Cost and value ratios of operating rebuilt English Secondary Schools

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Abstract:

The relative cost ratios of facility construction and operations, and the value generated from building use have been much debated in recent years. Relative values of these ratios are likely different between alternative facility types. Empirical analyses of ratio estimates are presented for English secondary schools over recent years. Findings challenge established views of the relative cost ratios of 1 (construction), 5 (facility management) to 200 (operations or staff), suggesting the ratios are actually 1/1/5 respectively. The study also estimates the value of investing in schools in terms of improved outcomes, applying educational attainment data for rebuilt schools. These are converted into monetary values using wage uplift indicators. This produces estimates of expected economic benefits (increased productivity and output) and benefits to government via future tax receipts (financial return). Findings suggest the present value of future tax revenues alone do justify investing in school rebuilding. Average economic returns are positive but highly variable, with high dispersion in expected benefits. These benefits are positive only in half the rebuilt schools. Results will help inform allocation of public resources in schools, while also assisting management of the growing independent and semi-autonomous school estate.

Keywords:

Schools, whole life cost, cost benefit analysis, building evaluation, human capital.

Introduction

The whole-life cost ratio of 1 Construction /5 Facility Management /200 Operations staff proposed by many (e.g. Constructing Excellence, 2004) as a rule of thumb, first put forward in a paper presented at the Royal Academy of Engineering in 1998 (Evans et al., 1998), has been shown to be fundamentally misleading both as general benchmark, and for the building type for which it was first proposed, London offices (Ive, 2006). The impacts of blindly accepting such an inaccurate 'rule of thumb' are two fold. First, to misestimate the importance of front-end aspects within the control of clients, designers and builders, namely the level of construction cost (C), and of facility management costs (F) to operators and users, relative to operational staffing costs, (S). Secondly, since it is usually part of the claim of the proponents of 1 /5 /200 that the value delivered from a new building will exceed its total costs (as it were, 'exceed 206') it also misleads regarding the size of both C and F relative to a building project's benefits or value (V).

The role of good quality school buildings in determining the outcomes of children's education was asserted as the rationale for the England and Wales Building Schools for the Future (BSF) investment programme (DfES[i], 2001a; Education and Skills Committee, 2007; Crace, 2010). What 'good' means in this sense is however yet to be comprehensively understood (Barrett et al., 2013). The investment case for the BSF programme was based on some evidence (PriceWaterhouseCoopers LLP, 2003) of a positive relationship between money spent on rebuilding and improved educational outcomes. With BSF cancelled as of 2010, public investment in the school estate has become more devolved and less co-ordinated, most evident with the controversial Academies and Free Schools policies. The need to continually maintain and, when appropriate, rebuild school buildings remains, whether that responsibility is taken on by central / local government, or, as is increasingly the case, quasi-independent schools. In this new context the variance in returns to investment in school renewal could be especially important in determining investment decisions and so warrants research.

This paper focuses on two themes within the Call for Papers for this special issue of BRI: (1) variance of cost and outcome, and thus in this case the difficulty of predicting returns from a school building initiative at project level; and (2) the lack of clear method in this programme of projects for policy makers to set measurable objectives, predict outcomes and rates of return and assess investment outcomes and rates of return *ex post*. It deals with a situation in which the recent national evidence base on costs and consequences of rebuilding English schools was necessarily thin *ex ante* because few English schools had been rebuilt in the preceding period. Further, a situation in which even the limited potentially available data set was incomplete, unconsolidated and little analysed prior to launch of the rebuilding programme.

This paper uses recent data to provide an empirical insight as to the costs and effects of some recent school rebuilds, attempting to ascertain what the impact of these investments might be on on-going operational cost and on educational outcomes, and to measure rates of return on capital investment. In this paper the term ‘rebuilt’ is used as an all-embracing term for:

a) new building on new site

b) new building on old site

c) major refurbishment[ii]

Factors affecting the uncertain nature of returns to this investment include:

- School-to-school variance in amount of construction expenditure and in the immediate impact on educational performance;
- The uncertain rate at which this impact will persist / decay over time;
- Degree of confidence held in the validity of the assumption that past correlations between crossing the 5+ GCSE[iii] A*-C threshold and highest qualification eventually obtained, and then between marginal increments in level of highest qualification held and lifetime earnings levels will persist into the future.

School-by-school findings are applied in an attempt to estimate what might be the real net present value (NPV) of each separate investment in schools. Benefits are measured as economic benefit, for which enhancement in lifetime earnings per former pupil, multiplied by the increment in number of pupils achieving 5+ A*-C GCSEs, is used as a proxy for enhanced productivity and output, and such increased. This increase in national output is assumed to be the appropriate measure of economic benefit from investing in education. Further, a financial perspective is considered for the returns to the government as investor in terms of increased tax receipts resulting from those higher earnings.

Theoretical framework and literature review

Two literatures and theoretical frameworks are central to this paper. The first concerns the returns to investing in rebuilding schools. The second concerns the whole life cost approach to buildings, and the average cost structure or average ratios between elements of whole life cost.

Investing in rebuilding schools

Out of previous research (PwC, 2003, Wing Yin, 2008, Rintala, 2008, 2009, 2010; Durbin and Yeshanew, 2010; Williams et al., 2014) a method has developed for measuring the impact of rebuilding schools on educational results. Durbin and Yeshanew (2010) attempted to compare average levels of exam attainment after rebuilding in rebuilt (BSF) schools with those in non-rebuilt schools. The problem with this approach is that schools were selected for inclusion in the early rounds of BSF precisely because the prior levels of attainment of these schools were relatively low. Adjusting for pupils prior attainment (at primary school) fails to deal with this problem, and leaves the finding that impact on attainment appears, using this method, to be negative. However, one recent study, involving the present authors, found the average effect of rebuilding on educational performance (as measured by the annual rate of improvement relative to national average in the proportion of pupils obtaining 5+ A*-C GCSEs) in the few years immediately following rebuilding to be statistically significant and positive (Rintala, 2010).

The method developed in this earlier work to measure impact on performance involved, first, establishing the national average rate of improvement in GCSE results. This was then taken as a moving benchmark, with the implication that it was the rate of improvement that would be expected of a large sample of schools in the absence of a capital investment intervention. Actual improvement in the sample of rebuilt schools was then measured relative to this national rate (for each school in each year performance was measured as ‘x’ percentage points above or below the national average for that year, where what was measured in percentage points was the proportion of all pupils, nationally or in the school, achieving 5+ A*-C GCSEs). For each school, the act of rebuilding was attributed to the single most appropriate year. Change in GCSE performance was then measured for 3 years before and 3 years after the year of renewal. The test for positive effect was whether the sample moving average performance in the post-renewal period was statistically significantly higher than in the pre-renewal period. This test was passed in the sub-sample of rebuilt schools (68 schools) though not in the sub-sample of refurbished schools (83 schools). The average annual rate of improvement relative to benchmark in 151 renewed schools was found to be 1.86 percentage points over the period and thus 0.46 percentage points per annum over in effect 4 years (the two moving averages being anchored respectively on 2 years before and 2 years after the year of renewal). All of the secondary schools in this earlier study were rebuilt in or prior to 2006 (whereas almost all those rebuilt in the data analysed in the present paper were rebuilt after 2006). If rebuilding had no effect on attainment (null hypothesis), then the measured annual average rate of improvement relative to benchmark in the sample of rebuilt schools would reflect only noise, or that the sample was not a random one (since the change in the benchmark tells us the mean rate of improvement to be expected in any large random sample of schools). Can this null hypothesis be rejected? The problem is that we know that the average attainment of the sample of rebuilt schools started below the national average and there may be some general regression to the mean at work over time in the relative performance of schools. The magnitude of any educational attainment effect of rebuilding is likely to be, at least in part, dependent on the school's position within the initial population of not-rebuilt schools. For example, there is likely to be some diminishing return to the positive effect on educational attainment from rebuilding when rebuilding schools starting at progressively higher levels relative to the national average.

In this earlier research no data were analysed measuring construction cost, and thus no measure of rate of return on investment could be attempted. Nor was it possible to see whether amount of construction expenditure correlated with amount of performance improvement, other than by the crude division of the sample into 'rebuilt' versus 'refurbished'. This found, unlike the rebuilt schools, no statistically significant improvement in performance in refurbished schools, in which, presumably, construction expenditure had been on average smaller. Incorporation of cost data, firstly construction cost but also facility and staffing cost, is the obvious requirement to take this approach a crucial step further.

Both this earlier research and the present paper use 5+ A*-C GCSEs as the sole measure of educational performance. The primary rationale for this is that this was the performance measure favoured by the government of the day, and therefore the presumed favoured objective and measure of impact of the BSF programme. The secondary reason is the supporting evidence for the idea that this level of

GCSE performance constitutes an important ‘hurdle’ for the life chances and future earnings of pupils, since there is observed to be a huge difference in the probabilities of going on to achieve degree level qualification between those who do, and those who do not jump over this hurdle. The third reason is its availability as a measure for each secondary school in the country throughout the period analysed (whereas, for example, no ‘grade point average’ information is published at school level).

The essential feature of this approach is that it involves investigation not of *average* educational performance in rebuilt schools but of the *difference* in performance ‘with’ versus ‘without’ rebuilding.

Whole life cost and average cost structure of building types

The applicability of the second theoretical framework in this study, the principles of whole life cost (WLC) averages for total cost and for cost structure, is limited by the completeness, scope and maturity of available data. Ive (2006) proposed a method for calculating whole-life economic cost for a project, divided this into initial construction project cost (C), facility management cost (F), and final service provision (business operation) cost (S); and reported on observed whole-life discounted and undiscounted ratios of C to F to S, for London commercial offices. It found the undiscounted ratios to be roughly 1/3/30, assuming a 20-year economic life for the building; and 1/1.5/15 if future costs were discounted at a 7% real cost-of-capital discount rate. It concluded for this project type that construction costs were much more substantial relative to facility management costs and, especially, relative to business occupancy costs, than had been suggested in an influential earlier paper (Evans et al, 1998). Other studies, such as (Hughes et al., 2004), have offered strong support for and agreement with the finding that the 1/5/200 ratio is profoundly misleading.

(Insert Table 1 & 2 here)

The current paper accepts the suggestion that "this common framework can be applied to analyse data and calculate mean ratios for buildings of any function" (Ive, 2006), and applies similar methods to data for English secondary comprehensive schools. Much resource has recently been expended in England on rebuilding the schools estate, most especially secondary schools via BSF. To estimate expected economic returns *ex ante* and observe *ex post* actual returns on this investment of resource, knowledge of these whole-life ratios in English schools is potentially helpful to policy makers considering the merits of future potential investment.

This paper adopts and adapts to schools the whole life cost and value approach to offices in Ive (2006). It starts by defining a 'project' whose life begins with investment in construction of a rebuilt asset ('building', C), continues through the period of operation to provide ancillary services and require intermediate consumption (facility management, F) and operating resources (mainly, staff, S). The final product / service leads to valuable outcomes (V), adding to the total value of final consumption or to the stocks of capital, including human capital (see Table 3). The project ends either when the flow of output ends, or when the built asset is abandoned, and / or redirected to a new use, and / or replaced, whichever comes sooner.

This approach makes ‘project life’ equivalent with the economic life of the building in its originally conceived use, except that if some of the output takes the form of additions to stocks of human capital (as with schools), then the flow of benefits, V, may continue after the end of use of the building, until retirement of the last former pupils. Such a project has a characteristic profile of flows of resource costs and economic benefits (commonly, but only sometimes accurately, called the project’s cash flows). The initial outflow is on C, then operating outflows on F and S, and inflows of V, such that within the operating period annual net inflows are positive ($V > \{F+S\}$), allowing a return on investment in C, if the discounted value of these net operating period inflows exceeds the present value of the initial construction outflow.

> “Resource costs should be counted when they arise, but regardless of who incurs them. Resource costs are the quantity of scarce resources (with alternative uses) used in the project, multiplied by the average opportunity cost of those resources…The key distinction is between resource costs and financing costs…The resource costs…of a project should be invariant to its method of financing. The latter…is subsumed under the discount rate (…at which the project’s future resource cash flows will be discounted to present value)”

(Ive, 2006).

Project economic benefits can either consist of revenues from a saleable output or an estimation of the economic value of project output. The latter applies either if output prices diverge from economic value, or if part or all of the output is not produced for sale.

The project can either be compared with the situation in which, without it, no flow of final outputs will occur, but also no costs of F or S will be incurred, or, with the situation where the 'do-nothing' comparator involves continuing to produce outputs using existing, un-modernised assets. In the latter case (which the authors assume to apply to the rebuilt schools) only the *differences* in F, S and V between the 'invest' and 'do nothing' cases need to be considered in the investment appraisal.

In the UK public sector the distinction between what in textbooks are called respectively 'financial' and 'economic' appraisals is known as that between 'resource budgeting' (affordability, actual cash flows of the public sector body; how the project will be funded) and 'appraisal' (total costs and benefits, including externalities, valued at opportunity cost) (HM Treasury, 2011). This paper considers both.

Defining and valuing outcomes of investment in school building

It is argued here that the final outcome of a school project is not a flow of consumption goods or services, but an enhanced stock of 'human capital' (Becker, 1962; Schultz, 1971). Therefore a school project is analogous to a project producing as its output an annual flow of fixed capital equipment. If produced capital (of any variety) is not sold at a market price by its producer, then each unit of this output in turn needs to be valued based on the discounted value of its expected future net returns. If labour market wage / salary differentials allow the recipient of an investment in human capital to capture for themselves, and fully, the returns from that investment, then the excess of salary ‘with’ that investment in their learning over salary as it would have been ‘without’ it may be used to measure the ‘market value of education’. Of course, this narrow definition cannot fully capture individual enrichment as a quality of life issue, as socialisation and as contributing to 'good citizenship'.

In practice, impatience to estimate returns, and the absence of a ‘futures market’ in the value of human capital, means that potential ‘investors’ in education look for a measure of the output that will be available more quickly than the outcome increment to lifetime earnings of students. The proxy measure most commonly used is enhancement of examination results. This seems to mistake the signal (exam result) for the thing thus imperfectly signalled (knowledge, learning, development). However, it may be true that ex-students will successfully use their examination results to signal the latter non-observed attributes to others (Akerlof, 1970).

The Green Book (HM Treasury, p14, 2011), provides a range of examples of the difference between outputs and outcomes, as illustrated in Table 3.

(Insert Table 3 here)

At the time of the BSF programme, the measure of exam results favoured by government was the proportion of pupils in a school obtaining at least 5 GCSE grades A*-C. To use this as the only measure of output is to assume in effect that schools are 'gaming the system' by which they are held to account by government, and that change in pupil attainment is concentrated upon 'marginal cases' of pupils lifted over this particular threshold, because this is where schools focus their marginal efforts. A less cynical view would be that an increase in the 5+ A*-C proportion is merely an imperfect signal of a general average improvement in attainment across all pupils (including, for example, the turning of C grade results into A and B grades, and of Bs into As and As into A*s). If this is the case, then using the 5+ A*-Cs proportion to measure the improvement in human capital will produce a serious under-estimate.

However, not only is there no available school-by-school data on weighted average grade results, but also the 'threshold' approach to increments in qualifications achieved has a certain appeal and logic. Crossing a threshold opens up an option to move on to the next level of education, an option that pupils may or may not take. The greatest returns in terms of increments to lifetime earnings come for those who cross a succession of thresholds (at age 16 and 18), take up the resulting options, and end with university honours degrees or above (level 4+ qualifications). Since it is known from recent studies (HEFCE, 2010; OECD, 2011) what proportion of the age cohort nationally end with university degrees, and what proportion end with level 3 (A levels or their vocational or other equivalent) as their highest qualification, and what proportion end with level 2 (5+

A*-C GCSE or vocational equivalents) as their highest qualification, it can then be assumed that the extra pupils crossing the level 2 threshold are subsequently 'typical' of the average of all pupils crossing that threshold in order to estimate final outcomes.

Of every 100 school pupils, *x* fail to cross the level 2 threshold. Of the 100 – *x* crossing the level 2 threshold, *y* obtain no further qualification. Of the 100 – *x* – *y* who proceed to level 3, z stop at level 3, leaving 100 – *x* – *y* – *z* to proceed to level 4.

National qualification statistics enable a direct observation of the following:

- 100 – *x* – *y* – *z*: numbers and proportion of age group obtaining degrees (31.9%, OECD, 2011)
- 100 – *x* – *y*: numbers and proportion of the age group obtaining A levels or equivalent (37.2%, DfE, 2012)
- 100 – *x*: numbers and proportion of the age group obtaining 5+ A*-C GCSEs (62.8%, DfE, 2013)

From these observed proportions, the values of *y* (25.6%) and *z* (5.3%) can be deduced. It can then be assumed that for each extra 62.8 pupils crossing the level 2 threshold (see above), *25.6* stop there (62.8 – 37.2), *5.3* go on to A levels but then stop there (37.2 – 31.9), and *31.9* go on to get degrees. These can be converted into percentages summing to 100, and thus into weights. These weights therefore are 0.408 (W_2 – see Equation 1 below), 0.084 (W_3) and 0.508 (W_4).

Lifetime earning increments for each level of qualification achieved are available, produced by comparing earnings of each level of highest qualification with earnings of those with only level 1 qualifications (Walker and Zhu, 2013). The proportions 25.6/62.8 (W_2), 5.3/62.8 (W_3) and 31.9/62.8 (W_4) then become the 3 'weights' used, to obtained a weighted average uplift in the lifetime earnings of each marginal 100, as compared to what they would have been had all 100 obtained only level 1 qualifications.

Assumptions and estimation – problems in the method for measuring and valuing outcomes

Table 4 below summarises the reasons why estimations of outcome values might differ from those that actually occur. These are broken down by whether they might lead to over or under estimation, as well as their source in terms of either being purely the consequence of fundamental and unavoidable Keynesian uncertainty (see quote below), those for which better data would assist, and those that are the consequence of the particular method used here, of valuing the effect of pupils crossing a qualification threshold. Further discussion of these important considerations from a policy design perspective is included in Appendix 1.

(INSERT TABLE 4)

Investment considerations

Compared with most physical investment, the returns expected from renewing schools continue exceptionally far into the future. If effects on pupil GCSE attainment persist for 20 years, and those pupils on leaving school then work for 40 years, then the effects on productivity, UK gross domestic product (GDP), output, and earnings will be supposed to continue for 60 years post-investment.

Thus Keynes' dictum applies with particular force, especially if schools no longer operate as monopolies but face competition from other schools:

> "Our knowledge of the factors which will govern the yield of an investment some years hence is usually very slight and often negligible. If we speak frankly, we have to admit that our basis of knowledge for estimating the yield ten years hence of a railway, a copper mine…the goodwill of a patent medicine…a building in the City of London amounts to very little and sometimes to nothing…. (and)…if we exclude the exploitation of natural resources and monopolies, it is probable that the actual average results of investments, even during periods of progress and prosperity, have disappointed the hopes which prompted them…If human nature felt no temptation to take a chance, no satisfaction (profit apart) in constructing…there might not be much investment merely as a result of cold calculation".
>
> (Keynes, Chapter 12, 1936)

To this, if the 'public choice theory' observation is added that in the case of the schools programme, those making the decision to invest are not investing and risking their own money, but that of the taxpayers, it might then not be surprising that there does not appear to exist any clear basis for confident calculation of returns to investment in schools, but that such investment nonetheless occurs.

England's school rebuilding programme

The commitment to increased spending on school buildings, which was in 2004 to become BSF, began in a small way. In the 1998 Budget, £90 million of capital funding was allocated: £35 million to remove the outside toilets still being used at 600 schools; £15 million to allow up to 500 schools to replace or improve their inefficient heating systems; and £40 million to provide extra classrooms to help the Government to deliver on its pledge that no child of 5, 6 or 7 should be taught in a class of more than 30 children. This was presented largely as the Government intending to address a backlog of maintenance and repairs in the schools sector, although the Department for Education and Employment (DfEE) did note that the improvements to heating systems would reduce fuel used and assist in reducing CO_2 emissions. In 1999 and 2000, various further announcements were made in what was known as the New Deal for Schools, all of which focused on the repairs backlog and the replacement of temporary classrooms (House of Commons, 2007, pg. 10). Up to this point, objectives were therefore more in terms of assuring a 'decent' minimum standard of facilities for all, rather than obtaining economic benefits.

The capital programme took on a different dimension later in 2000. In September, the Department announced capital expenditure of £7.8 billion for the years 2001-02 to 2003- 04. This funding was to be used to completely transform or replace 650 schools, both primary and secondary. By this time the Government had committed approximately £10 billion to be spent on school repairs and rebuilding since coming into office.

In January 2001, for the first time, the then Secretary of State also drew attention to the 'performance' case (DfES, 2001) referring to research undertaken by

PricewaterhouseCoopers (PwC, 2001). Later empirical work by PwC further supported the claim that capital investment is associated with educational attainment (PwC, 2003). The House of Commons Education Skill Committee later referred back to Department's belief that:

> "Capital investment impacts positively on pupil performance, particularly in terms of improving teacher morale and motivating pupils". The research referred to actually said "[...] on balance, the research suggests that, where there are statistically significant effects of capital on performance, these are positive."
>
> (Education and Skills Committee, 2007)

In a speech by David Miliband, then Minister of State for School Standards, in October 2002, the redevelopment of schools was put forward explicitly as a means of improving educational standards (House of Commons, 2007, pg. 11). Improvement of educational performance had become the main aim of and justification for the rebuilding programme. However, the criteria by which improved performance outcomes should be measured, to allow *ex ante* appraisal and *ex post* evaluation of the programme, were never made explicit. Whilst the government of the time had many goals for education, including those embodied in *Every Child Matters: Change for Children* (HM Government, 2003) of promoting and securing child health, safety, attendance at school, and behavior, as well as economic well-being through employment, in this paper the focus is therefore solely upon the last of these policy goals.

In 2004 BSF was launched. Building Schools for the Future was an ambitious programme designed to rebuild or refurbish all secondary schools in England over 15 years at a cost of £45 billion, with local authorities participating in a series of 15 'waves'. As well as being a project to improve radically the fabric of school buildings and provide massive investment in information and communication technologies (ICT), it was intended that it would transform the educational experiences of pupils (House of Commons, 2007, pg. 4). The Commons' Select Committee stated: "Investment in the three decades before BSF was announced had been minimal, meaning that there were very few architects, procurement experts or head teachers in the system with experience to build on. Even the research base has little to tell us about how we should design sustainable learning environments for the future" (House of Commons, 2007, pg. 12).

The original intention of the BSF programme seems to have been to have a clear split between *new build* schools which would be created and maintained under PFI contracts, and *refurbished* schools which would be the subject of DBOM contracts (Design, Build, Operate and Maintain). In most cases DBOM became just 'Design and Build', with or without separate facilities management (FM) contracts. In addition, many of the schools originally expected to be procured under PFI became conventional capital projects using Design and Build contracts.

What is an appropriate discount rate for schools projects?

The Treasury *Green Book* (only mandatory for central government departments and agencies, but recommended to local authorities and other public bodies) lays down 3.5% real discount rate to reflect social time preference (Table 5); with additional adjustment to the *cash flows* rather than to the discount rate to offset optimism bias in forecasts of cash flows. It also lays down that:

- “The valuation of costs or benefits should be expressed in ‘real terms’ or ‘constant prices’ (i.e. at ‘today’s’ general price level), as opposed to ‘nominal terms’ or ‘current prices’.” (section 5.42).
- “Where particular prices are expected to increase at significantly higher or lower rate than general inflation, this relative price change should be calculated.”
- “For projects with very long-term impacts, over thirty years, a declining schedule of discount rates should be used rather than the standard discount rate.” (section 5.51). It cites Weitzman (1998) and Gollier (2002) and their findings on the effect of uncertainty as its authorities for this declining rate.

(Insert Table 5 here)

The paper applies Green Book guidance on discount rate, except in respect of the declining long-term rate. Here, because the change would only be from 3.5% to 3% for years 30 to 60, it was simpler to apply 3.5% throughout.

Research method

The following section details how the cost and value ratios and estimated rates of return on investment presented have been calculated. Much of the work required for their calculation is in bringing different datasets together, as well as cleaning, indexing and normalising data. Estimates from periods of time before and after capital works are used to generate future cash flows for present value analysis. There follow separate sections on the processes for calculation of the concepts of C, F, S and V (and their normalised *per pupil capacity* equivalents *c*, *f*, *s* and *v*).

Data sources

The analysis focuses on a core sample of schools for which there is credible capital expenditure sums (C), as well as sub-samples for the other concepts that are limited by availability of data for expenditures and educational outcomes. A summary list of the datasets used and the information derived from each is given in Table 6.

(Insert Table 6 here)

Edubase

Since data per school has to be analysed across datasets, and the most comparable data is for 2012 and earlier, it was decided to take the population of schools from an early 2012 Edubase extract. Another key bit of information provided within the Edubase dataset is *pupil capacity*. This is used as the main normaliser for headline expenditures, in part because it is widely reported at the school level. There will be variance in the capacity utilisation between schools (*pupils on roll* / *pupil capacity*). This will be a source of some variance in expenditures, but is unlikely to be so significant as to affect the overall orders of magnitude for the key ratios. A simple analysis of capacity utilisation within a sub-sample of schools is provided.

School Building Survey (SBS)

The latest available survey of school buildings is from 2011. However, the reported actual and planned capital expenditure data is only included in the 2009 survey. Given that at least 3 years post rebuild data (cost and educational outcomes) is required to estimate much of the associated effects of rebuilding, the use of the 2009 survey is appropriate in identifying the relevant schools. Almost all of the schools analysed received their capital investment between the years 2006 and 2011 with the mode in 2010 (see Figure 1). The benefit of the capital expenditure data provided in this data source is that it allows a move from a discrete analysis (i.e. looking at whether a school has received rebuilding works (Rintala, 2010)) to a continuous analysis of the resource cost expended on such works (reported as an '*estimated or actual cost of works'*). The impending publication of a larger, more comprehensive survey of the schools estate will allow for more advanced and insightful analysis (see recommendations for further research).

Consistent Financial Reporting (CFR)

CFR reports expenditures for some elements of capital budgets. Previous investigation of these found them to be wholly unreliable. This is likely the result of this dataset pertaining only to school level expenditure, and as local government authorities in this period typically delivered the vast majority of capital investment for English schools, it is not surprising this data fails to properly account for significant rebuilding. Use of CFR data for OPEX analysis has previously proved insightful (Edkins et al., 2011), so long as adequate checks are made to ensure complete provision of data by each included school in the range of expenditure categories. CFR data was collated to cover a period from 2002/03 to 2012/13.

Educational attainment tables

The present paper uses school-specific changes in attainment to calculate the average overall change. These changes in attainment are then multiplied by estimates of the future net lifetime wage uplifts, resulting from educational attainment, to produce a measure of the economic benefit associated with rebuilding works.

Display Energy Certificates (DEC)

All buildings occupied by public authorities are now subject to surveys of their sustainability characteristics. Some of the schools within the samples have been surveyed to produce these certifications (from 2008 – 2012), which usefully provide data on the Total Useable Floor Area (TUFA). This is used to help provide a sense of the variability in the ratio of *pupils on roll* to *usable floor space*. TUFA is not used consistently as a normaliser as the coverage of this data for the schools being considered is not sufficient to maintain large sample sizes. This will improve in the coming years as more of the school estate is subject to these surveys.

Collation of data between sources

To assist further research with the range of datasets, the best method of dealing with issues arising when collating across them is considered. Within the datasets, schools have two unique identifiers, their unique reference number (URN) and their local authority / establishment number (LAESTAB). LAESTAB was found to result in superior matching between datasets and was generally preferred.

Sampling and data preparation

1. A complete list of just under 69,000 educational establishments in England and Wales was obtained from Edubase. The number of secondary schools within the dataset was 5,347. The dataset was filtered by admission type to include only comprehensives. This left 4,159 schools[iv]. A large number of schools not reporting admission type, including schools under Welsh administrations, are excluded.

2. 658 schools were seemingly repeated within this population. These were removed to leave 3501. A further 336 were recorded as having closed before September 2002. These were also removed to leave a population of 3,165 secondary comprehensive schools. There will remain some schools that have since closed, but these are left in as they may have usable interim data.

3. These 3,165 schools were then cross-matched with the SBS 2009 (and 2011)[v]. This identified which schools had received (or were soon due) significant capital works amounting to 'rebuilding' between financial years 1992/93 and 2011/12. This isolated some 556 schools.

4. These 556 schools formed the core sample of 'rebuilt' schools, from which further sub-samples were taken driven by availability of additional data.

Variables

Capital Expenditure (CAPEX): variable C

The estimates for cost of works come from SBS 2009 as the answer to the question 'Actual or estimated total cost of works at school?'. Of the 556 schools identified as renewed using the SBS 2009, only 266 reported a sum for works done, or soon to be done. Working with this data revealed some worrying issues even when normalised by some indicator of school size. In an attempt to clean the data, an estimated expected CAPEX was calculated for each school, to be compared with that reported. The method for this estimation is given in the Table 7.

(Insert Table 7 here)

This estimated CAPEX per school (the result from Step 2) was then regressed against reported CAPEX to investigate how well they correlated. This analysis revealed a raft of data points far too low to be considered as reasonable sums for significant works. These were identified by use of reasonable lower and upper limits and removed from the samples. This revealed a sub-sample of 166 schools (C:166, of the 266 that reported a sum) that had credible sums for CAPEX, which were taken forward for further analysis. To normalise the CAPEX data, pupil capacity was used. TUFA may have been more appropriate but is available for less than 50% of these 166 schools at present.

Operating expenditure (OPEX): variables F and S

For the 166 schools with credible CAPEX the associated expenditure data for each school was retrieved in accordance with the process below:

The Consistent Financial Reporting (CFR) dataset for financial years 2002/03 to 20012/13 was obtained from the DfE. There is thus a maximum of eleven years cost data potentially available for a specific school, if it was renewed before 2002/03; reducing to a minimum of one year following rebuilding if it was renewed in 2011/12.

Facility occupancy costs: F

From the range of available expenditure lines, an occupational cost basket was created. The components of the basket, and corresponding CFR references for clarity, include[vi]:

1. Premises staff (E04);
2. Building maintenance (E12);
3. Grounds maintenance (E13);
4. Cleaning and caretaking (E14);
5. Catering staff (E06);
6. Catering Supplies (E25)
7. Water and sewerage (E15);
8. Energy (E16);
9. Other insurance premiums (E23);
10. Other occupational cost (E18)
11. ICT learning resources (E20)
12. Bought in professional services - (E28);

Expenditures were converted to constant 2009 prices using the Retail Price Index excluding mortgage payments (RPIX) index (Dept. for Business, Innovation and

Skills, 2013). The expenditures for each school were divided by the school's pupil capacity[vii] for normalisation. Data for each school were rearranged into elapsed time from the year the school underwent rebuilding using the date of capital works from the SBS as a point of reference.

The F cost data were sampled separately for each school in elapsed years following rebuilding. A school was only included in the analysis if it had returns for all of the above expenditures. This was an attempt to minimise the possibility of bad reporting between expenditure categories.

Staffing costs: S

The staffing cost variable is sourced from CFR data. The expenditures included to make this variable include the following:

- Teaching Staff (E01);
- Supply teacher staff (E02);
- Education support staff (E03);
- Administration and Clerical staff (E05)

A similar method to that used for F was applied to produce cash flows for S.

Lifespan

For the ratio analyses, three years post construction data for F and S were averaged to produce annual estimates. These were then projected forward to produce 60 years of cash flows representing the asset life for which F and S are relevant. These are then discounted at both 3.5% (social time preference) and 7% (alternative discount rate allowing like for like comparison to commercial offices).

Investment Appraisal

The trend in F and S from before to after rebuilding was then compared to the benchmark trend in F and S for all 3,165 schools in the sample, to calculate ΔF and ΔS associated with rebuilding.

Economic and financial value of outcomes: V & T

The educational impact associated with rebuilding was calculated based on the observed difference in school reported achievement at level 2 (% of students achieving at least 5 A*-C GCSEs, (Dept. for Education, 1998 - 2013) relative to national benchmarks. This was then used to calculate the earnings effects of the change in educational outcomes based on two key concepts. The first is the proportion of students obtaining 5+ A*-C GCSEs going on to higher levels of qualifications (HEFCE, 2010; OECD, 2011) The second is the associated earnings differentials for individuals obtaining those levels of academic qualifications (Garrett et al., 2010, Dickerson et al., 2007). The wage differentials for vocational qualifications are not applied within the model for the analysis below, but are available for future analyses (Jenkins et al., 2007, McIntosh et al., 2009).

For the estimation of future cash flows based on educational outcomes, the 3 years following rebuilding were used to generate the first 3 years of cash flows, with the remaining 57 years (60 years in total) based on an average difference in the first three years after compared to the three years before rebuilding.

Equation 1: Example determination of 'v' cash flow in $t_{n:}$

$$\left\{[SPC \times EA\Delta \times DFR] \times \left[(WU_{lv1-lv2} \times W_2) + (WU_{lv1-lv3} \times W_3) + (WU_{lv1-lv4} + W_4)\right]\right\} + CF_{t-1}$$

SPC = School pupil capacity
$EA\Delta_N$ = Educational outcome change against national average
DFR = Decay function of rebuilding's effect on $EA\Delta_N$
WU_{lvn} = Wage uplift at attainment level *n* relative to level 1 (where *n* is 2, 3 or 4)
W_2, W_3 and W_4 = Proportion of pupils attaining level 2 with attainment at levels 2, 3 and 4 as their highest qualification (see earlier Method section)
CF_{t-1} = Previous period cash flow

The first pair of brackets, that is [ ], gives the number of pupils affected. The content of the second set of brackets gives the estimated average wage uplift per pupil affected.

An assumed 40-year working life of former pupils is used, such that in year t_{41}, the first cohort of students to benefit from the rebuilt asset (t_1) will retire, and hence their contribution to the cash flows becomes zero, and so forth for later cohorts.

The decay of the educational benefit associated with the rebuilding is assumed such that after 20 years of operation, its effect is zero. That is, over years $t_4 - t_{20}$, any change in educational outcomes (and their effect on the cohorts of students graduating from the school) returns to zero on a straight-line basis. The assumed decay of this effect will be a key sensitivity in the determination of V.

These cash flows are again discounted at 3.5% for economic and financial benefit analysis. The financial benefit, T (for tax revenue), to Treasury (as the potential investor facing affordability constraints as well as a choice of investing in a myriad of competing projects) has been estimated by multiplying the economic benefit by a notional tax rate of 0.4 (a rough estimate for longer term income tax, national insurance and VAT).

The resulting values of V and T should be interpreted within the context of the assumptions used within the analysis, given the potential for key determinants to change. Table 8 summarises the final sample sizes and period coverage of the above variables[viii].

<u>(Insert Table 8 here)</u>

Analysis

Before considering the results of the cost ratio and investment appraisal analysis, it might be useful to consider the sample of schools studied. Figure 1 is a time series of the annual reported C and number of schools receiving investment within the C:166 sample. As is clear, the majority of these schools were renewed between 2009 and 2011. Further, the majority of these schools (116) are reported within the SBS as BSF works, with additional schools reported as PFI contracts, which may also additionally be part of the BSF programme. The number of schools identified as part of PFI contracts is insufficient for further detailed analysis of mean and variance by PFI / other procurement route.

<u>(Insert Figure 1 here)</u>

Cost structure

The key findings on average cost ratios, for English secondary schools as a whole, discounted at the Treasury recommended public sector rate of 3.5% real, and over an assumed asset life of 60 years, are that the discounted ratio of F to S is 1/5.5; and for recently rebuilt schools the discounted ratio of C to F to S is 1/0.8/4.5. For like-for-like comparison with London offices, a comparable discount rate of 7% was also applied. Results for this are C 1 to F 0.5 to S 2.5 for schools, to be compared with C 1 to F 1.5 to S 15 for offices.

The much higher ratio of C to S in schools than in offices, the higher ratio of C to F in schools than in offices (1 to 0.5 or 1 to 0.8 in schools, depending on the discount rate used, compared to 1 to 1.5 in offices), and the higher ratio of F to S in schools (1/5 compared to 1/10) all have implications for where and how ‘smarter’ investment in C might pay off in cost savings. This suggests that, as with commercial offices, whilst it is still the less well understood and less predictable relationships between spending on C and consequent savings in S that could be crucial, rather than the more well modelled relationships between spending on C and potential saving on F, the latter could be relatively more important compared to the former in schools than in offices.

The lower ratio of (F + S) / C in schools (5.3/1 when discounted at 3.5%; 3/1 when discounted at 7%) compared to offices (16.5/1) implies that, overall and on average, it will be even ‘harder’ than in offices to design schools projects so that savings on F and S (in rebuilt schools in comparison to non-rebuilt) cover the cost of investing in C, the cost of rebuilding. This is so despite using a longer assumed asset life for schools (60 years) compared to offices (20 years). A subsequent paper will report some findings on this last point.

As can be seen from Table 9, the present value (discounted at 3.5%) of reported c to estimated f and s is, as a stylised representation, 1:1:5 on a per pupil capacity basis, their approximate values being: c = £20k; f = £16k; s = £91k.

(Insert Table 9 here)

The values of f and s (as the PV of future cash flows) of course reduce when discounted at the higher rate of 7%, producing stylized cost ratios of 1:0.5:2.5.

An additional benefit of this analysis is that it yields, in addition to averages, an insight into the variance of these costs about their mean. More information on the variance about average c is presented below, but the standard deviations and means in Table 9 indicate that facility maintenance costs per pupil seem to vary comparatively more between schools than do staffing costs per pupil.

It can be seen from Table 10 below that capacity utilization (in the sample of C:166) has some considerable variability about its mean of 0.87. There are seemingly schools that are over utilized at the upper limit of the distribution (100^{th} percentile = 1.97) and others that are under utilized (10^{th} percentile = 0.61). These are likely the schools driving most of the variance in f.

<u>(Insert Tables 10 and 11 here)</u>

Table 12 below provides average construction cost per Gross Internal floor Area (GIFA) m^2 for BSF schools in 2009 prices. This additional data was obtained from the DfE after the main analysis had been completed. It may therefore provide a useful cross-check on the representativeness of the research sample. Its use in this way is justifiable given the prevalence of BSF schools within our sample. With some interpretation, it can be compared to the sample data above, in Table 10. If the TUFA per pupil on roll average ratio from Table 10 (9.24 m^2) is used as a factor to transform per m^2 costs into a value on a per pupil basis, then the typical capacity utilisation rate can be applied. This provides a rough estimate on a pupil capacity basis. A reasonable average value of construction cost per GIFA m^2 from Table 12 might be £2,400. Multiplying this by 8.62 (weighted mean TUFA per pupil on roll 2012, from Table 10) gives £20,688 cost per pupil on roll. Multiplying this by the average capacity utilisation rate (0.86, from Table 10 above) gives £17,792 as construction cost per unit pupil capacity when estimated from DfE BSF data in Table 12, a figure comparable with that estimated in this current analysis (£19,982, as shown in Table 11)[ix]. There are of course considerable deviations from the averages within the ratios applied, and there is almost certainly some consistent difference, if small, between TUFA and GIFA (net to gross floor area). As shown in Table 12, there are considerable economies of scale in construction costs for school facilities, with a facility between 12,000-14,000 m^2 costing two thirds that of a facility between 0-2,000 m^2 on a per m^2 basis.

(Insert Table 12 here)

By analysing time series of average levels of f and s (lower case being per pupil capacity concepts) over a large sample of secondary comprehensives (n=3,165), an insight is provided into their actual annual cost and their change through time. It can be seen that while the average ratio of f:s of 1:5 remains a valid approximation through time, there is some recent tendency for the exact ratio to rise (that is, for f to increase relative to s). If f expenditure increases at a quicker rate than that on s, the ratio will increase. Compare the rough ratios for 2002/03 to that of 2012/13 indicated in Figure 2. Whereas in 2002/03 f of £500 to s of £2,800 gives a 1:5.6 ratio, 2012/13 f of £700 to s of £3,300 gives a 1:4.7 ratio, i.e. substantially higher relative expenditure on f. The driver in this divergence is the prevalence of years in which f increased more than s. Despite this short period finding, the analysis below uses the assumption that over a long enough period, changes in prices for f and s will be roughly neutral. Although public sector's pay, specifically teachers' pay, has remained considerably below inflation for the years following the global financial crisis, it is assumed that teachers' pay will in time seeing real wage increases, and thus track facility management costs.

(Insert Figure 2 here)

Investment rates of return: from cost structure averages to rebuild / not-rebuild cost and value differences

Beside the calculation of cost ratios presented above, a key intention of this paper is to provide some indication, however imperfect the data and method, of the returns to investing in school buildings. This is in an attempt to inform the future investment policies of those involved in capital expenditure in such facilities. Table 13 shows the equivalent average values of Δc, Δf and Δs resulting from rebuilding. That is the change associated with rebuilding relative to *not*-rebuilding, rather than absolute magnitude. Their sampling and estimation is described in the method section. It is relevant to restate that the estimation of F and S requires additional data to that for C, and as such they represent sub samples of C:166. The observed c above remains as Δc (as c is zero in the case of not-rebuilding), while the PV of Δf and Δs in Table 13 is estimated from data following rebuilding. As can be seen, even with 60 years of estimated cash flows, the difference in f and s relative to the benchmark of non-rebuilt schools is negligible. This suggests that overall, rebuilding has seemingly little discernable impact on ongoing expenditures on f and s in the schools measured. This may be a simplification of the real long-term impact of rebuilding on these expenditures, as this is based on only a few years post-rebuilding data.

Both Δf and Δs are negative (indicating a cost rather than saving), i.e. F and S are slightly higher after renewal than they would have been without renewal. Thus, far from cost savings in F and S resulting following investment in C, they actually increase, albeit only by small amounts.

(Insert Table 13)

As can be seen from Table 13, the overall estimated economic return to investing in schools as measured by expected increases in earnings (a proxy for increased productivity) for those achieving better educational outcomes greatly exceeds the PV of outward cash flows, at the order of 3.4 to 1 (discount rate 3.5%). Even the Exchequer makes an overall net gain on the investment (1.36 to 1).

The reality of this expected long-run return from investment in schools will depend on the actual future in which those gaining level 2 qualifications will live and work. This may turn out to be very different from that assumed in this analysis, but consideration of this point is fundamental to optimal policy design. If policy makers have reason to believe that key assumptions regarding the links between qualifications and lifetime earnings will be different in future than they have been in the recent past, they can take explicit account of this.

However, while these results regarding average return on resources invested may be regarded as justification of the BSF programme, another aspect of the findings (Figure 3 below) may equally be regarded as ammunition for its critics. For they show that almost all the benefits will flow from just one-third of schools included in the programme and thus from less than half of the total expenditure. The average C in the schools in the top percentiles for performance improvement is higher than the average C for all schools in the sample. This is because C tends to be higher in rebuilt than in refurbished schools, and performance impact is significantly greater in the rebuilt schools. Hence the share in total expenditure yielding almost all the benefits is higher than the share in number of rebuilt schools.

The position of the time curve for V per annum for each school evidently depends upon a variable (amount of improvement in school exam results) multiplied by a constant (value put on a unit of improvement). Figure 3 reflects and shows that there was no observed improvement in exam results (deducting national average trends) in the three years post-construction in half of all the rebuilt schools.

(Insert Figure 3 here)

Conclusions

Cost ratios

On average and typically for all schools, at present over their lifetime discounted f (£16k per pupil) is smaller than c (£20k per pupil). Therefore, even if it were claimed (completely implausibly) that a new building could not only generate all its own energy requirement but eliminate F altogether, that on its own would still not make a case for investment in C, unless the project were to involve untypically low C, or unless in future the inputs driving F were expected to rise dramatically in relative price. Though as (at £91k per pupil) is nearly 5 times the level of C, the linkages between C and S remain both poorly understood and weak.

Cost ratios for schools are very different to those found for offices. Because the built space in offices is mainly rather intensively occupied by employees, causing S to be some 15 times the size of C, project business cases suggesting that expenditure on C might pay for itself by achieving savings in S are not prima facie implausible. However, unlike offices, the great majority of costly-to-construct built space in schools is not occupied by paid employees, but by pupils. This results in a much higher ratio of floor area per employee in schools than in offices. This fact alone (rather than any difference in average salaries between teachers and office workers or in cost of construction per square metre) explains the greatest part of the difference in ratio of S to C in the two building types.

Thus in the case of schools, it is difficult to make a business case for construction investment on the basis of payback in savings on S and F. The rebuilt school would have to reduce combined costs of S and F by 20% compared with what they would be without rebuilding. The evidence is that, on average, S and F are slightly higher, and certainly not 20% lower, in rebuilt rather than in non-rebuilt schools. Instead the case must use potential increases in V to justify increased C.

Returns on investment

Where positive returns arise it is from improvement in educational performance. In some renewed schools, the improvement in examination results is substantial. However, at least half the rebuilt schools under study witnessed no increase in educational attainment relative to national average benchmarks. To place the assessment of BSF investments into context, the following quotation seems appropriate:

> "Half the money I spend on advertising is wasted; the trouble is
> I don't know which half".
>
> Variously attributed to John Wanamaker, US department store merchant (1838 - 1922) or to 1st Viscount Leverhulme, founder of Lever Brothers (1851-1925).

If the findings of this paper were to be regarded as a definitive evaluation, then to those wanting to be critical of the BSF programme, it might seem that, with addition of 'in advance' before 'which half", this quotation is relevant from a policy perspective.

On the other hand, the strongly positive average benefit-cost ratio for all renewed schools suggests that *not* investing at all (or cutting back investment in school building to its pre-2000 level) is not economically efficient either.

It is necessary to insist not only upon the usual caveats regarding a need for further research, and the need to wait for more years' data, but also to clarify that rather than being an attempt at definitive evaluation, the whole purpose of the 'investment' section of this paper has been to show how far short we still are of having method and data for such an evaluation. The results reported here follow from a series of assumptions made necessary by that lack, and its claim to value must lie in making those assumptions and the problems intrinsic to such evaluation more explicit.

It seems only fair to assert that this lack of understanding and measurement of longer-term determinants of project value comes at a cost. This cost includes less than optimal policy design and delivery, even when evaluated by the current prescribed forms of project and programme evaluation. The breadth of the assumptions required to undertake these analyses, along with the relatively limited samples supporting them, serve to highlight the potential insight future appraisals with more adequate data could provide.

Further Research

If it was not already apparent, this paper demonstrates that the determination of educational outcomes is a complex affair, let alone their future value. While the role of secondary school buildings may only play a relatively small part in the determination of educational outcomes (Leckie et al., 2010), as a high profile area of public policy, there will no doubt be further contention about the optimal amounts and methods of investing in school buildings.

All projected long-term future ‘cash flows’ are uncertain, those for F and S as well as those for V, in that all depend on assuming real prices or real wages behave in future as they have done in the past. The additional elements of uncertainty present in the forecasts for V and not in those for F and S are essentially two-fold: the rate of decay of the effect of rebuilding on exam results of a school; and the actual level of final qualification obtained by those pupils raised over the 5+ A*-C GCSE threshold.

It would now be appropriate and timely to revisit the rate of change in exam results in the sample of schools rebuilt before 2006 that were studied in Rintala (2010), for which at least seven years of post-rebuilding results should by now be available. This would throw more light upon the ‘rate of decay’ of the exam improvement effect. It would also be most useful to have an educational study of a confidential sample of all pupils obtaining, a few years ago, just better than 5+ A*-C GCSEs, to establish the actual final qualification outcomes for members of that sample.

Data on the quality of schools buildings should soon be made available by the Education Funding Agency, following a comprehensive survey of large parts of the estate (Property data survey programme, n.d.). This is in part thanks to the calls of Sebastian James (2011) for continual assessment of the quality of the estate as a means of guiding investment. This will be useful in controlling for one missing link in this analysis, that link being of observed building quality indicators associated with the outcomes of users. This data should be accessed and examined by researchers to investigate these causal links with a view to further informing policy. Returns to investment in school rebuilding do not take the form of cost saving. However, it is possible that the similar levels of expenditure on F found in rebuilt and non-rebuilt schools imply that higher maintenance standards are being set and achieved in the former. To know whether or not that is the case, it would be necessary to have good longitudinal school building condition survey data for a large sample of schools.

The increasingly devolved nature of school investment could prove to be counter-productive to maintaining a whole estate (national) perspective. The costs of this potential lack of co-ordination of investment, aimed at greatest overall return, are as yet unclear.

The considerable dispersion of outcomes in terms of change in examination results between the rebuilt school would seem to indicate the need for further inter-disciplinary research. This might include management, educational and design research focused upon those rebuilt schools where the improvement in educational performance has been greatest. This may identify which, if any, common management, educational and design factors tended to be present in these ‘successful’ cases.

The role of procurement methods remain a key area for further analysis. While sampled data within this study was insufficient to inform this area presently, further work with the diverse range of datasets applied is ongoing.

What is perhaps most startling to economists, given to assuming (or hoping) that calculative rationality underlies major public resource allocation decisions, is the lack in the UK of any public body (other than the National Audit Office and Public Accounts Committee on *ad hoc* bases) charged with systematically collecting and analysing all the evidence (much already being collected in different bits of government) that could, and should, be used to make *ex post* evaluations of investment programmes. Such a body could estimate policy outcomes compared with those anticipated in the business cases, and further increase transparency in assessing whether project business cases do indeed contain anticipated measurable outcomes and anticipated values for impact of these.

Finally, with the passage of time, data on exam results will become available for more elapsed years after the 'great rebuilding' of the second half of the last decade. At least, this would be the case except for the fact that 5 A*-C GCSEs in any subject, including equivalent vocational qualifications, is no longer the preferred official measure of schools' performance, whilst the preferred new measure is not available for years before its introduction, so that it may become harder for researchers to extract comparable information for the relevant whole period. Nevertheless, it should still be possible for future research to model the impact-decay function with far more confidence and accuracy, and this may result in major revisions to the provisional results reported here for benefit / cost ratios.

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[i] The government department responsible for schools in England and Wales has recently changed name several times. Before 2001 it was the Dept. for Education and Employment (DfEE); from 2001 to 2007 the Dept. for Education and Skills (DfES); from 2007 to 2010 the Dept. for Children, Schools and Families (DCSF); and since 2010 it has been called the Dept. for Education (DfE). In this paper the abbreviation used varies according to the period of the reference.

[ii] Refurbishment includes schools where between 50% and a 100% of the school's floor area had undergone capital works.

[iii] GCSEs are General Certificates of Secondary Education and are the standard qualification for assessing academic progress in UK secondary schools. Typically, pupils study towards these between the ages of 14 to 16. Normally, qualifications are pursued in between 8 and 12 separate chosen subject areas, subject to the requirement that pupils study English (Literature and Languages), Mathematics, Sciences and increasingly often at least one modern foreign language. The

coverage of GCSEs is designed around a national curriculum and is graded from A*-G. GCSE results are used by many school sixth forms and further education colleges for assessing admission onto courses leading to A and AS-levels, A levels being the standard qualification resulting from 16-19 year old education. These A and AS-levels are the principal criteria for entry into higher education university degree programs. Pupils typically take between 2 and 5 A levels over two years of further education, in combination with the single year AS-level qualifications (essentially, the first year of A levels). GCSEs (5 A*-C), A / AS-levels, and Bachelor degrees constitute levels 2, 3 and 4 respectively in the Qualifications and Credit Framework for England, Wales and Northern Ireland.

[iv] Other admissions types excluded included 'selective', 'modern' and 'N/A'. This step also removed Academies as well as Welsh establishments from the sample, as they did not have sufficient admission type data.

[v] Survey undertaken by DfE, completed by local authorities and provided to us by Partnerships for Schools.

[vi] Detailed descriptions of what each expenditure line includes can be found on the School Financial Benchmarking website: https://sfb.teachernet.gov.uk/Assets/metrichelp.htm#I01

[vii] Provided in the initial Edubase.gov dataset of educational establishments in England and Wales.

[viii] The subsamples for investigating both the cost ratios and investment returns for F, S and V are somewhat smaller than the initial C sample. The reasons for this include the following. For the cost ratio data, F and S seem to loose some 69 schools from the initial C sample. These can be broken down into 3 schools that were seemingly rebuilt too early for us to observe 3 years post rebuild data, 35 schools with incomplete data for a full F or S calculation (refer to method for constituent expenditures) and 31 schools for which there was no data reported in any year, likely the result of failure to match between datasets based on imperfect unique identifiers. The loss of an additional 41 and 43 schools for the investment appraisal of F and S respectively, is down to lack of reporting of constituent expenditures as well as some schools having been rebuilt too recently for us to have 3 years post rebuild data. As for the sub samples used for the investment appraisal looking at V, 76 schools were lost from the initial larger C sample. These can be broken down into 1 school which was rebuild too early to have amassed three years pre rebuild educational attainment data, 47 schools that were rebuilt too recently to have amassed post rebuild data, 7 schools which seemingly report no pre rebuild educational attainment and are assumingly completely new, and a remaining 21 schools that do not provide sufficient data both before and after rebuild. In some cases, failure to be included within the samples is the result of failure for datasets to match appropriately (unfortunately unique identifier can change for a number of reasons e.g. if the school undergoes institutional change such as becoming an Academy). Future work with the amassing datasets, and specifically in terms of matching efficiency and imputing reasonable values for missing cells, would assist in improving the sample sizes and hence the basis for our conclusions.

[ix] The actual sample behind the DfE cost data is as yet unpublished by the Department. Work continues to collate these data sources in building datasets for further empirical analysis of the school estate.

Appendices

Appendix 1 – Discussion of reasons why estimations of outcome values might differ from those that actually occur

Under-estimation:

- Improvements in educational attainment that do not move 16 year-old pupils over the level 2 thresholds have been ignored (see above for discussion).
- Increase in lifetime earnings of those obtaining qualifications may not fully capture the economic benefits resulting from an economy having a more highly qualified work force. There may be benefits captured by employers, and / or important spillover benefits, captured by others.
- It is assumed that the effect of school renewal investment on improving educational attainment starts to decay after 3 years have elapsed, decaying to zero over 17 more years (i.e. 20 years after construction), and at a rate of 1/17th per annum. This is assumption, rather than estimation based on actual observed long-term results, such results not being available for analysis. If improved premises had their effect on attainment in isolation from other factors affecting attainment, this assumption might be right. However, it seems more likely that complex dynamic interdependencies (with factors such as school intake, leadership, organizational culture, public perceptions and morale) are at work, meaning that some rebuilt schools are 'transformed' whilst others are not. Physical renewal of buildings would then work by increasing the chance for such a positive transformation to occur, without even being a necessary, still less a sufficient, condition for it. In the transformed schools, positive cumulative causation may occur, so that rather than beginning to decay after 3 years, as the premises begin to age, the effects on attainment continue to become stronger as time passes. Unfortunately, because the majority of the renewals for which there is data occurred only a few years ago, there is not (yet) sufficient data on post-investment attainment after say 10 elapsed years on enough schools to observe the details the longer-term trends. Instead data for 3 elapsed years was chosen as the period to measure change in attainment, in order to give better sample size. Thus, if positive cumulative causation occurs frequently, the method adopted will under-estimate total benefits.

Over-estimation:

- Lifetime earning increments are measured using retrospective data, and are thus reported at the levels they have been over the last several decades, including those reaching 16 in, say, 1960 and retiring in, say, 2010. There are some plausible reasons to think that the increments that will be obtained by those reaching 16 in say 2010 may be significantly lower. These reasons revolve around the idea that UK economic growth may be slower than it has been, for macroeconomic reasons, and that it is growth that creates skill shortages and raises wage premiums for possessing qualifications. Also, the wage premium data refer to a period when a much smaller proportion of the workforce possessed university degrees. On the other hand, there are also reasons to see stronger forces in the future than in the past tending to hold down the rate of increase of earnings for those without qualifications, and thus, perhaps, its level relative to the earnings of those with qualifications. First, it must be remembered that the past period includes the introduction of the national minimum wage. More general factors include reduced future demand for unskilled labour in the UK relative to its supply.
- Because the data is not available to allow its estimation, we have ignored the marginal costs of providing post-16 education to an increased number of students, i.e. to pupils moving over the level 2 threshold. Ideally, these should be estimated and then either be deducted from the earnings increment or added to the cash outflows.
- The threshold-and-national-average method may overstate the likely actual proportion of pupils raised above the level 2 threshold who will go on to obtain degrees. That is, what holds for all those with 5+ A*-C GCSEs may not hold for the 'marginal' pupils, who may be raised just above that threshold but may have a below average A level achievement.
- The role of vocational qualifications is not incorporated into the analysis, in part due to complications raised by their existence parallel to academic ones. Separate findings do exist that show lower lifetime earnings uplifts for those with each level of vocational rather than academic qualifications. Since a far from negligible proportion of students at each level do in fact obtain the vocational qualifications, this creates a problem. However, the method of deducing y and z required introduction of this over-simplification. It is difficult to deduce what separate proportions of students with vocational and academic level 2 stop at that level, stop at level 3 or go on to level 4. Thus, the analysis for earnings uplifts at present applies to all students the uplifts found for those (the great majority) pursuing academic qualifications.
- Flattening-out the actually crescent-shaped graph area for lifetime earnings premiums (the area between life time earning curves for unqualified and

qualified workers (Walker and Zhu, 2013)). To simplify, estimation of ‘cash flows’ average premiums over the whole age range are applied to workers of all ages. It is in fact known in general terms that premiums reach their maximum for workers aged around 40. For younger and older workers they are somewhat less. This simplification therefore overstates actual ‘cash flow’ benefits in the first 20 years and last 20 (i.e. 40 to 60 years on) after the investment in school renewal and understates benefits in the middle 20 years. When discounted, therefore, the PV of the total sum of benefit flows appears somewhat greater than it would if it were possible to input data reflecting accurate annual wage uplift curves. The fact that the discount rate in this case is only 3.5%, however, partially moderates the size of this over-estimation. For further research, it would be desirable to input alternative assumptions about the equation for the crescent area between earnings curves to explore the sensitivity of estimates of V to this.

Overall, at present, it is only possible to take the somewhat heroic view that perhaps the two sets of factors will roughly balance out.

Tables and Figures:

Gross floor area of the building	Occupation density (gross m^2 per person)	Number of persons	Construction cost/gross m^2	Total construction cost of the building (*C*) over a 20-year life	Total *C* per year	C/m^2 per year	*c* per person per year	Total *c* per person over a 20-year life
10 000 m^2	10 m^2	1000	£1000	£10 million	£500 000	£50	£500	£10 000
				Total employment cost of the building (*S*) over a 20-year life	Total employment cost (S) per year	S/m^2 per year	*s* per person per year	Total *s* per person over a 20-year life
				£2000 million	£100 million	£10 000	£100 000	£2 million
				Total facility management cost of the building (*F*) over a 20-year life	Total facility management cost (*F*) per year	F/m^2 per year	*f* per person per year	Total *f* per person over a 20-year life
				£50 million	£2.5 million	£250	£2500	£50 000

Table 1: Example of 1/5/200: London offices

Source: (Ive, 2006) derived from Evans et al, 1998.

Table 2: Resource costs to all parties (London offices), discounted at 7%; not 1:5:200 but rather 1:1.5:15

	'*c*' per person per year	'*f*' per person per year	'*s*' per person per year
1. Carried forward from Table 4	£1575	£4620	£45 000
2. Discount all cash flows arising in future to their PV in year 0; use a discount rate of 7% real	***C*** **per person over 20 years, discounted to PV**	***F*** **per person over 20 years, discounted to PV**	***S*** **per person over 20 years, discounted to PV**
3. PV_0 construction cost is not discounted because it arises in year 0	Lump sum of £2250/m^2 of NIA × 14 m^2 = £31 500	£4620 per annum for 20 years, discounted at 7% = £48 760	£45 000 per annum for 20 years, discounted at 7% = £477 000
4. Ratio	£31 500	£48 760	£477 000
5. Headline	1	1.5	15

PV, present value.

Source: (Ive, 2006)

Table 3: Examples of outputs and outcomes

BOX 6: EXAMPLES OF OUTPUTS AND OUTCOMES

Policy area	Outputs	Outcomes
Job search / Job matching	Number of job seekers assisted.	Value of extra output, or improvement in efficiency of job search
Development of skills	Number of training places and / or numbers completing training	Value of extra human capital, and / or earnings capacity
Social outputs: Schools; Health centres	Exam results (schools), People treated (health centres).	Improvements in human capital (schools); Measures of health gain (health centres).
Environmental improvement	Hectares of derelict land freed of pollution.	Improvement to the productivity of the land.

Source: Green book (HM Treasury, 2011)

Table 4: Summary of reasons for possible over / under estimation of project value

Direction	**Source**	**Cause**
Under est.	Particular method	Improvements in educational attainment that do not move 16 year olds over the level 2 threshold
Under est.	Keynesian uncertainty	Higher lifetime wages may not capture full benefits to the economy of having more highly skilled labour
Under est.	Lack of data	Uncertain decay of effect on educational attainment
Over est.	Keynesian uncertainty	The earning premiums associated with certain qualifications in the past may be quite different in the future
Over est.	Lack of data	The marginal cost of further education has been ignored
Over est.	Lack of data & particular method	Over statement of number of marginal students actually going on to higher education
Over est.	Particular method	Role of vocational qualifications not incorporated into the analysis
Over est.	Lack of data & particular method	Flattening out of the life time earning premiums rather than being sensitive to stage of career

Table 5: Declining long term discount rate

TABLE 6.1: THE DECLINING LONG TERM DISCOUNT RATE

Period of years	0–30	31–75	76–125	126–200	201–300	301+
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

Source: (HM Treasury, 2011)

Table 6: Data source and information

Dataset	Source	Period	Information
Edubase	Department for Education (DfE)	Full extract of database made on 18th January 2012	A comprehensive list of all educational establishments within England and Wales (in effect, the population of all schools). This source also provides *'pupil capacity'* for each school.
Schools Building Survey 2009, 2011 (SBS)	Partnerships for Schools (Now the Education Funding Agency)	2009 & 2011	A range of data including identifying those schools which have received significant capital investment – 'rebuilding' (along with year), as well as estimates for work done (CAPEX 'C' £s).
Consistent Financial Reporting database (CFR)	DfE	2002/03 – 2012/13	This is a centrally collated database recording the on-going annual expenditures at the school level for a range of cost categories. This provides the data for estimation of facility maintenance ('F') and staffing ('S') costs.
Educational attainment table	DfE	1998-2013	These datasets provide data on educational outcomes used to estimate 'V', as well as some data on characteristics of pupils, such as % on free school meals (FSM) and *pupils on roll* for capacity utilisation ratios and variance analysis.
Display Energy certificates (DEC)	DfE	2008 – 2012	This source provides total usable floor area (TUFA) for a limited coverage of our schools, sufficient to provide insight on m^2 to pupil ratios and variance.

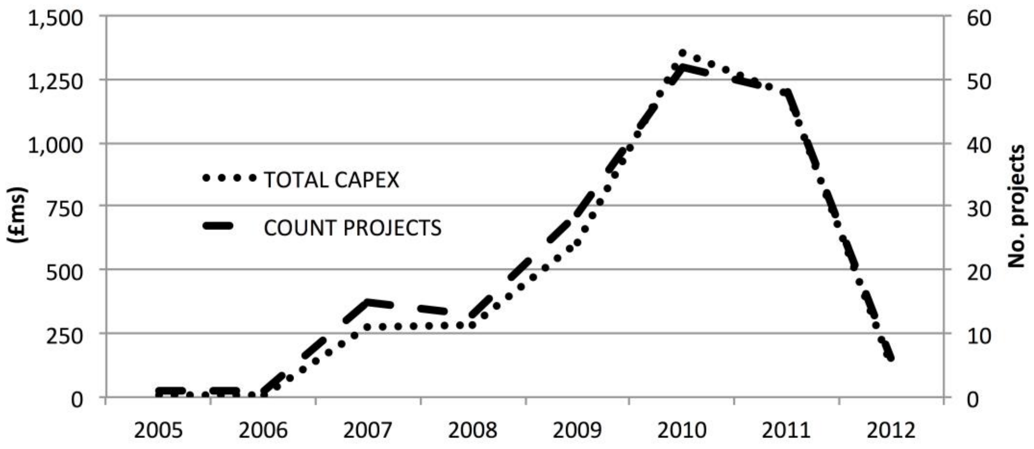
Table 7: Steps in calculating expected CAPEX for school works

Step	Method	Data source
1. Estimate school size in m^2	Take reported pupil capacity of school and multiply this by the minimum guidance space for schools (accounting for whether they include post 16 facilities).	Pupil capacity – \ (Dept for Education, 2012)) Space guidance – Building Bulletin 98 (DfES, 1998)
2. Multiply estimated school size by cost per m^2 indicators	Take estimated m^2 and multiply by EC Harris cost indicators for school buildings (with adjustment for London prices)	EC Harris cost indicators (EC Harris, 2006)
3. Normalise to CAPEX per unit of pupil capacity	Divide CAPEX per school at 2009 prices by the school's pupil capacity to obtain CAPEX per pupil capacity unit	Pupil capacity – (Dept for Education, 2012)

Table 8. Variable sample size and period coverage

Variable estimate	Sample size	Period coverage
C	166	1997-2012 (SBS 2009 / 2011)
F	97 (56)	3 years before rebuild within 2002/03 – 2012/13 CFR (and 3 years after)
S	97 (54)	3 years before rebuild within 2002/03 – 2012/13 CFR (and 3 years after)
V	90	3 years before and after rebuild within 1998 – 2013

Figure 1: Annual reported capital expenditure and number of projects within C:166 sample (2009 prices, £m)



* Note n = 165, one school was renewed in 1999, which is not included above.

Table 9: Cost ratios – c, f and s (normalised)

PV cost per pupil capacity	**(£)**	
c	**20,497**	
St Dev	6,383	
n	166	
	Discount rate	
	3.50%	**7%**
f	**16,380**	**9,219**
St Dev	5,841	3,288
n	97	97
s	**91,088**	**51,266**
St Dev	19,402	10,919
n	97	97

Table 10: C sample variance in key construction ratios and capacity utilisation rate

Variance on key ratios	Reported CAPEX per pupil capacity unit (£s)	Reported CAPEX per pupil on roll in 2012 (£s)	Reported CAPEX per TUFA m^2 (£s)	TUFA (m^2) per Pupil on roll 2012	TUFA per pupil capacity unit (m2)	Capacity utilisation rate (Pupils on roll 2012 / capacity)
Average	20,497	27,266	3,552	9.24	8.38	0.87
St Dev	6383	27925	5705	3.40	3.41	0.22
n	166	166	56	56	56	166
Min	3,672	3,679	703	0.79	0.72	0.12
Max	39,267	298,361	43,324	18.77	24.38	1.97
Percentile						
10^{th}	12,578	14,038	1,466	6.8	4.2	0.61
20^{th}	14,929	17,172	1,750	7.3	6.9	0.72
30^{th}	17,817	19,943	1,876	7.7	7.4	0.81
40^{th}	19,463	21,566	2,148	8.3	7.8	0.88
50^{th}	20,285	22,457	2,453	9.4	8.4	0.91
60^{th}	21,898	24,913	2,629	9.9	9.2	0.94
70^{th}	22,972	27,039	3,085	10.3	9.6	0.97

80th	24,541	30,332	3,641	10.8	9.8	1.00
90th	27,738	35,896	4,423	12.7	10.6	1.06
100th	39,267	298,361	43,324	18.8	24.4	1.97

* All monetary values are in 2009 prices

Table 11. C sample totals and weighted means of construction ratios and capacity utilization rate

Weighted averages	Total CAPEX (£s) / Total pupil capacity	Total CAPEX (£s) / Total no. pupils on roll	Total CAPEX (£s) / Total usable floor area (m2)	Total usable floor area (m2) / Total no. pupils on roll (2012)	Total usable floor area (m2) / Total pupil capacity	Total no. of pupils / Total pupil capacity
Average	19,982	23,282	2,550	8.62	7.95	0.86
Total numerator	3,872 mn	3,872 mn	1,289 mn	505,764	505,764	166,316
Total denominator	193,781	166,316	505,764	58,691	63,589	193,781
sample n	166	166	56	56	56	166

* All monetary values are in 2009 prices m^2

Table 12: Construction price m^2 BSF schools – 2009 prices

Construction price per square metre	**BSF (2q 2009 prices)**		
GIFA m2	Average	20th percentile	80th percentile
0-2000	£2,851	£2,021	£3,712
2000-4000	£2,780	£1,999	£3,442
4000-6000	£2,566	£1,914	£3,033
6000-8000	£2,303	£2,132	£2,508
8000-10000	£2,158	£1,863	£2,403
10000-12000	£1,980	£1,837	£2,081
12000-14000	£1,899	£1,701	£2,017
14000-16000	£2,075	£1,845	£2,299
16000-18000	£1,962	£1,690	£2,180
18000-20000	£1,938	£1,786	£2,105

Source: (DfE, 2009)

Figure 2: Time series actual annual *f* and *s* and change (rhs) for secondary comprehensives (2009 prices, £s) – 2002/03 to 2012/03

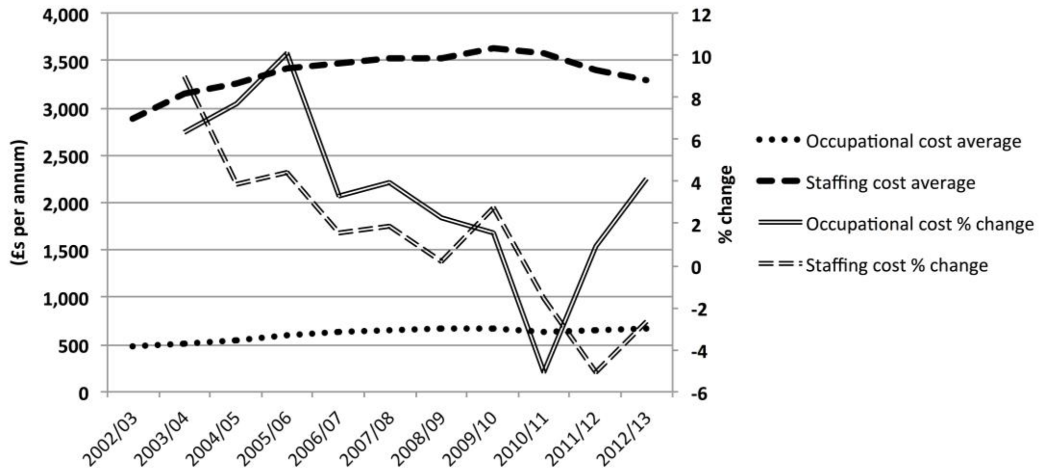


Table 13: Investment returns – change in cash flow on no-rebuilding versus rebuilding

PV per pupil capacity	**(£)**
Δc	**-20,497**
St Dev	6,383
n	166
Discount rate	**3.50%**
Δf	**-189**
St Dev	2,914
n	56
Δs	**-840**
St Dev	6,961
n	54
Δv	**73,323**
St Dev	272,024
n	90
Δt (v x Tax Rate*)	**29,329**

St Dev	108,809
N	90

* Tax rate = 0.4

Figure 3: Distribution of annual value of outcome per school (t1-t60, n =90, £m)