COMPASS LEXECON

The returns to investing in education

Report for the Confederation of School Trusts

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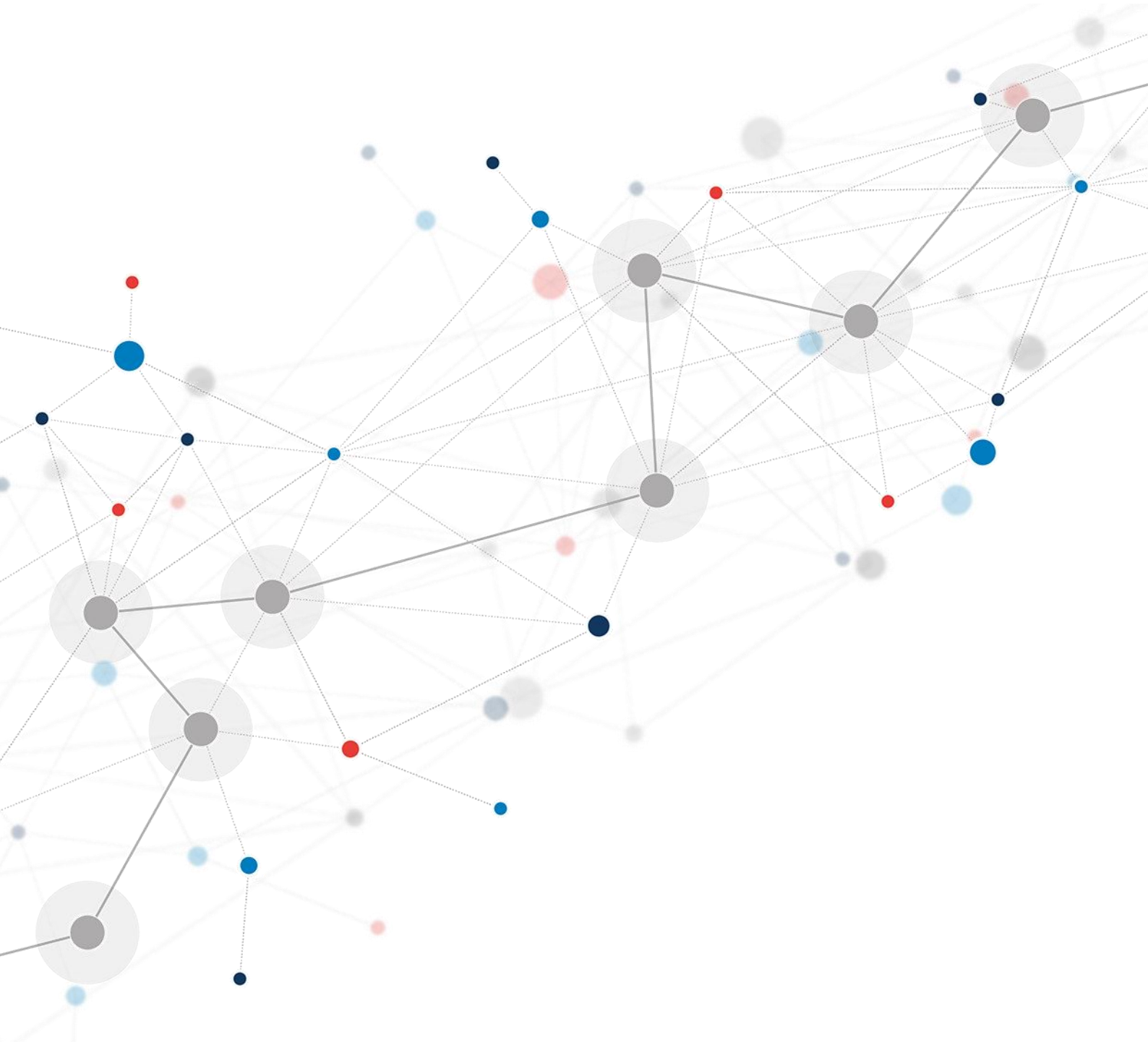
Non-Confidential



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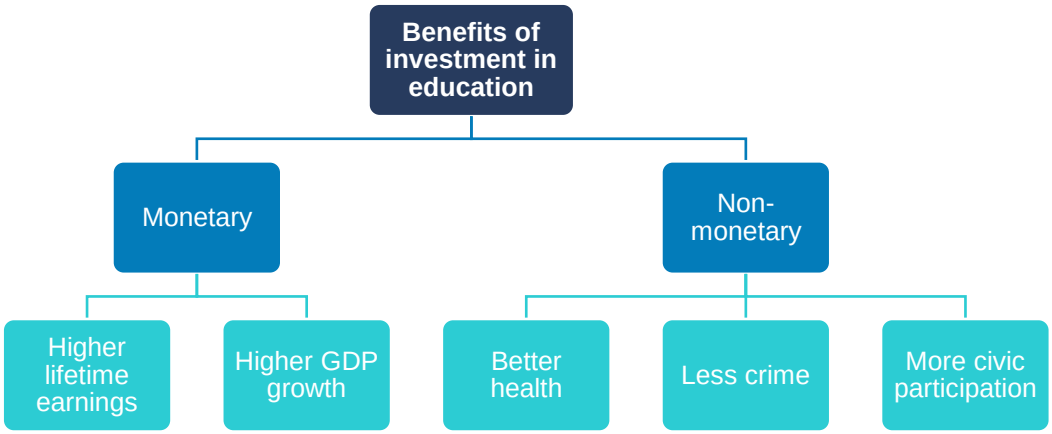
1 EXECUTIVE SUMMARY

1.1 **Education investment is widely acknowledged as a way to boost labour productivity by enhancing the skills of the workforce, thereby influencing both economic growth and social development**.[1] Yet, according to a study by the Institute of Fiscal Studies (hereafter "**IFS**"), school spending per pupil (in real terms) experienced an 8.5% decline in England between 2009/10 and 2019/20.[2]

1.2 This report evaluates the direct and indirect economic consequences of investing in education. The objective is to offer a well-informed assessment of the significance of such investment for the long-term economic outcomes in the United Kingdom.



1.3 Our findings show that**:**

- **A 10% increase in spending on primary and secondary education in the United Kingdom would generate £1,100 billion in net present value over the period 2024-2080. The average yearly benefit is £95 bn and the average yearly cost £17 bn.**
- This result is consistent with previous evidence from peer-reviewed academic papers, which shows that investing in education increases lifetime earnings and GDP growth via greater innovation and a more educated workforce. Further, peer-reviewed studies also highlight the non-monetary effects of investing in education, which encompass improved physical and mental health, reduced crime rates, and enhanced civic engagement.

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[1] See OECD (2024). Education at a Glance 2023. Retrieved from https://www.oecd-ilibrary.org/docserver/e13bef63-en.pdf?expires=1705655663&id=id&accname=guest&checksum=31FFFC51841223F9E065A242AB4A32D1

[2] See Drayton, E., Farquharson, C., Ogden, K., Sibieta, L., Tahir, I., & Waltmann, B. (2022). Annual report on education spending in England: 2022. *The Institute for Fiscal Studies*.

1.4 In addition to the overall level of education spending, the targeting of this investment matters. The returns are the highest for programs focussing on (i) early childhood, and (ii) disadvantaged children.[3]

1.5 Based on our quantitative analysis and our comprehensive evaluation of peer-reviewed research, **it is our view that a decrease in real terms in education funding may have detrimental effects for the long-term growth of the United Kingdom. The effect is likely to disproportionally fall on low-income citizens.**

[3] See Heckman, J. J. (2008). The case for investing in disadvantaged young children. *CESifo DICE Report*, *6*(2), 3-8.

2 INTRODUCTION AND SUMMARY OF CONCLUSIONS

Objectives

2.1 With the aim of assisting policymakers in making evidence-based decisions, Compass Lexecon has been commissioned by the Confederation of School Trusts to prepare a study that:

- quantifies the economic returns of investment in education in terms of increased lifetime earnings in the United Kingdom; and
- reviews the academic literature on the monetary and non-monetary benefits stemming from increased investment in education.

Background and context

2.2 Education is one of the main activities of modern societies. For example, 1/6 of the population of England goes to school each day as students or teachers. If we consider all those that have a connection to schools, including parents, as well as other stakeholders, this proportion increases to roughly 1/3.[4] Almost all people over six years old have a past or present connection to schools.

2.3 Investment in schooling has the potential to affect educational outcomes, and through these, a variety of macroeconomic indicators. This report evaluates the economic and societal effects of increasing the investment in education, knowing that (i) school-specific costs have risen faster than general inflation in the United Kingdom in the last five years, and, over the same period, (ii) school funding has decreased in real terms.

2.4 The report is structured as follows:

- Section 3 of the report uses the result from the peer-reviewed research of Jackson et al. (2016) that pupils who experience 10% higher spending in their school district during the 12 years in which they are expected to be in pre-tertiary education have, on average, 7.74% higher annual labour earnings over their working life. Our report calculates that over the period 2024-2080, a 10% proposed increase in education spending would generate a net present value of £1,100 billion in the United Kingdom.
- Section 4 shows that published research consistently finds a significant positive impact of educational investments on both the economy and society across multiple dimensions.

[4] Approximately 5 million households in England have school-age children. On average, 3.98 individuals (including children) live in each of these households, giving an estimated 20 million individuals living in households where children are engaged in primary and secondary education (Office of National Statistics 2020 data). In addition to the approximately 530,000 teachers in England (https://www.besa.org.uk/key-uk-education-statistics/), and assuming partial overlap between teachers and those living in households with school-aged children, we estimate that one third of the English population has a connection to schools.

- Section 4 proposes several policy recommendations based on our analyses. We conclude that **investing in education is a fiscally responsible policy in the long term**. Increasing the funding of the education system has the potential to improve multiple aspects of the lives of many people in the UK, especially those from disadvantaged backgrounds.

2.5 We summarise the findings of each section next.

The expected return on investment in education in the UK is large

2.6 Our report uses the peer-reviewed research findings of Jackson et al. (2016) to analyse the return on investment of a 10% increase in spending on primary and secondary education in the United Kingdom.[5] Jackson et al. (2016) show that the pupils who experience 10% higher spending in their school district during the 12 years in which they are expected to be in pre-tertiary education have, on average, 7.74% higher annual labour earnings over their working life. Over the 2024-2080 period, this proposed spending increase would generate a net present value of £1,100 billion in the United Kingdom. Per year, this is on average a benefit of £95 bn minus a cost of £17 bn (a 10% increase in education spending would be £11 bn in 2024). The annual benefits start exceeding costs already in 2036 and the investment breaks even in 2043. The investment during the whole appraisal period realises an internal rate of return ("**IRR**") of 13% per year.

2.7 Such large net present value (about half of the current GDP of the UK) demonstrates that, **on a monetary basis alone, investing in education improves public finances in the long run and generates significant value for society**. In conjunction with the many non-pecuniary benefits (health, lower crime rates) of education demonstrated by published research, our financial analysis reaffirms the critical importance of investments in education for the prosperity and well-being of the United Kingdom.

The academic literature consistently finds positive net effects from investment in education

2.8 To provide a comprehensive understanding of the implications of raising investment on education, we have reviewed the relevant academic and policy literature. Research consistently finds a significant positive impact of educational investments on both the economy and society across multiple dimensions. The economic impacts of investing in education are both direct and indirect.

Direct effects

2.9 There is a consensus in the economic literature that more investment in education causes increased lifetime earnings and higher GPD growth. The logic is as follows: more highly educated or better trained people are on average more productive, which increases economic growth and enables them to earn higher income.

Indirect effects

2.10 The benefits of investing in education extend beyond immediate financial considerations to encompass broader societal outcomes, which in turn may result in economic benefits. Education causes improved physical and mental health, reduced crime, lower incarceration rates, and is

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5 Jackson, C. K., Johnson, R. C., & Persico, C. (2016). The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. *Quarterly Journal of Economics*, *131*(1), 157-218.

associated with enhanced civic engagement and greater social capital. All these reduce costs to society and to the government budget and provide economic benefits.

Policy implications in the context of the United Kingdom

2.11 Over the past decade, the landscape of education in the United Kingdom has seen drastic changes. Funding reforms and austerity measures, precipitated by the 2008 financial crisis, triggered a 3.3% reduction in the size of the education budget. **Per-pupil spending on primary and secondary education fell by 9% in real terms from 2010 to 2021**. Simultaneously, schools experienced escalating costs due to inflation and a competitive labour market.

2.12 Although the UK government responded with spending reviews in 2019 and 2021 to restore per-pupil funding to 2010 levels in real terms, recent research by the IFS and the Education Policy Institute has raised concerns. These institutions anticipate that **the revised spending levels may fail to restore per-pupil funding in real terms due to the anticipated rise in costs.** A further reduction in real funding may occur.

2.13 These predictions emphasise the need for more substantial investments in education. **The findings of our report underscore the large public financial and non-financial returns from a greater investment in education in the United Kingdom.** Beyond the immediate benefits of a well-educated populace, our quantification of the economic return to education investment substantiates that **investing in education is a fiscally responsible policy in the long run, and a strategic imperative for securing a prosperous and innovative future.**

2.14 Averting the predicted scenario in which real funding decreases would create important benefits. A sufficient budget for education has the potential to significantly enhance the prospects of the UK. Reduced investments in education have been shown to detrimentally impact the outcomes of pupils in a way that is difficult to reverse. These adverse effects are particularly pronounced among disadvantaged groups.[6]

[6] See Jackson, C. K., Wigger, C., & Xiong, H. (2021). Do school spending cuts matter? Evidence from the Great Recession. *American Economic Journal: Economic Policy*, *13*(2), 304-335 and Shores, K., & Steinberg, M. P. (2019). Schooling during the Great Recession: Patterns of school spending and student achievement using population data. *AERA Open*, *5*(3), 2332858419877431.

3 THE EXPECTED RETURN ON INVESTMENT IN EDUCATION IN THE UK

Background

3.1 In this section, we quantify the value of increased investment in primary and secondary education in the UK. We outline a robust framework for a lower bound estimate, which is based on a granular modelling of cohort-level labour earnings. We show that a relatively modest increase in education investment generates significant value for society. Our results are robust to changes in all our assumptions.

Benefits from investment in education

3.2 While education has many benefits, including non-monetary, we focus on the value of an increased investment in education in terms of higher lifetime labour earnings. The reasons include:

- The interest of the policymakers and the public in pecuniary costs and benefits.
- The availability of data.
- The focus in the academic literature on quantifying monetary costs and benefits (which enables us to follow an established methodology).
- The clarity and transparency of the quantitative metrics.

3.3 When quantifying the effects of increased investment in primary and secondary education, we consider the return to a hypothetical 10% increase in real annual education spending from 2024 to 2080 ("**the appraisal period**"). The final year of the period is chosen based on data availability. A longer appraisal period would increase the net benefit we calculate.

3.4 The analysis is conducted in real terms and all the values are in 2024 pounds, according to Green Book guidance.[7] We quantify the impact of the increased investment in terms of two metrics: (a) the net present value, and (b) the internal rate of return.

a. Using net present value is the standard approach to valuing investments that involve cashflows in the future. To compare cashflows in future years to cashflows in the present, the future returns must be adjusted. For instance, the present value of £100 received 10 years from now must be such that if the present value is invested at the minimally acceptable rate of return, one obtains exactly £100 in 10 years. The minimally acceptable rate of return is called the discount rate.

[7] The Green Book is the official guide for policy appraisal issued by HM Treasury.

b. The internal rate of return is the discount rate which makes the net present value of an investment equal to zero. It is a standard measure used to rank investment opportunities of different size in terms of their profitability.

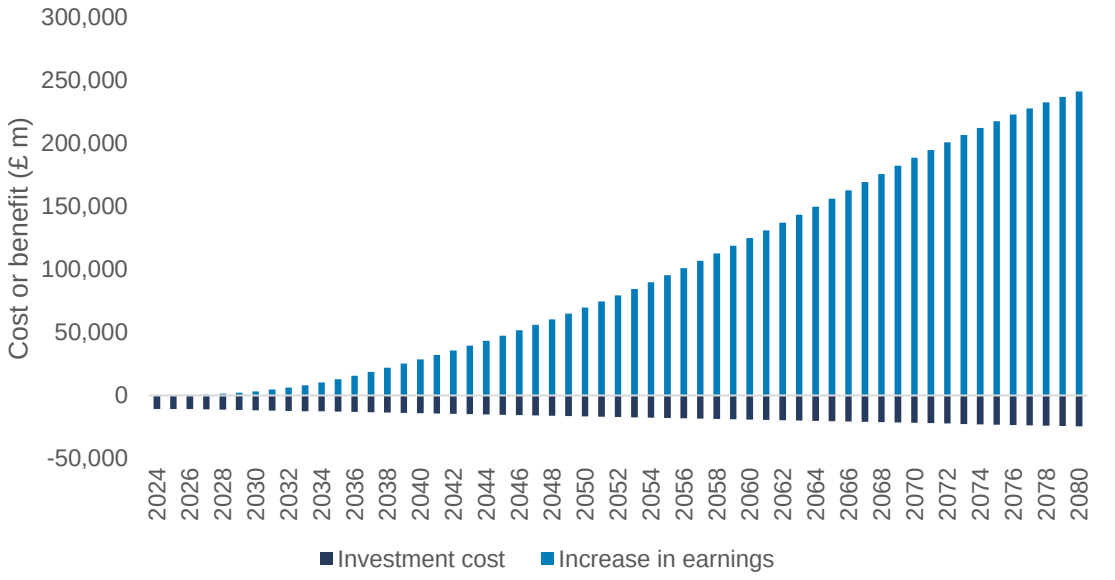
3.5 Our results should be considered a conservative estimate of the benefits of investment in education because, as we explain subsequently, (i) the positive impact of education on society goes beyond the earnings increase that we quantify, and (ii) we are relying on conservative assumptions for the parameters of our model.

Results

3.6 We find that a 10% increase in real annual education spending during the appraisal period results in a net present value of £1,100 bn (discounted benefits of £1,490 bn minus discounted costs £390 bn). Per year, this is on average a benefit of £95 bn minus a cost of £17 bn.[8] For comparison, the GDP of the UK in 2022 was £2,506 bn.[9] The annual benefits start exceeding costs already in 2036 and the investment breaks even in 2043. The investment during the whole appraisal period realises an internal rate of return of 13% per year.

3.7 For each year, the investment cost and the benefit are shown in Figure 1 (without discounting). The calculation is described in more detail below and the formula is in Annex B.

Figure 1: Yearly benefits and costs of increasing the education investment



Source: Compass Lexecon analysis based on the data sources in Table 1.

3.8 These values are lower bound estimates because they disregard non-pecuniary benefits and are based on conservative assumptions, as explained in more detail subsequently. The lower bound on the returns to investment in education is positive, large, and robust to changes in the model specification.

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8 Simple average across years, not weighted by the discount factor for each year.

9 See 'Gross Domestic Product (GDP): Key Economic Indicators' - https://commonslibrary.parliament.uk/research-briefings/sn02783/

Data

3.9 Table 1 below provides a general overview of the data used in our calculations, organised by data source. Detailed descriptions can be found in Annex A.

Table 1: Data sources

Source	Description
Jackson et al. (2016) "The effects of school spending on educational and economic outcomes"	Effect of education spending on labour earnings
Office for National Statistics	Nominal GDP, 2022 Compensation of Employees, % GDP, 2000-2022 Mixed Income, % GDP, 2000-2022 Population forecasts by age, 2024-2080 Population counts by labour market status and age, 2000 Q1-2022 Q2 (Labour Force Survey)
OECD	Share of spending on primary and secondary education, % GDP, 2020
Green Book	Discount factor, 2025-2080
Bank of England (Nov 2023) "Monetary Policy Report"	Real and nominal GDP growth forecasts, 2022-2026
Goldman Sachs Global Investment Research (Dec 2022) "Global Economics Paper: The Path to 2075"	Real GDP growth forecasts, 2027-2079

3.10 As Table 1 shows:

- We source the estimated effect of higher education spending on wages from Jackson et al. (2016).[10] We describe the rationale in greater detail in the methodology section below.
- We take the nominal GDP, as well as the shares of the Compensation of Employees and Mixed Income in GDP, from the Office of National Statistics (hereafter "**ONS**"), which is the standard primary source of data on the UK economy (including for the GDP decomposition which separates out labour compensation).
- The historical population counts by labour market status and age, and the population projections by age are also taken from ONS datasets, which are based on the most accurate and comprehensive population surveys in the UK.
- We take the share of spending on primary and secondary education from the OECD database, one of the most reliable sources for harmonised, internationally comparable macroeconomic indicators.

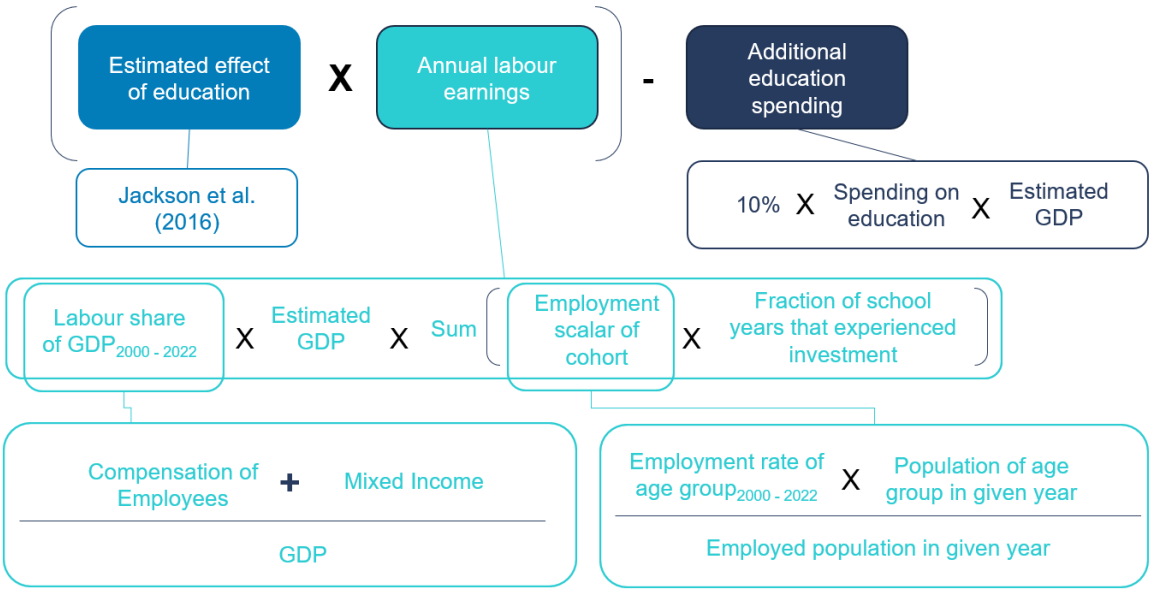
[10] Jackson, C. K., Johnson, R. C., & Persico, C. (2016). The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. *Quarterly Journal of Economics, 131*(1), 157-218.

- The sources for the short-term (until 2026) and long-term real GDP growth forecasts are the Bank of England and Goldman Sachs, respectively. Both are among the most reputable institutions for macroeconomic forecasts.
- For discount factors, we use the numbers provided in the Green Book, which is the official guidance on policy appraisal issued by HM Treasury.

Methodology

3.11 The formulas used in calculating the net present value and the internal rate of return are presented in Annex B. The calculation of the net benefit for a given year is illustrated in Figure 2. These benefits are discounted into 2024 pounds and summed across years.

Figure 2: Methodology of calculation



3.12 We describe each step of the calculation in detail next.

Effects of education on annual labour earnings

3.13 Many published papers estimate the effect of education investment (typically the effect of an extra year of education) on lifetime earnings. We reviewed the academic literature (detailed in Section 4) and chose the estimated effect of increased education spending on lifetime labour earnings from Jackson et al. (2016). This is a highly cited peer-reviewed paper published in one of the top five academic journals for economics. The authors use large, reliable datasets and leverage multiple complementary statistical approaches to identify causality and ensure the robustness of the results. Moreover, the metrics they use to measure education investment and lifetime labour earnings are clearly defined, and there is high-quality data on these metrics.

3.14 Jackson et al. (2016) found that a 10% increase in spending on schools during the 12 years that a pupil is expected to be in primary and secondary education increases the pupil's real lifetime labour earnings by 7.74% on average.[11]

3.15 In this report, we focus on modelling the impact of a 10% increase in education spending because (i) it is in line with the policy intervention evaluated by Jackson et al. (2016), and (ii) it is of reasonable and achievable magnitude. For example, the UK funding for secondary education grew 9.8% from 2017 to 2018,[12] and Jackson et al. (2016) find that during an average school finance reform, pupils from high-spending districts experienced a 6% increase in average school-age spending, and those in low-spending districts experienced a 12% increase. Assessing the effect of a different increase in investment would entail making additional assumptions due to the potentially non-linear effect of the investment.

3.16 The estimate of Jackson et al. (2016) that we use considers only the earnings increase during the ages between 20 and 45. We assume this increase also applies to earnings before (ages 18-20) and after this range. We make this assumption both to simplify the calculations and to be conservative. Jackson et al. (2016) show that the increased earnings caused by raising education spending increase nonlinearly with age, starting at 2.8% at the age of 20 years and reaching 13.4% at the age of 45 years. The increasing nature of the relationship suggests that the effect on the ages below 20 years would be less than 2.8%, while the effect for those aged above 45 years would exceed 13.4%.[13] Thus, extrapolating the 7.74% increase in earnings to ages outside 20-45 overestimates the impact for people aged under 20 and underestimates the impact for those older than 45. Since people younger than 20 years represent 3.4% of the labour force but people older than 45 represent 40.8%, our assumptions can be deemed very conservative.[14] Our estimate is, thus, a lower bound on the return on investment in education.

3.17 We assume that the effect of higher spending is uniformly distributed across the 12 years of schooling, in the sense that a person experiencing only one year of higher spending would benefit only from 1/12th of the 7.74% earnings boost. We perform the modelling separately for each age cohort and at annual frequency to obtain the earnings increase for each cohort in each future year. The discounted sum of these annual earnings gains is the total benefit of the higher investment in education. The formula we use is in Annex B. Using a cohort-level framework provides greater precision and transparency than approaches based on statistical relationships between macroeconomic aggregates (e.g., the correlation of education spending with real GDP per capita growth).

Projecting annual labour earnings

3.18 To estimate the labour earnings of the cohorts born each year from 2006 on (the cohorts who would experience the increased school spending in their school years), we apportion the aggregate labour earnings using the fraction of each cohort among the total employed population.

3.19 We estimate the aggregate labour earnings by applying the 2000-2022 average labour share of GDP to real GDP forecasts. We calculate the labour share as the ratio of Compensation of

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11 Jackson et al. (2016) provide estimates for a range of specifications in Table IV, and we choose their preferred specification as our estimate.

12 OECD (2023). See https://data.oecd.org/eduresource/education-spending.htm

13 Jackson et al. (2016) Appendix Figure J2 shows that the education-induced increase in earnings increases in the age of a person for ages 20-45. Extrapolating, the effect increases in age for all the ages we consider.

14 Based on 2022 Q2 data.

Employees and Mixed Income to GDP. According to the income approach to calculating GDP,[15] these are the two GDP components attributable to labour. We note that:

- Compensation of Employees includes not only wages, but also other forms of remuneration, such as benefits in kind and bonuses.
- Mixed Income, which covers self-employment income, contains earnings attributable to both labour and invested capital.

3.20 Whilst it is unclear which of the components of Compensation of Employees and Mixed Income were used in the earnings measured in Jackson et al. (2016), at the very least the authors must have considered labour compensation (i.e., wages and the part of mixed income attributable to labour). We assume that the remaining components (e.g., bonuses) of the Compensation of Employees are proportional to wages, and the remaining components of Mixed Income are proportional to the labour part of it. Labour compensation represents nearly all of Compensation of Employees and the majority of Mixed Income. We are not aware of a sufficiently accurate way to split out the labour compensation from these components of GDP. Hence, we include both Compensation of Employees and Mixed Income in full. We estimate both variables by applying the 2000-2022 average share of these items in GDP to our GDP projections. We choose the 2000-2022 period because it is both long enough to capture behaviour over an entire business cycle and sufficiently close to the present to capture only the most relevant trends. The 2022 share of Compensation of Employees plus Mixed Income in GDP is higher than the 2000 share, so our assumption is conservative.

3.21 To obtain the projections for real GDP, we follow the Green Book guidance stating that the benefits and costs of a policy should be adjusted for inflation with the base year being the first year of the proposal. We source the latest full-year nominal GDP numbers (2022) from the Office of National Statistics and forecast the 2024 value using forecasts of nominal GDP growth from the Bank of England. We then use the 2024 GDP value to forecast the real GDP series until 2080 using the projections of the annual real GDP growth rates from Bank of England (until 2026) and Goldman Sachs Global Investment Research.

3.22 For each age cohort and year, we forecast the fraction that the employed people in the cohort form of the total number of employed people, which we refer to as employment scalars. To obtain these scalars for each age cohort and year, we use (i) the population age structure forecast of the Office of National Statistics, specifically the predicted number of people of a given age in each future year, and (ii) the average age-specific employment rate (the fraction of people of a given age who are employed) in 2000-2022, also sourced from the ONS. For each year of the appraisal period, we multiply the employment rate of people of a given age with the predicted number of people of that age, and divide the result by the total number of employed people predicted for that year. This is the employment scalar for people of that age for that year.

a. The formula for the employment scalars is in Annex B.

b. To find the total number employed, which the formula uses, we sum the age-specific numbers of employed across ages.

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[15] GDP is the sum of Compensation of Employees, Gross Operating Surplus, Mixed Income, and Taxes less subsidies on Production and Products. See https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/aguidetotheuknationalaccountsmarch2020

c. Using the 2000-2022 period for the average of the employment rate is in line with our estimation of aggregate labour earnings.

3.23 We assume that people enter school at the age of 6, and the formal 12 years of primary and secondary school end at the age of 17. Thus, we calculate the policy benefits as the increase in earnings for individuals joining the labour force when they are 18 or older. For simplicity, we assume that there is no early entry into the labour force. We thus omit any earnings increase at age 17 or younger, to be conservative in our estimation.

3.24 In line with Jackson et al. (2016), we assume that each cohort's labour income as a whole increases by 7.74%. Further, since the investment is assumed to start in 2024, the first year of the appraisal period, the benefits start to accrue in 2025 when a (small but positive) fraction of pupils who were in school in 2024 is projected to enter the labour force.

Costs and discount factors

3.25 The chosen annual investment size is 10% of spending on primary and secondary education. For each year of the appraisal period, the amount of education spending is obtained by multiplying the forecast GDP that year and the share of education expenditure in GDP in 2020 (sourced from the OECD). We assume the first investment cost is incurred in 2024, the first year of the appraisal period.

3.26 In our cost calculations, we disregard financing costs (e.g., the deadweight loss from higher taxes, interest costs) to be in line with the standard practice of policy appraisal. According to the Green Book, the cost to the government of raising funds should not be considered because financing costs are relevant for setting the budget level. In contrast, the purpose of policy appraisal is to allocate resources between competing projects after the overall budget has been set. In addition, the cost of the investment would represent only 1% of total government expenditure (0.42% of GDP), thus the investment would not materially increase the government's financing costs.

3.27 We also disregard the opportunity cost of higher educational attainment. Jackson et al. (2016) estimate that increasing education spending by 10% in all 12 school-age years raises educational attainment by 0.31 years on average. By staying in education for longer, pupils are foregoing potential income, which would be considered as cost under our framework. However, this cost would have little impact relative to the length of our appraisal period, which is 56 years.[16] We do not consider the foregone earnings from higher educational attainment, which are also greatly outweighed by the higher earnings per year throughout the working life.

3.28 For discounting, we use the real discount rates provided in the Green Book (3.5% for the years 2025-2054, 3% for the remaining years). The discount rates imply that a benefit of £100 in 2080 (the last year of our analysis) is worth £16.5 in 2024. Our sensitivity analysis below repeats the calculation of the return on investment to education for other discount rates. The return remains positive for a wide range of discount rates (we consider 2.5%-4.5% in Table 2, but the return is positive for any discount rate below the IRR, which we find to be 13.2%).

Main results

3.29 As previously mentioned, we find that a 10% increase in real annual education spending during the appraisal period results in a net present value of £1,100 bn (discounted benefits of £1,490 bn minus

[16] In contrast, if someone joins labour force at the age of 18 and retires at the current State Pension age of 66, they will have worked for 48 years.

discounted costs £390 bn). Per year, this is on average a benefit of £95 bn minus a cost of £17 bn.[17] For comparison, the GDP of the UK in 2022 was £2,506 bn.[18] The annual benefits start exceeding costs already in 2036 and the investment breaks even in 2043. The investment during the whole appraisal period realises an internal rate of return of 13% per year.

3.30 In addition, our estimate is conservative because education investment has additional benefits and positive feedback effects that our calculation excludes:

- In our calculations, education investment is assumed to increase only labour income. As we will discuss, however, education is associated with an extensive range of additional benefits, which include business creation, innovation, a higher return on capital or financial investments, and other factors that contribute to economic growth. In addition, more investment in school education increases enrolment in and completion of further education (vocational, university, and graduate degrees). This extra education has additional benefits, e.g., on business creation and innovation.

- Education is also associated with a wide range of non-pecuniary benefits that are difficult to quantify in monetary terms. Examples include reductions in crime rates, better health outcomes, and more political and civic engagement.

- The quantitative and qualitative effects of education reinforce each other via positive feedback loops. For instance, better education translates into higher labour earnings, which enable better medical care, which in turn increases the ability and availability to work, thereby positively affecting earnings and reducing public expenditure on healthcare.

- Educated people create more educated people, both through peer effects and intergenerational pass-on. Better-educated peers motivate a person to acquire more education and facilitate learning. A higher level of education of the parents improves the education and health of their children, both of which increase the children's lifetime earnings.

- We assume the effect of investment in education is independent of the socioeconomic status of the pupils. This makes our estimate conservative, because the investment is usually targeted more to disadvantaged pupils, and the literature finds that the benefit of investment in education is greater for this group. For instance, Jackson et al. (2016) find that a 10% increase in education spending increases the future earnings of pupils from poor backgrounds by 9.6%, instead of the average 7.74% we are assuming in our quantification. In addition, such investment also leads to 0.46 additional years of completed education and reduces by 6.1 percentage points the annual incidence of adult poverty.

- Education spending is a part of government spending, so has the usual government spending multiplier of stimulating the economy. The stimulation is less than one-for-one in the amount of spending, but still positive: Kraay (2012)[19] estimates a multiplier of 0.48 and other authors larger than that.[20] A multiplier of 0.48 means that an extra £100 of government spending reduces the spending of firms and households by £52, so the net increase in spending is £48. By omitting the multiplier, we assume that education investment is budget neutral (the funds for increased

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17 Simple average across years, not weighted by the discount factor for each year.

18 See 'Gross Domestic Product (GDP): Key Economic Indicators' - https://commonslibrary.parliament.uk/research-briefings/sn02783/

19 Kraay, A. (2012). How large is the Government Spending Multiplier? Evidence from World Bank Lending. The *Quarterly Journal of Economics*, *127*(2), 829–887, https://doi.org/10.1093/qje/qjs008.

20 Christiano, L., Eichenbaum, M., & Rebelo, S. (2011). When is the government spending multiplier large? *Journal of Political Economy 119*(1), 78-121.

education investment come from other areas of government spending, as opposed to taxes or borrowing). Including the multiplier in our calculations would reduce the real economic cost of raising education spending.

Sensitivity checks

3.31 We have run sensitivity analysis to understand how sensitive our estimate of the return to education investment is to changes in the two key parameters: (i) the increase in annual labour earnings due to a 10% rise in education spending and (ii) the discount rate. We find that the return to education spending remains positive for a wide range of discount rates and estimates of the effect of the spending on labour earnings. Table 2 presents a sensitivity analysis of the net present value of the investment under changes to the two key parameters. For example, if the discount rate is 4.5%, and the result of 10% higher education spending is only a 4% gain in labour earnings (about half of the effect that Jackson et al. (2016) find), then the net present value of the increase in education investment is about £229 bn, which is about a tenth of the GDP of the UK in 2022.[21] This translates into an internal rate of return of 8.2%. On the other hand, a discount rate of 2.5% and an earnings increase of 11% result in a net present value of almost £2,557 bn, corresponding to an internal rate of return of 16.3%. The internal rate of return is independent of the discount rate and only depends on the increase in labour earnings, as Table 3 shows.

Table 2: Sensitivity analysis for the net present value of education investment over 2024-2080 (in 2024 pounds), £ bn.

		Discount rate				
		2.5%	3.0%	3.5%	4.0%	4.5%
Increase in annual labour earnings due to 10% increase in education spending	4.0%	614,919	484,479	380,008	296,145	228,677
	5.0%	892,459	715,032	572,398	457,423	364,494
	6.0%	1,169,999	945,585	764,788	618,700	500,311
	7.7%	1,653,752	1,347,439	1,100,124	899,807	737,041
	9.0%	2,002,620	1,637,244	1,341,958	1,102,533	907,763
	10.0%	2,280,160	1,867,797	1,534,348	1,263,811	1,043,580
	11.0%	2,557,700	2,098,350	1,726,738	1,425,089	1,179,397

Source: Compass Lexecon analysis.

Table 3: Sensitivity analysis for the internal rate of return of education investment over 2024-2080.

	Increase in annual labour earnings due to 10% increase in education spending						
	4.0%	5.0%	6.0%	7.7%	9.0%	10.0%	11.0%
IRR	8.2%	9.8%	11.2%	13.2%	14.5%	15.4%	16.3%

Source: Compass Lexecon analysis.

21 The ranges of the discount rate and the earnings effect in the sensitivity analyses were chosen to balance two considerations: covering a wide range of cases and keeping the parameters within an empirically reasonable range. For example, the long-term interest rate in the UK is unlikely to be below the Bank of England inflation target (2%) or above 5% for long periods. The earnings effect is unlikely to be less than half of what Jackson et al. (2016) estimated, or more than 1.5 times higher than their result.

3.32 Our results are also consistent with other academic papers. Estimates from Mankiw et al. (1992)[22] and Temple (2000)[23] show that if human capital investment as a share of GDP increases by 10%, then output per worker is predicted to rise by 6%. If changes in human capital investment are well approximated by changes in education spending, and changes in the output per worker well approximated by changes in labour earnings, then a 10% increase in education spending is predicted to raise labour earnings by 6%. As can be seen from Table 3, even if the rise in labour earnings is as low as 4%, investing in education still produces significant net present value.[24]

3.33 In summary, a 10% increase in education spending until 2080 generates large monetary returns to society which are robust to significant changes in all our assumptions. In addition to these quantified monetary returns, education has various non-pecuniary benefits, which translate indirectly into lower costs or higher benefits for society, e.g., into less need to spend on healthcare or law enforcement.

22 Mankiw, N. G., Romer D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. The *Quarterly Journal of Economics 107(*2), 407-437.

23 Temple, J. (2002). Growth effects of education and social capital in the OECD countries. *Historical Social Research/Historische Sozialforschung*, 5-46.

24 This 4% return is lower than Jackson et al. (2016) estimation of the effect of education spending on non-poor individuals, which amounts to 5.5%. As can be seen, even if the effect for every individual is as low as 4%, investment in education is profitable for society.

4 THE IMPACTS OF INVESTMENT IN EDUCATION

4.1 Investing in education can take various forms, ranging from direct public school spending (e.g., operational expenses, instructional materials, technology infrastructure) to investments in teacher salaries, professional development, and capital expenditure (e.g., infrastructure development, modernisation).

4.2 In our quantitative estimation of the return to investing in education in Section 3, we focus on public spending on education as the input and lifetime earnings as the output. These are the most clear and transparent metrics, with the best data and scientific evidence available. The public spending on education is the most policy-relevant input and is easier for the government to adjust than the private investments (the effort, time, and money individuals spend to educate themselves). In this section, we summarise the academic and policy literature on the influence that different types of investments in education have on economic indicators.

4.3 Many of the benefits of education are private and change individual-level outcomes, e.g., increased future earnings and higher employment. These private benefits are a component of the public benefit, and if widespread, add up to macroeconomic outcomes and broader societal advantages, such as economic growth, improved social outcomes, and a more robust and capable workforce. Public benefits further include the positive externalities that educated people have on others. Examples of such public benefits include improved health and lower crime rates. Educated people tend to exhibit healthier lifestyles and lower propensities for engaging in criminal activities. The better health and reduced crime reduce the public costs of healthcare and law enforcement, respectively. Healthy behaviours and reduced criminal activity also influence other people through peer effects – people tend to imitate the behaviours of those they interact with. Therefore, the impact of education on the economy and society exceeds what can be exclusively ascribed to individual-level measures. In other words, private benefits are a lower bound on the public benefits stemming from investments in education.

4.4 Given the above, we differentiate between direct and indirect effects. For example, education has the direct causal effect of increasing both lifetime earnings and GDP growth. Education funding also has indirect effects on macroeconomic indicators via better physical and mental health, less crime and incarceration, better student performance, improved cognitive skills, or more civic engagement and social capital, all of which in turn reduce costs to public finances or increase economic growth.

4.5 We first review the literature on the direct effects of education on economic outcomes, such as lifetime earnings and GDP growth. Then, we delve into the broader, indirect effects of education on the economy. By examining both direct and indirect impacts, we aim to provide a concise yet comprehensive understanding of how investing in education influences various aspects of society and the economy.

Evidence on the direct effect of education on the economy

4.6 The academic literature exploring the direct effects of education on the economy highlights significant impacts, including (i) education increases lifetime earnings; and (ii) education enhances GDP growth. In particular, and as explained in detail in Table 4, most of the literature exploring the

causal economic effects of investing in education finds an internal rate of return similar to or larger than Jackson et al. (2016). As explained in Section 3, we use their 7.74% return to investment in education, but this effect is even stronger for children from disadvantaged families. Further evidence shows that the rate of return for additional years of schooling on lifetime earnings tends to fluctuate between 8% and 12%.[25]

4.7 The literature also finds systematic positive relations between the quantity and especially quality of education and GDP growth. More detailed summaries of the papers, along with references, are in Annex C.

Table 4: Evidence on the causal effect of education on lifetime earnings and the relation between investment in education and GDP growth

Study	Research question	Main results
Jackson et al. (2016)	Effect of reforms that changed **public school spending** in the 1970s and 1980s in the US on **lifetime earnings**	A 10% increase in per pupil spending each year for all 12 years of public school leads to **0.31 more completed years of education, about 7% higher wages**, and a 3.2 percentage point reduction in the annual incidence of adult poverty.
Bhuller et al. (2017)	Years of **schooling** on **earnings** over the life cycle for males in Norway in the period 1967-2010	An **additional year of schooling leads to a 10% -12% increase in lifetime earnings**.
Brunello et al. (2017)	Years of **schooling** in 9 European countries on **lifetime earnings**	An **additional year of schooling increases lifetime earnings by 8.4%.**
Delaney and Devereux (2017)	The causal effect of **years of education on earnings variability**	An additional year of education **leads to a lower variability of earnings** for those below the age of 40. The probability of **receiving a pay cut decreases by 3.5** percentage points for each additional year of schooling.
Johnson and Jackson (2019)	Early **childhood program intervention** for low-income children ("Head Start") and **school finance reforms** in the 1970s and 1980s in the US **on lifetime earnings**	For children exposed to the average level of Head Start spending, **increasing school spending by 10%** leads to **20.5% higher adult earnings for poor children and 7.35% for non-poor**.
García et al. (2020)	Early **childhood program interventions** launched in the 1970s on **lifetime earnings** in North Carolina	**Internal rate of return** to the programs is **between 8% and 18.3%.**
Jamison et al. (2007)	**Education quality** (measured by international student achievement tests) in 51 countries on **GDP growth**	A one standard deviation increase in the test scores is associated with **a 0.5-0.9 percentage points higher annual growth rate in GDP per capita**.

[25] For completeness, in Annex C we also include a summary of other papers of the literature that perform meta-analyses of the relationship between education spending and economic outcomes and provide non-causal estimates of the relationship between education investment and economic growth.

Table 4: Evidence on the causal effect of education on lifetime earnings and the relation between investment in education and GDP growth

World Bank (2017)	**Quality of education** (test scores) in 23 OECD countries on **GDP growth**	Bringing all **test takers who are below 400 points** on PISA to the 400 level would increase **GDP in the US over 2015-2090 by 500% and in Mexico by 1.500%.**
Hanushek and Woessmann (2015)	**Quality of education** in 76 countries on **GDP growth**	**Bringing all students up to a basic skills level would increase the average level of GDP over the following 80 years by 3%** in lower-middle-income countries and **13%** in high-income countries.
Barro (2013)	**Quantity** (years) **and quality** (test scores) of schooling in 100 countries in the period 1960-1995 on **GDP growth**	An additional year of primary school is estimated to raise real GDP per capita growth by 0.11% for females and 0.19% for males. **Schooling quality is more important than quantity**.
Keller (2006)	Effects of primary, secondary, and higher education on **per capita growth** using worldwide panels since 1960	**Education expenditure and the enrolment in secondary and higher education explain 69% of the growth of GDP per capita**.

Source: Compass Lexecon analysis based on data from academic papers.

Evidence on the indirect effects of education on the economy

4.8 Education also has various indirect effects on the economy, such as:

a. Education improves physical and mental health, which improves productivity and reduces the cost of healthcare. Thus, education partly offsets the effect of population ageing.

b. Education reduces crime and incarceration, especially of children from disadvantaged backgrounds in their adult life. This in turn reduces the direct costs of crime on society and reduces spending on the prison system.[26] The mechanism is clear: as education spending increases, it provides individuals with better opportunities and skills, thereby reducing socio-economic disparities. This in turn can positively influence economic growth – a safer and more educated population tends to be more productive and engaged in the workforce. Indirectly, having less crime in a region attracts investment and increases growth.

4.9 Investing in the quality of education and in the incentives of teachers improves the test scores of students. Test scores are positively correlated with skills and future productivity. Numerous academic papers have scrutinised the impacts of investing in teachers, particularly examining strategies like wage increases and training programs. Increasing the wages of teachers aims to attract and retain high-quality educators, positively impacting the overall effectiveness of the education system. Professional development and training programs contribute to continuous improvement, aligning teaching methods with educational best practices.

[26] Crime has a high social cost. The investigation, prosecution, and detention of criminals is costly, as are the damage from crime, the increase in health care needs, and the lost earnings.

4.10 Education increases other factors that improve the economy, such as civic engagement, social capital, and innovation, and reduces income inequality. Civic participation reduces corruption and leads to better political decision-making. Social capital improves mental health and innovation and reduces transaction costs. Innovation increases economic growth. Inequality causes conflict and drives populism, so reducing it improves public safety and governance.

4.11 All these effects improve multiple economic outcomes. The scientific literature on these indirect effects is reviewed in more detail below and in Annex D.

Table 5: Evidence on the indirect effect of education on indirect outcomes

Study	Research question	Main results
Wei at al. (2020)	Causal effects of education on mental health outcomes in China	**An extra year of schooling reduces mental health** disorders by 0.09 standard deviations.
Heckman et al. (2018)	Causal effects of schooling on health, smoking, depression, self-esteem, incarceration, voting, welfare receipt, and trust	**College graduation decreases welfare use, lowers depression, and raises self-esteem**, especially for low ability individuals.
Galama et al. (2023)	Causal effect of education on health and longevity	There is no convincing evidence of an effect of education on obesity, and the effects on smoking are only apparent when schooling reforms affect individuals' track or their peer group. **The effect of education on mortality depends on the quality of education**.
Pradhan et al. (2018)	Effects of education on under-five mortality, adult mortality, and fertility	**Education quantity and quality reduce all measures of mortality** and fertility.
Gathmann et al. (2015)	The mean mortality effect, using data from 19 compulsory schooling reforms in Europe during the twentieth century	**Men benefit from compulsory education both in the short and long term**. Women are non-affected.
Kotschy and Sunde (2018)	The consequences of population aging and of changes in the education composition	**Education expansions tend to offset the negative effects of aging**.
Johnson and Jackson (2019)	Causal effects of changes in education spending on incarceration in the US	Investment in primary education for poor children reduced their likelihood of subsequent incarceration.
World Bank (2018)	The effects of schooling on crime in OECD countries	In the UK, school dropouts are three times more likely to commit crimes than those who have stayed in school.
Groot and van den Brink (2007)	Effects of education on offences and crimes using data from the Netherlands	An extra year of education reduces the probability of participating in blue-collar crimes by 0.2 percentage points but increases the probability of tax fraud by 0.4 percentage points.

Table 5: Evidence on the indirect effect of education on indirect outcomes

		The benefit from the reduction in blue-collar crime outweighs the cost from the increase in white-collar crime.
Adnot et al. (2017)	Causal effect of removing low-performing teachers on student performance in DC in the US	Firing lower-performing teachers improves student performance by 0.14 SD in reading and 0.21 SD in math.
Britton and Propper (2015)	The effect of teacher salaries on school performance in England	A 10% increase in the wage gap between the local labour market and teacher wages results in an average loss of 2% in school performance in the exams taken at the end of compulsory schooling in England.
World Bank (2017)	Effect of education on political activities	**People with more education consistently vote more and participate more in political activities** than those with less education.
Biasi et al. (2021)	The link between education and innovation	**Improvements in education access and quality encourage entrepreneurship and innovation**.
Clarke et al. (2022)	The importance of early schooling on educational outcomes	Children who attended pre-school had better attainment in language, pre-reading, and early number concepts at age 5 than students who did not attend pre-school.

Source: Compass Lexecon analysis based on data from peer-reviewed academic papers.

5 POLICY IMPLICATIONS FOR FUNDING IN THE UNITED KINGDOM

Context of education funding in the United Kingdom

5.1 Education is a cornerstone of modern society in England, involving one-sixth of the population as students or teachers, and one-third when including parents and other stakeholders. Education has a large influence both at the individual and societal level. As such, understanding the implications of investment in education is key for gaining insights on a range of future economic outcomes, both at the micro-level (e.g., earnings or health) and the macroeconomic level (e.g., productivity, innovation, and growth).

Education funding has dropped since 2010

5.2 In England, real spending on education declined over the period 2010-2021. This reduction in funding comes at a time when school costs are increasing at a rate which outpaces general inflation. Notably, teacher salaries, the largest portion of school expenses, increased by over 5% in September 2022, and support staff salaries saw an 8–9% growth. At the same time, expenses for energy, food, and other non-staff items have been on the rise.[27] The combination of declining real spending and escalating school-specific costs is placing financial pressure on schools.

5.3 Since 2010, total education spending in England has changed significantly, with the government implementing a series of funding reforms and austerity measures following the 2008 financial crisis. According to data from the Department for Education, the size of the education budget in England fell by about 3.3% between 2010 and 2021.[28]

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27 See Institute for Fiscal Studies. (n.d.). *Schools.* Retrieved from https://ifs.org.uk/education-spending/schools and Institute for Fiscal Studies. (2020). *Annual Report on Education Spending in England* (p. 58). Retrieved from https://ifs.org.uk/sites/default/files/output_url_files/R183-2020-annual-report-on-education-spending-in-England%252520%2525281%252529.pdf

28 Total education spending on primary and secondary education was £64.6bn in 2010 and £62.5bn in 2021 (in 2021 prices). See UK Government. (2021). *Country and Regional Analysis 2021*. Retrieved from https://www.gov.uk/government/statistics/country-and-regional-analysis-2021

5.4 Furthermore, spending per pupil decreased over 2010-2020: according to the IFS, per-pupil spending on schools (primary and secondary together) in England fell by 9% in real terms between 2009-10 and 2019-20.[29,30]

Costs increased faster than anticipated funding

5.5 Along with these cuts to funding, school costs have risen in recent years as a result of higher energy prices, inflation and increasing staff salaries. If the costs of schools increase faster than funding, then schools must reduce spending in order to balance their budgets. In the short run, schools can run a deficit, as 11% did in the year ending 31 March 2020.[31] Over 70% of school costs are staff pay[32], so a spending reduction will likely include reducing the number of teachers and support staff or increasing their work hours.

5.6 The UK government conducted a spending review in 2019 to set out its public spending plans for the years 2020-2021. It announced that schools in England would receive a £7.1 billion increase in funding over three years.[33] This was part of the government's commitment to "*restore the 2010 levels of per pupil funding in real terms".*[34] The government also plans to increase the core schools budget (funding for schools to spend on running costs such as teacher salaries, as opposed to capital funding for e.g., building maintenance) by £3.5 billion in 2023-24 to £58.8 billion.[35]

5.7 Critics of the spending review raised the concern that the return to the real level of funding in 2010 depends on the measure of inflation used - the government uses the GDP deflator.[36] The IFS estimates that the costs of schools (e.g., staff pay) will increase by 20% between 2019-20 and

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29 See Institute for Fiscal Studies. (2021). *School Spending in England: Trends Over Time and Future Outlook* (Table 1.1). Retrieved from https://ifs.org.uk/sites/default/files/output_url_files/BN334-School-spending-in-England-trends-over-time-and-future-outlook.pdf

30 One reason why spending per pupil decreased is that pupil numbers increased by 6% from 2015/16 to 2022/23. Secondary school pupil numbers are expected to increase by 1% (or 37,000) between 2022 and 2028, and nursery and primary school pupil numbers to decrease by 13% (or 532,000) in the same period. See School Pupils and Their Characteristics (2022-2023). [Data set] Retrieved from https://explore-education-statistics.service.gov.uk/data-tables/school-pupils-and-their-characteristics/2022-23?subjectId=6f21a19c-7bd1-4d70-a63d-08db5b647393 and National Pupil Projections (2022). Retrieved from https://explore-education-statistics.service.gov.uk/find-statistics/national-pupil-projections

31 See Committee of Public Accounts. (2022). *Financial sustainability of schools in England* (Forty-Second Report of Session 2021–22). Retrieved from https://publications.parliament.uk/pa/cm5802/cmselect/cmpubacc/650/report.html The proportion of maintained schools that reported a cumulative deficit varied from 0% to 46% across local authorities in England.

32 See Department for Education. (2018, May 9). *School Resource Management: Top 10 Planning Checks for Governors*. Retrieved from https://www.gov.uk/guidance/school-resource-management-top-10-planning-checks-for-governors

33 See Institute for Fiscal Studies. (2021). *School Spending in England: Trends Over Time and Future Outlook* (p. 3). Retrieved from https://ifs.org.uk/sites/default/files/output_url_files/BN334-School-spending-in-England-trends-over-time-and-future-outlook.pdf

34 See HM Treasury & The Rt Hon Rishi Sunak MP. (2021, October 27). *Autumn Budget and Spending Review 2021 Speech* [Oral statement to Parliament]. Retrieved from https://www.gov.uk/government/speeches/autumn-budget-and-spending-review-2021-speech

35 See Department for Education. (2023). *Implementing the Direct National Funding Formula: Government Consultation Response*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1153128/_Implementing_the_direct_national_funding_formula_government_consultation_response.pdf

36 See *Reflections on the Autumn Statement.* (2022, November). Retrieved from https://cstuk.org.uk/knowledge/guidance-and-policy/reflections-on-the-autumn-statement/

2024-25, which is higher than the estimated 14% increase in the GDP deflator. If the funding increase is adjusted using the IFS measure of school-specific inflation, then the resulting funding per pupil will remain 3% below the level in 2009-2010.[37] The Education Policy Institute estimates that after the adjustment, the funding is reduced compared to 2009-2010 by approximately one yearly salary of a teacher in an average primary school and approximately 3-4 teacher salaries in an average secondary school.[38]

Policy recommendations in this context

5.8 Education is a fundamental catalyst for the development of both the economy and the society. In recent years, however, the United Kingdom has witnessed a concerning trend**: investments in education have decreased in real terms since 2010, while the costs associated with education continue to rise.**

5.9 Evidence shows that students exposed to spending cuts, and especially those from poor neighbourhoods, had lower test scores and lower college-going rates.[39] The **failure to adequately fund education has long-run detrimental effects for the population**. Such detrimental effects mostly fall on disadvantaged groups.

5.10 Even considering the scarcity of resources and the importance of an efficiently allocated budget, **our analysis shows that a 10% increase in annual education spending is profitable for society and improves public finances in the long run**. The calculation of the return draws on the published research of Jackson et al. (2016) which finds that a 10% increase in education investment results in a private benefit of 7.74% higher earnings per year for the pupils whose school district experienced the increase in investment. Over the period 2024-2080, we find that a 10% increase in annual education spending in the UK would generate a net present value of 1,100 billion.

5.11 This conservative estimate does not account for other indirect effects of education on the economy. Education improves physical and mental health, which leads to greater productivity and lower healthcare costs. Additionally, investing more in education, particularly of disadvantaged children, reduces the future criminal activity and incarceration of the pupils who experience the increased investment. This, in turn, lowers the societal costs associated with crime and reduces spending on the justice system. Furthermore, investing in the quality of education and in teacher incentives improves student test scores, which correlate with enhanced skills and future productivity. All these effects foster a more stable and prosperous society.

5.12 Policymakers have several policy and budget choices for investment in education. Among these, the academic literature consistently emphasises the value of placing a higher priority on the quality of education rather than its quantity. Furthermore, research consistently affirms that early investments in a pupil's life and in more disadvantaged groups result in more significant impacts. Consequently, **directing investments towards the formative years and low-income students is optimal for generating the best long-term outcomes**.

5.13 In conclusion, the report underscores the critical importance of education as an engine for economic and societal development. The decline in education investment since 2010 poses potential risks,

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37 See Institute for Fiscal Studies. (2022). *School Spending and Costs: The Coming Crunch*. Retrieved from https://ifs.org.uk/sites/default/files/2023-02/IFS-BN347-School-spending-and-costs-the-coming-crunch-1.pdf

38 See *Current Estimates of School Funding Pressures.* (2022, October 24). Retrieved from https://epi.org.uk/publications-and-research/current-estimates-of-school-funding-pressures/

39 Jackson, C. K., Wigger, C., & Xiong, H. (2021). Do school spending cuts matter? Evidence from the Great Recession. *American Economic Journal: Economic Policy, 13*(2), 304-335.

as does the projected increase in the costs of schools over the coming years. The substantial return on investment for a 10% increase in education spending that this report calculates demonstrates the long-term value that education creates for society. Policymakers should recognise the large financial and non-financial benefits of education and should prioritise sustained investment to secure a prosperous and equitable future for the UK.

A ANNEX – DATA SOURCES

A.1 Details of the data sources and variables used are described in Table 6 below.

Table 6: Detailed information on data sources and variables.

Variable	Source	Description
Real GDP growth forecasts, 2027-2080	Goldman Sachs Global Investment Research (Dec 2022) "Global Economics Paper: The Path to 2075"	'Exhibit 14'
Real and nominal GDP growth forecasts, 2022-2026	Bank of England (Nov 2023) "Monetary Policy Report"	Tables 1.A and 1.D
Share of spending on primary and secondary education, % GDP, 2020	OECD	Education at a glance: Educational finance indicators
Nominal GDP, 2022	Office for National Statistics	'GDP at current prices – real-time database', YBHA
Population forecasts by age, 2024-2080	Office for National Statistics	'2020-based interim national population projections: year ending June 2022 estimated international migration variant'
Population counts by economic status and age, 2000 Q1-2022 Q2	Office for National Statistics	'Economic status by single year of age, UK: 2020-2022' Labour Force Survey
Compensation of Employees, % GDP, 2000-2022	Office for National Statistics	'Compensation of employees as % of Gross Domestic Product: CP SA' Source Dataset: UK Economic Accounts time series (UKEA)
Mixed Income, % GDP, 2000-2022	Office for National Statistics	'Mixed Income as % of Gross Domestic Product: CP SA' Source Dataset: UK Economic Accounts time series (UKEA)
Discount factor, 2025-2080	Green Book	Table 7
Effect of education spending on wage earnings	Jackson et al. (2016) "The effects of school spending on educational and economic outcomes"	Table VI

B FORMULAS

Net present value

B.1 The net present value ("**NPV**") equals the discounted sum of benefits minus the discounted sum of costs and in this report is calculated according to:

$$NPV = \sum_{t=t_0+1}^{t_1} \frac{GDP_t}{\prod_{\tau=t_0}^{t-1}(1+r_\tau)} \cdot \Delta earn \cdot Lshare \cdot \left(\sum_{b=t_0-18}^{t_1} \mathrm{f_{bt}} s_{bt} \right) - \sum_{t=t_0}^{t_1} \frac{GDP_t}{\prod_{\tau=t_0}^{t-1}(1+r_\tau)} \cdot 0.1 \cdot edshare$$

B.2 In the NPV formula:

- $t_0 = 2024$ is the starting year of the appraisal period. The costs start to accrue from t_0 but the benefits from $t_0 + 1$ because we assume that the pupils must be exposed to at least one year of higher spending to obtain the higher future earnings.
- $t_1 = 2080$ is the final year of the appraisal period.
- $\prod_{\tau=t_0}^{t-1}()$ denotes the product of the terms in parentheses from t_0 to $t-1$, analogously to the sum notation Σ. If $t - 1 < t_0$, then the convention used is that the product equals 1. If the interest rate is constant, then $\prod_{\tau=t_0}^{t-1}(1+r_\tau) = (1+r)^{t-t_0}$.
- r_τ is the interest rate for year τ from the Green Book (3.5% until 2054 and 3% after that).
- GDP_t is the gross domestic product forecast for year t, derived using

  $GDP_t = GDP_{2022} \cdot (1 + g_{2023}^{BoE}) \cdot (1 + g_{2024}^{BoE}) \cdot \prod_{\tau=2025}^{t}(1 + g_\tau^{GS})$,

  where GDP_{2022} is the GDP in 2022 from the ONS, g_t^{BoE} is the Bank of England GDP growth forecast for year t, and g_τ^{GS} is the Goldman Sachs GDP growth forecast for year τ.
- $\Delta earn = 0.0774$ is the 7.74% increase in earnings when education spending increases for all 12 years of school.
- $Lshare = 0.556$ is the 55.6% labour share of GDP, calculated as

  $Lshare = \frac{\sum_{t=2000}^{2022}(employeecomp_t + mixedincome_t)}{\sum_{t=2000}^{2020} GDP_t}$,

  where $employeecomp_t$ is the Compensation of Employees in year t and $mixedincome_t$ is the Mixed Income in year t.
- b is the birth year of the cohort. Thus $t - b$ is the age of the cohort in year t.
- $\mathrm{f_{bt}} = min\{1, \frac{b-(t_0-18)}{12}\}$ reflects the assumption that a cohort which experiences the increased education spending for fraction $\mathrm{f_{bt}}$ of their school-age years obtains the fraction $\mathrm{f_{bt}}$ of the 7.74% increase in labour earnings.
- s_{bt} is the employment scalar for cohort b in year t. It is zero if $t - b < 18$ (the cohort is under 18 in year t, has not entered the labour market). Otherwise, it is calculated as

$$s_{bt} = \frac{emp_{bt}}{empTot_t} = \frac{empRate_{t-b} \cdot pop_{t-b,t}}{\sum_{a=18}^{80+} empRate_a \cdot pop_{a,t}},$$

where emp_{bt} is the number of employed in cohort b in year t, $empTot_t$ is the total employed in year t, $empRate_{t-b}$ is the 2000-2022 average age-specific employment rate for those aged $t-b$ from the ONS, $pop_{t-b,t}$ is the ONS forecast of population of age $t-b$ in year t, and $80+$ is the highest age that the ONS uses. It aggregates all ages from 80 upward. All other ages are single-year.

- The 0.1 reflects the hypothetical 10% increase in education spending, the effect of which we evaluate.
- $edshare$ is the share of education spending in GDP.

B.3 Substituting the numerical values we use into the NPV formula, it becomes

$$NPV = \sum_{t=2025}^{2080} \frac{GDP_t}{\prod_{\tau=2024}^{t-1}(1+r_\tau)} \cdot 0.0774 \cdot 0.556 \cdot \left(\sum_{b=2006}^{2017} \frac{b-2006}{12} s_{bt} + \sum_{b=2018}^{2080} s_{bt} \right) - \sum_{t=2024}^{2080} \frac{GDP_t}{\prod_{\tau=2024}^{t-1}(1+r_\tau)} \cdot 0.1 \cdot 0.042$$

Internal rate of return

B.4 The internal rate of return is the interest rate that sets the net present value equal to zero. It does not have a closed form expression in general but is calculated numerically as a solution to $\sum_{t=0}^{T} \frac{cashflow_t}{(1+IRR)^t} = 0$.

B.5 For the quantification in this report, the IRR solves:

$$0 = \sum_{t=2025}^{2080} \frac{GDP_t}{(1+IRR)^{t-2024}} \cdot 0.0774 \cdot 0.556 \cdot \left(\sum_{b=2006}^{2017} \frac{b-2006}{12} s_{bt} + \sum_{b=2018}^{2080} s_{bt} \right) - \sum_{t=2024}^{2080} \frac{GDP_t}{(1+IRR)^{t-2024}} \cdot 0.1 \cdot 0.042$$

C THE EVIDENCE ON THE DIRECT EFFECTS OF EDUCATION ON THE ECONOMY

Evidence on the causal effect of education on lifetime earnings

C.1 Jackson et al. (2016)[40] utilise data on school finance reforms in the United States to analyse the effect of increased school spending on the educational and economic outcomes of students later in life. The paper employs rigorous empirical methods, such as natural experiments arising from policy changes, to isolate the causal effects of changes in school spending. The paper finds that increased school spending causes higher earnings and economic well-being for individuals in the long run. Namely, their findings reveal that a 10% increase in spending on schools in the school district of a pupil each year for the 12 years during which the pupil was expected to attend school leads to 7.74% higher future earnings for the pupil on average across her/his years of employment. By focussing on the earnings impact of an increase in public spending, Jackson et al. (2016) measure the private benefits from a public investment in education. These private benefits are a lower bound on the public benefit.

C.2 Bhuller et al. (2017)[41] study the effect of schooling on lifetime earnings. Using panel data for Norwegian males in the period 1967 to 2010, they establish a positive causal relationship between education, as measured by years of schooling,[42] and lifetime earnings. In addition, they find that the age-schooling profile becomes steeper with additional education. Using three well-established approaches, they estimate the internal rate of return from an additional year of schooling to be between 10% and 12% when controlling for income taxes and pension entitlements. The rate of return is above the market interest rate, so undertaking additional schooling is profitable.

C.3 Brunello et al. (2017)[43] also study the effect of education on lifetime earnings. Their analysis follows males in nine European countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, Netherlands, and Sweden) using data from the Survey of Health, Ageing and Retirement in

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40 Jackson, C. K., Johnson, R. C., & Persico, C. (2016). The Effects of school spending on educational and economic outcomes: Evidence from school finance reforms. *The Quarterly Journal of Economics, 131*(1), 157-218.

41 Bhuller, M., Mogstad, M., & Salvanes, K. G. (2017). Life-cycle earnings, education premiums, and internal rates of return. *Journal of Labor Economics, 35*(4), 993-1030.

42 A large body of research analyses the effect of an extra year of education on individual or societal outcomes, rather than the effect of additional spending. To make the results of the different papers comparable, an extra year of education can be converted into a percent increase in spending on education using the forgone earnings during the year of education, the lower earnings due to less work experience after it, the higher earnings due to more education after it, the education budget, and the average duration of education for that cohort. For example, if the population gets 12 years of education on average, then funding an extra year for everyone is expected to cost an additional 1/12 of the education budget. The conversion between the years of education and the spending on education would enable checking the robustness of the research findings.

43 Brunello, G., Weber, G., & Weiss, C. T. (2017). Books are forever: Early life conditions, education and lifetime earnings in Europe. *The Economic Journal, 127*(600), 271-296.

Europe. They compare individuals living in rural and urban areas in childhood, and individuals who had access to many books at home and those who did not. They instrument for years of schooling by using the exogenous variation created by reforms of the minimum school leaving age. The authors estimate that, on average, an additional year of schooling increases lifetime earnings by 8.4%, net of pension earnings. However, they find that these returns vary significantly by socioeconomic background: many individuals who had few books at home whilst living in rural areas during their childhood achieved low returns despite attaining higher education. From this, they conclude that policies such as education vouchers, which reduce the marginal cost of education, could be a more efficient way to realise high returns. The authors note that their analysis fails to consider the potential externalities arising from education, for example through reducing crime rates or generating productivity spillovers.

C.4 Johnson and Jackson (2019)[44] study whether early childhood investments designed to promote school readiness among disadvantaged children that are followed up with increases in public school spending are particularly effective at improving their long-run outcomes. They use well-established methods to estimate causal effects, and data on annual country-level spending on Head Start, which is an education programme targeting disadvantaged children, and public K-12 (kindergarten to grade 12) school spending at the school district level. They find that investment in primary education increases the likelihood of graduating, the number of years in education, and the post-school wages of children from poor backgrounds. For children exposed to the average level of K-12 spending, increasing Head Start spending by 4,230 USD per child (the average spending amount) increases wages between the ages 20 and 50 by 9.87% for poor children and has no impact for non-poor children. For children exposed to the average level of Head Start spending, increasing K-12 spending by 10% leads to 20.5% and 7.35% higher adult earnings for poor and non-poor children, respectively. The Head Start program and more funding for school education had synergies with each other.

C.5 García et al. (2020)[45] use a structural production function model to quantify the benefits of high-quality influential early childhood programmes for disadvantaged children, using the Carolina Abecedarian Project and the Carolina Approach to Responsive Education as a case study. Both programmes had two phases: (1) from birth till participants were five years old, (2) the first three years of public schooling and supported academic development. Participants were then surveyed through their mid-30s. The benefits of the programmes (the gains in the child's later income in adulthood, the parental labour income, the reduction in crime, and the improved health) were found to greatly outweigh the cost. Pooling male and female results, the authors find an internal rate of return to the programme of 13.7% and a cost/benefit ratio of 7.3. The authors acknowledge that the participants were from a homogenous population from a small town in North Carolina, which limits the generalisability of their findings.

Meta-analyses of the relationship between education spending and economic outcomes

C.6 Psacharopoulos and Patrinos (2018)[46] review the global literature on the return to investment in education. They find that the global average private rate of return to one extra year of schooling is about 9% per year and very stable over decades. The private return takes into account the after-

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44 Johnson, R. C., & Jackson, C. K. (2019). Reducing inequality through dynamic complementarity: Evidence from Head Start and public school spending. *American Economic Journal: Economic Policy, 11*(4), 310-349.

45 García, J. L., Heckman, J. J., Leaf, D. E., & Prados, M. J. (2020). Quantifying the life-cycle benefits of an influential early-childhood program. *Journal of Political Economy, 128*(7), 2502-2541.

46 Psacharopoulos, G., & Patrinos, H. A. (2018). Returns to investment in education: A decennial review of the global literature. *Education Economics, 26*(5), 445-458.

tax lifetime earnings and the private costs of education (including foregone earnings, and schooling fees, but excluding government expenditure). Those employed in the private sector of the economy tend to receive higher returns than those working in the public sector, further proving the productive value of education. The authors conclude that spending on human capital is a good investment, and funding priority should be given to earlier stages of education.

C.7 Krueger and Lindahl (2001)[47] review the microeconomics and macroeconomics literature and find that research using individual-level education and income data since the beginning of the 20th century provides robust evidence of a benefit to investment in education, particularly in individuals with low levels of schooling.

C.8 Temple (2000)[48] reviews cross-country macroeconomic evidence, finding that productivity gains due to education are at least as large as those identified by labour economists. The labour economics literature typically estimates a return to education of between 5% and 15%, depending on the time period and region studied. The difficulty is to establish a causal relationship between education and earnings. Temple mentions that Maddison (1987)[49] finds that changes in the quality of the labour force for France, West Germany, Japan, the Netherlands, the UK and the US for the period 1950-1984 increased annual growth rates by between 0.1 and 0.5 percentage points. Englander and Gurney (1994)[50] collate results from studies of the G7 countries and find that typically between 10% and 20% of growth in total output can be attributed to growth in labour quality between the 1960s and 1980s. The growth accounting method used in these papers fails to capture the indirect effects of education on output, such as investment and labour force participation, making it difficult to infer the effect of education on growth. Using growth regressions, Mankiw et al. (1992)[51] find that increasing human capital investment as a share of GDP by 10% increases output per worker by 6% for a sample of OECD countries. Doubling human capital investment leads to a 50% increase in output per worker. Temple (2000) concludes that education increases labour force participation and the output per worker per hour.

C.9 Heckman and Mosso (2014)[52] review the existing literature on the importance of early life decisions on future skills. They also model the effects found in previous research. The empirical literature shows high economic returns for investment in young, disadvantaged children.

Evidence on the relationship between education and GDP growth

C.10 Jamison et al. (2007)[53] analyse data from 51 countries at 10-year intervals in 1960-2000. They find that education quality, measured by the international student achievement test ISAT in mathematics, increases GDP growth. A one standard deviation increase in the test scores is

47 Krueger, Alan B., and Mikael Lindahl. "Education for growth: Why and for whom?." Journal of Economic Literature 39, no. 4 (2001): 1101-1136.

48 Temple, J. (2002). Growth effects of education and social capital in the OECD countries. *Historical Social Research/Historische Sozialforschung*, 5-46.

49 Maddison, A. (1987). Growth and slowdown in advanced capitalist economies: Techniques of quantitative assessment. *Journal of Economic Literature, 25*(2), 649-698.

50 Englander, A. S., & Gurney, A. (1994). Medium-term determinants of OECD productivity. *OECD Economic Studies, 22*(1), 49-109.

51 Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics, 107*(2), 407-437.

52 Heckman, J. J., & Mosso, S. (2014). The economics of human development and social mobility. *Annual Review of Economics, 6*(1), 689-733.

53 Jamison, E. A., Jamison, D. T., & Hanushek, E. A. (2007). The effects of education quality on income growth and mortality decline. *Economics of Education Review, 26*(6), 771-788.

associated with a 0.87 percentage points higher annual growth rate in GDP per capita. Once controlling for the quality of education, each additional year of schooling leads to a 0.071 percentage point gain in the growth rate. The likely mechanism how education quality increases GDP growth is through an increase in the rate of technological progress in the country. Education quality also decreases infant mortality. The effect is stronger in open economies.

C.11 The World Bank (2017)[54] finds similar effects. Across 23 OECD countries, as well as in many other countries, simple measures of foundational skills such as numeracy and reading proficiency explain hourly earnings, over and above the years of schooling completed. Socioemotional skills matter as well: various measures have been shown to significantly predict earnings, over and above the effects of schooling and cognitive skills. Learning outcomes turn out to be especially important: the test scores of the community in which a child lives (adjusted for the income of that community) are among the strongest predictors of upward social mobility later in life. The impact of improving learning outcomes is significant. For instance, merely bringing all test takers who attain below 400 points on PISA to the 400 level would increase GDP in the US over 2015-2090 by 500% and in Mexico by 1,500%.

C.12 In addition, Hanushek and Woessmann (2015)[55] show that education quality and institutional quality can reinforce each other. The effect of cognitive skills on growth is significantly larger in countries with a productive institutional framework. To quantify the above-mentioned effects, the authors simulate the impact of schooling reforms on economic growth. The results imply that the value of quality improvements is significantly higher than the impact of the quantity-oriented reforms (e.g., full access to education). Specifically, bringing all students up to a basic skills level (PISA Level 1) would increase the average level of GDP over the following 80 years by 3%-13% (in lower-middle-income countries and high-income countries, respectively). In contrast, ensuring that all children can access lower secondary schooling (while maintaining existing quality) has no impact for high income countries (because access is already high) and increases future GDP by 4.4% in lower-middle-income countries. The impact is largest when both quality and quantity reforms are implemented, yielding 28% and 4% gains in future GDP for lower-middle-income and high-income countries, respectively.

C.13 Using panel data for about 100 countries in 1960-1995, Barro (2013)[56] analyses the determinants of economic growth and investment, focusing on human capital, particularly education. The author uses three-stage least squares estimation and controls for the starting level of per capita GDP, investment ratio, a range of policy and institutional variables, and population health. The effect of education is measured both in terms of quantity (years of attainment) and quality (test scores). School attainment at the secondary and higher levels has a significant positive effect for adult males but not females, possibly caused by low labour force participation of highly educated women in many countries. For instance, increasing the average school attainment (secondary or higher) of males by one year is associated with 0.44% higher real GDP per capita growth. Primary school indirectly improves economic growth for both males (because primary school is a prerequisite for secondary) and females (through inducing a lower fertility rate). An additional year of primary school for females is estimated to raise real GDP per capita growth by 0.11% and an additional year for males by 0.19%. The quality of education has a stronger impact on economic growth than quantity, although the effect of the quantity of schooling is still significant after controlling for quality. Science test scores have a more significant positive effect on growth than reading and mathematics.

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54 World Bank. (2017). *World Development Report 2018: Learning to Realize Education's Promise*.

55 Woessmann, L. (2015). *Universal Basic Skills: What Countries Stand to Gain*. OECD Publishing.

56 Barro, R. J. (2013). Education and economic growth. *Annals of Economics & Finance, 14*(2).

C.14 Using panel data at ten-year intervals since 1960 for both developing and developed countries, Keller (2006)[57] investigates the effects of enrolment rates, public expenditures, and expenditures per student at various stages of education on per capita growth. The study finds that public expenditures on higher education are disadvantageous, but per-student expenditures on primary and secondary education have a significant positive effect, as do overall expenditures on primary education. Education expenditure and the enrolment in secondary and higher education explain 69% of the growth of GDP per capita. The author recommends reallocating public expenditures toward primary and secondary education stages, in addition to increasing enrolment rates.

[57] Keller, K. R. I. (2006). Investment in primary, secondary, and higher education and the effects on economic growth. *Contemporary Economic Policy, 24*(1), 18-34.

D THE EVIDENCE ON THE INDIRECT EFFECTS OF EDUCATION ON THE ECONOMY

Health mediates the effect of education on the economy

D.1 Wei et al. (2020)[58] use data on education reforms in China to show that an extra year of schooling reduces mental health disorders by 0.09 standard deviations. Better-educated individuals feel significantly less depressed, nervous, or agitated and are less likely to feel hopeless about the future, that everything is difficult or that life is meaningless. The positive effects of education on mental health are stronger for females and for people from rural areas. Schooling improves mental health via education-induced resources, cognitive skills, and social integration - these explain more than 60% of the effects of education on mental health according to the study.

D.2 Heckman et al. (2018)[59] looks at the causal effects of schooling on health, smoking, depression, self-esteem, incarceration, voting, welfare receipt, and trust. They estimate their model on a sample of males extracted from the National Longitudinal Survey of Youth. They find strong average causal effects of education on reducing smoking, and beneficial causal effects on health for high school graduates. The non-market returns to high school are similar across people of different abilities, but the returns to college are higher for low-ability people. They find that college graduation decreases welfare use, lowers depression, and raises self-esteem more for low ability individuals than high ability individuals.

D.3 Galama et al. (2023)[60] review the causal effect of education on smoking and obesity - two major causes of illness and mortality, and both negatively correlated with education. They find (1) no evidence that education affects obesity, (2) education only affects smoking when a schooling reform changes the education track or peer group of the individuals, not simply when schooling becomes longer. Education affects mortality in some contexts but not in others. The effect depends on (i) gender; (ii) the labour market returns to education; (iii) the quality of education; and (iv) whether education affects the quality of the peers of the individuals.

D.4 Pradhan et al. (2018)[61] examine how increases in the average years of schooling and in schooling quality affect under-five mortality, adult female mortality, adult male mortality, and fertility. The

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58 Jiang, W., Lu, Y., & Xie, H. (2020). Education and mental health: Evidence and mechanisms. *Journal of Economic Behavior & Organization, 180*, 407-437.

59 Heckman, J. J., Humphries, J. E., & Veramendi, G. (2018). Returns to Education: The Causal Effects of Education on Earnings, Health, and Smoking. *The Journal of Political Economy, 126*(Suppl 1), 197–246.

60 Galama, T. J., Lleras-Muney, A., & van Kippersluis, H. (2023). The Effect of Education on Health and Mortality: A Review of Experimental and Quasi-Experimental Evidence. *Oxford Research Encyclopedia of Economics and Finance*, forthcoming. National Bureau of Economic Research. (No. w24225)

61 Pradhan, E., Suzuki, E. M., Martínez, S., Schäferhoff, M., & Jamison, D. T. (2018). The Effects of Education Quantity and Quality on Child and Adult Mortality: Their Magnitude and Their Value. In D. A. P. Bundy, N. de Silva, S. Horton, D. T. Jamison, & G. C. Patton (Eds.), *Optimizing Education Outcomes: High-Return Investments in School Health for Increased Participation and Learning* (pp. 211-227).

authors augment the traditional rate of return analysis of education with its health effects. The data comes from 92 low- and middle-income countries at 5-year intervals between 1970 and 2010. Pradhan et al. find that education quantity and quality both reduce all measures of mortality and fertility, and that the health-inclusive social rate of return of one additional year of schooling is 1.5 times the standard social rate of return (which omits health benefits). The health-inclusive social rate of return is very close to the private rate of return (5% in upper-middle-income countries, greater in poorer countries).

D.5 Gathmann et al. 2015[62] find a strong statistical relationship between health, health behaviour, and education. They use 18 European compulsory schooling reforms over the 20th century to estimate the average mortality effect. They find that increasing the length of compulsory schooling is associated with small reductions in mortality among men, but no significant reductions for women. For men, the risk of dying between ages 18-38 is reduced by 2.9%, and similarly for the 30-50 range, but women's mortality is not affected at any age. The authors propose the explanations that education may increase the benefit of health inputs like doctor visits,[63] and education may reduce behaviours like smoking, drinking, and unhealthy eating. This could be because schools teach the importance of healthy behaviours, or that educated people are better at gathering health information.[64] Education raises income, which allows people to buy healthier food options, live in better environments, or purchase better insurance or healthcare.[65] Correlation does not imply a causal link between education and health. Unobserved social or genetic factors may contribute to both good health and better education. The correlation could also be explained by reverse causation if unhealthy people obtain less education.

D.6 Kotschy and Sunde (2018)[66] investigate the effect of population ageing and changes in the educational composition of the population on macroeconomic performance based on an extended empirical development accounting model. Using data from a cross-country panel of over 130 countries from 1950-2010, they find that population ageing has a strong negative effect on output. This is partly offset by the positive effect of higher human capital. To fully offset ageing with education, substantial increases in the education of young people are needed, based on an extended empirical model of development accounting.

Crime mediates the effect of education spending on the economy

D.7 Johnson and Jackson (2019)[67] find that investment in primary education for poor children reduced their likelihood of subsequent incarceration. The education improvement program Head Start complemented the spending on school education.

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62 Gathmann, C., Jürges, H., & Reinhold, S. (2015). Compulsory schooling reforms, education and mortality in twentieth-century Europe. *Social Science & Medicine, 127*, 74-82.

63 Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy, 80*(2), 223-255.

64 Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behavior by education. *Journal of Health Economics, 29*, 1-28. and Rosenzweig, M. R., & Schulz, T. P. (1981). Education and household production of child health. In *Proceedings of the American Statistical Association (Social Statistics Section)* (pp. 382-387).

65 Lochner, L. (2012). Nonproduction benefits of education: Crime, health, and good citizenship. In E. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the Economics of Education, Vol. 4* (pp. 4-29). Elsevier Science, North Holland.

66 Kotschy, R., & Sunde, U. (2018). Can education compensate the effect of population ageing on macroeconomic performance? *Economic Policy, 33*(96), 587-634.

67 Johnson, R. C., & Jackson, C. K. (2019). Reducing inequality through dynamic complementarity: Evidence from Head Start and public school spending. *American Economic Journal: Economic Policy, 11*(4), 310-349.

D.8 The World Bank (2018) argues that schooling reduces most types of crime committed by adults, as well as crime during late adolescence. In the UK, among 16- and 17-year-olds, school dropouts are three times more likely to commit crimes than those who have stayed in school. This gap persists until their early 20s. Also, completing high school makes youth less likely to commit crimes.

D.9 Groot and van den Brink (2007)[68] distinguish blue-collar crime (theft from a house or car, vandalism) and white-collar crime (tax fraud, insurance fraud, and social security fraud). The authors estimate a model with data from the Netherlands and find that the effect of education on crime depends on the type of crime. An extra year of education reduces the probability of participating in blue-collar crimes by 0.2% but increases the probability of tax fraud by 0.4% points. The benefit from the reduction in blue-collar crime outweighs the cost from the increase in white-collar crime. The authors estimated the net savings of an increase in the average level of education by one year to be 578 million euros in the Netherlands.

Student performance in exams mediates the effect of education spending on the economy

D.10 Adnot et al. (2017)[69] used panel data analysis to study the impact of teacher quality and turnover on student performance in the US District of Columbia (DC) public schools. In DC, teachers are evaluated on multiple measures and scored between 100 and 400. High performers obtain a $25,000 bonus and a permanent $27,000 increase to base pay. Low performers are dismissed if they stay in this classification for long. Adnot et al. found that teacher turnover had an overall positive effect on student achievement in math and in reading. The effect was concentrated in high-poverty schools and differed significantly across low- and high-performing teachers. More than 90 percent of the turnover of low-performing teachers occurs in high-poverty schools.

D.11 Britton and Propper (2015)[70] studied the impact of teacher salaries on school performance in England using data on over 3,000 schools, with over 200,000 teachers who educate half a million children per year. They regressed the test scores of the students on the wage gap, which is the difference between the average local wage and the wage of the teachers in the school in question. The average local wage is the 5-year average male wage in all Local Authorities whose headquarters are within 30 km around the school. The test scores that Britton and Propper used are the average examination scores in subjects such as Mathematics, English language, English literature, Science subjects, and History at school leaving age (Key Stage 4). The authors controlled for the average examination score of the students prior to secondary school entry (Key Stage 2). The authors checked the robustness of the results using other measures of school productivity, such as the proportion of pupils that obtained five General Certificates of Secondary Education (GCSE) at grades A*-C or better. They found that a 10% increase in the wage gap was associated with a reduction of 1 GCSE point per pupil. The effect occurred in regions where the wage of teachers was statistically significantly below the local labour market wage. Where the gap was insignificant, no effects were found. The effects became stronger when focussing only on community schools run by local authorities.

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68 Groot, W., & Maassen van den Brink, H. (2010). The effects of education on crime. *Applied Economics, 42*(3), 279-289.

69 Adnot, M., Dee, T., Katz, V., & Wyckoff, J. (2017). Teacher turnover, teacher quality, and student achievement in DCPS. *Educational Evaluation and Policy Analysis, 39*(1), 54-76.

70 Britton, J., & Propper, C. (2016). Teacher pay and school productivity: Exploiting wage regulation. *Journal of Public Economics, 133*, 75-89.

Other mediating variables for the effect of education on the economy

D.12 The World Bank (2017)[71] finds that people with more education consistently participate more in political activities than those with less education. The reasons are that education increases awareness and understanding of political issues, fosters the socialisation needed for effective political activity, and increases civic skills. Evidence from a variety of settings shows that this relationship is causal.

D.13 Delaney and Devereux (2017)[72] estimates the effect of an additional year of education on earnings variability. They study the impact of the 1972 change in compulsory schooling age in the UK, which raised the minimum school leaving age from 15 to 16. Focusing on males born between 1947 and 1967, the authors find that an additional year of education leads to a lower variability of earnings for those below the age of 40 but find no clear benefits for older males. In addition, they find that the probability of receiving a pay cut decreases by 3.5 percentage points for each additional year of schooling.

D.14 Biasi et al. (2021)[73] review the evidence on the relationship between education and innovation. They conclude that:

a. Investing more in basic skills ensures that innovators can use their talents fully.

b. Decentralising access to universities and increasing public university investment generates large increases in innovation.

c. Technology can lower the cost of education and therefore improve the returns to education.

D.15 Clarke et al. (2022)[74] identify the common elements in evidence-based early education programs. They point out that UK evidence has consistently shown that early childhood education has a significant impact on children's outcomes. The Effective Pre-school, Primary and Secondary Education Project – a longitudinal study on 2,800 children in England between 1997 and 2014 – revealed that children who attended pre-school had better attainment in language, pre-reading and early number concepts at age 5 than students who did not attend pre-school, controlling for the influence of background characteristics. Attendance at a high or medium-quality pre-school predicted better science grades and socio-emotional outcomes at age 14 (key stage 3), and a higher total GCSE score at age 16 (key stage 4).

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71 World Bank. (2017). *World Development Report 2018: Learning to Realize Education's Promise*. The World Bank.

72 Delaney, J. M., & Devereux, P. J. (2019). More education, less volatility? The effect of education on earnings volatility over the life cycle. *Journal of Labor Economics, 37*(1), 101-137.

73 Biasi, B., Deming, D. J., & Moser, P. (2021). Education and innovation (No. w28544). National Bureau of Economic Research.

74 Clarke, A., Baker, S., Ghiara, V., Burridge, H., Davie, P., Eberhart, J., ... Jackson, A. (2022). *Common Elements: An Innovative Approach to Improving Children's Outcomes in Early Childhood Education*. Early Intervention Foundation.

Locations

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