

The economic effects of pre-school education and quality

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Executive summary

Background

- The Effective Pre-School, Primary and Secondary Education (EPPSE) project is the first large-scale British study on the effects of different pre-school experiences on children's outcomes. It enables researchers to look at the impact of both pre-school education and pre-school quality not only on short-term education outcomes, but also on long-term education and possible future labour market outcomes for a cohort of individuals who did not have access to universal pre-school education. It is these long-term economic consequences that are the focus of this report.

Research questions

- This report focuses on the long-term economic consequences of pre-school education and quality for
 - educational outcomes at age 16, the last year of compulsory schooling.
- It uses these results to estimate
 - the likely difference in future employment and earnings outcomes that arise from pre-school education;
 - the likely overall costs and benefits to the exchequer of pre-school education.

Methodology (Chapter 2)

- Our methodological approach to the research questions involves a two-stage process. First, we estimate the effect of different pre-school experiences (attendance and quality) on outcomes in Key Stage 4 exams taken in the final year of compulsory schooling. Second, we *predict* the effect of different pre-school experiences on lifetime gross and net earnings in order to estimate the likely exchequer benefits of these different pre-school experiences in the long term. This involves complex modelling and a number of strong assumptions, which are clearly outlined.

Findings – educational outcomes at age 16

- Our analysis begins by looking at the impact of receiving pre-school education versus none (or only a minimal amount) – what we call attendance – on a variety of Key Stage 4 outcomes. We find that going to pre-school increases the probability of obtaining five or more GCSEs at grades A*–C by 8.4 percentage points, on average, while it increases the average number of GCSEs achieved at these grades by 0.8 GCSEs. The effect of receiving pre-school education is more than twice as large for those whose mothers have low educational qualification levels as for the whole sample, suggesting that pre-school education may play an important role in reducing long-term educational gaps for children of mothers with low education. These children

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are likely to be particularly disadvantaged in the education system, as mother's educational qualification level has been found to be the strongest predictor of educational attainment across different phases of education. Our results are very similar for boys and girls. Note that the magnitude of all the results on the effect of attendance on educational outcomes at age 16 needs to be treated with some caution, as the study has no baseline data on cognitive ability (at age 3) for those who did not attend pre-school. (Chapter 3)

- The next part of our analysis looks at the impact of receiving high- versus low-quality pre-school education on a variety of Key Stage 4 outcomes. Unlike pre-school attendance, the long-term impact of pre-school quality is either small or insignificant. Where it is statistically significant, it is only very high-quality pre-schools (in the top 20% of the distribution) that have a significantly greater effect on GCSE outcomes at age 16 than do lower-quality pre-schools. For example, attending a pre-school that scores in the top 20% on the quality measure ECERS-R scale (compared with a pre-school that scores in the bottom 20% on the same scale) is found to increase the number of GCSEs and equivalents achieved at grades A*-C by just over one GCSE, which represents an increase of just under 20% relative to the sample mean (5.41). Similarly, attendance at such a 'high-quality' pre-school increases the probability of a young person achieving five or more GCSEs and equivalents at grades A*-C by about 7 percentage points, or 13% relative to the sample mean of 55%. In line with the results for pre-school attendance, pre-school quality seems to benefit children with low-educated mothers more than children with high-educated mothers. Again, there is little evidence of differential effects for boys and girls. (Chapter 4)

Findings – individual economic benefits

- Having found evidence that pre-school attendance and higher pre-school quality show benefits in terms of increased academic outcomes at the end of Key Stage 4, the next phase of this research estimates how such gains might translate into long-term economic benefits for the individual (in terms of the discounted present value of lifetime gross earnings). We estimate that children who received the average pre-school experience amongst the EPPSE sample will go on to earn, on average, around £27,000 more over their working lives in discounted present-value terms than children who received little or no pre-school experience, and around £36,000 more if we take into account the earnings of other members of their household. These figures translate into average percentage gains of around 7.9% and 5.1% of gross earnings per individual and per household respectively. They need to be considered with some caution because of various difficulties in predicting future gross and net earnings for the cohort. Our calculations also predict that gross lifetime earnings would be about £12,500 higher per individual and £19,000 higher per household on average for an EPPSE child who had attended a high-quality pre-school than for a child who had attended a low-quality pre-school. These figures represent an average percentage increase of

4.3% per individual and 2.6% per household in gross lifetime earnings for those who attended a high-quality setting compared with those who attended a low-quality one. Interestingly, it is the people who are predicted to be relatively low earners who have the highest percentage gains from both pre-school attendance and higher pre-school quality in terms of gross lifetime earnings, which suggests that pre-school could help reduce lifetime earnings inequality. (Chapter 5)

Findings – benefits to the exchequer

- The differences in gross lifetime earnings from attending pre-school translate into estimated benefits to the exchequer of around £11,000 per individual pre-school attender if we only account for individual earnings, and of around £16,000 per household if we account for both the pre-school attender's own earnings and those of their future partner. These figures are likely to be upper bounds unless the benefits of pre-school attendance extend beyond retirement age (assumed to be 60), have intergenerational effects or affect other important outcomes such as improved health or pensions or reduced criminal behaviour. More modest effects are found for attending high- versus low-quality pre-schools. For example, we estimate a difference in net lifetime earnings of £7,500 between individuals attending a low-quality pre-school and those attending a high-quality pre-school. This generates a saving to the exchequer of around £5,000 per individual, suggesting that those who attended high-quality pre-schools will pay around £5,000 more in tax (or receive £5,000 less in benefits, or some combination of the two) than those who attended low-quality pre-schools. The equivalent figure at the household level is around £8,000. (Chapter 6)

Sensitivity analysis

- We test the sensitivity of our results by using different methods, different earnings growth assumptions and different discount rates. The findings are not substantially altered by making any of the changes considered (Chapter 7)

1. Introduction

The Effective Pre-School, Primary and Secondary Education (EPPSE) project is the first large-scale British study on the effects of different pre-school experiences on children's outcomes. As part of this project, about 2,800 children were assessed at the start of pre-school around the age of 3 and their development was monitored until they entered school around the age of 5. An additional group of about 300 children with no pre-school experiences (or very little, hereafter referred to as the 'no pre-school' or 'home' group) were recruited at school entry at age 5. This brought the total (pre-school plus no pre-school group) to just over 3,000. The full sample were subsequently assessed at important points of their academic career up until their final year of compulsory schooling (age 16). Their subsequent education, training and employment choices were captured six months after leaving school.

Previous analyses of the EPPSE study have documented long-lasting impacts of high-quality pre-school and family experiences on educational attainment and socio-behavioural development up to age 14 (Sylva et al., 2004, 2008 and 2012). In this report, we describe new research on the impact of different pre-school experiences on academic outcomes at the end of Key Stage 4 (KS4, age 16) and relate this to the potential longer-term economic benefits for both the individuals themselves and the exchequer. In particular, we consider possible effects on employment and earnings between ages 18 and 60 using other data sets to estimate potential future trajectories.

The first part of our analysis focuses on comparing children who received pre-school education with those who did not on a variety of KS4 outcomes. These outcomes include results achieved in GCSEs¹ and equivalent qualifications, measured in a variety of ways. For this part of the analysis, it is important to note that the cognitive and socio-behavioural development of children who joined the study at age 5 (those who received little or no pre-school education) was not measured at baseline (age 3). To the extent that early measures of ability influence subsequent educational attainment, it is possible that our analysis may overestimate the impact of pre-school education on KS4 outcomes. Our robustness checks on this matter suggest that this might be the case and that the bias could be substantial. Also, our estimates do not allow for the fact that a minority of the pre-school sample will have had pre-school experience before 3 years of age, which may also impact on our estimated outcomes. With these caveats in mind, our analysis suggests that receiving any pre-school education has a large and significant effect on most of the KS4 outcomes measured.

The second part of the analysis focuses on the effect of different pre-school qualities on the same KS4 outcomes. Overall, the analysis provides evidence of a positive impact of pre-school quality on educational attainment at age 16, although these findings are not consistent across outcomes or the measures of

¹ GCSEs are high-stake exams taken at the end of compulsory schooling in England.

pre-school quality used. For example, we find a moderate significant effect of attending a pre-school of high quality compared with one of low quality (defined using the ECERS-R scale) on the number of GCSE and equivalent qualifications achieved at grades A*–C, even after accounting for differences in early development, family background and parental characteristics. However, if we measure quality using the ECERS-E scale, this effect is not significant and there is no significant difference in the likelihood of achieving the benchmark indicator of at least five GCSEs and equivalents at grades A*–C.

Focusing on the positive significant effects, we then address the question of how these gains in KS4 outcomes may translate into lifetime (gross) earnings and employment experiences. This requires us to *predict* the earnings and employment patterns of individuals in the EPPSE sample, since the KS4 outcome data were collected when they were just over 16 years old and most had not yet completed their education or started their working life. As a result, this part of the analysis is more speculative and the report presents a series of robustness checks in order to assess the sensitivity of these results to assumptions underlying the exercise. Our results suggest that receiving any pre-school compared with no pre-school education could translate, on average, into an increase of up to 7.9% in the discounted present value of gross (pre-tax) lifetime earnings. We also find that those attending a high-quality pre-school have a discounted present value of gross lifetime earnings that is around 4.3% higher than if those same individuals attended a low-quality pre-school, though there is a lot of uncertainty around these estimates and they are different for different margins and measures of quality.

The last part of our analysis addresses the implications of our findings for the exchequer, in terms of potential future tax receipts and benefit payments. This involves comparing the average gross and net earnings gains (i.e. the gains before and after taking into account taxes paid and benefits received) that arise from attending pre-school or from attending a high- rather than low-quality pre-school. The difference between these gross and net figures in each case represents the saving to the exchequer in terms of taxes received and benefits paid. Again, this is a complicated exercise that makes a number of assumptions, such as partnership status, number and age of children, and housing tenure. We illustrate the sensitivity of our results to such assumptions by looking at the exchequer gains for individuals (assuming that they remain single and childless) as well as for a more realistic sample of households.

We find that receiving any pre-school education compared with none could translate, on average, into an increase of up to 7.9% in the discounted present value of gross lifetime earnings and of up to 6.6% in the discounted present value of net lifetime earnings, leading to a gross saving to the exchequer (i.e. abstracting from the cost of provision) of around £11,000 per individual and £16,000 per household if we account for both the pre-school attender's own earnings and those of their future partner. Given the data at hand, however, these figures should all be interpreted as upper bounds of the consequences of receiving any pre-school education, as the estimated treatment effect is likely to

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capture both the impact of pre-school education and the impact of the child's early cognitive and socio-behavioural development on later outcomes.² If the effects of pre-school last into retirement or if there are intergenerational effects, we may be underestimating them (for example, if there are health benefits or increases in pension income linked to higher earnings). We estimate that attending a high-quality rather than a low-quality pre-school may give rise to a saving to the exchequer of between £4,000 and £5,000 per individual, and between £6,500 and £8,000 per household, in discounted present-value terms reported in 2013 prices discounted from the age of 4 (the time of the pre-school investment). Importantly, it should be noted that these are *gross* savings, as the figures do not account for the cost of providing high-quality pre-school education over low-quality pre-school education.

The remainder of the report is organised as follows. Chapter 2 describes the methodology. Chapter 3 reports estimates of the impact of receiving any pre-school education on KS4 results, whilst Chapter 4 focuses on the impact of pre-school quality on these outcomes. Chapter 5 discusses how these influences translate into lifetime gross earnings and Chapter 6 discusses what the results imply in terms of savings to the exchequer. Chapter 7 reports our sensitivity analysis of the estimates presented in Chapters 3, 4, 5 and 6. Chapter 8 concludes.

² Measures of the young children's cognitive and socio-behavioural development were available at entry to primary school for all children in the EPPSE sample, but similar measures were available at age 3 only for those children who had attended pre-school. For this reason, it would be inappropriate to include earlier development in statistical models, because it has been shown that pre-school shaped children's cognitive progress and social behaviour between the ages of 3 and 5 years for the pre-school sample (Sammons et al., 2004 and 2008; Sylva et al., 2006).

2. Methodology

The analysis presented in this report is twofold. First, we estimate the effect of different pre-school experiences (attendance versus non-attendance and quality) on Key Stage 4 outcomes (results in GCSEs and equivalents; hereafter referred to as ‘GCSEs’). Second, we predict the effect of different pre-school experiences on lifetime gross and net earnings. It is important to be precise about how we define the ‘effect’ that we estimate in this research, as it is likely to vary depending on the group of children of interest and the group of children with which we are comparing it (what we term a control group). In particular, we will focus on measuring the average treatment effect (ATE), i.e. the average effect of a particular pre-school experience versus another one for *all* children in the sample. In other words, our results report the average difference in GCSE outcomes and lifetime earnings and employment between two counterfactual situations – one in which all children of the EPPSE sample experienced a particular pre-school provision (for example, high quality) and one in which all children experienced another pre-school provision (for example, low quality).³ Now that we have defined the effect of interest, let us discuss the method we use to estimate it.

2.1 Estimating the effect of pre-school attendance and pre-school quality on Key Stage 4 outcomes

The first step in our analysis consists of evaluating the impact of different qualities of pre-school provision on KS4 outcomes. For expositional clarity, we describe our methodology in the context of estimating the impact of going to a high-quality pre-school rather than a low-quality pre-school. The discussion applies to any other comparisons, such as the one between children who do and do not attend pre-school.

Suppose individuals who attended pre-school were categorised into two groups – those who attended a low-quality pre-school and those who attended a high-quality pre-school (definitions of high and low quality are detailed in Section 4.1). For each individual who attended pre-school in the sample, we define $D_i = 1$ if individual i attended a high-quality pre-school and $D_i = 0$ if s/he attended a low-quality pre-school.

We assume that academic outcome Y_i is linearly determined by the quality of the pre-school the individual attended as a child, a rich set of observable characteristics X_i (parents’ education, number of siblings, etc.; see further discussion below) and some unobservable characteristics ϵ_i . We can summarise this relationship using the following regression equation:

³ There are other treatment effects of interest – for instance, what the average outcomes for children who attended a low-quality pre-school would have been had they attended a high-quality pre-school or what the average outcomes for children who attended a high-quality pre-school would have been had they attended a low-quality pre-school.

$$Y_i = \gamma X_i + \beta D_i + \epsilon_i. \quad (1)$$

In this equation, β measures the association between outcome Y_i and attending a high-quality pre-school relative to attending a low-quality pre-school. This association can be interpreted as the *causal* effect of pre-school quality provided two assumptions hold. The first assumption is that equation (1) is a correct representation of the relationship between outcome Y_i and its determinants (D_i and X_i). The second assumption is that the unobservable determinants (ϵ_i) of outcome Y_i are uncorrelated with the quality of the pre-school attended. In other words, once we control for observable differences between individuals who attended a high-quality pre-school and those who attended a low-quality pre-school, there are no remaining systematic unobserved differences between them.

If both of these assumptions hold, then the coefficient β will measure the average treatment effect of attending a high-quality pre-school versus attending a low-quality pre-school. In other words, it will measure the difference in average KS4 outcomes between a situation in which all individuals in the sample had been assigned to a high-quality pre-school and a situation in which they had all been assigned to a low-quality pre-school. However, if one or both of these assumptions are violated in the data, then our estimates of the effect of pre-school quality will be biased.

In order to minimise the potential bias arising from a violation of the first assumption, we allow the effect of attending a high-quality pre-school to be heterogeneous across individuals (in terms of a selection of their observable characteristics, X_i), thus enabling us to investigate whether the benefits of attending a high-quality pre-school differ for individuals from different backgrounds.

In order to minimise the potential bias coming from a violation of the second assumption, we include in the vector X_i a large set of characteristics measured at baseline, which are likely to affect academic outcomes and be correlated with unmeasured determinants of the choice of pre-school quality. Specifically, we control for parental characteristics (educational qualification levels, employment status, marital status), a measure of the quality of the early years' home learning environment (HLE), characteristics of the child at birth and age 3 (an indicator for low birthweight, number of older and younger siblings, verbal and non-verbal cognitive ability, an indicator for behavioural problems, an indicator for development problems), a measure of local deprivation⁴ and basic demographic characteristics (gender, ethnicity). Note, however, that because the group of children who did not receive any pre-school education was added to the study later on, data on cognitive ability and behavioural and developmental problems of the child at age 3 are not available for these children. As a result, differences in these variables cannot be controlled for when comparing children who attended

⁴ To measure local deprivation, we use the Income Deprivation Affecting Children Index (IDAC) score in the Super Output Area of residence. This measures the proportion of families with children who are in receipt of Department for Work and Pensions (DWP) benefits. In the regression, we include four indicators, one for each of the top four quintiles on this scale.

pre-school and children who did not. We will return to this point and its implications for the interpretation of our estimates of the effect of receiving some pre-school education (versus none) in Chapters 3, 5 and 6. Details about the exact construction of the variables are provided in Appendix A. It should be noted that past analyses have shown the effects of pre-school on cognitive and socio-behavioural development at school entry (age 5) for the pre-school sample compared with the 'home' group (see, for example, Sammons et al. (2004)). They also showed variation in the effects of pre-school for the main pre-school sample in terms of duration of attendance (in months) and quality of provision. For this reason, it was not appropriate to control for cognitive and socio-behavioural development at age 5 in these analyses as it would discount the already-identified pre-school effect for those who had been to a pre-school.

2.2 Estimating the effect of pre-school provision on lifetime earnings and employment

Overview of the methodology

After estimating the effect of pre-school provision and quality on KS4 scores, the analysis aims to assess their effect on lifetime earnings and employment. The EPPSE data set provides longitudinal information about individuals from the start of their pre-school experience until the end of compulsory schooling. Therefore, so far, we do not have data on these individuals' labour market experiences as some of them are only between 16 and 18 years old. This implies that we cannot directly estimate the effect of pre-school provision on lifetime earnings and employment.

Instead, we develop a methodology to predict the lifetime earnings and employment profiles the EPPSE respondents would have if they had gone to a low-quality pre-school (*counterfactual situation A*) and the profiles they would have if they had gone to a high-quality pre-school (*counterfactual situation B*). Along the same line of reasoning as in Section 2.1, the difference between the predicted profiles associated with each counterfactual situation will measure the average effect of attending a high-quality versus a low-quality pre-school on lifetime earnings and employment.

We now summarise each step and then provide further details about them in the next four subsections. Note that we will discuss the methodology in the context of estimating the effect of attending a high-quality versus a low-quality pre-school, and we will follow a very similar reasoning when estimating the effect of receiving some pre-school education versus none.

Step A: Using the EPPSE data, we estimate the effect of pre-school quality on various measures of KS4 outcomes, including (a) the probability of obtaining at least five GCSEs at grades A*–C and (b) the number of GCSEs obtained at grades A*–C. (This is exactly what is described in Section 2.1.) We do so for the full sample and for boys and girls separately.

Step B: Next, we predict the highest educational level these individuals will go on to attain on the basis of their KS4 outcomes. We assume that anyone achieving fewer than five GCSEs at grades A*–C at age 16 does not go on to further study. Amongst those achieving at least this benchmark level, we use data from the Longitudinal Study of Young People in England (LSYPE) to predict whether they will stop at that level or go on to A levels and/or a university degree. We do so on the basis of the number of GCSEs they achieve at grades A*–C, plus a variety of demographic and family background characteristics.

Step C: We simulate the lifetime (gross) earnings and employment profiles of individuals in each of the four possible educational qualification levels (fewer than five GCSEs at A*–C, five or more GCSEs at A*–C, A levels, university degree). We do so for males and females separately.

Step D: We run these simulated lifetime profiles of gross earnings through the Institute for Fiscal Studies (IFS) tax and benefit model to compute the implied lifetime profiles of net earnings.

Step E: We use results from Steps A and B to predict the probability that each individual in the EPPSE study will achieve each educational level in counterfactual situation A (low-quality pre-school) and counterfactual situation B (high-quality pre-school). Combining this with results from Steps C and D, we compute a weighted average of the discounted present value (DPV) of lifetime gross and net earnings each individual in EPPSE is predicted to have under each counterfactual situation. We measure the average effect of attending high-quality rather than low-quality pre-school on lifetime gross and net earnings as the average difference in predicted DPV between each situation across the whole sample.

Let us now describe each step in greater detail. Step A is accomplished in the first part of the analysis and described in Section 2.1, so we do not provide any further details below.

Estimating the effect of GCSEs on educational attainment (Step B)

Step B consists of estimating the effect of the number of GCSEs achieved at grades A*–C on the highest educational level attained by the time of entering the labour market, among individuals who have at least five GCSEs at A*–C.

To do so, we use the Longitudinal Study of Young People in England. The LSYPE follows a nationally-representative cohort of a similar age to the cohorts surveyed in the EPPSE study (LSYPE cohort members were born in 1991–92, while EPPSE cohort members were born in four consecutive cohorts, the oldest in 1992–93 and the youngest in 1995–96) and has been matched to the National Pupil Database (NPD) and therefore includes KS4 outcomes. While one might be concerned that the slightly different ages of the two samples might matter given the difficult economic circumstances in which the EPPSE cohorts in particular will have been making their educational decisions, it seems unlikely that this will

systematically bias our results: in particular, only the final EPPSE cohort of 115 students would have been affected by the increase in tuition fees in 2012–13.

For every individual who achieved five or more GCSEs at grades A*–C, we define the highest educational level they eventually attain as one of the following three categories: five or more GCSEs at A*–C; one or more A-level passes; and a university degree. Ideally, we would like to measure the highest educational qualifications of LSYPE respondents when they enter the labour market. In the last wave of the LSYPE (Wave 7), however, respondents are 19–20 years old and many have not entered the labour market yet. We therefore have to assume that the highest level of education they have completed or are studying for in Wave 7 is the highest educational level they will ever achieve. This may not be a bad approximation given that dropout from university is relatively low in the UK and that relatively few individuals go on to achieve higher qualifications as mature students.

Using the sample of individuals who have ever obtained five or more GCSEs at grades A*–C, we estimate how the probability of having attained one of the three educational levels described above depends on the number of GCSEs obtained at grades A*–C along with a set of other observable characteristics using a *multinomial logit model*.⁵ Further details of this model are provided in Section B.1 of Appendix B.

Table 2.1 reports the marginal effect of the number of GCSEs achieved at grades A*–C (along with other selected background characteristics) on the probability that an individual's highest educational qualification is five or more GCSEs at A*–C (first column), one or more A-level passes (second column) and a university degree (last column). The results show that the number of GCSEs achieved at grades A*–C has a positive effect on the highest level of education attained by labour market entry. In particular, an additional GCSE (above five) increases the probability of going to university by over 3 percentage points and decreases the probability of attaining only A levels by nearly 3 percentage points. Because pre-school quality can potentially affect both the probability of achieving at least five GCSEs and the number of GCSEs achieved at grades A*–C, these results indicate that pre-school quality can possibly affect final educational attainment. Besides GCSE results, the child's geographical deprivation level, ethnicity, parents' marital status and qualification levels are other significant predictors of educational attainment.

⁵ Specifically, we control for gender, ethnicity, low birthweight, numbers of younger siblings and older siblings, mother's and father's highest educational qualification level, IDACI and parents' marital status. We find these characteristics in earlier waves of the LSYPE. For the sake of this exercise, it is important to only include explanatory variables that are included in both the LSYPE and EPPSE data sets.

Table 2.1. Marginal effects of observable characteristics on educational attainment

	Marginal effect of observable characteristics on the probability that each following category is the highest educational level attained by labour market entry		
	<i>5+ GCSEs A*-C</i>	<i>A levels</i>	<i>University</i>
Number of GCSE qualifications A*-C	-0.006*** (0.002)	-0.027*** (0.003)	0.033*** (0.004)
Number of GCSE qualifications A*-C interacted with Female	-0.003 (0.003)	0.002 (0.004)	0.002 (0.005)
Female	0.035 (0.025)	0.007 (0.041)	-0.042 (0.047)
White	0.090*** (0.007)	0.140*** (0.013)	-0.230*** (0.014)
Low birthweight	0.006 (0.014)	-0.022 (0.022)	0.016 (0.025)
Number of younger siblings	0.004 (0.004)	0.006 (0.007)	-0.010 (0.008)
Number of older siblings	0.007 (0.004)	0.006 (0.007)	-0.013 (0.008)
Parents were married	-0.011 (0.010)	-0.030* (0.018)	0.041** (0.020)
<i>IDACI deprivation index</i>			
2 nd quintile	0.013 (0.017)	-0.027 (0.025)	0.014 (0.029)
3 rd quintile	0.003 (0.016)	-0.009 (0.027)	0.007 (0.031)
4 th quintile	-0.019 (0.015)	-0.047* (0.028)	0.066* (0.031)
5 th quintile	-0.053*** (0.016)	-0.075** (0.030)	0.127*** (0.034)
<i>Father's qualification level</i>			
Age-16 academic qualification	0.026 (0.018)	-0.008 (0.026)	-0.018 (0.031)
Vocational qualification	0.023* (0.013)	0.022 (0.021)	-0.045* (0.023)
Age-18 academic qualification	0.017 (0.013)	0.009 (0.022)	-0.026 (0.025)
University degree	-0.023 (0.014)	-0.046* (0.024)	0.069** (0.027)
<i>Mother's qualification level</i>			
Age-16 academic qualification	0.030 (0.018)	0.041 (0.030)	-0.071** (0.033)
Vocational qualification	0.003 (0.013)	0.042* (0.023)	-0.045* (0.026)
Age-18 academic qualification	-0.003 (0.013)	0.043* (0.024)	-0.041 (0.026)

Simulating lifetime profiles of gross earnings and employment profiles (Step C)

Step C aims to produce simulated lifetime earnings and employment profiles for individuals who have eventually attained one of four different educational levels: fewer than five GCSEs at grades A*–C; at least five GCSEs at grades A*–C; A levels; and a university degree.

In order to do so, we estimate, for each educational group and gender, a rich statistical model of earnings and employment dynamics that takes into account the likely persistence of earnings and employment shocks (for example, a recession). The model is estimated using two large data sets that contain survey information on British individuals' labour market outcomes – the Labour Force Survey (LFS) and the British Household Panel Survey (BHPS). The statistical model generates cross-sectional earnings distributions that are consistent with the high-quality cross-sectional data from the LFS. Transitions between employment and non-employment, and year-on-year earnings fluctuations, are consistent with the dynamics observed in the BHPS. More details about the statistical model are provided in Section B.2 of Appendix B.

For each educational category, we use the corresponding estimates from the earnings and employment model to simulate artificial earnings and employment paths for a cohort of 10,000 individuals, and compute the discounted present value of gross lifetime earnings. The EPPSE children attended pre-school up to the age of 4 years 9 months on average. Following the Treasury Green Book (HM Treasury, 2011), we need to start discounting from the time of the investment (when the children were aged 4) until the fruition of the investment (which we assume is at age 60). We use a discount rate of 3.5% for the first 30 years and of 3.0% for the following 25 years (as specified in table 6.1 of the Green Book). Our estimates will therefore be slightly conservative, if pre-school provision has longer effects than this, or indeed intergenerational effects, but we feel a 55-year time horizon is reasonable. To test the sensitivity of our estimates to using different discount rates, we also use discount rates 0.5 percentage points higher and lower than this central scenario (see Chapter 7).

Table 2.2 presents the results of this exercise. It shows that the average discounted gross lifetime earnings (including periods of non-employment) increases with educational level for both men and women, as one would expect. For example, men achieving fewer than five GCSEs at grades A*–C earn around £365,000 over their lifetimes in discounted present-value terms, while men with a degree earn approximately double this amount, at just under £740,000. Women who achieved fewer than five GCSEs at grades A*–C have lifetime earnings that are around 45% of those of men in the same category, whereas in the middle two educational groups the fraction is around 50%. For university graduates, women's lifetime earnings are, on average, around 60% of men's. It is also clear that there is much more variation in outcomes (compared with the mean) for those in the lowest educational group than for those in higher educational groups. Of course, these estimates are much lower than those typically reported

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in other types of analysis, because we have discounted future earnings from the age of 4 (as the initial investment in pre-school provision was at this age). The gap before the earnings fruition of this investment can be realised explains the *discounted present value* of lifetime earnings being lower than that typically used when considering initiatives aimed at adults.

Table 2.2. Average discounted present values of simulated lifetime earnings, by qualification level, as predicted by the earnings and employment model

Qualification level	Males	Females
Fewer than 5 GCSEs A*–C	£364,435 (159,296)	£163,915 (112,269)
At least 5 GCSEs A*–C	£477,563 (158,208)	£243,238 (123,498)
A levels	£525,512 (172,983)	£259,400 (129,191)
University graduates	£736,366 (252,790)	£446,823 (191,236)

Note: Standard errors of the means are given in parentheses. The average discounted present values of earnings are calculated based on simulations of 10,000 profiles for each educational category and gender.

Simulating lifetime net earnings profiles (Step D)

Step D consists of computing, for each lifetime profile of gross earnings simulated in Step C, the corresponding profile of net earnings, along with the amount of tax paid and benefits received. We use the IFS tax and benefit model to calculate the amount of tax paid and benefits received by each individual in the EPPSE sample if s/he attended a low-quality pre-school and if s/he attended a high-quality pre-school. An additional difficulty arises because the tax and benefit system in the UK is intrinsically dependent on a number of characteristics, which we do not observe for individuals in the EPPSE data set. These characteristics include the individual's family structure (marital status, partner's age, number and age of dependent children), region, housing situation (whether renting, the value of the rent, the council tax band), number of hours worked, earnings, and partner's number of hours worked and earnings. We therefore need to predict all these characteristics for each period the individuals in the EPPSE data set will spend in the labour market (up to age 60), as doing so is the only way we have to compute the net earnings profiles for EPPSE individuals. But, of course, this adds another level of uncertainty to our calculations of the effect of pre-school education on lifetime net earnings and of savings to the exchequer.

To form the predictions, we first estimate the empirical distribution of these characteristics in the BHPS for each gender, education and age group (using weights so as to approximate a nationally-representative distribution). We then randomly pick values of these characteristics for each period the individuals in the EPPSE data set spend in the labour market from the relevant gender-education-age distribution. (See Section B.3 of Appendix B for further details.)

We perform two alternative calculations. First, we assume that the individual remains single and without children all his/her life in order to compute the change in net earnings from attending a high-quality rather than a low-quality pre-school that is only related to tax and benefit changes. This gives an estimate of the savings to the exchequer at the individual level. This is a less realistic scenario than the alternative in the next paragraph, as it relies on a limited set of predicted characteristics (such as hours of work and housing tenure).

Second, we assume individuals will marry/cohabit and have children. We use the predicted earnings and hours of work of the partner when computing the gross earnings of the household and we use all the predicted characteristics to compute the net earnings of the household. This is a more realistic scenario, not least because it accounts for the fact that, if attending a high-quality pre-school changes the final educational level an individual reaches, their family structure and partner's labour supply choices may differ as well.

Predicting the average effect of pre-school attendance and pre-school quality on lifetime gross and net earnings (Step E)

The last step of the exercise combines results from Steps A, B, C and D to predict the average effect on lifetime earnings and employment of attending a high-quality pre-school rather than a low-quality pre-school. First, we use results from Step A to predict the number of GCSEs at grades A*-C and the probability of obtaining five or more GCSEs at A*-C that each individual in EPPSE would have if s/he had attended a low-quality pre-school (counterfactual A) and if s/he had attended a high-quality pre-school (counterfactual B).

Next, based on these counterfactual KS4 scores and the results from Step B, we predict the probability that each individual in EPPSE would have of attaining each of the four educational levels as her/his highest level if s/he had attended a low-quality pre-school and if s/he had attended a high-quality pre-school. To each individual in EPPSE, we then match 400 (100 per education group) possible profiles of earnings and employment from each of the artificial cohorts simulated in Steps C and D. We compute the discounted present value of gross and net lifetime earnings conditional on being in each educational category.

Finally, we compute a weighted average of the discounted present value of lifetime earnings using the probabilities associated with each individual and each counterfactual resulting from Step B and the first part of this step. For each counterfactual, we then average these results across all individuals. The difference between the averages in gross (net) earnings is the predicted average effect on lifetime gross (net) earnings of attending a high-quality pre-school rather than a low-quality pre-school. We compute the savings to the exchequer by comparing the difference between lifetime gross and net earnings in the case that all individuals went to a low-quality pre-school and in the case that all individuals went to a high-quality pre-school.

2.3 Limitations of the methodology

Before we turn to the results in Chapter 3, we make a few remarks about the methodology we use to predict the effect of differing experiences of pre-school provision on lifetime earnings and employment. As the description of the methodology in Section 2.2 makes clear, this analysis relies on the predictions of several statistical models based on three different data sets. This inevitably implies that there are many sources of uncertainty in our calculations, which should be borne in mind should the results be used, even superficially, to inform policy discussions.

The first source of uncertainty comes from the fact that we use estimates from various statistical models to predict future outcomes of the EPPSE sample. Even if the statistical models achieve a good fit of the data, we inevitably introduce some error when using them to predict the KS4 outcomes (Step A) and final educational levels (Step B) the EPPSE sample would be most likely to achieve if they had attended a low-quality pre-school and if they had attended a high-quality pre-school.

Similarly, we introduce some error when simulating the lifetime earnings and employment profiles of artificial cohorts in Step C. Figures B.1 and B.2 in Appendix B provide an analysis of the goodness-of-fit of our earnings and employment model. While the fit is remarkable for such a rich model, it is obviously not perfect, especially for women (for whom it is harder to predict employment patterns). In addition, when using the estimates from the earnings model to simulate lifetime earnings profiles, we are making the non-trivial assumption that the dynamics underlying earnings and employment profiles in the next 40 years will be the same as the ones experienced over the past 26 years by the BHPS respondents between 1993 and 2008 (an assumption common to all out-of-sample forecasting exercises).

As mentioned in Section 2.2, another source of uncertainty is introduced in order to compute the gains from attending a high-quality pre-school in terms of net earnings, which depend on a variety of future (and hence currently unknown) household characteristics in addition to gross earnings, such as family structure, housing situation, number of hours worked and partner's labour supply (number of hours worked and earnings). As a result, we need to predict most of these variables. In doing so, we ensure that the distribution of characteristics we predict in the EPPSE sample matches the nationally-representative distribution for each age, gender and educational group as measured in the British Household Panel Survey 1993–2008.

The second main source of error is the reliance on different data sets in order to perform the exercise and predict the life trajectories of EPPSE individuals 40 years into the future. One consequence of this is that it is not always possible to define variables in a consistent way through all data sets. Another consequence is that we have to assume that the empirical relationships we establish in one particular data set (for example, LSYPE) are an appropriate representation of the

expected behaviour of individuals in another data set (EPPSE). Finally, another limitation arises when we use coefficients estimated from LSYPE data to predict outcomes of individuals in EPPSE because it constrains us to only include explanatory variables that are common to the two data sets.

In sum, it is important to note that the methodology contains inherent uncertainty. We perform rigorous sensitivity checks in Chapter 7 in order to gauge the magnitude of some of this uncertainty. Although the results are very speculative, the exercise remains an interesting one. Chapters 3–6 explore the findings in more detail.

3. The impact of attending pre-school on Key Stage 4 outcomes

3.1 Introduction

In this chapter, we briefly consider the impact of attending pre-school on a number of Key Stage 4 outcomes. It is interesting to look at this because the EPPSE cohort is probably one of the last groups of children for whom this question can be addressed in a reasonably robust way, as they were of pre-school age in the late 1990s, before the introduction of universal provision for 3- and 4-year-olds. However, the children who did not attend pre-school in EPPSE were recruited at the age of 5, which means that there are no baseline measures of their cognitive and socio-behavioural development at age 3. For this reason, the main results from this chapter should be viewed with a degree of caution.

3.2 Main results

Table 3.1 reports the effect of receiving any pre-school education compared with none on selected KS4 outcomes for the sample as a whole, as well as separately by gender and by mother's qualification level.⁶ There are likely to be many reasons why some children attended pre-school and some did not. The EPPSE data contain information on a wide range of demographic and family background characteristics, but these may not be sufficient to fully capture the 'selection' of different types of children into different kinds of pre-school provision or no provision. While this is also a concern for our estimates of the influence of pre-school quality on children's outcomes reported in the next chapter, it is of greater concern here because baseline measures of the cognitive and socio-behavioural development of those who did not attend pre-school were not collected at age 3.⁷ As a result, the estimated effects of receiving some pre-school education (versus none) should probably be interpreted as an upper bound of the likely effects of pre-school education on the outcomes of interest.

Bearing in mind these caveats, the effect of attending pre-school is positive and statistically significant. For example, going to pre-school increases the probability of achieving five or more GCSEs at grades A*–C by 8.4 percentage points, on average, while it increases the average number of GCSEs achieved at grades A*–C by 0.8 GCSEs. Interestingly, these effects are slightly smaller than estimates when the GCSEs include English and maths (see Appendix C). We do not highlight these measures, as they are not recorded in the BHPS or the LFS, which are used to simulate our lifetime earnings. Nonetheless, it is recognised that achieving five

⁶ Tables C.1–C.3 in Appendix C report the effect of receiving some pre-school education on a larger set of Key Stage 4 outcomes. In contrast to the results for pre-school quality in Chapter 4, the estimates for many of these outcomes are reasonably large and generally significant.

⁷ One might also argue that if pre-school quality is not (fully) observable to parents, then they may be less able to select into high-quality provision than into provision of some sort.

A*-C GCSEs including English and maths is an outcome of greater policy interest and more likely to predict success at A level and entry to higher education. These outcomes are studied in more depth in Sylva et al. (2014).

Table 3.1. Average effect of receiving some pre-school education (versus none) on selected KS4 outcomes

Type of pre-school provision evaluated	Key Stage 4 outcomes	
	Probability of achieving 5 or more GCSEs and equivalents at grades A*-C	Number of GCSEs and equivalents achieved at grades A*-C
Full sample		
Some pre-school education (vs none)	0.084** (0.038)	0.848* (0.499)
Boys		
Some pre-school education (vs none)	0.100 (0.065)	0.913 (0.756)
Girls		
Some pre-school education (vs none)	0.069 (0.042)	0.787 (0.595)
Low maternal qualification levels		
Some pre-school education (vs none)	0.197** (0.068)	1.646*** (0.340)
High maternal qualification levels		
Some pre-school education (vs none)	0.026 (0.057)	0.460 (0.612)

Note: This table shows the average treatment effects for the whole sample and for various subgroups calculated based on the estimates of the fully-interacted linear model, where we also control for father's qualifications, mother's qualifications (except when breaking the sample by low/high maternal qualification levels), father's and mother's employment, parents' marital status, early years' home learning environment, low birthweight, deprivation index, family structure (number of younger and older siblings) and demographic characteristics (gender – except when breaking the sample by boy/girl – and ethnicity). Low maternal qualification levels identify children whose mothers have no qualifications, some vocational qualifications and/or age-16 academic qualifications. High maternal qualification levels identify children whose mothers have A-level or equivalent qualifications and/or degree-level qualifications. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors are given in parentheses.

The effect of receiving pre-school education is concentrated among those individuals whose mothers have low educational qualification levels – for example, a 20 percentage point effect on the likelihood of achieving five GCSEs at grades A*-C rather than an insignificant 3 percentage point effect for those whose mothers have high educational qualifications. This suggests that pre-school education may play an important role in reducing later educational gaps in attainment for children who have mothers with low educational qualifications, which is an important policy finding. There is little evidence that attending pre-school has any differential long-term impact in predicting differences in education outcomes for girls and boys (for whom the effects shown in Table 3.1 are similar).

4. The impact of pre-school quality on Key Stage 4 outcomes

4.1 Measures of quality

The analysis in this chapter is based on the EPPSE children who attended pre-school and excludes the no pre-school group. It considers the effect of pre-school quality on Key Stage 4 outcomes, in particular the probability of achieving five or more GCSEs at grades A*-C and the total number of GCSEs achieved at grades A*-C.⁸ We measure quality using the Early Childhood Environment Rating Scale - Revised (ECERS-R) and Early Childhood Environment Rating Scale - Extended (ECERS-E) (on both, see Sammons et al. (2004) and references therein). The ECERS-R is designed to evaluate quality of provision for children aged 2½ to 5 years in centre-based settings. It contains a wide range of statements or 'indicators' with which to evaluate the quality of the early years' environment in its broadest sense. The ECERS-R evaluates seven broad dimensions of quality:

- *space and furnishings* (e.g. room layout; accessibility of resources; display);
- *personal care routines* (e.g. welfare requirements such as health & safety and provision for sleeping);
- *language and reasoning* (e.g. supporting children's communication, language and literacy development; critical thinking);
- *activities* (e.g. provision of an exciting and accessible learning environment; resources to support specific types of play);
- *interaction* (e.g. supervision; support for social interactions);
- *programme structure* (e.g. opportunities for children to access their own curriculum; planning schedules/routines to meet children's needs);
- *provision for parents and staff* (e.g. partnership with parents; staff training and development).

The ECERS-E is an extension to the ECERS-R developed as part of the EPPSE project. It provides greater depth and additional items in four educational aspects of provision:

- *literacy* (e.g. opportunities for emergent writing, letters and sounds);
- *mathematics* (e.g. number; reasoning);
- *science and environment* (e.g. supporting children's critical thinking and understanding of the natural and physical world);
- *diversity* (e.g. planning for children's individual learning needs; valuing and respecting other cultures; gender differences).

For each quality scale and each outcome, we report:

⁸ Results for other outcomes are presented in Appendix C.

- the effect of attending a pre-school that scores in the top 20% of the ECERS-R or ECERS-E scale rather than a pre-school that scores in the bottom 20% of the relevant scale ('high' versus 'low' quality);
- the effect of attending a pre-school that scores in the middle 60% of the ECERS-R or ECERS-E scale rather than a pre-school that scores in the bottom 20% of the relevant scale ('medium' versus 'low' quality);
- the effect of attending a pre-school that scores in the top 20% of the ECERS-R or ECERS-E scale rather than a pre-school that scores in the bottom 80% of the relevant scale ('high' versus 'medium/low' quality);
- the effect of attending a pre-school that scores above the median of the ECERS-R or ECERS-E scale rather than a pre-school that scores below the median of the relevant scale.

Section 4.2 reports the results for the whole sample, while Section 4.3 reports the results for subgroups defined by gender and maternal qualification level.

4.2 Main results

Table 4.1 presents the effects of attending pre-school settings that differ in quality on the probability of achieving five or more GCSEs at grades A*–C (left-hand column) and on the number of GCSEs obtained at grades A*–C (right-hand column).⁹ Note that these measures do not require the GCSEs obtained at grades A*–C to include English and maths, which are the focus of Sylva et al. (2014). We report our results for these outcomes in Tables C.1–C.3 in Appendix C.

Overall, the results provide mixed evidence of the impact of pre-school quality on Key Stage 4 attainment.¹⁰ In Table 4.1, we focus on results for all students. We find evidence of a moderate and statistically significant effect of attending a high-quality pre-school rather than a low-quality pre-school measured using the ECERS-R scale on the number of GCSEs (and equivalents) achieved at grades A*–C, but little evidence of any significant effects on the likelihood of achieving five GCSEs at grades A*–C, or of significant effects on the number of GCSEs achieved when quality is defined using the ECERS-E rather than the ECERS-R scale.

For example, attending a pre-school that scores in the top 20% on the ECERS-R scale (compared with a pre-school that scores in the bottom 20% of the ECERS-R scale) is found to increase the number of GCSEs and equivalents achieved at grades A*–C by just over one GCSE, which represents an increase of just under 20% relative to the sample mean (5.41). Similarly, attendance at such a 'high-quality' pre-school increases the probability of a child achieving five or more

⁹ The results reported in Table 4.1 are estimates of the fully-interacted linear model described in Section 2.1. While not all the interactions between the treatment and the observable characteristics included in the model are statistically significant, we cannot reject that they are jointly different from zero. This suggests that the treatment effect is heterogeneous across individuals based on their observable characteristics and justifies our use of the fully-interacted linear model over the linear specification (1).

¹⁰ Results for other KS4 outcomes are shown in Appendix C.

GCSEs and equivalents at grades A*–C by about 7 percentage points, or 13% (relative to the sample mean of 55%).

Table 4.1. Average effect of pre-school quality on selected KS4 outcomes

Type of pre-school provision evaluated	Key Stage 4 outcomes		
	<i>Probability of achieving 5 or more GCSEs and equivalents at grades A*–C</i>	<i>Number of GCSEs and equivalents achieved at grades A*–C</i>	
ECERS-E High vs Low	0.054 (0.035)	0.448 (0.435)	
	Medium vs Low	–0.010 (0.019)	–0.122 (0.268)
	High vs Medium/Low	0.046* (0.024)	0.525* (0.269)
	Above 50% vs Below 50%	0.003 (0.015)	0.137 (0.232)
ECERS-R High vs Low	0.070** (0.025)	1.032*** (0.307)	
	Medium vs Low	0.028 (0.024)	0.474* (0.287)
	High vs Medium/Low	0.035** (0.015)	0.526*** (0.159)
	Above 50% vs Below 50%	0.054*** (0.013)	0.648*** (0.162)

Note: This table presents the results of the fully-interacted linear model, where we also control for baseline cognitive ability at age 3, baseline behavioural and development problems at age 3 (except for pre-school experience), parental characteristics (educational qualifications, employment and marital status), early years’ home learning environment, low birthweight, deprivation index, family structure (number of younger and older siblings), demographic characteristics (gender and ethnicity) and duration of pre-school experience. We use a probit model for the first outcome and a linear model for the second one. High quality refers to the top 20%, medium quality to the middle 60% and low quality to the bottom 20%. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors are given in parentheses.

4.3 Subgroup analysis

Previous analysis of the EPPSE data suggests that disadvantaged children and boys in particular can benefit from good-quality pre-school experiences at ages 3–7, 7–11 and 11–14 (Sylva et al., 2008). In this subsection, we explore whether such patterns persist when evaluating the effect of pre-school on Key Stage 4 outcomes.

Differences by gender

Table 4.2 reports the effects of pre-school quality on the same KS4 outcomes as shown in Table 4.1, for boys and girls separately. The results do not show any particularly stark differences in the effect of pre-school quality on these

outcomes between boys and girls. Unlike the results found at earlier ages, firm conclusions cannot be drawn about differential gender effects on GCSE outcomes.

For example, measuring quality using the ECERS-R scale, on average boys achieve an additional 0.7 GCSEs, and girls just an additional 0.3 GCSEs, at grades A*–C if they attend a high-quality pre-school setting rather than a medium- or low-quality setting. However, girls appear to benefit relatively more from attending a high- rather than low-quality setting (again measured using the ECERS-R scale), experiencing an increase of 1.3 GCSEs, on average, at grades A*–C compared with an increase of just 0.8 GCSEs at these grades for boys. However, none of these gender differences in effects is statistically significant. We can conclude that both girls and boys show modest benefits from attending higher-quality settings.

Table 4.2. Average effect of pre-school quality on selected KS4 outcomes, by gender

Type of pre-school provision evaluated	Key Stage 4 outcomes				
	Probability of achieving 5 or more GCSEs and equivalents at grades A*–C		Number of GCSEs and equivalents achieved at grades A*–C		
	Boys	Girls	Boys	Girls	
ECERS-E	High vs Low	0.053 (0.037)	0.055 (0.047)	0.418 (0.477)	0.481 (0.552)
	Medium vs Low	–0.019 (0.024)	0.000 (0.030)	0.100 (0.317)	–0.360 (0.505)
	High vs Medium/Low	0.054** (0.026)	0.038 (0.034)	0.546 (0.342)	0.503 (0.370)
	Above 50% vs Below 50%	–0.007 (0.022)	0.013 (0.022)	0.188 (0.336)	0.082 (0.202)
ECERS-R	High vs Low	0.050 (0.032)	0.093** (0.033)	0.779** (0.387)	1.331** (0.516)
	Medium vs Low	–0.006 (0.031)	0.064** (0.027)	0.132 (0.251)	0.840** (0.412)
	High vs Medium/Low	0.043* (0.023)	0.027 (0.024)	0.721** (0.303)	0.321 (0.328)
	Above 50% vs Below 50%	0.038* (0.021)	0.070** (0.021)	0.881** (0.268)	0.402** (0.173)

Note: This table presents the results of the fully-interacted linear model, where we also control for baseline cognitive ability at age 3, baseline behavioural and development problems at age 3 (except for pre-school experience), parental characteristics (educational qualifications, employment and marital status), early years' home learning environment, low birthweight, deprivation index, family structure (number of younger and older siblings), demographic characteristics (ethnicity) and duration of pre-school experience. The table reports the average treatment effects computed for girls and for boys separately. We use a probit model for the first outcome and a linear model for the second one. High quality refers to the top 20%, medium quality to the middle 60% and low quality to the bottom 20%. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors are given in parentheses.

Differences by maternal qualification level

Table 4.3 reports the results from the same analysis as above, this time separating children on the basis of maternal qualification levels. More precisely, we define the group of children with low maternal qualification levels as those whose mothers have no qualifications, some vocational qualifications and/or age-16 academic qualifications, and the group of children with high maternal qualification levels as those with A-level or equivalent qualifications and/or degree-level qualifications.

Table 4.3. Average effects of pre-school quality on selected KS4 outcomes, by maternal qualification levels

Type of pre-school provision evaluated		Key Stage 4 outcomes			
		<i>Probability of achieving 5 or more GCSEs and equivalents at grades A*–C</i>		<i>Number of GCSEs and equivalents achieved at grades A*–C</i>	
		Low maternal qual. level	High maternal qual. level	Low maternal qual. level	High maternal qual. level
ECERS-E	High vs Low	0.079** (0.037)	0.047 (0.053)	0.035 (0.035)	0.562 (0.507)
	Medium vs Low	0.004 (0.024)	0.004 (0.040)	–0.014 (0.027)	–0.094 (0.290)
	High vs Medium/Low	0.035 (0.023)	0.071** (0.034)	0.059* (0.032)	0.778* (0.466)
	Above 50% vs Below 50%	0.018 (0.017)	0.046* (0.024)	–0.008 (0.021)	–0.009 (0.295)
ECERS-R	High vs Low	0.078** (0.025)	0.049 (0.057)	0.054 (0.034)	0.671 (0.442)
	Medium vs Low	0.051** (0.025)	0.014 (0.053)	0.008 (0.032)	0.156 (0.377)
	High vs Medium/Low	0.041** (0.018)	0.004 (0.022)	0.034 (0.027)	0.403 (0.289)
	Above 50% vs Below 50%	0.042** (0.021)	0.053** (0.025)	0.061*** (0.018)	0.662** (0.218)

Note: This table shows the average treatment effects for pupils whose mother has low or high qualification levels, calculated using the estimates of the fully-interacted linear model, where we also control for baseline cognitive ability at age 3, baseline behavioural and development problems at age 3 (except for pre-school experience), parental characteristics (father's qualifications, parents' employment and marital status), early years' home learning environment, low birthweight, deprivation index, family structure (number of younger and older siblings), demographic characteristics (gender and ethnicity) and duration of pre-school experience. We use a probit model for the first outcome and a linear model for the second one. Low maternal qualification level includes no qualifications, vocational qualifications and age-16 academic qualifications. High maternal qualification level covers age-18 academic qualifications and above. High quality refers to the top 20%, medium quality to the middle 60% and low quality to the bottom 20%. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors are given in parentheses.

Overall, the results show that children with low-educated mothers receive higher returns from attending a pre-school of higher quality than children with high-educated mothers. For example, amongst children with low-educated mothers, attending a medium- or high-quality pre-school compared with a low-quality pre-school is associated with an increase in the likelihood of achieving five A*–C grades at GCSE of between 5 and 8 percentage points (measuring quality with the ECERS-R scale).

Although these estimated effects of attending a higher- versus a lower-quality pre-school are unquestionably smaller than the estimated effects of receiving some pre-school education versus none, we should be extremely careful when making this comparison. As mentioned earlier, it is not possible for us to control for cognitive, socio-behavioural and other developmental differences measured at age 3 between children who attend pre-school and those who do not, because of the lack of baseline measures for the no pre-school group. Tables C.4–C.6 in Appendix C replicate the results of our analysis of the effect of pre-school quality on KS4 outcomes, this time excluding controls for these baseline differences. When we do this, it is clear that the estimates can increase substantially, which further highlights the need to treat the estimates from Chapter 3 with a degree of caution.

4.4 Summary

The results presented in this chapter provide some evidence that the effects of pre-school quality on educational attainment persist up to age 16, although they are by no means robust to either the outcome or the measure of quality used, and even the largest and most significant estimates suggest only a moderate effect of attending higher-quality pre-schools on the number of GCSEs achieved at grades A*–C. It appears that the effects are much smaller than the effects of attending any pre-school rather than none, presented in Chapter 3, though comparison of the two sets of results is not straightforward. In line with previous analyses, pre-school quality seems to benefit children with low-educated mothers more than children with higher-educated mothers. In contrast with previous analyses, the differences in effects between boys and girls are not clear enough to draw any firm conclusions about differential effects.

5. The impact of pre-school attendance and pre-school quality on gross lifetime earnings

5.1 Introduction

Analysis in Chapters 3 and 4 indicated that pre-school and pre-school quality showed some benefits for children's later academic outcomes up to the end of Key Stage 4. The second phase of this research consists of evaluating how gains might translate into long-term economic benefits for the individual (this chapter) and the government (Chapter 6).

This is accomplished by combining the treatment effects of attending a pre-school (presented in Chapter 3) and a higher-quality pre-school (presented in Chapter 4) with the impact of KS4 outcomes on highest educational level (presented in Table 2.1) and simulated lifetime earnings (presented in Table 2.2).

This chapter estimates the average effect of pre-school attendance and pre-school quality on *gross* lifetime earnings (i.e. earnings before taxes have been deducted or benefits added). We present results both for individuals (who remain single and have no dependent children) and for households (attempting to account for family formation and labour supply decisions in our modelling). The latter results include any future partner's earnings as well as those of the EPPSE member. The differences between the two perspectives are particularly pertinent when it comes to understanding the impact of pre-school quality on *net* lifetime earnings (i.e. after paying taxes and receiving benefits) and the benefit to the exchequer, which we discuss in more detail in Chapter 6.

5.2 Attending pre-school

As discussed in Chapter 3, one of the advantages of the EPPSE sample is that the children were in pre-school at a time when there was no universal access to free pre-school provision, thus potentially enabling us to estimate the long-term benefits of receiving some pre-school education versus none.

Table 5.1 shows how these differences in pre-school attendance translate into differences in gross lifetime earnings using the estimates from Chapter 3. Given that those estimates are, if anything, likely to overestimate the relationship between pre-school attendance and Key Stage 4 outcomes, these figures can be regarded as upper bounds on the potential effects of pre-school attendance on lifetime earnings.

Table 5.1. Impact of receiving some pre-school education on final educational attainment and on lifetime gross earnings in discounted present-value terms (at the individual and household level)

	(A) No pre-school experience	(B) Some pre-school experience	(C) Difference between (A) and (B)
<i>Probability for males of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.31	0.21	–0.10
At least 5 GCSEs at grades A*–C	0.11	0.12	0.01
A levels	0.20	0.22	0.01
University degree	0.37	0.45	0.08
<i>Probability for females of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.21	0.14	–0.07
At least 5 GCSEs at grades A*–C	0.17	0.17	0.01
A levels	0.22	0.21	–0.01
University degree	0.40	0.47	0.07
<i>Discounted present value of gross lifetime earnings at individual level</i>			
Average of individual gains in £	£432,150 (135,151)	£458,938 (136,055)	£26,788 (58,787)
Average of individual gains in percentage points			7.9% (16.1)
Gain in percentage points based on average gains in £			6.2%
<i>Discounted present value of gross lifetime earnings at household level</i>			
Average of household gains in £	£838,353 (87,566)	£874,346 (71,578)	£35,993 (82,352)
Average of household gains in percentage points			5.1% (10.9)
Gain in percentage points based on average gains in £			4.3%

Note: Numbers in parentheses are standard deviations.

The table shows that if none of the children in the EPPSE sample had any pre-school experience, our model predicts that 31% of boys would achieve fewer than five A*–C grades at GCSE, while 37% would go on to university. If, by contrast, they all received some pre-school experience (of varying quality), our model predicts that the proportion of boys with fewer than five GCSEs at grades A*–C would fall to 21%, while the proportions achieving each of the higher educational qualifications would increase, with the largest rise occurring for those going to university, which is predicted to increase by 8 percentage points to 45%. These figures are similar to those for girls.

These substantial predicted differences in final educational attainment translate into large differences in gross and net lifetime earnings. For example, Table 5.1 shows that children who receive some pre-school experience amongst the EPPSE sample earn, on average, around £27,000 more over their working lives in discounted present-value terms than children who receive no pre-school experience, and around £36,000 more if we take into account the earnings of other members of their household. These figures translate into average percentage gains of around 7.9% and 5.1% of gross earnings respectively.

5.3 Pre-school quality

In this subsection, we apply the same methodology and report the average effect on gross lifetime earnings of three different measures of pre-school experience, which were found in Chapter 4 to have significant effects on KS4 outcomes:

- the effect of attending a pre-school that scores in the top 20% on the ECERS-R scale rather than a pre-school that scores in the bottom 20% on the ECERS-R scale (Table 5.2);
- the effect of attending a pre-school that scores in the middle 60% on the ECERS-R scale rather than a pre-school that scores in the bottom 20% on the ECERS-R scale (Table 5.3);
- the effect of attending a pre-school that scores above the median on the ECERS-R scale rather than a pre-school that scores below the median on the ECERS-R scale (Table 5.4).¹¹

Table 5.2 shows that our calculations predict that gross lifetime earnings would increase by about £12,500 per individual and £19,000 per household (in discounted present-value terms) on average if an EPPSE member had attended a pre-school in the top 20% on the ECERS-R scale instead of one in the bottom 20% on the ECERS-R scale. This represents an average percentage increase of 4.3% per individual and 2.6% per household in gross lifetime earnings compared with if they had attended a pre-school of low quality.

However, Table 5.2 also makes clear that it is relatively low earners who have the highest percentage gains from pre-school quality in terms of gross lifetime earnings, as it shows that the average percentage gain per individual is higher than the percentage gain to the cohort as a whole (compare the figures of 4.3% and 2.7% at the individual level, and 2.6% and 2.2% at the household level); if percentage gains were evenly distributed, then these two figures would be identical. This suggests that access to high-quality pre-school education may make a small contribution to reducing lifetime earnings inequality, which has important policy implications.

¹¹ We also considered the effect of attending a pre-school that scores in the top 20% on the ECERS-R scale rather than a pre-school that scores in the bottom 80% on the ECERS-R scale as well as other dimensions of pre-school quality. These were not found to have large, robust or significant effects and therefore are not considered in this part of the report.

Table 5.2. Impact of attending a high-quality pre-school versus a low-quality pre-school on final educational attainment and on gross lifetime earnings in discounted present-value terms (at the individual and household level)

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the top 20% on the ECERS-R scale	(C) Difference between (A) and (B)
Probability for males of attaining each final educational level			
Fewer than 5 GCSEs at grades A*–C	0.23	0.20	–0.03
At least 5 GCSEs at grades A*–C	0.12	0.13	0.01
A levels	0.22	0.23	0.01
University degree	0.44	0.45	0.01
Probability for females of attaining each final educational level			
Fewer than 5 GCSEs at grades A*–C	0.21	0.13	–0.09
At least 5 GCSEs at grades A*–C	0.17	0.18	0.02
A levels	0.21	0.22	0.01
University degree	0.42	0.47	0.05
Discounted present value of gross lifetime earnings at individual level			
Average of individual gains in £	£449,236 (144,405)	£461,571 (138,582)	£12,335 (48,024)
Average of individual gains in percentage points			4.3% (12.2)
Gain in percentage points based on average gains in £			2.7%
Discounted present value of gross lifetime earnings at household level			
Average of household gains in £	£857,495 (87,373)	£876,315 (81,582)	£18,820 (67,450)
Average of household gains in percentage points			2.6% (8.5)
Gain in percentage points based on average gains in £			2.2%

Note: Numbers in parentheses are standard deviations.

Table 5.3 shows results for those attending a pre-school scoring in the middle 60% on the ECERS-R scale, compared with a pre-school scoring in the bottom 20% on the ECERS-R scale. The figures are very similar to those for high-quality pre-schools. Our calculations predict that gross lifetime earnings would increase by about £11,000 per individual and £16,000 per household, on average, if an EPPSE member had experienced a pre-school in the middle 60% on the ECERS-R

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scale instead of one in the bottom 20% on the ECERS-R scale. This represents an average percentage increase of 4.1% per individual and of 2.3% per household in gross lifetime earnings compared with if they had attended a pre-school of low quality.

Table 5.3. Impact of attending a medium-quality pre-school versus a low-quality pre-school on final educational attainment and on gross lifetime earnings in discounted present-value terms (at the individual and household level)

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the middle 60% on the ECERS-R scale	(C) Difference between (A) and (B)
<i>Probability for males of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.22	0.21	0.00
At least 5 GCSEs at grades A*–C	0.12	0.12	0.00
A levels	0.22	0.21	–0.01
University degree	0.44	0.46	0.01
<i>Probability for females of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.21	0.13	–0.08
At least 5 GCSEs at grades A*–C	0.17	0.18	0.01
A levels	0.21	0.21	0.00
University degree	0.42	0.48	0.06
<i>Discounted present value of gross lifetime earnings at individual level</i>			
Average of individual gains in £	£451,302 (144,984)	£462,320 (139,475)	£11,018 (53,063)
Average of individual gains in percentage points			4.1% (13.9)
Gain in percentage points based on average gains in £			2.4%
<i>Discounted present value of gross lifetime earnings at household level</i>			
Average of household gains in £	£860,309 (86,003)	£876,267 (86,718)	£15,959 (74,757)
Average of household gains in percentage points			2.3% (9.3)
Gain in percentage points based on average gains in £			1.9%

Note: Numbers in parentheses are standard deviations.

Table 5.4. Impact of attending a pre-school above the median quality versus a pre-school below the median quality on final educational attainment and on gross lifetime earnings in discounted present-value terms (at the individual and household level)

	(A) Attending a pre-school below the median on the ECERS- R scale	(B) Attending a pre-school above the median on the ECERS- R scale	(C) Difference between (A) and (B)
<i>Probability for males of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.20	0.17	-0.04
At least 5 GCSEs at grades A*–C	0.12	0.13	0.01
A levels	0.22	0.23	0.01
University degree	0.46	0.47	0.02
<i>Probability for females of attaining each final educational level</i>			
Fewer than 5 GCSEs at grades A*–C	0.16	0.09	-0.07
At least 5 GCSEs at grades A*–C	0.17	0.19	0.02
A levels	0.20	0.23	0.03
University degree	0.47	0.49	0.02
<i>Discounted present value of gross lifetime earnings at individual level</i>			
Average of individual gains in £	£460,336 (141,389)	£470,299 (138,377)	£9,963 (27,548)
Average of individual gains in percentage points			2.9% (7.0)
Gain in percentage points based on average gains in £			2.2%
<i>Discounted present value of gross lifetime earnings at household level</i>			
Average of household gains in £	£872,905 (83,861)	£888,426 (73,164)	£15,521 (38,655)
Average of household gains in percentage points			2.0% (4.9)
Gain in percentage points based on average gains in £			1.8%

Note: Numbers in parentheses are standard deviations.

Finally, Table 5.4 looks at those attending a pre-school scoring below the median on the ECERS-R scale rather than one scoring above the median on the ECERS-R scale. Our calculations predict that lifetime gross earnings would increase by about £10,000 per individual and £15,500 per household, on average, if an EPPSE member had experienced a pre-school above the median on the ECERS-R scale instead of one below the median. This represents an average percentage increase

of 2.9% per individual and of 2.0% per household in gross lifetime earnings compared with if they had attended a pre-school below the median.

5.4 Summary

This chapter has investigated the implications of attending pre-school versus no pre-school and then explored the implications of experiencing high- versus low-quality pre-school provision. The latter analysis focused on dimensions of pre-school quality that were found to have some effect in Chapter 4. These are exclusively based on the ECERS-R measure, for which the largest impacts were found.

We find that children who receive some pre-school experience amongst the EPPSE sample earn, on average, around £27,000 more over their working lives in discounted present-value terms than children who receive little or no pre-school experience, and around £36,000 more if we take into account the earnings of other members of their household. These figures translate into average percentage gains of around 7.9% and 5.1% of gross earnings respectively.

Interestingly, we find that attending a high- or medium-quality pre-school has only a modest effect on the estimated discounted present value of gross lifetime earnings at both the individual level and the household level. The highest percentage gains do seem to be for relatively lower earners, however, which provides some suggestive evidence that offering high-quality pre-school may help to reduce lifetime earnings inequality. Given the uncertainty associated with these calculations, however, these results should only be interpreted as indicative of the possible magnitude of the long-term individual economic benefits of higher pre-school quality.

6. The effect of pre-school attendance and pre-school quality on net lifetime earnings and savings to the exchequer

6.1 Introduction

Previous chapters have considered the implications of attending pre-school and of high- versus low-quality pre-school provision for gross lifetime earnings. However, in order to look at the potential savings to the exchequer and to work out what the individual gains are likely to be in terms of net earnings (take-home pay), we need to work out the taxes the EPPSE sample, as adults, are likely to pay and the benefits they are likely to receive over their lifetimes. This is a difficult exercise to carry out, as explained in Chapter 2, and requires a number of strong assumptions.

The first assumption is that the latest tax and benefit system will operate as it is for the next 40 years, which is highly unlikely to be the case. Estimates should therefore be interpreted as the likely implications for the exchequer given the tax system that operates today, assuming nothing else changes.

Second, although the level of gross earnings an individual receives is probably the most important element in working out his/her net earnings, the latter also depends on a variety of other characteristics, which we obviously do not yet observe for EPPSE cohort members. These include aspects of family structure, labour supply (number of hours worked), partner's earnings, whether individuals rent or own their own home and which council tax band it is in. In order to calculate the differences in net earnings and benefits to the exchequer as a result of investing in high-quality pre-school provision, we therefore need to predict these variables and this will necessarily involve a high degree of error.

Whilst we use the best available methodology and data, the process is far from perfect. Labour supply, family formation and housing decisions have changed dramatically over the last 40 years and it is highly likely that they will continue to do so into the future. These decisions also depend on an individual's characteristics and previous choices in a way that is far too complicated to model here. We therefore rely on proxying the overall distributions of characteristics in a nationally-representative population and hope that this generates average net earnings profiles that are broadly consistent with the average gross earnings profiles that we have simulated.

To ensure that this simulation of additional characteristics is not solely responsible for the results that we present, we have adopted two approaches. The first is to assume that the EPPSE cohort members remain single and have no children, and calculate net income on this basis (earnings gain at the individual level). The second approach involves modelling their family formation decisions

and the likely earnings and hours of their partner and calculating net income on that basis (earnings gain at the household level).

For all of these reasons, the estimates of exchequer savings presented in this chapter, which only consider savings resulting from increased earnings, should be treated with extreme caution and viewed simply as a broad indicator of the potential longer-term benefits from one source – i.e. increased adult taxed labour income – of investing in high-quality pre-school provision.

6.2 Attending pre-school

We begin by briefly looking at the impact of attending some pre-school versus not doing so. Table 6.1 shows how the differences in gross lifetime earnings reported in Section 5.2 translate into benefits to the exchequer of around £11,000 per treated individual if we only account for individual earnings, and around £16,000 per treated individual if we account for both their own earnings and those of their partner. Note that these are likely to be upper bounds on the potential financial benefits to the exchequer arising from increased earnings as a result of pre-school experience, given that the estimated treatment effects are, if anything, likely to overestimate the causal effect of pre-school experience on Key Stage 4 test results. It is also worth re-emphasising the considerable degree of uncertainty inherent in these estimates, highlighting that these figures should be taken as indicative, rather than precise estimates of the returns.

6.3 Pre-school quality

As was the case in Chapter 5, we present results for:

- the effect of attending a pre-school that scores in the top 20% on the ECERS-R scale rather than a pre-school that scores in the bottom 20% on the ECERS-R scale (Table 6.2);
- the effect of attending a pre-school that scores in the middle 60% on the ECERS-R scale rather than a pre-school that scores in the bottom 20% on the ECERS-R scale (Table 6.3);
- the effect of attending a pre-school that scores above the median on the ECERS-R scale rather than a pre-school that scores below the median on the ECERS-R scale (Table 6.4).

Table 6.2 shows that the difference in gross lifetime earnings of about £12,500 between attending a pre-school scoring in the bottom 20% of the ECERS-R scale and attending a pre-school scoring in the top 20% of the ECERS-R scale translates into a difference in net lifetime earnings of around £7,500 in discounted present-value terms once we strip out the estimated taxes paid and benefits received. This generates a saving to the exchequer of around £5,000 per individual, suggesting that those who attend high-quality pre-schools pay around £5,000 more in tax (or receive £5,000 less in benefits, or some combination of the two)

than those who attend low-quality pre-schools. The equivalent figure at the household level is around £8,000.

Table 6.3 provides evidence of very similar estimates arising from attendance at a pre-school scoring in the middle 60% on the ECERS-R scale (compared with a pre-school scoring in the bottom 20% on the ECERS-R scale), again highlighting that it is more important to move children out of very low-quality pre-school provision than to move those at average-quality institutions into very high-quality pre-schools (at least in the case of observable returns in terms of an individual's own educational attainment and lifetime earnings, and financial benefits to the exchequer; we cannot rule out that there may be other routes through which very high-quality provision proves to be important to either individuals or the government).

Finally, Table 6.4 presents evidence of slightly smaller (but still positive) net earnings returns and benefits to the exchequer from attending an above-median- rather than below-median-quality pre-school.

While it would be tempting to conclude from these results that the government should invest in high-quality pre-school provision for all children, it must be remembered that these estimates are liable to contain a lot of measurement error, such that we cannot be sure that they are significantly different from zero (or even positive). It should also be noted that these estimates represent the gross benefit to the exchequer, which abstracts from any costs associated with increasing pre-school quality. There are currently very few well-developed estimates of how much it would cost the government to increase the quality of low-quality pre-schools. This will depend on the number of such pre-schools and on whether the focus is on all low-quality settings or those with more disadvantaged intakes (for example, pre-schools with a high proportion of children having a mother with relatively low educational qualifications, where the benefits of increasing quality seem to be highest). This is a question for future research.

Table 6.1. Impact of receiving some pre-school education on net lifetime earnings and to the exchequer per individual and per household

	(A) No pre-school experience	(B) Some pre-school experience	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£432,150 (135,151)	£458,938 (136,055)	£26,788 (58,787)
Average of individual gains in percentage points			7.9% (16.1)
Gain in percentage points based on average gains in £			6.2%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£294,207 (84,297)	£309,984 (84,836)	£15,777 (34,851)
Average of individual gains in percentage points			6.6% (13.4)
Gain in percentage points based on average gains in £			5.4%
<i>Savings to the exchequer per individual</i>			
			£11,011
Earnings gains and savings to the exchequer at household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£838,353 (87,566)	£874,346 (71,578)	£35,993 (82,352)
Average of household gains in percentage points			5.1% (10.9)
Gain in percentage points based on average gains in £			4.3%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£518,811 (55,766)	£538,889 (49,231)	£20,079 (46,490)
Average of household gains in percentage points			4.5% (9.8)
Gain in percentage points based on average gains in £			3.9%
<i>Savings to the exchequer per household</i>			
			£15,914

Note: Numbers in parentheses are standard deviations.

Table 6.2. Impact of attending a high-quality pre-school versus a low-quality pre-school on net lifetime earnings and savings to the exchequer per individual and per household

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the top 20% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£449,236 (144,405)	£461,571 (138,582)	£12,335 (48,024)
Average of individual gains in percentage points			4.3% (12.2)
Gain in percentage points based on average gains in £			2.7%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£304,031 (89,668)	£311,563 (86,362)	£7,532 (28,715)
Average of individual gains in percentage points			3.6% (10.5)
Gain in percentage points based on average gains in £			2.5%
<i>Savings to the exchequer per individual</i>			£4,803
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£857,495 (87,373)	£876,315 (81,582)	£18,820 (67,450)
Average of household gains in percentage points			2.6% (8.5)
Gain in percentage points based on average gains in £			2.2%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£529,592 (57,562)	£540,322 (53,955)	£10,730 (38,494)
Average of household gains in percentage points			2.4% (7.7)
Gain in percentage points based on average gains in £			2.0%
<i>Savings to the exchequer per household</i>			£8,090

Note: Numbers in parentheses are standard deviations.

Table 6.3. Impact of attending a medium-quality pre-school versus a low-quality pre-school on net lifetime earnings and savings to the exchequer per individual and per household

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the middle 60% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£451,302 (144,984)	£462,320 (139,475)	£11,018 (53,063)
Average of individual gains in percentage points			4.1% (13.9)
Gain in percentage points based on average gains in £			2.4%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£305,236 (90,023)	£311,929 (86,911)	£6,692 (31,904)
Average of individual gains in percentage points			3.4% (11.9)
Gain in percentage points based on average gains in £			2.2%
<i>Savings to the exchequer per individual</i>			
			£4,326
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£860,309 (86,003)	£876,267 (86,718)	£15,959 (74,757)
Average of household gains in percentage points			2.3% (9.3)
Gain in percentage points based on average gains in £			1.9%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£531,173 (57,170)	£540,047 (56,431)	£8,874 (42,736)
Average of household gains in percentage points			2.1% (8.5)
Gain in percentage points based on average gains in £			1.7%
<i>Savings to the exchequer per household</i>			
			£7,084

Note: Numbers in parentheses are standard deviations.

Table 6.4. Impact of attending a pre-school above the median quality versus a pre-school below the median quality on net lifetime earnings and savings to the exchequer per individual and per household

	(A) Attending a pre-school below the median on the ECERS-R scale	(B) Attending a pre-school above the median on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£460,336 (141,389)	£470,299 (138,377)	£9,963 (27,548)
Average of individual gains in percentage points			2.9% (7.0)
Gain in percentage points based on average gains in £			2.2%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£310,671 (88,046)	£316,660 (86,264)	£5,989 (16,354)
Average of individual gains in percentage points			2.5% (5.9)
Gain in percentage points based on average gains in £			1.9%
<i>Savings to the exchequer per individual</i>			
			£3,974
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£872,905 (83,861)	£888,426 (73,164)	£15,521 (38,655)
Average of household gains in percentage points			2.0% (4.9)
Gain in percentage points based on average gains in £			1.8%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£538,141 (55,698)	£547,020 (50,392)	£8,879 (21,893)
Average of household gains in percentage points			1.9% (4.4)
Gain in percentage points based on average gains in £			1.6%
<i>Savings to the exchequer per household</i>			
			£6,642

Note: Numbers in parentheses are standard deviations.

7. Sensitivity analysis

7.1 Estimating the effect of pre-school provision on Key Stage 4 outcomes using propensity score matching

In order to evaluate the robustness of our estimates of the causal effect of pre-school provision on Key Stage 4 results, we use a different method to estimate the average treatment effects presented in Chapters 3 and 4: specifically, we use kernel-based propensity score matching instead of the fully-interacted linear model in Section 2.1. Matching has the advantage of being non-parametric (i.e. it does not require the imposition of a functional form for the relationship between the treatment (D) and the outcome of interest (Y)), but it relies on the same main assumption that underlies the linear model – namely, that all outcome-relevant differences between pupils attending high- and low-quality pre-schools (or any pre-school provision versus little or none) are captured by their observable attributes. In essence, matching uses children attending low-quality (or no) pre-school provision as a control group for children attending high-quality (or any) pre-school provision – the treatment group. The children in the control group are then ‘re-weighted’ to ‘look’ as similar as possible to individuals in the treatment group in terms of their observable characteristics. Under the matching assumption, the difference between the outcomes of the treated group and those of the matched control group estimates the causal effect of going to a high-quality rather than a low-quality pre-school (or receiving any pre-school experience versus none).

Table 7.1 reports the estimates of average treatment effects for the different pre-school provisions that we evaluated in Chapter 3 (any pre-school versus none) and Chapter 4 (high- versus low-quality provision). Overall, we do not observe much difference between the point estimates obtained by propensity score matching and the results presented earlier (in Tables 3.1 and 4.1), thus providing greater confidence that our estimates are not relying on functional form assumptions in order to produce these effects. Concerns remain, however, regarding the potential bias resulting from the fact that families that use pre-school provision and pre-schools of particular quality might differ in baseline characteristics that we cannot account for with our data.

Table 7.1. Average effect of different types of pre-school experiences on selected KS4 outcomes based on propensity score matching

Type of pre-school provision evaluated	Key Stage 4 outcomes	
	<i>Probability of achieving 5 or more GCSEs and equivalents at grades A*–C</i>	<i>Number of GCSEs and equivalents achieved at grades A*–C</i>
Some pre-school education (vs none)	0.115* (0.060)	1.490** (0.703)
ECERS-E High vs Low	0.014 (0.039)	0.091 (0.404)
Medium vs Low	–0.024 (0.027)	–0.202 (0.283)
High vs Medium/Low	0.042** (0.021)	0.455* (0.268)
Above 50% vs Below 50%	–0.007 (0.023)	0.195 (0.162)
ECERS-R High vs Low	0.071*** (0.035)	1.032*** (0.440)
Medium vs Low	0.027 (0.035)	0.551* (0.297)
High vs Medium/Low	0.028 (0.020)	0.450* (0.249)
Above 50% vs Below 50%	0.046*** (0.019)	0.733*** (0.208)

Note: This table shows estimates based on propensity score matching, where the propensity score is calculated from a probit regression including baseline cognitive ability at age 3, baseline behavioural and development problems at age 3 (except for pre-school experience), parental characteristics (educational qualifications, employment and marital status), early years' home learning environment, low birthweight, deprivation index, family structure (number of younger and older siblings), demographic characteristics (gender and ethnicity) and duration of pre-school experience. High quality refers to the top 20%, medium quality refers to the middle 60% and low quality refers to the bottom 20%. * denotes significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors computed by bootstrap (50 replications) are given in parentheses.

7.2 Analysis of sensitivity to the real earnings growth rate

The main results presented in Chapters 5 and 6 relied on particular assumptions regarding the real earnings growth rate and discount rates. In particular, we assumed a discount rate of 3.5% for the first 30 years and 3.0% thereafter, and a real earnings growth rate of 1.2% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.6% in 2016–17 and 2.0% thereafter (Emmerson, Johnson and Miller, 2014).

In order to assess the sensitivity of the results to these assumptions, we compute the change in present value of lifetime net and gross earnings under other assumptions about the real earnings growth and discount rates:

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- a pessimistic scenario in terms of real earnings growth, with rates of -0.4% in 2013-14, 1.5% in 2014-15, 0.9% in 2015-16, 0.7% in 2016-17 and 1.5% thereafter;
- an optimistic scenario in terms of real earnings growth, with rates of 1.6% in 2013-14, 1.8% in 2014-15, 0.8% in 2015-16, 0.5% in 2016-17 and 2.5% thereafter;
- a lower discount rate of 3.0% for the first 30 years and 2.5% thereafter;
- a higher discount rate of 4.0% for the first 30 years and 3.5% thereafter.

Table 7.2 presents estimates of the returns to receiving any pre-school experience rather than none in terms of gross and net earnings and benefits to the exchequer under these various assumptions about expected future real earnings growth and the discount rates used. Similar figures for the effects of attending a pre-school that scores in the top 20% on the ECERS-R scale compared with attending a pre-school that scores in the bottom 20% on the ECERS-R scale are shown in Table 7.3, and those for attending a pre-school in the middle 60% versus the bottom 20% on the ECERS-R scale and for attending a pre-school of above rather than below median quality can be found in Tables 7.4 and 7.5.

Table 7.3 shows that these potential differences in the real earnings growth rate and/or using different discount rates make relatively little difference to our estimates of the impact of pre-school quality on gross or net lifetime earnings, or benefits to the exchequer. For example, the difference in terms of potential exchequer savings per treated individual varies by around £1,000 in either direction on the basis of individual earnings (and around £1,500 either way when we take into account the earnings of other members of the household). Given the overall levels of uncertainty over these figures, differences in real earnings growth rates of half a percentage point, on average, over a lifetime do not appear to be one of the worst sources of bias that we are facing. Of course, the absolute figures are larger when it comes to estimates of the effect of any pre-school versus none (shown in Table 7.2), but as a proportion of the overall figures they are still reasonably small.

7.3 Summary

This chapter has suggested that changing either the method of analysis or the real earnings growth rate or discount rate chosen would not substantially alter the picture presented by our earlier findings. As highlighted throughout the rest of the report, however, of greater concern is the substantial uncertainty inherent in any attempt to forecast future earnings, and – particularly in the case of the estimated effects of receiving any pre-school experience versus none – the potential bias arising from the selection of children into pre-school on the basis of characteristics that we do not observe and hence cannot account for in our data.

Table 7.2. Sensitivity to real earnings growth and the discount rate of the benefits of receiving some pre-school education versus none, in terms of gross and net earnings and the savings to the exchequer

Scenario:	Baseline	High growth	Low growth	Low discount rate	High discount rate
Discounted present value of gross lifetime earnings at individual level					
Average of individual gains in £	£26,788 (58,787)	£30,120 (66,132)	£23,860 (52,337)	£32,377 (71,087)	£22,230 (48,760)
Average of individual gains in percentage points	7.9% (16.1)	8.0% (16.2)	7.8% (15.9)	8.0% (16.2)	7.8% (15.9)
Gain in percentage points based on average gains in £	6.2%	6.3%	6.1%	6.3%	6.1%
Discounted present value of net lifetime earnings at individual level					
Average of individual gains in £	£15,777 (34,851)	£17,622 (38,487)	£14,321 (31,227)	£19,054 (42,116)	£13,100 (28,923)
Average of individual gains in percentage points	6.6% (13.4)	6.7% (13.7)	6.6% (13.3)	6.6% (13.5)	6.5% (13.2)
Gain in percentage points based on average gains in £	5.4%	5.5%	5.3%	5.4%	5.3%
Savings to the exchequer per individual	£11,011	£12,498	£9,539	£13,322	£9,130
Discounted present value of gross lifetime earnings at household level					
Average of household gains in £	£35,993 (82,352)	£40,433 (92,489)	£32,084 (73,437)	£43,462 (99,419)	£29,891 (68,417)
Average of household gains in percentage points	5.1% (10.9)	5.1% (11.0)	5.0% (10.8)	5.1% (11.0)	5.0% (10.8)
Gain in percentage points based on average gains in £	4.3%	4.3%	4.3%	4.3%	4.3%
Discounted present value of net lifetime earnings at household level					
Average of household gains in £	£20,079 (46,490)	£22,385 (51,520)	£18,129 (41,773)	£24,276 (56,201)	£16,651 (38,566)
Average of household gains in percentage points	4.5% (9.8)	4.6% (10.0)	4.4% (9.6)	4.5% (9.9)	4.4% (9.6)
Gain in percentage points based on average gains in £	3.9%	3.9%	3.8%	3.9%	3.8%
Savings to the exchequer per household	£15,914	£18,047	£13,956	£19,187	£13,240

Note: The baseline scenario has a 3.5% discount rate for years 0–30, a 3.0% discount rate for years 31–56 and a growth rate of 1.2% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.6% in 2016–17 and 2.0% thereafter. The low growth rate scenario has the baseline discount rate and a growth rate of –0.4% in 2013–14, 1.5% in 2014–15, 0.9% in 2015–16, 0.7% in 2016–17 and 1.5% thereafter. The high growth rate scenario has the baseline discount rate and a growth rate of 1.6% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.5% in 2016–17 and 2.5% thereafter. The low discount rate scenario has a 3.0% discount rate for years 0–30, a 2.5% discount rate for years 31–56 and the baseline growth rate pattern. The high discount rate scenario has a 4.0% discount rate for years 0–30, a 3.5% discount rate for years 31–56 and the baseline growth rate pattern.

Table 7.3. Sensitivity to real earnings growth and the discount rate of the benefits of attending a high-quality pre-school instead of a low-quality pre-school, in terms of gross and net earnings and the savings to the exchequer

Scenario:	Baseline	High growth	Low growth	Low discount rate	High discount rate
Discounted present value of gross lifetime earnings at individual level					
Average of individual gains in £	£12,335 (48,024)	£13,791 (53,998)	£11,052 (42,777)	£14,825 (58,044)	£10,296 (39,853)
Average of individual gains in percentage points	4.3% (12.2)	4.3% (12.3)	4.2% (12.1)	4.3% (12.3)	4.2% (12.1)
Gain in percentage points based on average gains in £	2.7%	2.8%	2.7%	2.8%	2.7%
Discounted present value of net lifetime earnings at individual level					
Average of individual gains in £	£7,532 (28,715)	£8,267 (31,473)	£6,755 (25,557)	£9,049 (34,674)	£6,289 (23,850)
Average of individual gains in percentage points	3.6% (10.5)	3.7% (10.6)	3.6% (10.3)	3.6% (10.6)	3.6% (10.4)
Gain in percentage points based on average gains in £	2.5%	2.5%	2.4%	2.5%	2.5%
Savings to the exchequer per individual	£4,803	£5,525	£4,297	£5,776	£4,007
Discounted present value of gross lifetime earnings at household level					
Average of household gains in £	£18,820 (67,450)	£21,032 (75,733)	£16,866 (60,163)	£22,608 (81,408)	£15,713 (56,050)
Average of household gains in percentage points	2.6% (8.5)	2.6% (8.5)	2.6% (8.4)	2.6% (8.5)	2.6% (8.4)
Gain in percentage points based on average gains in £	2.2%	2.2%	2.2%	2.2%	2.2%
Discounted present value of net lifetime earnings at household level					
Average of household gains in £	£10,730 (38,494)	£11,817 (42,319)	£9,672 (34,323)	£12,899 (46,521)	£8,951 (31,941)
Average of household gains in percentage points	2.4% (7.7)	2.4% (7.8)	2.4% (7.6)	2.4% (7.8)	2.4% (7.6)
Gain in percentage points based on average gains in £	2.0%	2.0%	2.0%	2.0%	2.0%
Savings to the exchequer per household	£8,090	£9,215	£7,194	£9,709	£6,762

Note: The baseline scenario has a 3.5% discount rate for years 0–30, a 3.0% discount rate for years 31–56 and a growth rate of 1.2% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.6% in 2016–17 and 2.0% thereafter. The low growth rate scenario has the baseline discount rate and a growth rate of –0.4% in 2013–14, 1.5% in 2014–15, 0.9% in 2015–16, 0.7% in 2016–17 and 1.5% thereafter. The high growth rate scenario has the baseline discount rate and a growth rate of 1.6% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.5% in 2016–17 and 2.5% thereafter. The low discount rate scenario has a 3.0% discount rate for years 0–30, a 2.5% discount rate for years 31–56 and the baseline growth rate pattern. The high discount rate scenario has a 4.0% discount rate for years 0–30, a 3.5% discount rate for years 31–56 and the baseline growth rate pattern. High-quality pre-schools are the top 20% and low-quality ones are the bottom 20% on the ECERS-R scale.

Table 7.4. Sensitivity to real earnings growth and the discount rate of the benefits of attending a medium-quality pre-school instead of a low-quality pre-school, in terms of gross and net earnings and the savings to the exchequer

Scenario:	Baseline	High growth	Low growth	Low discount rate	High discount rate
Discounted present value of gross lifetime earnings at individual level					
Average of individual gains in £	£11,018 (53,063)	£12,326 (59,649)	£9,866 (47,277)	£13,249 (64,119)	£9,191 (44,046)
Average of individual gains in percentage points	4.1% (13.9)	4.2% (14.0)	4.1% (13.8)	4.2% (14.0)	4.1% (13.8)
Gain in percentage points based on average gains in £	2.4%	2.5%	2.4%	2.5%	2.4%
Discounted present value of net lifetime earnings at individual level					
Average of individual gains in £	£6,692 (31,904)	£7,387 (34,821)	£6,040 (28,281)	£8,045 (38,529)	£5,584 (26,494)
Average of individual gains in percentage points	3.4% (11.9)	3.5% (12.0)	3.4% (11.7)	3.5% (12.1)	3.4% (11.8)
Gain in percentage points based on average gains in £	2.2%	2.2%	2.2%	2.2%	2.2%
Savings to the exchequer per individual	£4,326	£4,939	£3,825	£5,204	£3,607
Discounted present value of gross lifetime earnings at household level					
Average of household gains in £	£15,959 (74,757)	£17,840 (83,905)	£14,296 (66,708)	£19,177 (90,192)	£13,318 (62,147)
Average of household gains in percentage points	2.3% (9.3)	2.3% (9.3)	2.3% (9.2)	2.3% (9.3)	2.3% (9.2)
Gain in percentage points based on average gains in £	1.9%	1.9%	1.8%	1.9%	1.8%
Discounted present value of net lifetime earnings at household level					
Average of household gains in £	£8,874 (42,736)	£9,885 (46,780)	£8,088 (37,969)	£10,668 (51,632)	£7,402 (35,473)
Average of household gains in percentage points	2.1% (8.5)	2.1% (8.5)	2.1% (8.3)	2.1% (8.6)	2.0% (8.4)
Gain in percentage points based on average gains in £	1.7%	1.7%	1.7%	1.7%	1.7%
Savings to the exchequer per household	£7,084	£7,955	£6,208	£8,508	£5,916

Note: The baseline scenario has a 3.5% discount rate for years 0–30, a 3.0% discount rate for years 31–56 and a growth rate of 1.2% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.6% in 2016–17 and 2.0% thereafter. The low growth rate scenario has the baseline discount rate and a growth rate of –0.4% in 2013–14, 1.5% in 2014–15, 0.9% in 2015–16, 0.7% in 2016–17 and 1.5% thereafter. The high growth rate scenario has the baseline discount rate and a growth rate of 1.6% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.5% in 2016–17 and 2.5% thereafter. The low discount rate scenario has a 3.0% discount rate for years 0–30, a 2.5% discount rate for years 31–56 and the baseline growth rate pattern. The high discount rate scenario has a 4.0% discount rate for years 0–30, a 3.5% discount rate for years 31–56 and the baseline growth rate pattern. Medium-quality pre-schools are in the middle 60% and low-quality ones the bottom 20% on the ECERS-R scale.

Table 7.5. Sensitivity to real earnings growth and the discount rate of the benefits of attending a pre-school of above the median quality instead of a pre-school of below the median quality, in terms of gross and net earnings and the savings to the exchequer

Scenario:	Baseline	High growth	Low growth	Low discount rate	High discount rate
Discounted present value of gross lifetime earnings at individual level					
Average of individual gains in £	£9,963 (27,548)	£11,168 (30,970)	£8,904 (24,541)	£12,005 (33,291)	£8,295 (22,864)
Average of individual gains in percentage points	2.9% (7.0)	2.9% (7.1)	2.8% (7.0)	2.9% (7.1)	2.8% (7.0)
Gain in percentage points based on average gains in £	2.2%	2.2%	2.1%	2.2%	2.1%
Discounted present value of net lifetime earnings at individual level					
Average of individual gains in £	£5,989 (16,354)	£6,589 (18,051)	£5,357 (14,660)	£7,212 (19,754)	£4,989 (13,579)
Average of individual gains in percentage points	2.5% (5.9)	2.5% (6.1)	2.4% (5.9)	2.5% (6.0)	2.4% (5.9)
Gain in percentage points based on average gains in £	1.9%	1.9%	1.9%	1.9%	1.9%
Savings to the exchequer per individual	£3,974	£4,579	£3,547	£4,793	£3,306
Discounted present value of gross lifetime earnings at household level					
Average of household gains in £	£15,521 (38,655)	£17,383 (43,393)	£13,881 (34,487)	£18,686 (46,645)	£12,932 (32,129)
Average of household gains in percentage points	2.0% (4.9)	2.0% (4.9)	2.0% (4.9)	2.0% (4.9)	2.0% (4.9)
Gain in percentage points based on average gains in £	1.8%	1.8%	1.8%	1.8%	1.8%
Discounted present value of net lifetime earnings at household level					
Average of household gains in £	£8,879 (21,893)	£9,754 (24,255)	£7,957 (19,678)	£10,695 (26,463)	£7,392 (18,165)
Average of household gains in percentage points	1.9% (4.4)	1.9% (4.5)	1.8% (4.4)	1.9% (4.5)	1.8% (4.4)
Gain in percentage points based on average gains in £	1.6%	1.7%	1.6%	1.7%	1.6%
Savings to the exchequer per household	£6,642	£7,629	£5,924	£7,991	£5,539

Note: The baseline scenario has a 3.5% discount rate for years 0–30, a 3.0% discount rate for years 31–56 and a growth rate of 1.2% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.6% in 2016–17 and 2.0% thereafter. The low growth rate scenario has the baseline discount rate and a growth rate of –0.4% in 2013–14, 1.5% in 2014–15, 0.9% in 2015–16, 0.7% in 2016–17 and 1.5% thereafter. The high growth rate scenario has the baseline discount rate and a growth rate of 1.6% in 2013–14, 1.8% in 2014–15, 0.8% in 2015–16, 0.5% in 2016–17 and 2.5% thereafter. The low discount rate scenario has a 3.0% discount rate for years 0–30, a 2.5% discount rate for years 31–56 and the baseline growth rate pattern. The high discount rate scenario has a 4.0% discount rate for years 0–30, a 3.5% discount rate for years 31–56 and the baseline growth rate pattern. Median quality is assessed on the ECERS-R scale.

8. Conclusions

This report has sought to estimate the potential causal impacts of having some pre-school education (versus none) and of different qualities of pre-school on academic achievement at Key Stage 4 (KS4). It has then used these estimates to predict potential differences in lifetime earnings and resultant gains to the exchequer that might result from these differences in educational attainment.

We began by comparing KS4 outcomes for members of the EPPSE sample who receive some pre-school education with KS4 outcomes for those who do not (the 'home' sample). This is an important question which can no longer be answered using current cohorts, as pre-school attendance is now virtually universal. Unfortunately, the home sample could not be identified until entry to primary school and therefore there was no baseline screening at age 3 for these children (whereas the pre-school sample had baseline assessments at age 3 at entry to the study). Assessments at age 3 would have been desirable for both home and pre-school samples to provide greater control for potential earlier influences. Early measures of ability influence subsequent educational attainment, so it is possible that the present analysis may overestimate the impact of pre-school education (versus none) on KS4 outcomes. This is because it was only possible to control for a set of robust child and family demographics, including the early years' home learning environment (HLE), not for their age-3 prior social and cognitive development, when comparing the home and pre-school samples' later outcomes at GCSE. Therefore, these figures should be interpreted as being likely to reflect the upper bounds of the consequences of receiving any pre-school education. Nonetheless, earlier EPPSE evidence (Sammons et al., 2004 and 2008) found that there were strong effects on both cognitive and socio-behavioural outcomes and developmental progress between ages 3 and 5 for the pre-school sample. Further analysis showed that the home group were well behind pre-school children with similar characteristics (in terms of level of multiple disadvantage) at school entry and that this difference remained evident at all subsequent assessment points in both primary and secondary education (Sylva et al., 2012).

We then moved on to analyse the effect of different measures of pre-school quality on KS4 outcomes. Overall, we found some evidence of a positive impact of pre-school quality on educational attainment at age 16, although these findings are not very consistent across outcomes or the measures of pre-school quality used. In line with previous research, these effects are stronger for children whose mothers have relatively low educational attainment themselves, but we find less evidence of any gender differences.

Focusing on the outcomes and pre-school experience (attendance and quality) for which we obtained positive significant effects, we then addressed the question of how these gains in KS4 outcomes may translate into lifetime (gross) earnings and employment experiences. This required us to *predict* the earnings and employment patterns of the EPPSE sample. As a result, this part of the analysis is more speculative and should be interpreted with more caution. We found that

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our estimates of the effects of pre-school attendance could translate, on average, into an increase of up to 7.9% in the discounted present value of gross (pre-tax) lifetime earnings. Overall, we found that, on average, individuals who attend a high-quality pre-school (in the top 20% on the ECERS-R scale) have a discounted present value of gross lifetime earnings that is 4.3% higher than if those same individuals had attended a low-quality pre-school (in the bottom 20% on the ECERS-R scale). However, there is a lot of uncertainty around all of these estimates.

The last part of our analysis addressed the implications of such findings for the exchequer, in terms of tax receipts and benefit payments. This involved comparing the average gross and net earnings gains (i.e. the gains before and after taking into account taxes paid and benefits received) that arise from attending pre-school or from attending a high-rather than low-quality pre-school. The difference between these gross and net figures in each case represents the gross saving to the exchequer in terms of taxes received and benefits paid (i.e. abstracting from the cost of provision). As has been highlighted throughout this report, this is a complicated exercise that makes a number of assumptions. Attending pre-school may give rise to a gross saving to the exchequer of around £11,000 per individual, or £16,000 per household when the earnings of other household members are taken into account, in discounted present-value terms reported in 2013 prices (discounting from when the child was aged 4). We found that attending a high-quality rather than a low-quality pre-school may give rise to an exchequer saving of between £4,000 and £5,000 per individual, or between £6,500 and £8,000 per household. Importantly, it should be noted that these are *gross* savings, as these figures do not account for the cost of providing more pre-school places or improving the quality of pre-school education over low-quality pre-school education. It should also be noted that given the multiple sources of uncertainty present in our estimates, it is possible that these gross savings may be lower (or even negative), thus highlighting the caution with which these specific figures should be treated.

This report has repeatedly highlighted the uncertainties around predictions of likely lifetime labour market outcomes, family formation decisions and fertility outcomes over the next 40 years for the EPPSE participants. Moreover, the fact that the estimated treatment effects for high- versus low-quality pre-school provision are not robust to different definitions of the outcomes and quality measures means that these figures should probably be regarded as upper bounds on the potential effects.

Appendix A. Data

A.1 Effective Pre-School, Primary and Secondary Education (EPPSE)

EPPSE is the first UK large-scale, longitudinal study of children from pre-school to post-compulsory education. The data set contains rich information on over 3,000 children who were recruited at age 3 and were studied from pre-school years until the final year of compulsory schooling (age 16). The first round of data contains wide information about pre-school settings, as well as background characteristics, children's development profiles (both cognitive/academic and socio-behavioural) and the child's home learning environment. A sample of children who had no or minimal pre-school experience were also recruited to the study at entry to school for comparison with the group of children who had some pre-school experience. Unfortunately, because this sample of children were identified later on, cognitive and socio-behavioural indicators were not collected for this sample at age 3. Later rounds of data included information the cognitive/academic and socio-behavioural development of all the children, as well as their academic progress measured at every Key Stage (age 7, 11, 14 and 16).

The analysis described in this report focuses on the first (age 3) and last (age 16) rounds of data. The only age-16 variables used in the analysis are Key Stage 4 outcomes listed in Appendix C. The following baseline variables were included in the analysis:

- An indicator of whether the child is female, which equals 1 if the raw variable **gender** equals 1.
- An indicator of whether the child is white, which equals 1 if the raw variable **ethnicg** has values between 2 and 8.
- An indicator for low birthweight, which equals 1 if the raw variable **bweigh** equals 3.
- Four cohort indicators, based on the raw variable **cohort**.
- Mother's and father's education qualification levels. For each parent, we create a five-category variable, which equals 0 for no qualification, 1 for vocational qualifications, 2 for academic qualifications up to age 16, 3 for academic qualifications up to age 18 and 4 for university degree. These new variables are based on the raw variables **pimqual1** (for the mother) and **pifqual1** (for the father).
- Indicators for whether the mother/father is employed, which equal 1 if the raw variable **pimempl1** (for the mother) / **pifempl1** (for the father) is between 1 and 3 and equal 0 if it is 4.

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- An indicator for whether the child's parents are married, based on the raw variable **married**.
- An index of socio-economic deprivation based on the Key Stage 4 IDACI index (**ks4_idaci**). We construct indicators for being in one of five quintiles (lowest quintile is the reference category and indicates the highest deprivation).
- Developmental problems indicator at age 3, which equals 1 if the variable **devprb** equals 1 or 2.
- Behavioural problems indicator at age 3, which equals 1 if the raw variable **bvrprb** equals 1 or 2.
- Baseline verbal test scores, based on the raw variable **bbasv**.
- Baseline non-verbal test scores, based on the raw variable **bbasnv**.
- Number of younger siblings and number of older siblings, based on the raw variable **piborder** measuring birth order and the raw variable **pisibs** measuring the number of siblings.
- Pre-school experience (both attendance and quality). We define various binary measures of pre-school attendance and quality, with the quality measures being based on the raw categorical variables **ec_e3wy** and **ec_r3wy** reflecting quality ratings from the ECERS-E and ECERS-R scales. These binary indicators are defined in the text.

A.2 Longitudinal Study of Young People in England (LSYPE)

LSYPE is a panel study of young people that brings together data from several sources, including administrative sources and annual interviews with young people and their parents. LSYPE respondents were first interviewed in the spring of 2004 (at age 13) and were interviewed annually until 2010, resulting in a total of seven 'waves'. We make use of data from all waves in order to construct background variables as well as highest educational qualification completed (if the individual is no longer studying) or being studied (if the individual is currently studying).

Our main outcome is the highest educational level attained by age 19–20 (Wave 7). We define it as being one of the following four categories: (1) fewer than five GCSEs at grades A*–C; (2) at least five GCSEs at grades A*–C; (3) any A levels at grades A*–C; and (4) a university degree. We assign any individual reporting being in university as her/his main activity in Wave 7 to category 4. If the respondent does not report being in university in Wave 7, we then classify her/him in category 3 (A levels) if s/he has received any A levels at grades A*–C. If s/he has none and is not in university at Wave 7, we classify her/him in category 2 or 1 depending on the number of GCSEs obtained at grades A*–C.

Our explanatory variables are defined as follows:

- A female indicator.
- A non-white indicator.
- Mother's and father's highest qualification, defined according to the same five categories as we used for parental qualifications in the EPPSE data set.
- Number of younger siblings and number of older siblings in the first round of the survey (age 13).
- An indicator for whether the respondent's parents were married/partnered in the first round of the survey (age 13).
- An index of social deprivation constructed by Principal Component Analysis of family log income, mother's and father's highest educational qualifications, mother's, father's and family's National Statistics socio-economic classification (NS-SEC), household tenure, and a variable measuring how well the household is managing on its income. With the exception of family log income, which is averaged over the first three survey years, the other variables are measured in the first survey round. As with the IDACI index in the EPPSE data set, we construct indicators for each quintile of this index and treat the lowest quintile (indicating the highest deprivation) as the reference category.

A.3 British Household Panel Survey (BHPS)

The BHPS is a survey that began in 1991 and follows the same representative sample of individuals over a period of years. It is household-based and therefore interviews every adult member of sampled households on household composition, housing conditions, education and training, health, labour market behaviour, income and socio-economic values.

Sample selection

We define each individual's education level as the highest level attained by age 22. Education level can be one of the following four categories: fewer than five GCSEs at grades A*-C; at least five GCSEs at grades A*-C; A levels; and a university degree. We create four samples, covering all individuals who attained one of these four categories by age 22. For all but university graduates, we include their observations from ages 19 to 60. For university graduates, we include their observations from ages 22 to 60. Our data are from the waves of the BHPS between the years 1993 and 2008.

Definition of earnings

Annual earnings are defined as annual labour income in the reference year, which runs from September in the year prior to the interview until September in the

year in which interviewing begins. All earnings are expressed in 2013 pounds uprated according to the retail price index (all items). We treat observations with annual earnings below £1,000 as having zero annual earnings.

A.4 Labour Force Survey (LFS)

The LFS is a survey of the employment circumstances of the UK population. It is a repeated cross-section of the population, in which a representative sample aged 16 years and over are asked a wide range of questions covering labour supply, wages, training and occupation, in addition to personal characteristics. The LFS began in 1973 as an annual survey, but from March 1992 quarterly data were made available.

Sample selection

We define each individual's education level as the highest level attained by age 22. We define education levels in a similar fashion to in the BHPS; that is, as one of the following four categories: fewer than five GCSEs at grades A*-C; at least five GCSEs at grades A*-C; A levels; and a university degree. We include all individuals in the sample from ages 19 to 60 if their highest attained level is not a university degree and from ages 22 to 60 if it is. Our data are quarterly, from 1993Q1 to 2012Q4.

Definition of earnings

Annual earnings are defined as gross weekly pay in the main job, multiplied by 52. All earnings are expressed in 2013 pounds uprated according to the retail price index (all items). We treat observations with annual earnings below £1,000 as having zero annual earnings.

Appendix B. Econometric methodology

B.1 Educational attainment model

Given that an individual has achieved at least five GCSEs at grades A*–C, the probability of attaining one of the other three educational categories as the highest level by age 22 (five or more GCSEs at grades A*–C, A levels, a university degree) is modelled using a multinomial model. In this type of model, the explanatory variables do not vary over the alternatives, but their effect on the probability of attaining each educational level is allowed to vary across alternatives. In particular, the model specifies that individual i 's probability of reaching educational level j by age 22 can be written as

$$p_{ij} = \frac{\exp(x_i' \beta_j)}{\sum_{l=1}^3 \exp(x_i' \beta_l)}$$

where x_i is a vector of explanatory variables and β_j is the vector of associated coefficients. Note that the coefficients are indexed by j since they are alternative-specific. This model is based on the behavioural model where an alternative is chosen if the underlying utility derived from choosing this alternative is greater than the underlying utility derived from all other alternatives and the random component of this utility follows an Extreme Value Type I distribution.

B.2 Earnings and employment dynamics model

Earnings model

The model for log earnings (y_{iat}) for individual i at age a in year t is:

$$\begin{aligned} y_{iat} &= \beta X_{iat} + \hat{y}_{iat} \\ \hat{y}_{iat} &= \alpha_i + \gamma_i a + u_{iat} + z_{iat} \\ u_{iat} &= \epsilon_{iat} + \theta \epsilon_{i,a-1,t-1} \\ z_{iat} &= \rho z_{i,a-1,t-1} + \eta_{iat} \\ z_{i0t} &= 0 \\ \epsilon_{i0t} &= 0 \end{aligned}$$

where X_{iat} is a vector of observable characteristics for individual i that includes a quartic polynomial in age, a full set of year dummies, and dummies for region and ethnicity. α_i is an individual-specific fixed effect and γ_i is an individual-specific deterministic linear trend in age. Together, α_i and γ_i allow for cross-sectional heterogeneity in both the level and age-profile of the deterministic component of

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earnings. The idiosyncratic stochastic component comprises two parts: z_{iat} is a first-order autoregressive persistent shock and u_{iat} is a first-order moving-average transitory shock. We allow the variances of both shocks, ϵ_{iat} and η_{iat} , to be quadratic functions of age and we allow the autoregressive parameter, ρ , to be a cubic function of age. The moving-average parameter, θ , is assumed to be fixed across ages.

The model parameters are estimated separately for male and for female graduates using the BHPS sample described in Appendix A. Estimation takes place in three stages:

1. Regress log earnings on the observed characteristics X_{iat} and store the residuals as \hat{y}_{iat} .
2. Calculate the sample auto-covariance function of the residuals \hat{y}_{iat} at each age for up to 10 lags. This generates a set of estimated auto-covariances, $Cov(y_a, y_{a-d})$ for $d = 0, \dots, 10$.
3. Choose the parameters of the earnings model to minimise the distance between the sample auto-covariance function and the theoretical auto-covariance function implied by the model. Each element of the auto-covariance function is weighted by $n_{a,d}^{0.5}$, where $n_{a,d}$ is the number of observations that were used in the construction of the sample auto-covariance at age a and lag d .

In total, 374 moments were used in the estimation for university graduates and 407 moments were used in the estimation for non university graduates.

Models for annual employment

We define an individual to be non-employed in year t if they are observed to have annual earnings less than £1,000 in that year. We estimate three models for employment dynamics: the probability of moving from employment to non-employment, the probability of moving from non-employment to employment, and the annual earnings of re-employed workers.

Exit to non-employment

The probability of a currently employed worker becoming non-employed is assumed to be a probit model with age and log earnings as independent variables. Age enters as a quartic polynomial. Log earnings enter as a quadratic polynomial.

Entry to employment

The probability of a previously non-employed worker becoming employed is assumed to be a probit model with age and duration of non-employment as independent variables. Age enters as a quartic polynomial. Duration enters as dummy variables for up to one year, one to two years and more than two years.

Re-entry earnings

Log earnings of a previously non-employed worker are assumed to be a function of age, duration of non-employment and last log annual earnings before becoming non-employed. Age enters as a quartic polynomial. Duration enters as dummy variables for up to one year and more than one year. Last log annual earnings enter linearly.

Simulating the BHPS model for earnings and employment

The estimated earnings and employment models are simulated alongside each other, using the simulated earnings as inputs to determine both the probability of becoming non-employed and the re-entry earnings upon re-employment. The only thing that remains to be specified is how the stochastic (random) component of earnings upon re-employment is divided between the persistent and transitory components. This is done differently for males and females. For males, it is assumed that the transitory component is equal to the stochastic component of the re-entry earnings equation; the persistent component is equal to the remainder. For females, it is assumed that the persistent component is a weighted average of the persistent component as just described for males, and a random draw from the unconditional distribution of the persistent component (assuming full employment) at the relevant age; the weights used are 0.35 on the former and 0.65 on the latter. These specifications were chosen because they were found to generate employment patterns and re-entry earnings distributions that match the BHPS well at each age.

To generate a simulated series for raw earnings from the simulated series for logs, we first add back the estimated quartic age profile from the first-stage regression. Next we randomly assign each simulated individual to a region-ethnicity group, according to the observed region-ethnicity distribution. We then add back the relevant region-ethnicity constants. Finally, we add back the intercept term that corresponds to the year effect for the most recent year (2008) and exponentiate log earnings to obtain raw earnings.

Adjusting for consistency with the LFS

The final step is to adjust the cross-sectional distributions of non-zero earnings to be consistent with the observed cross-sectional distributions of non-zero earnings in the LFS. To do this, we calculate the following percentiles of the log-earnings distribution in the LFS at each age: 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 99. Each percentile is smoothed across ages using a five-point moving average.

For each simulated log-earnings realisation, we calculate its rank in the simulated distribution at that age. We then re-assign it the corresponding log earnings from the smoothed percentiles in the LFS, using linear interpolation to evaluate ranks that lie between the percentiles listed above. Two things should be noted. First, non-employed simulations (i.e. those with zero earnings) are not affected by this transformation; hence, the fraction of people employed at each age is left

unchanged. Second, since annual earnings in the LFS are calculated as weekly earnings multiplied by 52, it is likely that the LFS overstates earnings in the bottom parts of the distribution, due to the presence of part-year workers.

Goodness-of-fit of the earnings and employment model

It is very important that the model delivers a good fit of the data since we rely heavily on its predictions to compute the effect of pre-school quality on lifetime earnings. Figures B.1 and B.2 compare the data with the predictions of the model on several dimensions of earnings and employment. In the interests of space, we only report such goodness-of-fit exercises for male and female university graduates, but the patterns are similar for the other educational categories.

B.3 Predicting characteristics to estimate net earnings profiles

As explained in Chapter 2, one step of our methodology (Step D) consists of computing, for each lifetime profile of gross earnings simulated in Step C, the corresponding profile of net earnings, along with the amount of tax paid and benefits received. We use the IFS tax and benefit model to calculate the amount of tax paid and benefits received by each individual in the EPPSE sample if s/he attended a low-quality pre-school and if s/he attended a high-quality pre-school. An additional difficulty arises because the tax and benefit system in the UK is intrinsically dependent on a number of characteristics, which we do not observe for individuals in the EPPSE data set. These characteristics include the individual's family structure (marital status, partner's age, number and age of dependent children), region, housing situation (whether renting, the value of the rent, the council tax band), number of hours worked, earnings, and partner's number of hours worked and earnings. We therefore need to predict all these characteristics for each period the individuals in the EPPSE data set will spend in the labour market (up to age 60).

To do so, we first estimate the empirical distribution of these characteristics in the BHPS for each gender–education–age group (using weights so as to approximate a nationally-representative distribution). We then randomly pick values of these characteristics for each period the individuals in the EPPSE data set spend in the labour market from the relevant gender–education–age distribution.

Tables B.1–B.4 show the means of the characteristics we predict in this exercise against their means as estimated in the BHPS. We report these means by gender and educational group (we do not condition on age in the tables for the sake of space).

Figure B.1. Goodness-of-fit of the earnings and employment model for male university graduates

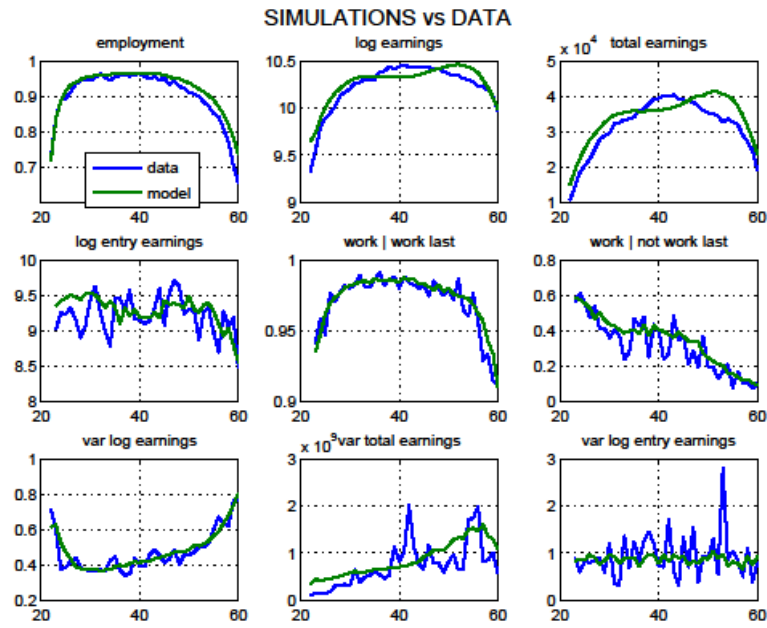


Figure B.2. Goodness-of-fit of the earnings and employment model for female university graduates

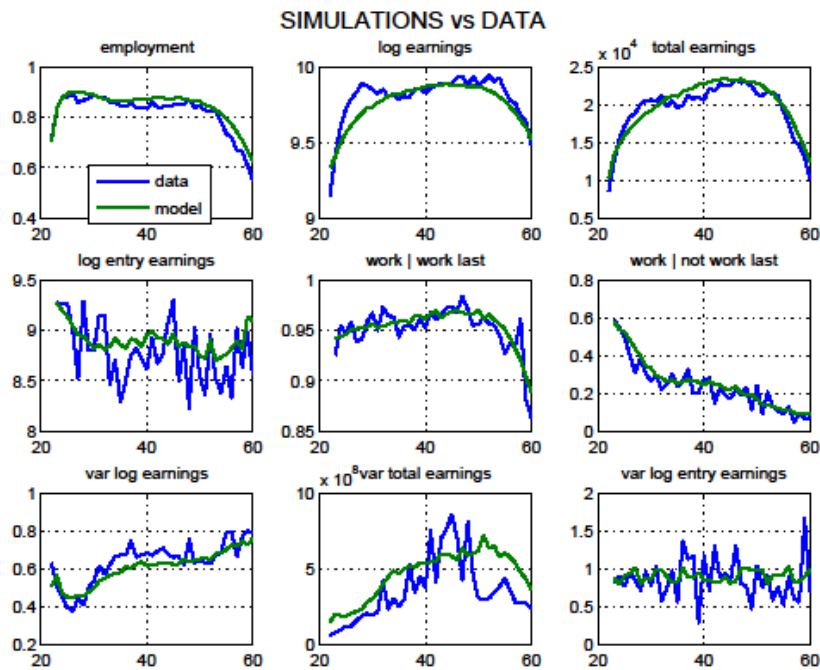


Table B.1. Mean of the characteristics predicted in order to estimate net earnings profiles against their means in the BHPS among males and females with fewer than five GCSEs at grades A*–C

	Males		Females	
	<i>BHPS</i>	<i>Predicted</i>	<i>BHPS</i>	<i>Predicted</i>
In couple	0.63	0.60	0.64	0.60
Married	0.52	0.47	0.57	0.49
Partner's age	41.60	37.50	44.96	41.59
Weekly hours of work	30.05	30.71	13.47	13.39
Partner's weekly hours of work	18.09	18.32	32.33	34.74
Partner's weekly earnings	438.98	431.22	714.11	641.64
Weekly rent	53.71	54.91	55.54	56.02
Number of children	0.69	0.93	0.81	1.02
Region of residence:				
Inner London	2.32	2.42	2.17	2.11
Outer London	4.83	4.12	6.84	6.79
South East	14.88	15.06	17.95	17.06
South West	8.06	8.27	9.15	8.70
East Anglia	4.05	4.03	3.77	3.69
East Midlands	10.47	11.06	9.79	10.40
West Midlands Conurbation	5.75	5.48	4.58	4.96
West Midlands	5.82	5.93	4.55	4.41
Greater Manchester	3.89	4.10	3.62	3.32
Merseyside	2.32	2.30	2.35	2.16
North West	4.99	4.79	3.80	4.09
South Yorkshire	2.47	2.38	3.08	2.89
West Yorkshire	4.38	4.85	4.48	5.54
Yorks and Humberside	3.56	3.57	2.80	3.21
Tyne and Wear	3.17	3.46	2.20	2.06
North	4.38	4.00	3.58	3.58
Wales	5.76	5.72	5.46	5.52
Scotland	6.96	6.60	7.63	7.48
Northern Ireland	1.95	1.85	2.21	2.03
Council tax band:				
Band A	31.93	33.89	28.13	30.97
Band B	23.48	22.99	24.69	25.14
Band C	17.37	17.50	18.88	17.76
Band D	15.37	14.30	17.83	17.62
Band E	6.91	6.57	6.17	5.21
Band F	2.04	2.22	2.28	1.73
Band G	2.41	2.11	1.47	1.11
Band H	0.48	0.43	0.55	0.46

Table B.2. Mean of the characteristics predicted in order to estimate net earnings profiles against their means in the BHPS among males and females with at least five GCSEs at grades A*–C

	Males		Females	
	<i>BHPS</i>	<i>Predicted</i>	<i>BHPS</i>	<i>Predicted</i>
In couple	0.65	0.66	0.66	0.65
Married	0.50	0.52	0.54	0.53
Partner's age	38.19	37.79	41.25	41.54
Weekly hours of work	35.56	35.15	20.48	20.81
Partner's weekly hours of work	21.31	22.82	36.76	37.25
Partner's weekly earnings	456.27	464.80	744.14	654.88
Weekly rent	62.25	64.01	60.47	61.06
Number of children	0.72	0.75	0.92	0.81
Region of residence:				
Inner London	2.33	2.31	2.57	2.79
Outer London	7.02	7.28	6.33	6.26
South East	16.52	16.56	20.02	19.96
South West	11.44	11.28	9.65	10.11
East Anglia	5.75	5.80	5.11	5.20
East Midlands	7.52	7.38	7.79	7.88
West Midlands Conurbation	3.40	3.74	3.15	2.87
West Midlands	5.56	5.38	3.21	3.17
Greater Manchester	4.03	3.74	4.34	4.32
Merseyside	2.89	3.05	2.69	2.73
North West	3.98	3.89	5.40	5.56
South Yorkshire	1.81	1.78	2.97	2.90
West Yorkshire	3.05	2.84	3.61	3.61
Yorks and Humberside	3.07	2.96	3.37	3.37
Tyne and Wear	1.57	1.40	2.71	2.61
North	4.45	4.50	3.34	3.15
Wales	4.59	4.85	4.42	4.40
Scotland	8.99	9.25	7.45	7.35
Northern Ireland	2.02	2.01	1.85	1.77
Council tax band:				
Band A	20.44	19.68	20.48	20.71
Band B	24.80	23.65	19.72	19.58
Band C	20.56	20.71	21.01	20.25
Band D	18.69	18.90	20.30	20.21
Band E	8.69	9.76	9.42	9.77
Band F	5.07	5.22	4.30	4.41
Band G	1.18	1.32	3.87	4.12
Band H	0.58	0.77	0.88	0.94

Table B.3. Mean of the characteristics predicted in order to estimate net earnings profiles against their means in the BHPS among males and females with A levels

	Males		Females	
	<i>BHPS</i>	<i>Predicted</i>	<i>BHPS</i>	<i>Predicted</i>
In couple	0.58	0.64	0.58	0.63
Married	0.46	0.52	0.43	0.49
Partner's age	38.01	37.67	39.08	41.74
Weekly hours of work	32.11	33.30	21.19	22.27
Partner's weekly hours of work	22.09	23.55	38.80	41.10
Partner's weekly earnings	507.96	487.65	803.28	658.68
Weekly rent	71.07	68.92	76.86	77.40
Number of children	0.59	0.73	0.77	0.69
Region of residence:				
Inner London	3.75	3.85	2.46	1.99
Outer London	5.26	5.23	6.35	6.60
South East	22.14	23.10	19.62	20.07
South West	9.01	8.88	7.50	7.42
East Anglia	3.76	3.79	4.26	4.12
East Midlands	8.35	8.34	8.48	7.72
West Midlands Conurbation	1.46	1.27	1.71	1.79
West Midlands	4.09	4.08	6.57	5.87
Greater Manchester	4.49	4.41	1.78	1.63
Merseyside	2.32	1.85	2.22	1.84
North West	4.35	4.59	5.03	5.15
South Yorkshire	2.04	1.83	4.05	4.15
West Yorkshire	4.07	4.08	3.14	3.10
Yorks and Humberside	4.35	4.18	2.87	3.42
Tyne and Wear	2.08	2.24	1.16	0.98
North	3.90	3.80	2.86	2.87
Wales	4.07	4.03	5.77	5.99
Scotland	9.17	9.09	12.39	13.57
Northern Ireland	1.33	1.35	1.78	1.72
Council tax band:				
Band A	15.92	15.48	15.91	14.42
Band B	17.87	18.35	20.92	21.11
Band C	18.12	17.98	17.67	16.96
Band D	23.44	23.24	20.66	20.04
Band E	11.65	11.24	13.24	14.93
Band F	6.96	7.59	4.93	5.32
Band G	4.20	4.33	4.84	5.26
Band H	1.84	1.80	1.84	1.97

Table B.4. Mean of the characteristics predicted in order to estimate net earnings profiles against their means in the BHPS among males and females with a university degree

	Males		Females	
	<i>BHPS</i>	<i>Predicted</i>	<i>BHPS</i>	<i>Predicted</i>
In couple	0.65	0.65	0.63	0.63
Married	0.53	0.53	0.49	0.51
Partner's age	39.38	39.12	41.66	42.65
Weekly hours of work	35.51	35.66	24.83	25.17
Partner's weekly hours of work	22.03	23.94	37.37	38.60
Partner's weekly earnings	512.54	542.07	808.02	767.58
Weekly rent	78.82	80.73	82.63	82.79
Number of children	0.67	0.68	0.77	0.69
Region of residence:				
Inner London	5.52	5.38	5.73	5.79
Outer London	7.17	7.23	6.98	7.27
South East	21.23	21.38	20.05	19.94
South West	7.55	7.48	8.23	8.22
East Anglia	3.76	4.02	3.40	3.24
East Midlands	8.22	8.28	7.24	7.04
West Midlands Conurbation	3.05	3.04	2.91	3.07
West Midlands	4.91	4.78	5.82	5.69
Greater Manchester	4.17	4.00	4.09	4.05
Merseyside	1.81	1.89	1.87	1.89
North West	5.48	5.51	4.34	4.55
South Yorkshire	2.50	2.40	2.34	2.32
West Yorkshire	2.33	2.40	3.43	3.49
Yorks and Humberside	3.02	2.90	3.28	3.32
Tyne and Wear	1.95	1.85	2.13	2.05
North	3.48	3.43	2.92	2.87
Wales	4.58	4.65	4.68	4.73
Scotland	8.02	8.15	9.20	9.07
Northern Ireland	1.25	1.24	1.36	1.39
Council tax band:				
Band A	13.53	13.10	13.23	13.19
Band B	17.20	17.00	16.87	16.65
Band C	18.07	17.40	19.57	19.15
Band D	23.67	23.78	23.29	23.43
Band E	12.52	12.88	12.64	12.72
Band F	6.93	7.16	6.85	6.93
Band G	6.67	7.15	6.26	6.56
Band H	1.41	1.53	1.29	1.36

Appendix C. Estimates of the average effect of pre-school attendance and quality on additional Key Stage 4 outcomes

Tables C.1–C.6 present additional results related to the analysis described in Chapters 3 and 4 on the effects of pre-school attendance and quality on Key Stage 4 outcomes.

Table C.1. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes

Type of pre-school provision evaluated	Probability of achieving 5 or more GCSEs and equivalents at grades A*–C, including English and maths	Probability of achieving 5 or more GCSEs/GNVQs at grades A*–C	Number of GCSEs and equivalents at grades A*–C, including English and maths	Number of GCSEs/GNVQs at grades A*–C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.105 (0.066)	0.144** (0.055)	1.153 (0.826)	1.203** (0.531)	0.328** (0.145)	0.188 (0.153)	0.267** (0.101)
ECERS-E High vs Low	0.035 (0.040)	0.022 (0.063)	0.344 (0.532)	0.494 (0.433)	0.135 (0.100)	0.047 (0.096)	0.017 (0.084)
Medium vs Low	0.012 (0.033)	–0.001 (0.032)	–0.056 (0.397)	0.272 (0.232)	0.094 (0.059)	0.088 (0.063)	0.010 (0.058)
High vs Medium/Low	0.038* (0.021)	0.029 (0.031)	0.440 (0.266)	0.189 (0.252)	0.010 (0.059)	–0.027 (0.046)	0.026 (0.051)
Above 50% vs Below 50%	0.029 (0.018)	0.022 (0.022)	0.340 (0.277)	0.149 (0.154)	0.003 (0.034)	–0.008 (0.044)	0.045 (0.028)
ECERS-R High vs Low	0.064 (0.041)	0.049 (0.056)	1.057** (0.473)	0.482 (0.340)	0.063 (0.068)	–0.118 (0.085)	0.091 (0.080)
Medium vs Low	0.013 (0.036)	0.052 (0.045)	0.428 (0.461)	0.599* (0.314)	0.119* (0.070)	0.003 (0.065)	0.012 (0.062)
High vs Medium/Low	0.028 (0.018)	–0.010 (0.019)	0.455** (0.228)	–0.154 (0.131)	–0.088** (0.026)	–0.113** (0.050)	0.018 (0.034)
Above 50% vs Below 50%	0.047** (0.019)	0.029 (0.022)	0.669** (0.253)	0.194 (0.167)	0.016 (0.037)	–0.021 (0.048)	0.023 (0.033)

Note: See notes to Tables 3.1 and 4.1.

Table C.2. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes: boys

Type of pre-school provision evaluated	Probability of achieving 5 or more GCSEs and equivalents at grades A*–C, including English and maths	Probability of achieving 5 or more GCSEs/GNVQs at grades A*–C	Number of GCSEs and equivalents at grades A*–C, including English and maths	Number of GCSEs/GNVQs at grades A*–C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.106 (0.104)	0.142 (0.102)	1.051 (1.315)	0.969 (0.818)	0.266 (0.203)	0.164 (0.255)	0.281* (0.161)
ECERS-E High vs Low	0.067 (0.046)	0.041 (0.057)	0.690 (0.590)	0.520 (0.375)	0.084 (0.091)	0.045 (0.099)	0.043 (0.081)
Medium vs Low	0.028 (0.033)	–0.006 (0.031)	0.413 (0.396)	0.336 (0.293)	0.064 (0.089)	0.086 (0.066)	0.066 (0.057)
High vs Medium/Low	0.067* (0.035)	0.055 (0.034)	0.656 (0.467)	0.356 (0.283)	0.036 (0.058)	0.008 (0.059)	0.055 (0.059)
Above 50% vs Below 50%	0.017 (0.025)	0.024 (0.024)	0.320 (0.375)	0.234 (0.194)	0.004 (0.048)	–0.008 (0.046)	0.062 (0.045)
ECERS-R High vs Low	0.069* (0.039)	0.032 (0.049)	0.986** (0.484)	0.185 (0.304)	–0.051 (0.083)	–0.199** (0.085)	–0.006 (0.117)
Medium vs Low	–0.016 (0.043)	0.002 (0.039)	0.074 (0.423)	0.206 (0.314)	–0.001 (0.086)	–0.060 (0.078)	–0.068 (0.069)
High vs Medium/Low	0.058* (0.030)	0.020 (0.022)	0.839** (0.380)	–0.013 (0.187)	–0.082* (0.042)	–0.150** (0.046)	0.013 (0.066)
Above 50% vs Below 50%	0.059** (0.025)	0.023 (0.021)	1.010** (0.391)	0.286 (0.205)	0.025 (0.051)	–0.010 (0.051)	0.054 (0.054)

Note: See notes to Tables 3.1 and 4.1, with the exception that gender is not among the demographic controls.

Table C.3. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes: girls

Type of pre-school provision evaluated	Probability of achieving 5 or more GCSEs and equivalents at grades A*–C, including English and maths	Probability of achieving 5 or more GCSEs/GNVQs at grades A*–C	Number of GCSEs and equivalents at grades A*–C, including English and maths	Number of GCSEs/GNVQs at grades A*–C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.104** (0.052)	0.147*** (0.024)	1.250** (0.522)	1.424*** (0.321)	0.385*** (0.096)	0.210** (0.090)	0.253*** (0.067)
ECERS-E High vs Low	0.000 (0.052)	0.002 (0.100)	–0.034 (0.654)	0.465 (0.697)	0.190 (0.168)	0.050 (0.153)	–0.011 (0.122)
Medium vs Low	–0.005 (0.068)	0.005 (0.052)	–0.559 (0.819)	0.203 (0.500)	0.126 (0.108)	0.091 (0.145)	–0.048 (0.102)
High vs Medium/Low	0.007 (0.024)	0.002 (0.050)	0.213 (0.314)	0.014 (0.332)	–0.017 (0.084)	–0.063 (0.059)	–0.003 (0.074)
Above 50% vs Below 50%	0.041* (0.021)	0.020 (0.033)	0.362 (0.263)	0.059 (0.187)	0.002 (0.042)	–0.008 (0.057)	0.026 (0.035)
ECERS-R High vs Low	0.059 (0.059)	0.069 (0.078)	1.140* (0.616)	0.833* (0.471)	0.199* (0.105)	–0.020 (0.118)	0.203* (0.106)
Medium vs Low	0.044 (0.060)	0.106* (0.063)	0.806 (0.735)	1.019** (0.457)	0.247** (0.102)	0.069 (0.117)	0.094 (0.109)
High vs Medium/Low	–0.004 (0.024)	–0.042 (0.029)	0.053 (0.272)	–0.301 (0.185)	–0.094* (0.049)	–0.074 (0.092)	0.023 (0.047)
Above 50% vs Below 50%	0.035 (0.024)	0.035 (0.036)	0.308 (0.273)	0.097 (0.195)	0.007 (0.045)	–0.033 (0.066)	–0.009 (0.037)

Note: See notes to Tables 3.1 and 4.1, with the exception that gender is not among the demographic controls.

Table C.4. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes, not controlling for baseline cognitive, behavioural and development differences between children

Type of pre-school provision evaluated	Achieved 5 or more GCSEs and equivalents at grades A*-C	Achieved 5 or more GCSEs and equivalents at grades A*-C, including English and maths	Achieved 5 or more GCSE/GNVQs at grades A*-C	Number of GCSEs and equivalents at grades A*-C	Number of GCSEs and equivalents at grades A*-C, including English and maths	Number of GCSEs/GNVQs at grades A*-C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.084** (0.038)	0.105 (0.066)	0.144** (0.055)	0.848* (0.499)	1.153 (0.826)	1.203** (0.531)	0.328** (0.145)	0.188 (0.153)	0.267** (0.101)
ECERS-E High vs Low	0.077** (0.032)	0.060* (0.036)	0.060 (0.051)	0.899** (0.366)	0.825* (0.422)	0.679* (0.372)	0.123 (0.093)	0.095 (0.096)	0.143** (0.066)
Medium vs Low	0.010 (0.024)	0.029 (0.035)	0.036 (0.032)	0.177 (0.221)	0.246 (0.355)	0.441* (0.235)	0.105 (0.064)	0.109* (0.064)	0.092* (0.049)
High vs Medium/Low	0.052** (0.021)	0.035* (0.019)	0.025 (0.027)	0.647** (0.235)	0.556** (0.231)	0.245 (0.210)	0.015 (0.053)	0.004 (0.052)	0.063* (0.033)
Above 50% vs Below 50%	0.020 (0.018)	0.042** (0.014)	0.039* (0.022)	0.365* (0.198)	0.574** (0.189)	0.364** (0.166)	0.055 (0.047)	0.046 (0.046)	0.103*** (0.026)
ECERS-R High vs Low	0.076*** (0.019)	0.060 (0.037)	0.058 (0.039)	1.045*** (0.243)	1.023** (0.382)	0.616** (0.248)	0.081 (0.060)	-0.076 (0.085)	0.105 (0.067)
Medium vs Low	0.037 (0.025)	0.042 (0.034)	0.087** (0.033)	0.599** (0.219)	0.696** (0.350)	0.866*** (0.224)	0.184** (0.055)	0.050 (0.054)	0.064 (0.048)
High vs Medium/Low	0.036** (0.017)	0.025 (0.019)	-0.019 (0.017)	0.533** (0.165)	0.452** (0.208)	-0.141 (0.121)	-0.086** (0.031)	-0.099* (0.052)	0.039 (0.035)
Above 50% vs Below 50%	0.058*** (0.014)	0.058** (0.018)	0.037 (0.024)	0.742*** (0.159)	0.836*** (0.232)	0.373** (0.168)	0.060 (0.040)	0.019 (0.043)	0.090** (0.032)

Note: See notes to Tables 3.1 and 4.1, with the exception that gender and baseline measures of cognitive, development and behavioural development are not among the demographic controls.

Table C.5. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes, not controlling for baseline cognitive, behavioural and development differences between children: boys

Type of pre-school provision evaluated	Achieved 5 or more GCSEs and equivalents at grades A*-C	Achieved 5 or more GCSEs and equivalents at grades A*-C including English and maths	Achieved 5 or more GCSE/GNVQs at grades A*-C	Number of GCSEs and equivalents at grades A*-C	Number of GCSEs and equivalents at grades A*-C, including English and maths	Number of GCSEs/GNVQs at grades A*-C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.100 (0.065)	0.106 (0.104)	0.142 (0.102)	0.913 (0.756)	1.051 (1.315)	0.969 (0.818)	0.266 (0.203)	0.164 (0.255)	0.281* (0.161)
ECERS-E High vs Low	0.087** (0.037)	0.114** (0.042)	0.086* (0.045)	1.006** (0.420)	1.364** (0.495)	0.873** (0.360)	0.119 (0.104)	0.108 (0.104)	0.226** (0.086)
Medium vs Low	0.022 (0.031)	0.062* (0.035)	0.051 (0.036)	0.526* (0.306)	0.845** (0.360)	0.634** (0.303)	0.114 (0.094)	0.128* (0.066)	0.196** (0.060)
High vs Medium/Low	0.056** (0.026)	0.063** (0.032)	0.042 (0.029)	0.582* (0.328)	0.726* (0.418)	0.364 (0.253)	0.025 (0.060)	0.024 (0.069)	0.072 (0.056)
Above 50% vs Below 50%	0.014 (0.027)	0.037 (0.024)	0.036* (0.021)	0.448 (0.270)	0.592** (0.250)	0.382** (0.191)	0.041 (0.053)	0.046 (0.050)	0.126** (0.042)
ECERS-R High vs Low	0.063** (0.030)	0.076* (0.039)	0.044 (0.039)	0.899** (0.341)	1.120** (0.403)	0.413 (0.277)	-0.004 (0.098)	-0.135 (0.085)	0.058 (0.112)
Medium vs Low	0.016 (0.032)	0.022 (0.045)	0.042 (0.037)	0.281 (0.238)	0.363 (0.407)	0.481 (0.301)	0.068 (0.089)	0.004 (0.075)	0.012 (0.070)
High vs Medium/Low	0.054** (0.024)	0.063** (0.029)	0.014 (0.020)	0.823** (0.317)	0.967** (0.357)	0.071 (0.198)	-0.058 (0.052)	-0.107** (0.046)	0.054 (0.067)
Above 50% vs Below 50%	0.049** (0.023)	0.073** (0.023)	0.029 (0.020)	0.962*** (0.280)	1.165** (0.379)	0.429** (0.215)	0.067 (0.058)	0.036 (0.060)	0.108* (0.059)

Note: See notes to Tables 3.1 and 4.1, with the exception that gender and baseline measures of cognitive, development and behavioural development are not among the demographic controls.

Table C.6. Average effects of pre-school attendance and of different pre-school quality measures on Key Stage 4 outcomes, not controlling for baseline cognitive, behavioural and development differences between children: girls

Type of pre-school provision evaluated	Achieved 5 or more GCSEs and equivalents at grades A*-C	Achieved 5 or more GCSEs and equivalents at grades A*-C, including English and maths	Achieved 5 or more GCSE/GNVQs at grades A*-C	Number of GCSEs and equivalents at grades A*-C	Number of GCSEs and equivalents at grades A*-C, including English and maths	Number of GCSEs/GNVQs at grades A*-C	Total GCSE/GNVQ new-style point score	Grade achieved in full GCSE maths	Grade achieved in full GCSE English
Some pre-school education (vs none)	0.069 (0.042)	0.104** (0.052)	0.147*** (0.024)	0.787 (0.595)	1.250** (0.522)	1.424*** (0.321)	0.385*** (0.096)	0.210** (0.090)	0.253*** (0.067)
ECERS-E High vs Low	0.066 (0.043)	-0.001 (0.050)	0.031 (0.092)	0.779 (0.501)	0.217 (0.566)	0.459 (0.611)	0.128 (0.143)	0.080 (0.129)	0.052 (0.091)
Medium vs Low	-0.004 (0.030)	-0.005 (0.063)	0.020 (0.052)	-0.199 (0.382)	-0.398 (0.690)	0.234 (0.420)	0.096 (0.092)	0.089 (0.118)	-0.016 (0.088)
High vs Medium/Low	0.047 (0.033)	0.006 (0.026)	0.007 (0.051)	0.716** (0.321)	0.375 (0.294)	0.116 (0.314)	0.005 (0.080)	-0.016 (0.056)	0.054 (0.056)
Above 50% vs Below 50%	0.026 (0.023)	0.048** (0.018)	0.041 (0.036)	0.279 (0.225)	0.555** (0.226)	0.345 (0.233)	0.069 (0.061)	0.045 (0.062)	0.080** (0.034)
ECERS-R High vs Low	0.091** (0.035)	0.041 (0.056)	0.074 (0.066)	1.218** (0.521)	0.908 (0.611)	0.856** (0.384)	0.181** (0.082)	-0.002 (0.123)	0.160* (0.092)
Medium vs Low	0.060** (0.028)	0.064 (0.059)	0.137** (0.054)	0.949** (0.345)	1.062* (0.610)	1.288*** (0.325)	0.311*** (0.079)	0.099 (0.101)	0.119 (0.096)
High vs Medium/Low	0.017 (0.028)	-0.016 (0.028)	-0.055* (0.029)	0.225 (0.324)	-0.094 (0.316)	-0.367** (0.176)	-0.115** (0.048)	-0.091 (0.096)	0.025 (0.044)
Above 50% vs Below 50%	0.068*** (0.020)	0.043** (0.021)	0.046 (0.035)	0.513** (0.215)	0.494** (0.229)	0.315 (0.195)	0.054 (0.049)	0.002 (0.059)	0.072** (0.034)

Note: See notes to Tables 3.1 and 4.1, with the exception that gender and baseline measures of cognitive, development and behavioural development are not among the demographic controls.

Appendix D. Estimates of the effect of pre-school attendance and quality on gross and net lifetime earnings and exchequer savings, by gender

Table D.1. Effect of receiving some pre-school education on lifetime earnings and exchequer savings: men

	(A) No pre- school experience	(B) Some pre- school experience	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£548,692 (74,807)	£581,285 (63,476)	£32,593 (69,705)
Average of individual gains in percentage points			7.2% (14.5)
Gain in percentage points based on average gains in £			5.9%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£365,970 (43,301)	£384,860 (36,493)	£18,889 (40,544)
Average of individual gains in percentage points			6.1% (12.4)
Gain in percentage points based on average gains in £			5.2%
<i>Exchequer savings per individual</i>			£13,703
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£846,403 (95,369)	£888,319 (78,735)	£41,917 (90,915)
Average of household gains in percentage points			5.9% (12.0)
Gain in percentage points based on average gains in £			5.0%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£538,474 (53,260)	£561,839 (43,399)	£23,365 (51,022)
Average of household gains in percentage points			5.0% (10.4)
Gain in percentage points based on average gains in £			4.3%
<i>Exchequer savings per household</i>			£18,551

Note: Numbers in parentheses are standard deviations.

Table D.2. Effect of receiving some pre-school on lifetime earnings and exchequer savings: women

	(A) No pre- school experience	(B) Some pre- school experience	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£311,499 (52,456)	£332,278 (44,133)	£20,779 (44,010)
Average of individual gains in percentage points			8.6% (17.5)
Gain in percentage points based on average gains in £			6.7%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£219,721 (40,461)	£232,267 (37,688)	£12,547 (27,389)
Average of individual gains in percentage points			7.0% (14.3)
Gain in percentage points based on average gains in £			5.7%
<i>Exchequer savings per individual</i>			£8,233
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£830,019 (77,866)	£859,879 (60,038)	£29,860 (71,977)
Average of household gains in percentage points			4.2% (9.7)
Gain in percentage points based on average gains in £			3.6%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£498,401 (50,780)	£515,069 (43,266)	£16,667 (41,019)
Average of household gains in percentage points			3.9% (9.1)
Gain in percentage points based on average gains in £			3.3%
<i>Exchequer savings per household</i>			£13,193

Note: Numbers in parentheses are standard deviations.

Table D.3. Effect of attending a high-quality pre-school versus a low-quality pre-school on lifetime earnings and exchequer savings: men

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the top 20% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£574,300 (72,668)	£581,261 (72,546)	£6,961 (57,511)
Average of individual gains in % points			1.8% (11.0)
Gain in % points based on average gains in £			1.2%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£380,795 (41,896)	£384,902 (41,805)	£4,107 (33,490)
Average of individual gains in % points			1.5% (9.5)
Gain in % points based on average gains in £			1.1%
<i>Exchequer savings per individual</i>			£2,854
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£879,379 (90,962)	£888,784 (91,002)	£9,405 (75,428)
Average of household gains in % points			1.5% (9.3)
Gain in % points based on average gains in £			1.1%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£556,834 (50,322)	£562,250 (50,380)	£5,416 (42,529)
Average of household gains in % points			1.3% (8.2)
Gain in % points based on average gains in £			1.0%
<i>Exchequer savings per household</i>			£3,989

Note: Numbers in parentheses are standard deviations.

Table D.4. Effect of attending a high-quality pre-school versus a low-quality pre-school on lifetime earnings and exchequer savings: women

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the top 20% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£315,331 (53,195)	£333,420 (48,520)	£18,089 (34,256)
Average of individual gains in % points			6.9% (12.9)
Gain in % points based on average gains in £			5.7%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£221,598 (40,742)	£232,808 (40,082)	£11,210 (21,923)
Average of individual gains in % points			5.8% (11.1)
Gain in % points based on average gains in £			5.1%
<i>Exchequer savings per individual</i>			£6,879
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£834,064 (76,789)	£862,963 (67,670)	£28,899 (56,025)
Average of household gains in % points			3.8% (7.4)
Gain in % points based on average gains in £			3.5%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£500,339 (50,020)	£516,774 (47,368)	£16,436 (32,708)
Average of household gains in % points			3.6% (7.0)
Gain in % points based on average gains in £			3.3%
<i>Exchequer savings per household</i>			£12,463

Note: Numbers in parentheses are standard deviations.

Table D.5. Effect of attending a medium-quality pre-school versus a low-quality pre-school on lifetime earnings and exchequer savings: men

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the middle 60% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£577,755 (69,984)	£581,342 (76,716)	£3,587 (61,301)
Average of individual gains in % points			1.1% (11.3)
Gain in % points based on average gains in £			0.6%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£382,818 (40,303)	£384,862 (44,247)	£2,044 (35,630)
Average of individual gains in % points			0.9% (9.8)
Gain in % points based on average gains in £			0.5%
<i>Exchequer savings per individual</i>			£1,542
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£884,005 (87,371)	£888,150 (96,650)	£4,145 (80,006)
Average of household gains in % points			0.8% (9.5)
Gain in % points based on average gains in £			0.5%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£559,465 (48,240)	£561,711 (53,644)	£2,246 (44,951)
Average of household gains in % points			0.7% (8.4)
Gain in % points based on average gains in £			0.4%
<i>Exchequer savings per household</i>			£1,899

Note: Numbers in parentheses are standard deviations.

Table D.6. Effect of attending a medium-quality pre-school versus a low-quality pre-school on lifetime earnings and exchequer savings: women

	(A) Attending a pre-school in the bottom 20% on the ECERS-R scale	(B) Attending a pre-school in the middle 60% on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£315,909 (53,020)	£334,884 (50,562)	£18,975 (41,089)
Average of individual gains in % points			7.3% (15.6)
Gain in % points based on average gains in £			6.0%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£221,925 (40,632)	£233,609 (41,358)	£11,684 (26,475)
Average of individual gains in % points			6.2% (13.3)
Gain in % points based on average gains in £			5.3%
<i>Exchequer savings per individual</i>			£7,291
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£834,937 (76,856)	£863,544 (72,577)	£28,607 (66,463)
Average of household gains in % points			3.9% (8.7)
Gain in % points based on average gains in £			3.4%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£500,790 (49,988)	£516,782 (49,717)	£15,992 (39,018)
Average of household gains in % points			3.6% (8.3)
Gain in % points based on average gains in £			3.2%
<i>Exchequer savings per household</i>			£12,615

Note: Numbers in parentheses are standard deviations.

Table D.7. Effect of attending a pre-school above median quality versus a pre-school below median quality on lifetime earnings and exchequer savings: men

	(A) Attending a pre-school below the median on the ECERS-R scale	(B) Attending a pre-school above the median on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£582,841 (71,715)	£592,452 (65,770)	£9,610 (33,109)
Average of individual gains in % points			2.0% (6.4)
Gain in % points based on average gains in £			1.6%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£385,758 (41,307)	£391,359 (37,816)	£5,601 (19,293)
Average of individual gains in % points			1.7% (5.5)
Gain in % points based on average gains in £			1.5%
<i>Exchequer savings per individual</i>			£4,010
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£890,334 (89,629)	£902,988 (81,598)	£12,654 (43,386)
Average of household gains in % points			1.7% (5.4)
Gain in % points based on average gains in £			1.4%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£562,985 (49,589)	£570,131 (45,035)	£7,146 (24,458)
Average of household gains in % points			1.5% (4.7)
Gain in % points based on average gains in £			1.3%
<i>Exchequer savings per household</i>			£5,508

Note: Numbers in parentheses are standard deviations.

Table D.8. Effect of attending a pre-school above median quality versus a pre-school below median quality on lifetime earnings and exchequer savings: women

	(A) Attending a pre-school below the median on the ECERS-R scale	(B) Attending a pre-school above the median on the ECERS-R scale	(C) Difference between (A) and (B)
Earnings gains and savings to the exchequer at the individual level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of individual gains in £	£329,171 (50,963)	£339,512 (43,794)	£10,341 (19,964)
Average of individual gains in % points			3.8% (7.5)
Gain in % points based on average gains in £			3.1%
<i>Discounted present value of net lifetime earnings</i>			
Average of individual gains in £	£230,038 (41,011)	£236,445 (38,258)	£6,407 (12,451)
Average of individual gains in % points			3.2% (6.3)
Gain in % points based on average gains in £			2.8%
<i>Exchequer savings per individual</i>			£3,935
Earnings gains and savings to the exchequer at the household level			
<i>Discounted present value of gross lifetime earnings</i>			
Average of household gains in £	£854,244 (72,780)	£872,834 (59,097)	£18,590 (32,596)
Average of household gains in % points			2.4% (4.3)
Gain in % points based on average gains in £			2.2%
<i>Discounted present value of net lifetime earnings</i>			
Average of household gains in £	£511,463 (49,205)	£522,202 (43,599)	£10,739 (18,592)
Average of household gains in % points			2.3% (4.0)
Gain in % points based on average gains in £			2.1%
<i>Exchequer savings per household</i>			£7,851

Note: Numbers in parentheses are standard deviations.

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