of project work and is typically undertaken by pupils at the end of Key Stage 3 or start of Key Stage 4.

Figure 1. Overview of different CREST Programme levels

CREST Award level	Target age group	Activities
Star	5-7 year olds	8 x 1 hour challenges
Superstar	7-11 year olds	8 x 1 hour challenges
Discovery	10-14 year olds	One day project
Bronze	11+ year olds	Introduction to STEM project work, 10 hours
Silver	14+ year olds	Running their own STEM projects in teams or individually, 30 hours
Gold	16+ year olds	Open-ended project suitable for enhancing UCAS applications, 70 hours

What is the impact of the CREST Silver Award at KS4 and KS5?

The 2016 PBE report evaluated the impact of the CREST Silver Award on pupils' academic attainment at Key Stage 4 (KS4) and STEM subject selection at Key Stage 5 (KS5). In this study, data collected by the BSA on students starting Silver CREST Awards between 2010 and 2013 was linked to data in the National Pupil Database to bring together information on the characteristics of Silver CREST participants with data on KS4 attainment and KS5 subject selection outcomes.

The impact of the programme was assessed by comparing outcomes for CREST Silver participants to a control group of students with similar characteristics who did not take part in CREST Silver.[5] The study found that CREST Silver participation:

- Achieved better attainment in GCSE science, with an improvement in the highest science GCSE point score of 3.3 percentage points on average (i.e. from 46.5 to 49.8 points). This is equivalent to around half a grade increase in a student's best science GCSE result, compared to a statistically matched control. The increase was larger for CREST students eligible for free school meals at two thirds of a grade.

[5] This is known as a 'quasi-experimental' approach. Propensity score matching techniques were used to create a statistically matched control group of students. This is a widely used statistical technique that allows researchers to create control groups that are matched as closely as possible to the group of interest, based on observable characteristics such as gender and prior attainment.

- Increased the likelihood that students who progressed to AS level chose a STEM subject at AS level by 14 percentage points on average (i.e. 82% vs 68%). This difference was larger for students eligible for free school meals at 21 percentage points.

The 2016 report also found that CREST Silver students did better at GCSE than other students, with 95% achieving 5+ A*-C grade GCSEs including English and Maths, compared to 70% of non-CREST students. However, these differences are not based on a matched control group and therefore cannot be taken as a measure of impact as they will reflect differences in the composition of the two groups of students as well as the effect of CREST participation.

The PBE report recommended that the impact of the CREST Awards should be further evaluated through a Randomised Control Trial that would allow further testing of the causal effect of participation in the Awards on pupil outcomes. The use of a randomised control trial approach would allow one to control for selection bias more effectively than the quasi-experimental approach used in our 2016 study (for example, to account for the effect of unobserved variables such as pupil motivation that may affect outcomes).

EEF evaluation of CREST Silver

The Education Endowment Foundation (EEF) is funding an effectiveness trial of the CREST Silver Award that is being delivered by NatCen. The aim is to test the programme as it is delivered at scale and in a large number of schools.[6] The trial is structured as a two-arm randomised control trial (RCT), with schools randomised to treatment or a business as usual control. This involved the recruitment of a cohort of 499 students onto the CREST Silver programme in the treatment schools in 2017/18. This cohort is additional to, and separate from, the larger group of 1,275 student who participated in CREST Silver outside of the RCT.

The primary outcome in the EEF study is science attainment, as measured by a standardised science test at the end of Year 9. The secondary outcomes will include progression to GCSE study (focusing on the type of science qualification they take and the numbers progressing to different routes, including progression to study triple science) and a character measure looking at science-specific attitudes and aspirations.

The EEF evaluation report is expected to be published in autumn 2019.

CREST Silver participation in 2017/18

In addition to the RCT cohort of 499 students noted above, a further 1,275 children participated in CREST Silver in 2017/18 (this is broadly typical of the size of CREST Silver programme in a normal year). BSA enrolment data for 2017-18 show a gender split of 43% male and 57% female, which we understand from BSA is a significantly higher female participation rate than in other school-based science interventions. It is also different to the 50:50 split in the 2016 report. We consider further below whether or not the gender distribution is material to our conclusions, based on gender differences in the STEM premium (see Appendix 2).

[6] See https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/british-science-association-crest-silver-award-enquiry-based-learning-in-sc/#why.

3 Our approach

To develop a cost-benefit analysis of CREST Silver, we need to consider:

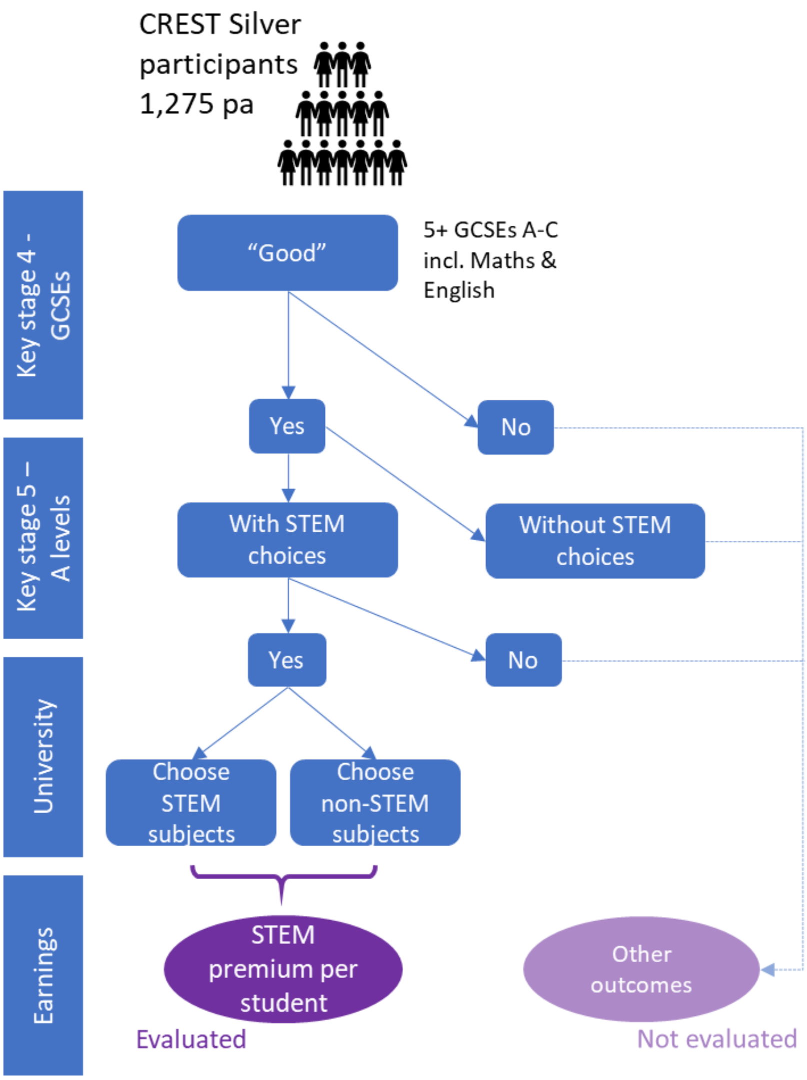
- the outcomes being evaluated, the counterfactual to these, and the economic evidence for the benefits of such outcomes. In this report, we focus on the potential impact of participation in CREST Silver on the likelihood that a pupil will be able to study a STEM degree and benefit from the related earning premium that exists for STEM graduates.
- the costs of the programme.

We can then compare estimated societal benefits to estimated programme costs to calculate breakeven points.

Framework for assessing the potential economic benefits from CREST Silver

Figure 2 below shows the potential progressions or pathways for students, starting with "good" attainment at Key Stage 4. Given the evidence from the 2016 report that CREST Silver boosts science attainment at GCSE and also increases interest in science at AS level, it is plausible that the Award could potentially play a material role in degree and career choice (albeit alongside other factors).

Figure 2. Pathways through education for CREST Silver students



CREST Silver participants do generally achieve 5+ good GCSEs including Maths and English, which is a good proxy for the minimum entry criteria for university applications. In the 2016 report, this was established to be 90%. For STEM degrees, it will also be the case that students need to be studying STEM subjects at A levels.[7] Of course, not all CREST Silver students will go on to university or even Key Stage 5 formal education. These "other outcomes" (as depicted in Figure 2) may still attract a STEM premium in earnings, as employers typically place a premium on STEM-related skills. Also, any impact of CREST Silver on generally higher educational attainment, for example higher proportion progressing to A levels (of any subject) has not been considered. The literature reviewed for this report repeatedly demonstrates large economic benefits for higher attainment, eg a graduate premium relative to A levels being highest qualification.

Given our focus on calculating the benefits arising from just one possible pathway, we consider the results to be conservative.

Approach used in this study

As noted earlier, there is no data available that allows us to track the progress of CREST Silver students over time that can be used to assess the impact of the programme on the likelihood of going on to study a STEM degree. Given this, we focus on estimating the breakeven impact of the programme that is required to ensure that the expected benefits exceed the programme costs. This involves three key steps:

- Step 1: Calculation of the earnings differential for graduates in STEM subjects.
- Step 2: Calculation of the cost of delivering the STEM Silver Award.
- Step 3: Estimation of the breakeven impact on STEM degree choice by comparing the economic benefits associated with higher earning for graduates in STEM subjects to the cost per pupil of the Crest Silver programme.

These steps and the evidence used are described in more detail below.

In using increased earnings as the key economic variable for societal benefit, we are implicitly assuming that the higher earnings reflect higher labour productivity and hence higher overall GDP. In this scenario, we do not need to model any potential displacement effects (for example other workers seeing lower earnings or fewer jobs) since the benefits are wholly additional to society.

Step 1: the STEM premium for graduate earnings

To calculate a STEM premium for graduate earnings, we have used the Longitudinal Educational Outcomes (LEO) dataset, as reported in DfE (2016), DfE (2018) and DfE (2019). In this report we are relying on the published data tables for all students (see DfE (2016)) rather than direct access to the underlying student-specific data.[8]

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[7] One of the key results of the 2016 report was an improvement in highest science grades at GCSE. This is likely to influence the range of universities that can be applied to, for example higher grades are required by say Russell Group universities, vs other universities with lower entrance requirements. In the LEO data, we also see earnings differential between universities, with graduates from Russell Group universities generally outperforming others. In this report, we have not considered this further level of characterisation of earnings premiums.

[8] This use of secondary data is in contrast to the 2016 PBE report which relied on primary data by directly accessing individual results from the National Pupil Database.

The LEO dataset is relatively new and can be used to yield a range of insights into earnings patterns. We set out more details on the dataset and insights in Appendix 2. In our research, we also considered the wide range of other potential sources of data, a brief summary of which is covered in Appendix 3.

For our analysis, we use the data on median earnings by subject for 2003/4 graduates at 1, 3, 5, and 10 years after graduation. We have allocated subjects to two categories, "STEM" and "non-STEM" using the JACS codes (see Figure 8 in Appendix 2). We then use:

- the number of students by subject, and
- median earnings by subject

to calculate weighted average earnings for the aggregate categories "STEM" and "non-STEM". Key results are shown in Figure 3.

Figure 3. Earnings by aggregated groupings for 2003/4 cohort

	1 year	3 years	5 years	10 years
STEM	£18,900	£24,500	£28,500	£33,700
Non-STEM	£15,500	£21,100	£24,800	£29,800
Differential	£3,400 23%	£3,400 16%	£3,700 15%	£3,900 13%

Source: Pro Bono Economics analysis based on DfE (2016). All data in current prices and rounded to nearest £100.

The STEM differential is substantial and although it declines in real terms it does persist over time. Where possible, we have further analysed these results (eg by gender, and for later cohorts), and repeated the analysis using the slightly different 2018 and 2019 LEO datasets. We find the same broad outcomes for the STEM differential across all the analyses, albeit with small differentials as would be expected from different groups and time periods (see Appendix 2).

To calculate a lifetime earnings STEM premium, we then take the above results and adjust as follows:

- interpolate for missing years (2, 4, 6, 7, 8, 9)
- rebase average earnings data to 2003/4 constant prices using the whole economy average earnings series published by the ONS
- recalculate differentials, and deflate them back to year 1 using 3.5% pa discount rate (per Green Book principles).

For the whole sample, these calculations give us an estimate of the 10-year STEM premium for graduate earnings of £27,300 per student in 2003/4 prices, equivalent to £37,400 per student in 2017/18 prices. We note two caveats to this figure as follows.

Firstly, the figure of £37,400 is not a pure "lifetime" calculation, as we have not allowed for any differential that may persist beyond 10 years. It is therefore a more conservative estimate than a true "lifetime" figure. This is discussed further in Appendix 2.

Secondly, the figure is based on the population of all graduates tracked in LEO. The "average" student in this population may not match the demographic and prior attainment characteristics of the "average" CREST Silver participant. If CREST Silver participants are already "above average", then this may lead to the premium estimate being an overestimate as we should be estimating both STEM and non-STEM average earnings from the upper parts of the distributions of earnings, not the whole range.

Step 2: Costs of the BSA programme

To complete a cost-benefit analysis, we need to understand the full costs of the programme. This includes both BSA's own costs in running CREST Silver, and also any costs incurred outside of BSA (eg at schools themselves) or in wider society.

BSA Costs

BSA have calculated the costs of running the CREST Silver programme for the academic year 2017/18 as part of their overall education programmes. Costs have been built up covering:

- Direct CREST Silver variable costs – eg costs of assessors' fees, certificates, etc
- CREST programme fixed costs allocated to Silver – eg education team, CREST IT platforms and website, sales and marketing
- BSA overhead costs allocated to CREST Silver

The category "CREST programme fixed costs" covers items generally common to all 6 programme levels, but where it is not possible to directly allocate as solely relating to any one level. Therefore an allocation of 1/6th has been applied to these items (where items are only common to fewer than 6 programmes, a similar relevant proportionality is applied). The same 1/6th approach is applied to allocated BSA overhead costs. The BSA team are confident this is reflective of time spent by their staff across CREST.

School costs

We have included an estimate for the incremental costs incurred by schools in facilitating CREST Silver projects. Approximately 88% of projects are practical, the remaining 12% being desk research. For the practical projects, which require some laboratory consumables, we need to include an estimate of these costs. BSA expert advice was that such consumables would be c.£10 per student where the project was a practical one. We have therefore added an estimate for this cost across the 88% of projects that are lab-based and assumed zero additional costs for the remaining 12% of projects that are desk-research based.

Other costs

The principal societal cost that we need to consider is the value of the volunteer time involved in running the projects. This is largely that of school teachers who run the science clubs and other mentors who help facilitate.

While it would be relatively straightforward to calculate a figure (eg number of hours, multiplied by an appropriate hourly earnings figure), this would only identify the cost and not any benefits that the individuals might accrue to themselves. Further, we consider that the actual "financial cost" incurred by schools when their teachers are running lunchtime (or similar) clubs is zero, as teachers are on fixed pay and will be expected to run such clubs as part of the general employment. The opportunity cost of a BSA science club is therefore not sum other economic activity, but another extra-curricular activity.

In the general literature on volunteering, we also note that volunteers will accrue personal benefits, most typically some form of wellbeing. Therefore, if the cost of volunteering is to be included, so too should the benefits. In practice, we are unable to estimate this wellbeing component so have excluded both the costs and benefits to volunteers' time.

Total costs

Based on the above approach, and as shown in Figure 4 below, we have calculated total costs of the CREST Silver programme for 2017/18 to be £89,600. This is equivalent to £70 per student.

Figure 4. Total costs of CREST Silver

Category		CREST Total	Of which, CREST Silver
BSA	Direct Silver variable costs		£ 2,900
	Allocated CREST programme costs and BSA overheads	£443,000	£75,500
Total BSA costs			£78,400
Schools - consumables	88% practical projects, across 1,275 students, with consumables @ £10 per student		£11,200
Total costs			£89,600

Step 3: Calculation of breakeven threshold and sensitivity

We calculate the breakeven threshold by dividing the total programme costs (£89,600) by the estimated STEM degree earnings premium (£37,400) per pupil, and round the answer from 2.40 to 3. In other words, of the students doing CREST Silver Awards and going on to university, only 3 extra students need to study STEM subjects at university rather than non-STEM subjects to breakeven. This is equivalent to 0.2% of the 2017/18 cohort of 1,275 CREST Silver students.

As set out above, this breakeven level considers only the one pathway. We have not calculated any estimated benefits for the other pathways, so our results are conservative. In other words, fewer than 3 extra students choosing STEM at university would be needed if we also allowed for other types of uplift, for example, more students per se going on to university (even if choosing non-STEM subjects).

To illustrate the sensitivity of this result, we have also calculated the breakeven impact for higher programme costs and for a lower STEM premium of only £13,000 (this is the earnings uplift over only the first three years' earnings after graduation, not 10 years). Under these more pessimistic assumptions the breakeven number of additional students taking STEM subjects (rather than non-STEM subjects) rises to 11 (or 0.9% of the 2017/18 cohort of students) in the worst case, as set out in Figure 5.

Figure 5. Number of additional students required for breakeven under sensitivity analysis

			STEM premium	
Programme costs			Central estimate (10 year premium) £37,400	Lower estimate (3 year premium) £13,000
	Central estimate	£89,600	3	7
	Higher costs (+50%)	£134,400	4	11

Conclusions and implications

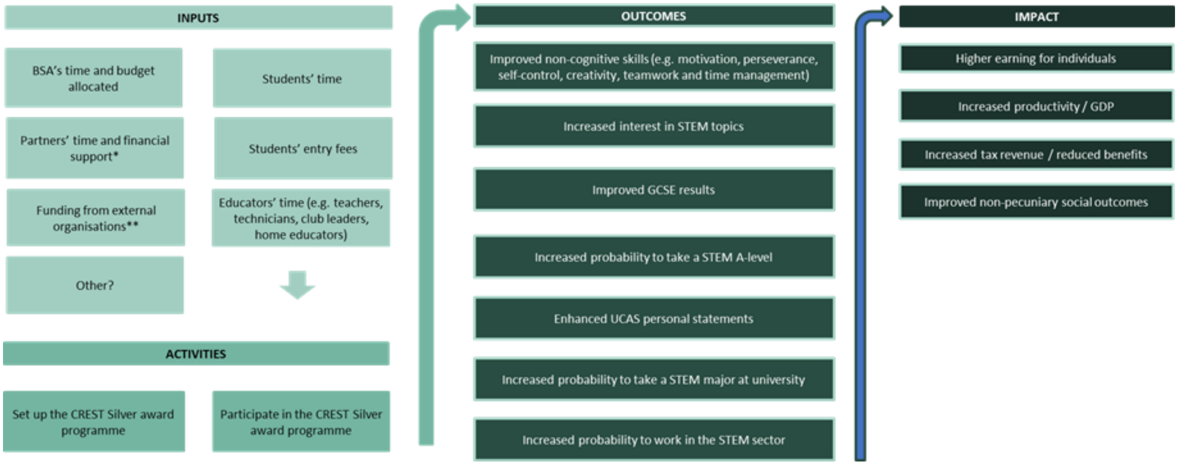
Our analysis suggests that CREST Silver only needs to have a relatively small effect on degree choice for the societal net benefits to exceed the costs. Whilst this is not implausible, we do not currently have the evidence needed to assess the longer term impact of CREST Silver on degree choice. The earlier PBE study in 2016 suggests that CREST Silver boosts attainment in science subjects at GCSE and also increases the likelihood of choosing a STEM subject at AS level and the EEF RCT study mentioned earlier should provide further useful evidence on these linkages.

However, the impact of CREST Silver participation on STEM subject choice at university, whilst plausible, remains a key area of uncertainty. The ideal method for examining these longer term effects would be a longitudinal study tracking both the cohort of CREST Silver participants and a matched control group through A level outcomes, university subject choices and post university earnings. This would also enable the results to be controlled for demographic and prior attainment characteristics of participants, as well exploring issues such as the gender dimensions that we have only touched on. We understand from the Department for Education that they are currently working with the ONS to release the LEO dataset on the same basis of access as the National Pupil Database. This will potentially enable a further study to evaluate the impact of CREST Silver on degree choice in a well-designed quasi-experimental study that compares outcomes for CREST students to a matched control group of non-CREST students.

Appendix 1: Simplified logic model

As part of this project, a simplified logic model was developed for CREST Silver that links the various inputs and activities of the programme to the short run outcomes for pupils and longer term social and economic outcomes. This is shown in Figure 6.

Figure 6. Logic model for BSA's CREST programme



From this logic model, it can be seen that the 2016 PBE report focused on some of the **outcomes** from the CREST programme, specifically **improved GCSE results** (for science) and **increased probability to take a STEM A-level** (using AS level as a proxy).

In this report, we have focused on the **impact** of the programme, and specifically **higher earnings for individuals**.

Appendix 2: The Longitudinal Education Outcomes (LEO) dataset

Introduction to the LEO dataset

The Department for Education published its first LEO dataset in 2016 (see DfE (2016)) and has published new datasets in 2018 and 2019. The 2018 dataset formed the basis of two IFS reports looking at returns to higher education (IFS 2018a, IFS 2018b).

The LEO dataset reports the actual earnings for students at fixed time points after graduation, by matching educational records and PAYE records. LEO data provides lower quartile, median and upper quartile earnings by subject, with further splits by gender. Different time periods are used, namely earnings at 1 year, 3 years, 5 years and 10 years after graduation.

In the 2016 LEO dataset, results up to and including tax year 2014/15 are reported. Different cohorts are presented, for example the 1-year outcome for 2012/13 graduate, the 1-year and 3-year outcomes for 2011/12 students and so on. For the 2003/4 cohort, a full set of results at 1,3, 5 and 10 years is presented.

In the 2018 and 2019 LEO datasets, a slightly different methodology for earnings is used, including PAYE data and self-assessment returns (resulting in better capture of self-employment income). However, the results in the 2018 LEO dataset only report individual cohorts for the most recent tax year (ie the 10-year results for the 2004/5 graduates, 5-year results for the 2009/10 cohort etc), not the continuous results for a single cohort.

In our analysis and in the rest of this report, we use the 2016 LEO dataset so we can see the 10-year earnings progression for the same cohort. By using a single longitudinal approach, rather than chain-linking results from different groups, we avoid any potential errors or bias that could be caused by different demographic or other characteristics across and between groups. However, we do compare the results to the later LEO datasets to check that results are still reliable.

It is important to note that DfE data is reported in current prices throughout, ie all values are in nominal values for the tax year to which they relate. In the next two sections describing the LEO data and our results, we continue this convention. Our final results are then converted to "real" measures in a separate stage of the analysis, by using the ONS deflators for average earnings growth.

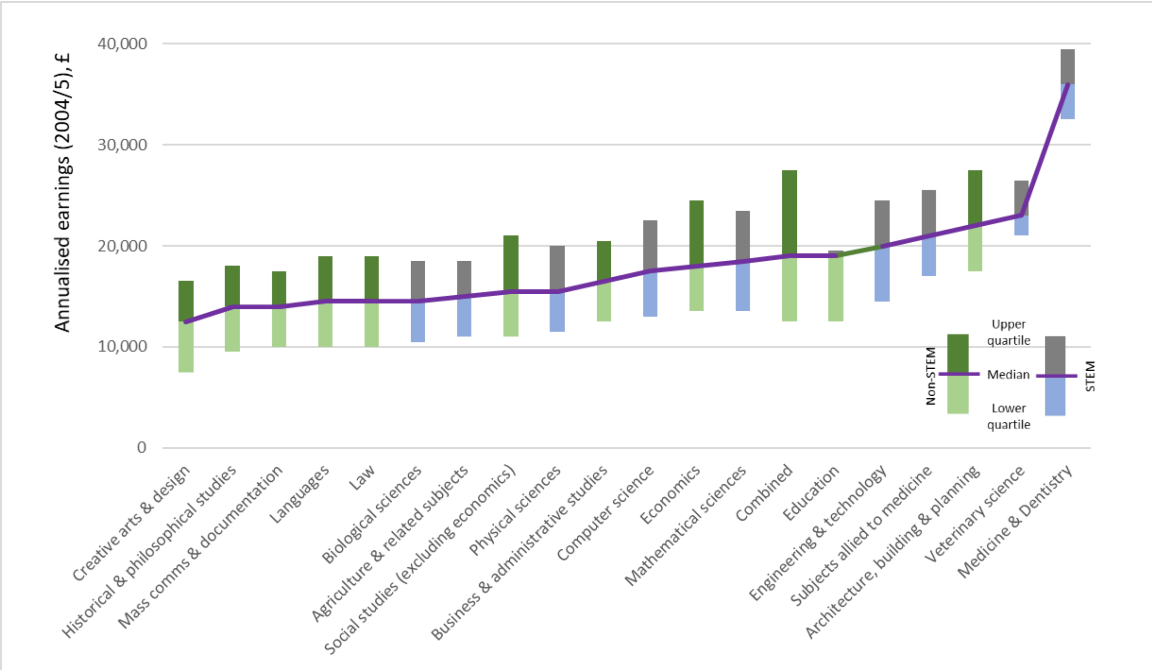
In this report, we rely on the published tables from the LEO dataset, rather than direct access to the underlying student-specific data. In other words, we are using statistics (such as median) derived from the population of all students, not the specific outcomes of CREST participants compared with a control group.

What does the data show: earnings by subject

Figure 7 shows the pattern of earnings by each subject in the 2016 LEO dataset. This shows that STEM subjects – as defined in Figure 8 - are more prevalent at the upper end of the earnings range.

Although not shown in this report, we see the same broad pattern by subject across all the different cohorts in both the 2018 and 2019 LEO datasets. The pattern is also apparent in the various disaggregations by number of years since graduation and gender.

Figure 7. Earnings after 1 year by subject



Source: DfE (2016).

Figure 8. Aggregation of JACS subject groupings for 2003/4 cohort[9]

STEM		Non-STEM	
1	Medicine & Dentistry	A	Architecture, building & planning
2	Subjects allied to medicine	B	Social studies (excluding economics)
3	Biological sciences	L1	Economics
4	Veterinary science	C	Law
5	Agriculture & related subjects	D	Business & administrative studies
6	Physical sciences	E	Mass communications & documentation
7	Mathematical sciences	F	Languages
8	Computer science	G	Historical & philosophical studies
9	Engineering & technology	H	Creative arts & design
		I	Education
		J	Combined

Calculating the STEM premium

From the 2016 LEO dataset, we use

- the number of students by subject, and
- median earnings by subject

to calculate weighted average earnings for STEM and non-STEM as a whole.

[9] The Joint Academic Coding System (JACS) is used by the Higher Education Statistics Agency (HESA) to classify all Higher Education courses. The current version, JACS 3.0, has been in use since 2012/13.

Based on this aggregation, there were 81,000 STEM students in the 2003/4 cohort, and 121,000 in the non-STEM cohort (the latest 2013/14 cohort in the DfE (2018) statistics had 87,000 and 136,000 respectively, reflecting expansion of the university sector over the period).

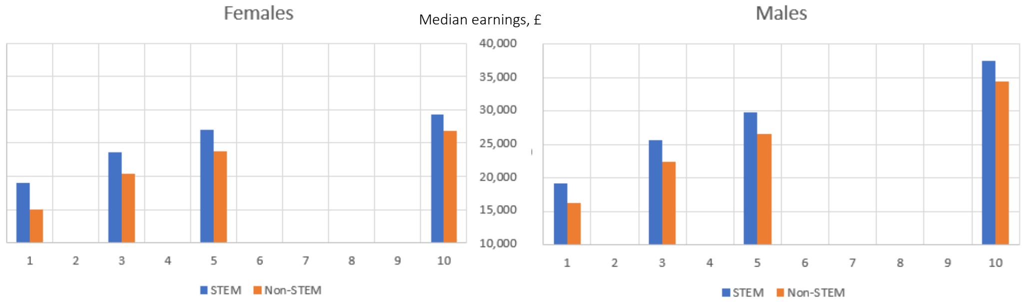
Results for the 2003/4 cohort are shown in Figures 9 (all students) and 10 (separate results split by gender).

Figure 9. Earnings by aggregated groupings for 2003/4 cohort

	1 year	3 years	5 years	10 years
STEM	£18,900	£24,500	£28,500	£33,700
Non-STEM	£15,500	£21,100	£24,800	£29,800
Differential	£3,400	£3,400	£3,700	£3,900
	23%	16%	15%	13%

Source: Pro Bono Economics analysis based on DfE (2016). All data in current prices and rounded to nearest £100.

Figure 10. Earnings by aggregated groupings, by gender



Insights and discussion

There are a number of interesting trends in the data here:

- The percentage differential declines over time

  Although the nominal differential increases year-on-year, this is largely due to wage inflation. As demonstrated by the percentage (ie controlling for inflation), the premium declines over time. We consider the decreasing differential to be indicative of the declining relevance of degree type to later year job market outcomes. This is important to our assumptions about how long the effect of CREST Silver effect endures.

- Female and male progressions differ

  These calculations show that both females and males see a STEM premium in earnings, but the trends are different. For earnings 1 year after graduation, females enjoy a larger STEM premium (£3,900 or 26%) than males (£2,900 or 18%). However, this drops to £2,400 (9%) for females by year 10 (9%) while the male differential remains broadly the same in nominal terms though still dropping in relative terms (£3,100, 9%). The cumulative differentials over 10 years turn out broadly the same (£30,700 and £31,600 respectively).

The primary finding here is that earnings progression over 10 years, and particularly over years 5 to 10, is much lower for females. We see this in individual subject data for both STEM and non-STEM subjects and in all three LEO datasets. We therefore consider it likely that these gender differences are driven by other factors in the labour market, such as the propensity for career progression combined with the impact of family breaks (for females). We also note that this data is based on the 2003/4 cohort, and that this pattern may have changed such that in today's labour market, the progression for new graduates may not have as marked gender differences.

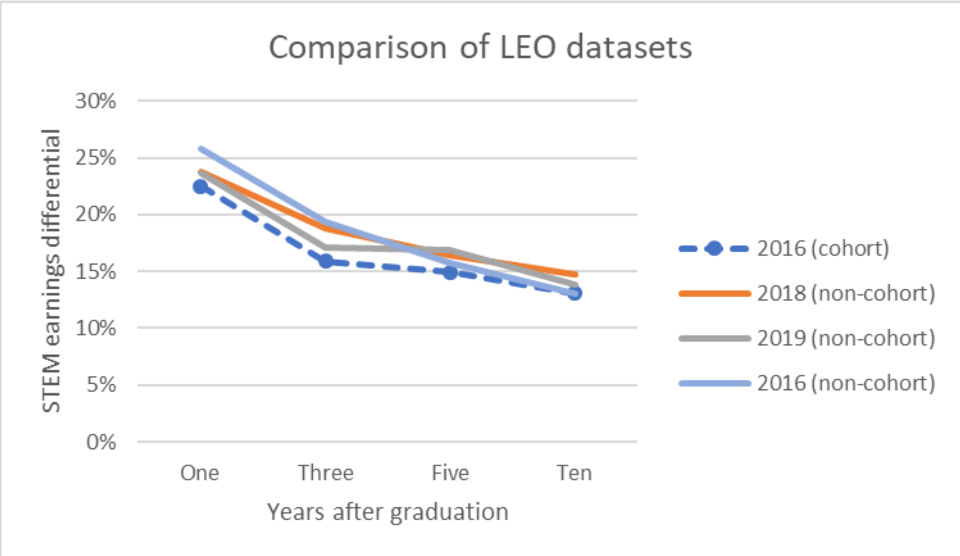
The above results are all taken from the 2016 LEO dataset. Where possible, we have compared these results to the differentials calculated against the different cohorts from the 2018 LEO dataset. The same broad outcomes are repeated, albeit with small variations in actual differentials as would be expected from different economic time periods:

- a 24% STEM premium at year 1 (2013/14 cohort) and 15% at year 10 (2004/5 cohort).
- a larger differential for females than males in the early years, which reverses over time.

Similar results are derived from the 2019 dataset.

To illustrate the repeated findings, Figure 11 shows the STEM premium as a percentage for the different groups. The 2016 "cohort" group is the continuous series used as the basis for our results, the other "non-cohort" groups are the latest results by tax year and so represent different populations of students each time.

Figure 11. Premiums compared across datasets



Given that the results based on the earliest data are repeated in the later datasets, we are therefore confident that the patterns from the 2003/4 cohort, the true longitudinal dataset in the 2016 LEO dataset, are robust and therefore use these results rather than linking together different cohorts from the 2018 or 2019 LEO datasets.

Lifetime earnings premiums

To calculate the lifetime earnings STEM premium for this report, we take the 2003/4 cohort (whole sample) data from the 2016 LEO dataset as above and adjust as follows:

- interpolate for missing years (2, 4, 6, 7, 8, 9)
- rebase average earnings data to 2003/4 constant prices using the whole economy average earnings series published by the ONS

- recalculate differentials, and deflate back to year 1 using 3.5% pa discount rate (per Green Book principles).

For the whole sample, these calculations give us an estimate of the 10-year STEM premium for graduate earnings of £27,300 in 2003/4 prices, equivalent to £37,400 in 2017/18 prices.

As LEO data only goes up to 10 years, we cannot directly calculate a full lifetime STEM premium. We have experimented with calculations that extrapolate the 10th year premium out to later years at a declining percentage, for example if the premium drops to 0% by 20th year (and remains zero thereafter), the lifetime figure in nominal terms is about 40% higher than the 10-year STEM premium. When we model the premium persisting longer than 20 years, the lifetime figure increases further.

However, there are two factors specific to CREST Silver that guide our judgement of which figure to use:

- the earnings progression for females drops noticeably after year 5
- we also need to ensure we are not over attributing whole lifetime income differentials to a single, 30 hour, intervention as year 9 pupils.

We therefore choose to use the 10-year figure for aggregated differentials, £37,400 (at 2017/18 prices), as it is more conservative than an extrapolated "lifetime" figure to ensure that we are not overstating the benefits and attribution.

Appendix 3: the economic value of educational qualifications

There is now an extensive literature on the economic value of educational and vocational qualifications. In the UK, the government has also been prominent in developing datasets and commissioning research which have generated estimates of the monetary benefits to society of a more educated workforce.

Economic theory tells us that higher earnings for individuals represent the higher productivity that comes from increased human capital, and can be considered to represent additional GDP. At an individual level, higher earnings have two sources: a higher incidence of being in employment or self-employment (though this is typically a relatively small factor); and higher salaries from occupations and industries putting a premium on STEM skills.

To put the results from the 2016 LEO dataset in context, in this appendix we summarise the three main reports published by the Department for Education in 2014, 2015 and 2018. These reports each contain extensive surveys of the relevant academic literature which we do not repeat here.

The three reports draw on different underlying data sets, but give broadly consistent outcomes. In Figure 12, we highlight the estimates most relevant to the CREST Silver evaluation.

Figure 12. Key results from government studies

	DfE (2014)	DfE (2015)	DfE (2018)
Underlying data sources	Labour Force Survey (LFS) 2006-13	British Cohort Study (BCS70)	Longitudinal Educational Outcomes (LEO) 2015/16 tax year
Qualification	5+ good GCSEs incl. Eng/Maths (vs anything else)	A levels incl. STEM (vs O levels/GCSEs)	University degree
Key economic variable	Lifetime earnings premium Central estimate of "average" effect[10]	Annual earnings premium	Annual earnings, 1 year after graduation
Earnings	Men: £62,930 Women: £54,486 *(at 2013 prices)*	Men: £7,000 pa Women: £4,500 pa *(at 2014 prices)*	STEM: £21,934 Non-STEM: £17,714 *(at 2015/16 prices)*
Source	Tables 13, 15	Executive summary	PBE analysis (see Appendix 2)

[10] Note: returns to qualifications are typically estimated for both "marginal" and "average" effects. Marginal returns are the benefit from the qualification level of interest as the individual's highest qualification level, eg 5 good GCSEs vs anything lesser, and not progressing further in education or training (for either group). Average returns estimate the benefit whether or not it is the individual's highest qualification. These allow for either group (with or without) to progress to higher education / earnings profiles, and is the best method for isolating the independent impact of the higher attainment level.

From DfE (2014), we see the value of increased educational attainment per se. In the 2016 report, it was established that 95% of CREST Silver students attained 5+ good GCSEs including English and Maths. We don't know the PSM-matched results for the control group (this will be a key result from the EEF study), but for every 1% uplift relative to a matched control group, there would be a societal gain of £0.75m (assuming a 50:50 gender split as in the 2016 report).

The DfE (2015) report confirms these results, with "strong positive wage returns to A levels, irrespective of whether the individual goes on to complete further or higher qualifications"[11].

More pertinently for our interest in the STEM premium, the DfE (2015) report also details the increments separately for STEM vs non-STEM A levels. This shows an earnings premium of 13.1% for STEM A levels (vs O levels/GCSEs) compared with 4.8% for individuals whose A Levels were without any STEM subjects.

The latest report, DfE (2018) enables us to go further and look specifically at the STEM premium for early-career earnings according to subject at university. This shows a STEM premium of £4,220 or 24% for first year earnings for the 2013/14 graduating cohort. This differential persists in nominal terms (albeit with decline in percentage terms) at 3 years, 5 years and 10 years after graduation.

Of the various reports considered here, we view the LEO dataset to be the strongest possible data, as it tracks individuals with known characteristics (degree type, also institution) to actual outcomes data.

At present, LEO data is only accessible in aggregate or results form, but we understand the Department for Education is working on enabling access to individual results on the same basis as the National Pupil Database. We strongly welcome this step as it will enable much better analysis with cohort-specific results for the type of study reported here and other work.

[11] In all cases, results from DfE (2015) are quoted for the most highly specified model that controls for demographic factors and prior attainment – ie family background and age 10 test scores.

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