How Good Was The Profitability Of British Railways, 1870-1912?

Brian Mitchell, David Chambers and Nicholas Crafts

No 859

WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

THE UNIVERSITY OF WARWICK

HOW GOOD WAS THE PROFITABILITY OF BRITISH RAILWAYS, 1870-1912?

BRIAN MITCHELL
(Cambridge University)

DAVID CHAMBERS
(Oxford University)

&

NICHOLAS CRAFTS
(Warwick University)

June 2008

Abstract

This paper provides new estimates of the return on capital employed (ROCE) for major British railway companies. It shows that ROCE was generally below the cost of capital after the mid-1870s and fell till the turn of the century. Addressing issues of cost inefficiency could have restored ROCE to an adequate level in the late 1890s but not in 1910. Declines in ROCE hit share prices and returns to shareholders were negative after 1897. Optimal portfolio analysis shows that, whilst railway securities would have had a substantial weight prior to this date, investors would have been justified in rushing to the exits thereafter.

We are indebted to Michael Edelstein for providing us with his data set and to the staff of the British Transport Commission Record Offices in London, Edinburgh and York for their generous help. Tony Arnold, Richard Grossman and Tim Leunig made helpful comments on an earlier draft. Hyun J. Im provided valuable research assistance. We have also benefited from suggestions by seminar participants at University College Dublin and the LSE Cliometrics Study Group. The normal disclaimer applies.

In the late nineteenth century British railway companies operated a significant fraction of the nation's capital stock and comprised a major part of the asset base held in private portfolios. The performance of these businesses mattered.

Recent writers have been highly critical. Arnold and McCartney found that the weighted–average return on capital employed fell from 4.81 per cent in 1872 to 3.85 per cent in 1892 and to 3.54 per cent in 1912 as the railway network continued to expand and described both the industry's results and also the returns that it offered investors during this period as 'consistently disappointing'.[1] Goetzmann and Ukhov who performed a portfolio analysis for the period 1870 to 1913 in which domestic railway shares were one of the available asset classes concluded that the optimal weighting for this sector was zero.[2] Kennedy and Delargy noting the persistent tendency for railway shares to exhibit low dividend yields (high price to earnings ratios) as a sign of 'irrational exuberance' on the Victorian stock exchange.[3]

Earlier writers were somewhat less damning in their assessments. Irving disputed the suggestion that railway investment policies were at fault and stressed the role of operating inefficiency in undermining rates of return before the turn of the century and a recovery of profitability when these problems were addressed.[4] Cain freely conceded that 'There was waste and inefficiency on the railway system of Great Britain between 1870s and 1914.' but his preferred estimates using net paid-up capital showed a return on capital employed falling from 4.61 per cent in 1870/4 to 4.06 per cent in 1900/04 but then recovering to 4.32 per cent in 1910/12 and he argued that before 1900 at least the large railway companies were generally regarded as blue chips and their equity was an excellent investment.[5]

A number of issues remain to be resolved. For example, the profitability record of individual companies on a net paid-up capital basis needs to be established as do its implications for share prices and shareholder returns. Furthermore, it is not clear quite when the experience of railway shareholders turned sour or whether a detailed analysis would reveal that some companies remained good investments. Similarly, there has been no explicit quantification of the extent to which profitability could have been improved by reducing inefficiency.

This paper seeks to fill these gaps. In particular, the following questions are addressed.

1) What was the return on capital employed (ROCE) of major railway companies and how did this relate to stock market returns ?

[1] Arnold and McCartney, 'Rates of return', p. 54.
[2] Goetzmann and Ukhov, 'British investment'.
[3] W. P. Kennedy and R. Delargy, 'Explaining Victorian entrepreneurship: a cultural problem?, a market problem?, no problem?', LSE Department of Economic History working paper no. 61/00 (2000), p. 23.
[4] Irving, 'Profitability and performance' and 'Capitalisation of Britain's railways'.
[5] Cain, 'Railways, 1870-1914', p. 96, 110, and 120.

2) Was eliminating inefficiency a route to restoring earlier levels of profitability as ROCE fell in the late nineteenth century ?

3) When did the securities of these various railway companies cease to be worth holding in investors' portfolios ?

The starting point for our analysis is a comparison of net revenues from the *Railway Returns* with estimates of paid-up capital and accumulated capital expenditures extracted from company accounts. This permits estimates of ROCE at the level of the individual company which can then be related to holding returns (taking account both of dividends and capital gains) on the company's securities using the data collected by Edelstein from the *Investors' Monthly Manual*.[6] These data also permit an optimal portfolio analysis which takes account of both risk and return and explicitly recognizes that railway shares may have valuable diversification properties. This extends earlier work by considering individual companies rather than the sector as a whole and by looking at sub-periods. Finally we draw on the estimates of cost functions and cost inefficiency made by Crafts et al. to examine the feasibility of improving ROCE by controlling costs better or by amalgamation.[7]

I

This section presents evidence on the profitability (ROCE) of Britain's railways between 1870 and 1912. The concept of profit is a comparatively simple one: business receipts minus business costs equals profit, divide by capital employed to obtain the rate of profit. Of course, any accountant will tell you that it is not as simple as that, and that receipts, costs and capital are all capable of various definitions, even in the case of a small one-person business. This applies *a fortiori* in the case of complex corporate businesses. Moreover, in the case of late nineteenth-century British railway companies there are peculiarities which complicate things, especially to modern minds. We must, therefore, give some consideration to the concepts of capital and profit as seen by investors and managers of the period.

The most readily available data that approximate to profits for the railway companies are those of "net traffic revenue" given in the official *Railway Returns*, published annually in the Sessional Papers of Parliament, and known initially as *Returns of Capital, Traffic and Working Expenditure*. Whilst some of these appeared before 1870 under earlier legislation, the returns for the period from then up to 1912 were collected under the Act of 1868 which standardized the form in which companies had to make the returns, and these constitute a uniform and consistent series. They do not, however, correspond precisely to a modern concept of profit, nor even to one which would have been recognized at the time. Only *traffic* receipts and expenditures are taken into account, thus ignoring such things as head office expenses, professional fees, bank charges, rent

[6] These data were the basis of the research report in Edelstein, *Overseas investment*.
[7] Crafts et al., 'Were British railway companies'.

charges either received or paid out, and receipts from investments other than in the enterprise concerned. Fortunately, so far as the major companies are concerned, where these can be traced they did not come to very much in proportion to traffic outlays and revenues; and since our main concern is with the profitability of the railways as carriers there may even be some advantage in looking at net traffic revenues alone.[8]

One major difference between normal concepts of profit and those used in relation to late-nineteenth century railway companies lies in the treatment of debt charges. In most businesses at the time as well as later, interest payments on debt incurred would have counted as a cost, to be deducted from revenue before arriving at profit. But so far as railway accounts were concerned, debt – or, more precisely, long-term debt – was regarded as part of the capital of a company. This point should be borne in mind when assessing rates of return on capital. *En passant,* it may be noted that short-term borrowings, including loans from banks, seldom, if ever, amounted to very much in relation to the size of the capital account as a whole.

Data on the paid-up capital of the railway companies is given in the *Railway Returns* but a more satisfactory source is the half-yearly accounts and reports to their shareholders. These survived for all the main companies and a great many lesser ones, and were at one time kept by the then British Transport Commission Historical Records offices in London, Edinburgh and York. Not only does this source enable one to correct the occasional error in the official figures, but it provides the possibility of assessing the expenditure side of the capital accounts as well as giving additional detail on paid-up capital, especially prior to 1890, which was the first year in which nominal additions to capital were noted in the *Returns*.

Apart from the inclusion of long-term debt as part of the capital of the railway companies, there are other complexities in the definition of nineteenth-century railway capital which make it inappropriate simply to use the statistics given in the *Railway Returns.* The main one is the inclusion in the statistics of paid-up capital of the nominal additions, or occasionally deductions, which many companies made to their capital for various reasons. In the early days, they were usually associated with company amalgamations. For example, at the amalgamation of the London & Birmingham, Grand Junction and Manchester & Birmingham, which constituted the London & North Western, the shares of the GJ were valued at 25% more than their nominal value because of their relative market price, and this resulted in the nominal addition to the new company's paid-up capital of nearly £965,000. Whilst in a capital of £13.5 million this was not insignificant, it was nothing to what was to come later and unlike the LNWR in 1847 could in no way be seen as reflecting a change in the actual value of the companies.

By the 1880s, the most common cause of nominal additions was the consolidation of preference or loan stocks, so that one stock with a uniform rate of interest or dividend replaced a variety of pre-existing stocks. A good example is the Midland Railway

[8] The largest example we found was for LNWR in 1907 where total revenue was £280,000 higher than its traffic revenue of £5,730,000.

Company, which in 1897-8 converted its debentures from 4% or 6% stocks to a uniform 2.5%; but in order to satisfy the owners, and to ensure fairness between the holders of the different original stocks, increased the nominal value of its debentures from £28.8 million to £35 million. At the same time, all its preference shares were converted to a 2.5% basis, which entailed the nominal addition of £15.7 million to that category, whilst its ordinary shares were split into preferred 2.5% and deferred shares, thus nominally doubling the £34.7 million of its equity. This was a massive addition to the reported paid-up capital of the company but, of course, nothing additional was paid. The result o all the Midland's conversions in 1897-8 was to increase the nominal value of its paid-up capital (including debentures) from £100 million to £168 million, with less than £5 million representing actual investment. The effect of this on the recorded rate of return would appear to suggest catastrophic misfortune or mismanagement but this is actually quite illusory.

Other companies which behaved similarly were the Caledonian in 1895-6, the Great Northern in 1890-1, the London & South Western in 1890-1, and the North British in 1889-90.[9] Most companies made nominal additions to their capital at some time or other, and, as mentioned above, it is only from 1890 onwards that these were recorded in *Railway Returns.* However, they appear in the companies' accounts for earlier years, and it is usually possible to subtract them from the figures of finance received.[10] All figures of paid-up capital in this paper are exclusive of nominal additions or deductions except those in Table 2C which illustrate their pitfalls.[11]

Three other changes need to be made to the paid-up capital as recorded in *Railway Returns,* or, for that matter, in the companies' accounts, before they can be used to provide rates of return which reflect the realities of capital employed and enable accurate comparisons between companies to be made. A minor change is the addition of the balance of premiums and discounts on stock issues. By 1912, these amounted to an extra 10% or so on the paid-up capital of one or two of the more successful companies, such as the London & North Western and the Great Western; and this was probably also true of the Midland and the North Eastern, though neither of these showed the balance separately. The proportion had been much lower in 1870 and was usually less than 2% until the 1880s. The Great Eastern had a small negative balance throughout, though it was insignificant by 1900. The Manchester, Sheffield & Lincolnshire also had a negative

[9] The Great Western and the London, Brighton and South Coast actually made some small nominal deductions in the course of amalgamations before our period.

[10] Nominal additions have sometimes been referred to as 'water' in the capital. They did not represent finance actually received and used. A minor point may be made here: A relatively small sum – about £0.2 million, the result of the notorious Redpath frauds – cannot be removed accurately from the Great Northern's capital account in the 1850s.

[11] The distortions resulting from the inclusion of nominal additions to capital were clearly pointed out by Cain, 'Railways, 1870-1914' and by Irving 'Capitalisation of Britain's railways'. Both of these authors highlighted the implications for perceptions of profitability of the railway sector as a whole but did not give detailed figures for each company.

balance during the 1870s, whilst almost certainly this should apply to the London, Chatham & Dover too.[12]

The last two changes concern the relationship of the major company with other companies. Most of the majors worked lines which they leased from other smaller companies. Clearly these lines contributed to both the receipts and expenditures, and hence the net revenues, of the big company; therefore their capital account (for which, unlike the revenue account, they made separate returns) should be included with that of the major for the purpose of assessing the rate of return to either paid-up capital or to capital expended.[13] Finally, most of the majors at some time or other made subscriptions to other companies, often, but not always, those whose lines they leased and worked. The amount of these subscriptions needs to be deducted from their paid-up capital. Not to do so in the case of lines worked by the majors would be to double-count this part of the capital which they employed; whilst in the case of lines worked independently, these made their own separate returns of net revenue and did not contribute to those of the majors. This also applies to contributions to joint lines set up by two or more companies where they made separate traffic returns, though it may be noted that these sometimes made a small contribution to the *non*-traffic revenues of the majors.

Another feature of railway accounting which seems unfamiliar to modern eyes relates to internal financing of expenditure on capital equipment. Apart from suspense accounts for the renewal of rolling stock, steamboats and, occasionally, rail track, there was little deliberate retention of earnings in order to finance capital expenditure, certainly prior to 1900 or thereabouts. In other words, expenditures which the accounting conventions of the day regarded as appropriate to the capital account were very largely financed through that account, which was not itself financed out of profits. However, expenditures which were regarded as maintenance or renewal of capital equipment were covered in the revenue accounts. In other words, they were treated as current expenses, to be met before net revenue was arrived at. These expenditures naturally included elements of addition to the stock of capital, both through replacements which were more modern and efficient than the original items and through the purchase of additional items. The majority of maintenance expenditure was, however, in the nature of depreciation expenditure, something which did not appear in railway company accounts at the time. To all concerned, the assumption at that period was that, provided they were properly maintained, railway assets, or at any rate the majority of them, had an indefinite life. Those that clearly did not, such as rails and rolling stock, were either dealt with by the

[12] The actual paid-up capital of this company cannot be ascertained owing to great irregularities in its accounting up to the late 1860s, though many share issues were certainly discounted and others were awarded as payment to contractors. The figures which are given here are based on a court award made in 1870 and are almost certainly inflated, even though no nominal additions were officially admitted when they were first officially recorded in 1890. The company's accounts for the second half of 1869 give its paid-up shares and loans as £7.2 million and £4.0 million respectively, whereas a year later, after the court award, they were given as £12.1 million and £5.0 million. At that time the cumulated capital expenditures of the company amounted to £14.7 million.

[13] Including worked lines raises capital expended by about 10 per cent at the start of our period and by about 3 per cent at the end.

suspense accounts mentioned previously, or by expenditure out of revenue. The question therefore arises as to whether it is appropriate to measure the rate of profit in relation to gross (*i.e.* un-depreciated) capital stock. In an ideal world, it would surely be better to use net capital, but, given the limitations of the available data imposed by contemporary accounting conventions, this would only be possible by making assumptions about the length of life of the various items of capital and reworking the companies' accounts. And, if this were done, the figures of gross capital derived from the companies' capital accounts would first need to be increased by estimates of their expenditure on renewals of scrapped equipment, which would require yet more assumptions. This scarcely seems worthwhile in the light of the subsequent survival of the railways into the second half of the twentieth century. Much of the roadbed, the tunnels, cuttings and embankments, and even many of the bridges and stations remained in use until after 1950, and quite a large amount is still being operated. It seems likely that the contemporary assumption that proper maintenance and renewal was a substitute for an amortization account will not distort the picture by very much.

Whilst railway historians have measured the rate of profit in relation to the liabilities side of the balance sheet, i.e., its paid-up capital, it is also possible to do so in relation to the capital assets employed. As was mentioned earlier, the many surviving accounts of railway companies allow us to measure the capital expenditure over time of all the larger ones and most of the smaller ones which were operated by them. Provided one is prepared to accept the accounting convention of the day that structures did not wear out and obsolesce, and that the depreciation of other assets was covered by maintenance and renewals expenditures on the revenue account, cumulated capital expenditures at the end of each year probably present a more accurate picture of the value of the capital involved than do the finances raised, though, of course, the differences should not be great. And, indeed, they were only rarely higher than 0.5 per cent except in the case of the Taff Vale Company, which had by some way the highest rate of return on every measure and was the only company to make significant investments out of revenue. It should be pointed out, however, that whilst the cumulated capital expenditures of lines worked, but not owned, by the major companies have mostly been taken from the reported accounts of the lines concerned, a few such accounts have not survived, and in these cases the change in the paid-up capital given in *Railway Returns* had to be used as a proxy.[14]

We believe that a case can be made for using either the adjusted paid-up capital as described above or the cumulated capital expenditures for all lines worked as a measure of ROCE. In Tables 1 and 2 both are shown and generally they give a quite similar picture of performance. It is not, however, appropriate to use estimates based on own paid-up capital including nominal additions. In Table 2C these are displayed for comparison and it is clear that the discrepancy is sometimes large, notably in the case of the Midland.

[14] Fortunately, the great majority of the records of the lines leased by the GER, the GWR, and the Scottish companies have survived, these major companies being the principal ones which operated leased lines in our period.

In general, the use of estimates of ROCE which are based on paid-up capital including nominal additions tends to exaggerate the fall in profitability of railway companies in the latter part of the period. This was recognized by both Cain and Irving.[15] The ROCE estimates in Table 1 decline by considerably less than those reported by Arnold and McCartney who appear not to have adjusted for nominal additions to paid-up capital.[16]

The picture that emerges from Tables 1 and 2 is the following. Taking the fifteen companies as a whole, Table 1 reports that the 5-year moving average of ROCE fell from 5.11 per cent in 1872 to a low of 4.29 per cent in 1893 but had recovered to 4.46 per cent in 1910 based on paid-up capital or from 5.63 per cent in 1872 to a low of 4.51 per cent in 1903 before recovering to 4.62 per cent in 1910 based on cumulated capital expenditures. This is similar to the estimates reported by Cain but a much better performance than suggested by Arnold and McCartney.[17] Table 2 shows that there were quite big differences in profitability across companies and that changes in profitability over time were by no means perfectly correlated. Indeed, three or four companies actually had a higher ROCE in 1910 than in 1872.

II

The reasons for the decline in railway profitability documented above have been disputed. Aldcroft stressed the role of poor investment policies which led to over-expansion of the network while Irving argued that the real problems lay in operating inefficiency especially prior to 1900.[18] Cain underlined the importance of waste and inefficiency but also pointed out that from the mid-1890s railways were subject to regulation which both raised their costs and prevented them increasing their freight prices.[19] Arnold and McCartney suggested that these problems were exacerbated by the failure of railway management to pursue amalgamations with other companies.[20]

This section seeks to quantify the contribution of waste and inefficiency in undermining profitability using the results obtained by Crafts et al. based on deriving a cost frontier for the British railway industry and thus estimating cost inefficiency (the ratio of actual to minimum feasible costs) for each major company in every year from 1893 to 1912.[21] These authors estimated an equation of the type

$$C_{jt} = \alpha_j + \beta X_{jt} + v_{jt} + u_{jt} \qquad (1)$$

where C is total costs, X is a vector of inputs or outputs, v is an idiosyncratic random error term, u is the non-negative cost-inefficiency component, and where the intercept

[15] Cain, 'Railways, 1870-1914', p. 110; Irving, 'Capitalisation of Britain's railways', p. 3, 17.
[16] Arnold and McCartney, 'Rates of return'.
[17] Ibid., Table 2 and Cain, 'Railways, 1870-1914', Table 4.
[18] Aldcroft, *British railways*, ch. 1 and Irving, 'Profitability and performance', p. 65 and 'Capitalisation of Britain's railways', pp. 18-19.
[19] Cain, 'Railways, 1870-1914', pp. 108-112.
[20] Arnold and McCartney, 'Rates of return', pp. 54-55.
[21] Crafts et al., Were British railway companies'.

term varies across companies to take account of heterogeneity of operating conditions. The implementation of this approach took account of variations in input prices, density of traffic, capital and operating expenditures, and passenger and freight outputs and allowed cost inefficiency to vary over time. The results also allow the extent of economies of scale to be inferred. Crafts et al. found that cost inefficiency was considerable in the late nineteenth century but was much reduced by the end of the period.

Estimates of cost inefficiency (the percentage by which actual costs exceeded minimum feasible costs) for 1897 and 1910 are reported in Tables 3 and 4. Generally speaking, cost inefficiency was a good deal higher in the former compared with the latter year while its extent varied quite a lot across companies. These estimates of cost inefficiency are used in Tables 3 and 4 to calculate counterfactual ROCE (1) on the basis that operating expenditure was reduced by the equivalent percentage and net traffic revenue increased accordingly. This may be thought of as an estimate of what would have happened if the companies had successfully addressed the shortcomings emphasized by Irving.

In Table 3 the (unweighted) average ROCE goes up by 0.6 percentage points but six companies (CR, GNR, LYR, LNWR, MSLR, MR) would still be below their 1872 level of profitability and only LNWR and TVR would be above 6 per cent while eight companies would still be below 5 per cent. Obviously, to a significant extent this vindicates Irving. If, however, capital expenditures were also reduced by the cost–inefficiency percentage as in counterfactual ROCE (2), then the average ROCE would be raised by 1.2 percentage points and all companies but CR and GNR (both only marginally below) are back to at least the 1872 profitability level. This suggests that wasteful use of capital did make an important contribution to declining profitability and that Aldcroft's indictment cannot be dismissed out of hand. That said, capital is a fixed factor of production and could only have been adjusted in the long run rather than instantaneously.

Nevertheless, in 1897, if railway management had exerted better control of operating costs, then the 1870s level of profitability could have been more or less restored. This was no longer the case in 1910. The estimates of counterfactual ROCE (1) in Table 4 show that removing cost inefficiency in operating expenditures would only have raised average ROCE by 0.3 percentage points and eleven companies would be below the 1872 profitability level. Under the pressure of addressing capital market concerns about declining returns, much of the inefficiency of 1897 had been removed and counterfactual ROCE (3) in Table 4 suggests that this was just as well.[22] The implication of the estimates in Table 4 is that railways were indeed operating in a more difficult environment.

The cost function estimated by Crafts et al. implies that there were modestly increasing returns to scale in the railway industry such that if output doubled, average costs would

[22] Cain, 'Railways, 1870-1914', p. 117 underlines the threat to railway management posed by the decline in profitability by the turn of the century.

be predicted to fall by 8 per cent. This has implications for the potential of amalgamations to rescue profitability. The two largest proposals in the early twentieth century were LNWR + MR + LYR and GER + GNR + GCR. In each case, the implied average cost reductions, including both capital and operating costs, would have been sufficient to raise ROCE of the combined enterprise compared with the weighted average of the separate enterprises by about 1 percentage point to 5.75 and 5.06 per cent, respectively.

This is surely an unduly optimistic view of the possibilities of amalgamation. First, it should be borne in mind that mergers frequently disappoint in terms of expected cost savings since management fails to deliver. Second, it seems clear that parliamentary approval, at least on terms acceptable to the companies, was unlikely. Third, mergers would have probably have involved further regulation including perhaps of passenger fares.[23]

In sum, the implications of this analysis are that whereas in the 1890s there was still scope for management action to restore ROCE to something like 1870s levels by the end of our period this had evaporated. This was bound to have repercussions on the attractiveness of holding railway shares, even though this concept of profitability does not strictly relate to the profit due to holders of the railway securities analyzed below, because it will have a major impact on the cash flow available to reward them.

III

The expansion of railways in the mid-19th century played a major role in the development of British capital markets.[24] By the early 1870s, the railway sector represented around one quarter of all securities quoted on the London Stock Exchange (LSE), excluding British government debt. Investors, such as the Phoenix Assurance, continued to commit new investment funds to railways through the following decade.[25] Towards the end of the 19th century, domestic railway securities were regarded as "blue chip", a status confirmed by the citing of railway securities as eligible investments for any trust fund under the 1889 and 1893 Trust Investment Acts. This legislation created considerable investor demand for domestic railway debentures in the 1890s, and the rise in debenture prices pushed the yields of the leading companies close to Consols, and considerably below those available from leading foreign railways.[26]

As well as debenture stocks, late Victorian investors were able to trade preference shares and ordinary shares issued by domestic railway companies. The 15 domestic railway companies in our sample issued a total of 33 different securities continuously quoted on

[23] The attitudes of parliament and the Board of Trade towards amalgamation bills are fully discussed in Cain, 'Railway combination'.
[24] Mitchell, 'The coming of the railway'.
[25] Trebilcock, *Phoenix Assurance*, pp.70.
[26] "British and Argentine Railway Debentures", *The Economist*, 10 June, 1893, pp.692; and "English and Foreign Railway Debenture Stocks", *The Economist,* 14 March, 1896.

the LSE (see Appendix 1).[27] Investors could earned a total return on any quoted security comprising a capital gain (or loss) and an income component. Hence, total returns are defined as:

$$r_{ijt} = \frac{(P_{ijt} + D_{ijt}) / I_{ijt}}{P_{ijt-1} / I_{t-1}} - 1 \qquad (2)$$

where P_{ijt} = the sterling price of the security issued by the ith company of the jth type and $j = 1$ (ordinary shares), 2 (preference shares), 3 (debentures) published for the last week of December of the tth year, D_{ijt} = the sterling cash dividend or interest payment by the ith company on the jth security type published for the last week of December of the tth year, I_t = the annual price deflator for the tth year.[28]

The annual time-series of the total real returns to each security is taken from the dataset constructed by Edelstein for which the primary source for security prices, debenture coupons, and preference and ordinary share dividends was *The Investors Monthly Manual* (IMM).[29]

The mean and standard deviation of the annual total real returns for each ordinary share, preference share, and debenture are summarized in Table 5. The equally-weighted average returns for each of the three railway asset classes are graphed in Figure 1. Ordinary share returns were considerably more volatile than preference share and debenture returns, between which there was little to choose. Further study of all three series also suggests a break in all around 1897/98. This break is consistent with the

[27] We have included Taff Vale Railway in this section, but excluded it from the section following because it was a much smaller capitalization stock than the other 14 railways, at around half the size of the next largest, London Chatham and Dover, and less than one-tenth the size of the London and North-Western Railway, based on total capitalization in 1868. Kennedy and Delargy, 'Explaining Victorian entrepreneurship', Table 1.

[28] To preserve comparability of results, we use the same deflator series, namely, Phelps Brown's cost of living index, as Edelstein, *Overseas investment,* pp.121, and as Goetzmann. and Ukhov, 'British investment'.

[29] Edelstein, *Overseas investment*. This dataset was supplemented with the year-end ordinary share returns for Taff Vale based on annual share prices and dividends also taken from the IMM. Any missing observations were checked against the same source. If prices were still missing, they were in-filled with the mean values for the other railway securities of the same class in that year. We also adjusted returns to take account of any capital changes. CR, GNR, LBSCR, LSWR, MSLR/GCR, MR, and NBR split their ordinary shares into preferred ordinary and deferred ordinary shares. In the case of LBSCR, NBR, GNR, and MR and MSLR/GCR in 1883, 1888, 1891, and 1897 respectively, the ordinary shares appear to have been retired and were no longer quoted in IMM. Hence, after these dates we have used changes in dividends and share price returns on the deferred ordinary shares as representing the residual returns to shareholders. We did not adopt this approach with CR and LSWR because the split into preferred and deferred ordinary was at the option of the shareholder, and the ordinary shares both continued to trade and had dividends declared on them.

pattern of quinquennial returns reported by Kennedy and Delargy.[30] Hence, we also compute returns for the sub-periods, 1870-97 and 1898-1913 in Table 5. Ordinary shares, preference shares and debentures on average returned +7.4%, +6.8% and +6.3% per annum, respectively, between 1870 and 1897. In the later period up to WWI, however, all three railway asset classes generated losses of between 1.5% and 2% per annum when the ordinary shares of Taff Vale Railway were the only security to deliver a positive return to investors.

More importantly, the relative returns of domestic railway securities of all three types deteriorated. In the earlier period to 1897, they offered a healthy premium of 2 to 3% over the 4.6% real return on Consols (Table 5, Panel C). Subsequently, this premium shrank to less than 0.5%, as Consols averaged only a slightly inferior real return of -2%. Similarly, the decline in domestic railway returns relative to those on foreign railway securities was marked. Hence, although foreign railway debenture returns performed in line with their domestic cousins prior to the late 1890s, they proved far more attractive investments later on, and in no single year delivered a negative return.[31]

Investors receive their return on any security through price changes and income, either in interest or dividends. Rearranging equation (2), we obtain an expression for total return which in the case of ordinary shares decomposes into its capital return in real terms plus the dividend yield as follows:

$$r_{ijt} = \frac{P_{ijt} / I_t}{P_{ijt-1} / I_{t-1}} + \frac{D_{ijt}}{P_{ijt-1}} - 1 \qquad (3)$$

Now, we can consider the relative contribution of each component to the total returns of railway shares.

As residual claimants on a company's assets, ordinary shareholders receive dividends on their shares from any profits remaining after payment of the fixed interest and fixed dividends due to debenture and preference shares, respectively. Overall, ordinary share dividends in the sector trended down after about 1890. The fall in the 5-year moving average of sector dividends paid as a percentage of par value between the 1870s and early 1900s reflects the deterioration in the returns on capital employed discussed above (Table 6, Panel A).

There was, of course, considerable variation in dividends paid and dividend yields across companies. This tended to reflect underlying business performance. TVR paid a very healthy dividend throughout. On the other hand, MLSR (GCR) passed their dividend from the late 1890s onwards, whilst the LCDR paid no dividends at all in any year during the period. Nevertheless, there is a strong correlation between changes in ROCE and

[30] Kennedy and Delargy, 'Explaining Victorian entrepreneurship', Table 11a.
[31] The mean return (standard deviation) of foreign railway debentures was 6.3% (2.9%) and 3.4% (1.6%) in 1870-97 and 1898-1913, respectively, based on Edelstein's data.

changes in dividends relative to par value as the following regression based on the combined data of Tables 2 and 6 shows (t-statistics in parentheses):

$$\Delta\,(\text{Div/Par}) = \underset{(0.08)}{0.0003} + \underset{(3.49)}{3.174}\,\Delta\text{ROCE} \qquad R^2 = 0.635$$

Dividend yields fell steadily from an average of 3.7% in 1877 to 2.8% in 1897, followed by a recovery to 3.5% in 1910 (Table 6, Panel B). The implication is that when dividends relative to par value fell in the 1880s the market did not reduce equity prices so as to maintain the dividend yield but prices began to slide in the 1890s more or less up to 1913. This process of de-rating the shares generated negative capital returns. Capital returns to the 15 railway ordinary shares fluctuated considerably more than their dividends, and losses first began appearing in the early 1890s (Table 6, Panel C). The dividend yield kept total returns on domestic railways in positive territory until the turn of the century; thereafter, capital losses more than offset the dividend yield to push total returns into negative territory (Table 6, Panel D).

Thus, as would be expected, the deterioration in returns on capital employed had adverse consequences for shareholders. The long-term implications were that dividends were reduced and then share prices fell, notably from the late 1890s. There ensued a lengthy period of negative total returns.

IV

Far from considering the investment merits of domestic railways in isolation, investors would have assessed their attractiveness in a diversified portfolio of quoted securities. The benefits of spreading investment risk were well understood by late Victorian investors.[32] Given the considerable change in the fortunes of this sector in the late 1890s, how might a rational investor have reassessed exposure to railway securities in such a diversified portfolio?

We can estimate the composition of an optimal portfolio of a late Victorian investor by employing the tools of modern portfolio theory. The starting point of this theory is the assumption that investors possess mean-variance preferences. In other words, they care only about the expected return, defined by mean return, and the risk, defined by variance, of any investment in assembling a portfolio.[33] Furthermore, investors prefer more return and less risk.

[32] Lowenfeld, *Investment*.

[33] This theory was originated by Markowitz, *Portfolio selection*. An accessible textbook introduction to portfolio optimization is Bodie, Kane and Marcus, *Investments*, ch.7.

The decision as to which portfolio chosen from the many securities available is optimal can then be analyzed in two stages. Firstly, we identify the minimum variance frontier, which is the hyperbola in Figure 2, and represents those portfolios with the lowest risk for a given level of return. In other words, each point on this curve is associated with a set of weights, w_i, for a subset of *i* securities chosen from the investment universe, where these weights minimize the portfolio variance for a given level of portfolio expected return (μ). Formally, it is the solution to the following quadratic programme:

$$\text{Min} \qquad \sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_{ij}$$

$$\text{subject to} \qquad \sum_i w_i r_i = \mu$$

$$\text{and} \qquad \sum_i w_i = 1$$

The efficient frontier is that part of the hyperbola which lies above the minimum variance portfolio (MVP). The intuition here is that any investor will do better to diversify his or her wealth across a basket of securities, thereby reducing risk for a given target return. This process will result in a portfolio represented by a point on the efficient frontier.

At the second stage, we identify which portfolio on the efficient frontier investors should choose by assuming that any investor's objective is to maximize return for a given level of risk. Investors are interested in the portfolio return achieved in excess of the benchmark risk-free asset, such as Consols, which earns a risk-free return. This objective is graphically represented by the line, known as the capital allocation line (CAL), which intersects the y-axis at the risk-free rate (r_f) and forms a point of tangency (P) with the efficient frontier. The slope of this line is equivalent to the expected return on the portfolio (μ) in excess of the risk-free return (r_f) relative to the standard deviation of the portfolio return (σ_p). This is the Sharpe ratio, and is expressed algebraically as:

$$S_p = \frac{\mu - r_f}{\sigma_p}$$

The ratios for the various securities and the optimal portfolio are graphed in Figure 3. As might be expected, the risk-reward trade-off is most attractive for the portfolio. Also note that the highest ratio among the domestic railway securities, RAIL(MAX), is exceeded by that of the foreign railway debenture sector, WRAIL, and by the mean ratio for all non-domestic railway sectors, NON-RAIL(MEAN), from the late 1890s.

The optimization problem confronting the rational investor now becomes:

$$\text{Max} \qquad S_p = \frac{\mu - r_f}{\sigma_p}$$

subject to $\sum_i w_i = 1$

and $w_i \geq 0$ (short sale constraint)

where w_i.is the weight of the i^{th} security in the portfolio. Again the solution generates a set of weights, w_i^*, of those securities comprising the optimal portfolio, P. These weights are the optimal weights. The portfolio P is also called the market portfolio, since it represents the aggregate portfolio of securities held by all investors, which equates to the market itself.

Furthermore, according to the fund separation theorem, any investor is able to hold any linear combination of the risk-free asset and the market portfolio, as described by the CAL. Risk-averse investors will choose a point on this line to the south-west of the tangency point, P, and in the extreme case would hold just the risk-free asset, Consols. Risk-loving investors, on the other hand would borrow to invest in the market portfolio and locate themselves somewhere on the same line but to the north-east of point P. Investors do not need to vary the individual security holdings within their optimal portfolio to take account of their risk preferences, but simply shift the proportion of their wealth that they allocate to the optimal portfolio, P.

The intuition of this second stage is that the particular point on the efficient frontier chosen by the investor represents exactly that portfolio which maximizes his or her return in excess of the risk-free asset for the risk taken. The optimal portfolio, P, has the highest Sharpe ratio given the expected returns, variances and covariances of all the securities, or assets, available to investors. A security has two chances to get into the optimal portfolio. The higher its return relative to other securities, the more likely it will be selected. In addition, the lower the contribution made to portfolio risk, the more likely it will make the cut. Hence, in the case of individual domestic railways, modest return expectations might be compensated by their diversifying advantages when added to a portfolio.

Goetzmann and Ukhov applied such a theoretical framework in examining how investors would have diversified their portfolios in the 1870-1913 period across a total of 19 domestic and foreign broad asset classes.[34] Building on Edelstein's earlier finding that on a risk-adjusted basis investors were more than adequately compensated for investing overseas, and using the same sample, the authors concluded that British investors behaved rationally in acting on these attractive returns and allocating a large portion of their wealth to foreign assets.

More relevant to our line of enquiry, they found that rational investors on the eve of WWI would have held absolutely no domestic railway securities at all.[35] This is, perhaps, unsurprising given the substantial deterioration in railway returns from the late 1890s

[34] Goetzmann and Ukhov, 'British investment'.
[35] Ibid., Table XI, Panel A. In fact, Panel B shows that had they been able to do so, investors would have been substantial short sellers of the domestic railway ordinary share asset class.

onwards, both relative to the benchmark asset, Consols, as discussed above, and to other sectors. Average returns of railway ordinary and preference shares were the poorest amongst domestic sectors with the exception of the insignificant Canals and Docks, and were considerably below those on foreign railway shares.[36] Railway debenture returns, although in line with other domestic sector returns, were inferior to foreign debenture returns by a considerable margin.

We wish to pin down the implications of declining railway profitability for portfolio choice more precisely. Accordingly, we disaggregate the domestic railway asset classes into their constituent securities, and consider which individual railway securities a rational investor would have held as part of an optimal portfolio, given the considerable cross-sectional variation in total returns described above and we seek to identify the point at which this investor would have begun to reduce exposure to domestic railways in such a portfolio.

We assume that late Victorian investors had mean-variance preferences, were unable to sell short, and maximized their portfolio's Sharpe ratio. The available investment universe comprised 7 domestic asset classes, excluding the domestic railway sector, and 8 foreign asset classes, as represented by the Edelstein sample. This part of the sample is similar to that utilized by Goetzmann and Ukhov.[37] In place of the 3 domestic railway asset classes, we substituted the 32 domestic railway securities, consisting of 14 ordinary shares, 6 preference shares and 12 debentures, (see Appendices 1 and 2). This makes a total of 47 assets available for investment.[38]

Given the expected real returns, the variances and the co-variances of these 47 assets, we estimate the weights allocated to individual domestic railway securities given that rational investors maximized their portfolio's Sharpe ratio. We assume investors required at least fifteen years of returns history in order to formulate their returns expectations. Portfolios are then optimized for various periods, all of which start in 1870, and end in any year between 1884 and 1913, as we extend one year at a time the period over which an investor computed his return expectations. The detail of the optimization procedure is described in Appendix 2.

The weights of each railway security included in the optimal portfolio are summarized in Table 7. There is a mixture of ordinary and preference shares and debentures, although ordinary shares predominate. Some of the weights such as GWR are very small and

[36] Ibid., Tables IX, X and XI.

[37] Ibid.. The 7 domestic asset classes are the ordinary shares of domestic Banking and Finance, Light Industry and Commerce, Heavy Industry, and Infrastructure, the preference shares of domestic Manufacturing and Commerce, and the debentures of domestic Municipals, and Infrastructure. We excluded the domestic industrial debenture sector because there were too many missing observations. The 8 foreign asset classes are the ordinary shares of foreign Railways, Banking and Finance, Infrastructure, and Tea and Coffee Plantations, and the debentures of Colonial Governments, Colonial Municipals, foreign Railways, and foreign Infrastructure.

[38] The results from including Taff Vale Railway ordinary shares in the investment universe are summarized in Appendix 3.

insignificantly different from zero as indicated by the bootstrap standard errors in brackets. Overall, the railway portfolio holdings chime with our estimates of railway economic returns. Long-term holdings included LSWR, one of the stronger economic performers, whereas the ordinary shares of poor economic performers such as MSLR (GCR) were never included in the portfolio. Although LNWR, one of the most reputable railways, only saw its ordinary and preference shares feature briefly and insignificantly in the portfolio, its debentures claimed a more substantial holding of up to 4% in the 1890s. The main holding was the NER preference share which occupied 15% of the portfolio in the period to 1889.[39] The attraction of this security was not so much its level of returns as the diversification benefits offered by its low correlations with non-railway assets.

Edelstein concluded that foreign assets earned superior risk-adjusted returns, and that domestic railway ordinary shares were a particularly poor investment.[40] However, this was the position looking back from 1913. Our analysis enables us to look at how the investment environment evolved in the years leading up to 1913. Summing our results for individual railway security weights in the optimal portfolio for each period (RAIL, Table 7), a clear picture of the decline in the domestic railway allocation emerges (Figure 4). The total weight begins at approximately the 10% level in 1884, rising to a peak of 27% in 1897, thereafter falling away sharply to zero from 1902 onwards.[41] In contrast, the allocation to foreign railway securities, largely comprising debentures, increased steadily from a level of 9% for the period ended 1884 to above 40% on the eve of WW1 (WRAIL, Table 7). Thus, the rational investor would have produced the sort of portfolio that Edelstein's earlier analysis suggested, but would have started out in the 1880s with an allocation to domestic railways at least as large as that to foreign railways.[42]

Whilst we have focused on deteriorating returns as the main determinant of the decline in the domestic railway weighting, the risk-reward characteristics of these securities were unable to rescue the situation. As we saw in Figure 3 above, the highest Sharpe ratio provided by the most attractive domestic railway security fell below those available from other assets and also from foreign railway debentures after the late 1890s. Furthermore, the co-variances between domestic railway securities and the other sectors on offer were

[39] Such a large weighting in one security might be deemed in appropriate. We experimented by constraining the NER preference share weight to a maximum of either 5% or 10 %. In these cases, both other railway assets and non-railway assets increase and the peak allocation to domestic railways (RAIL) declines to about 20% in 1892. The finding of a subsequent decline to zero by the early 1900s is not affected so the story is the same in broad outline.

[40] Edelstein, *Overseas investment*, pp.135.

[41] Our optimization results for the whole period 1870-1913 are similar to those of Goetzmann and Uhkov and omit domestic railways in favour of foreign railways. Although we adopt a slightly different procedure from them (see Appendix 2), the non-railway sector weights are also similar to those of the top 3 ranked portfolios in their constrained case, 'British investment', pp.289-290, Table X, Panel A.

[42] Our results ar not sensitive to the use of 1870 as the base date for the formation of return expectations. If we suppose that investors formed their expectations at any time based solely on the previous 20 years experience, then the evolution of the resulting domestic railway weight in the optimal portfolio over time is very similar to that portrayed in Figure 4.

such that their inclusion after the turn of the century failed to lower overall portfolio risk sufficiently to warrant their inclusion.[43]

The question arises as to whether the subsequent disappearance of domestic railways from the optimal portfolio is driven by the deterioration in their returns or an improvement in other returns. Real returns in other sectors declined on average by 53 per cent in the period 1898-1913 compared with 1870-1897 but still remained in positive territory. To address this question, we constrain the mean return for each domestic railway security in 1898-1913 to fall in line with other assets, otherwise leaving standard deviations and correlations unchanged, and re-run the optimization procedure for the whole period to 1914. In this case, all domestic railway securities would have amounted to over 10 per cent of the rational investor's portfolio. The suggestion is, therefore, that it was poor domestic railway returns rather than improvement in other returns which led to their ejection from the optimal portfolio.

The poor relative price performance of railway securities after 1897 indicates that some investors did sell their railway holdings. Phoenix Assurance, for example, reduced its domestic railway weighting from 10% in 1890 to 2.6% in 1900, and then to 1.3% in 1913.[44] Some investors, however, were effectively forced to retain their railway securities, in particular those whose activities were governed by the Trustee Acts which severely restricted the type of security in which guardians of "widow and orphan" savings could invest.

Other investors, particularly those focused on past dividends, may have delayed revising their return expectations downwards, preferring to cling to the belief that railway securities after 1898 would bounce back and do just as well as they had in the earlier part of this pre-1913 period. Thus, in 1901, *The Economist* counseled its readers as follows:

"When all is said, however, it is hard to believe that the prosperity of British railways is a thing of the past, or even that a permanent reduction of dividends of more than moderate extent is to be regarded as inevitable."[45]

The most vociferous critic of the domestic railway sector was *The Investors' Review*, as widely regarded as the *Investor's Monthly Manual*, and carrying far more financial commentary. This journal bemoaned the inability of railway management to control capital expenditures and working expenses. However, they reserved their most stinging criticisms for the senior management themselves.[46] Yet, as late as 1909, the magazine

[43] Beta is the simplest measure of the contribution of a stock to overall portfolio risk. However, the small number of the annual returns and the lack of a suitable world equity index makes the estimation of individual security betas with any degree of accuracy a hazardous business. An examination of the correlation matrix of returns on all assets and securities, however, suggests the absence of diversifying properties among domestic railways. This matrix is available on request.

[44] Trebilcock, *Phoenix Assurance*, Table 1.6, pp.73.

[45] *The Economist*, "Are Home Railway Stocks Cheap?" 17 August, 1901, pp.1238.

[46] *The Investors' Review*, "The Home Railway Position", 17 February, 1906, pp.199: "We cannot look at such figures without feeling that there is a lack of business perspicacity in the management of our railways.

despaired of the vast majority of investors investing the time and effort to understand the degree of mismanagement taking place.[47]

Notwithstanding this selling, domestic railways still accounted for over one third of the entire London market in 1913.[48] In the case of ordinary share market values alone, domestic railways represented a much smaller proportion) of the equity market.[49] The implication is that investors remained overexposed to domestic railways on the eve of WW1. However, whilst one can argue that the Victorian investor would have been well advised not to hold railways from the late 1890s onwards, it is conceivable that the railway sector weighting in 1913 represented an equilibrium position. Having seen the sector de-rated and the dividend yield recover over the previous decade and a half, some investors might have expected the ordinary shares of the better companies to revert towards their mean long-run performance and to deliver a more attractive return of around 4% to 5% per annum with modest volatility in the future. In such a case, they might well have included such steady performers as Midland in their optimal portfolios.[50] Therefore, having shunned these shares in the late 1890s when their ratings were propelled by the irrational exuberance of others, the well-informed investor may have waited until dividend yields had returned to a level at which investment once more became attractive.

Alternatively, had investors taken the above analysis to heart and decided to sell out immediately, we might ask how far these shares would have fallen in the late 1890s before re-entering the optimal portfolio. In the case of ordinary shares, assuming that a dividend yield of 3.5% was required and prices in 1913 represented fair value, a decline of about one-third would have been needed.

Nevertheless, it seems clear that the weight given to domestic railway securities by a rational investor would have been much lower in 1913 than in 1897. During the intervening years railway shareholders had a bad time as the longer-run consequences of declining ROCE were reflected in negative returns. As argued in section II, the scope for

---

They are still amateurish in many respects, presided over by great landowners and gentlemen of means….and the presiding directorate too frequently stands in the way of thorough reform, of good account keeping, of careful husbandry in finance." See also "State Ownership of the Railways", 15 February, 1908, pp.205, poor management "is tending to reduce the railways to a state of unprofitableness unexampled in the history of this branch of modern scientific development in any other part of the world".

[47] *The Investors' Review*, "Why Home Rails Refuse to Rise", 29 September, 1909, pp.363: "Even now we doubt if one railway shareholder in five thousand has really taken the trouble to master what a loose and free and easy treatment of the capital account is coming to mean to him."

[48] This weighting is taken from the *Stock Exchange Daily Official List* figures quoted in Michie, *The London Stock Exchange*, Table 3.3. British government securities, as the risk-free asset, are excluded as are foreign government stocks and railways. Any change in weights, of course, reflects both the relative amount of new issues as well as relative price changes.

[49] Grossman, *New Indices,* Table 1. The railway sector, including sterling denominated foreign railway shares, represented 15% of the total equity market, compared to 76% in 1870.

[50] If we rerun the same optimization as above, but substitute return expectations for the domestic railway ordinary shares based on normal fluctuations around a steady dividend yield at the level seen on the eve of WWI in place of realized returns 1898-1913, then ordinary railway shares re-enter the optimal portfolio at around the 10% level. These results and the detailed assumptions are available on request.

management to instil investor confidence by further addressing cost inefficiencies was extremely limited by 1910. Consequently, the portfolio options available to investors had been significantly diminished by the difficulties that beset railway profitability in the late Victorian and Edwardian periods.

V

This section discusses the railways' profitability record in terms of the quality of resource allocation in the British economy. The private return on capital expenditure is compared with the cost of capital and the social rate of return. Finally, the implications of cost inefficiency are considered in the context of the long-standing debate about entrepreneurial failure.

Investments are justified if they cover the cost of capital. This can be written as

$$CC = \lambda(rf + dp) + (1 - \lambda)(rf + \beta rp) \qquad (5)$$

where CC is the weighted-average cost of capital, dp is the debt premium λ is the gearing level, rf is the risk-free interest rate, rp is the equity risk premium and β is the ratio of the covariance of the returns on the company's shares with those of the overall market divided by the variance of the market returns.

The data used above to analyze portfolio decisions suggest that average values for these variables are dp = 1.5, rf = 2.5, λ = 0.3, β = 1. Estimates of the equity risk premium tend to be lower than once was the case and 4 per cent is perhaps a reasonable assumption.[51] This implies that the average cost of capital for the railway sector was 5.75 per cent which is fairly similar to the costs of capital allowed by regulators of UK privatized utilities nowadays who generally have used similar values for the key parameters.[52]

The estimates reported in Tables 1 and 2 indicate that, with the exception of the Taff Vale Railway, the benchmark of 5.75 per cent for ROCE was not reached after the mid-1870s. Indeed, the rate of return for the sector as a whole fell below 5 per cent in the early 1890s and did not regain this level. This is consistent with the suggestion that investment in the sector had turned out to be excessive, especially since by the end of our period there was no scope to reach the benchmark by addressing issues of cost inefficiency. This does not, however, necessarily imply that part of the railway network should have been shut down straightaway. Given that the fixed costs of capital had been incurred, continued operation was justified as long as variable costs were covered.

In any case, in evaluating the contribution of railways to the British economy it is important to consider the social rate of return which was much greater than the private ROCE. In this context the appropriate comparison is with the social discount rate. The average social rate of return can be written as

[51] Cf. Dimson et al., 'The worldwide equity premium'.
[52] Jenkinson, 'Regulation'.

$$\frac{\text{Social Saving + Net Revenue + Net Externalities}}{\text{Cumulated Capital Expenditure}} \qquad (6)$$

This formula recognizes the value of lower transport costs to users captured by the social savings, i.e., consumer surplus gains, from railways. Given the relative stability of returns, an evaluation of this expression for 1890 will serve our purpose.[53]

The additional information that is required is for the social savings. For passenger services this is provided by Leunig who took account both of monetary and time savings and also of the price elasticity of demand. His estimates is that the passenger social savings was 4.4 per cent of GDP in 1890, i.e., £68.6 mn.[54] The starting point for freight social savings is the estimate made by Hawke for 1865.[55]

The mid-point of Hawke's estimate for the freight social saving was 3.2 per cent of GDP in 1865. This was an upper bound estimate which assumed a zero price elasticity of demand. Fogel suggested that this overestimates the true social savings by 24 per cent.[56] Accepting this correction, implies a freight social saving of £26.8 mn. for Britain in 1865. This can be converted into an estimate for 1890 by taking account of the extra volume of traffic in the latter year and the further reduction in transport costs in line with TFP growth.[57] The latter is taken to be 0.8 per cent per year in line with the estimates given by Crafts et al.[58] This results in a freight social savings of £72.8 million in 1890, i.e., 5.0 per cent of GDP.

Thus, the average social rate of return on railways in 1890 was 28.6 per cent based on a total social saving of £141.4 mn. plus (from Table 1) net revenue of £31.5 mn. compared with cumulated capital expenditure of £603.8 mn. This is a classic example of a technological innovation whose benefits accrue to consumers rather than proprietors.[59] The implication is that on average railways were a great investment from society's point of view, if not for the private investors who financed them.

The standard formula for the social discount rate is

$$SDR = \delta + \eta g \qquad (7)$$

---

[53] McClelland, 'Social rates'. There is no quantitative evidence on externalities so we disregard them. In view of the estimates presented below, this is unlikely to be a serious omission.
[54] Leunig, 'Time is money', figure 6; data kindly supplied by the author.
[55] Hawke, *Railways and economic growth*, p. 188.
[56] Fogel, 'Notes', pp. 11-12. This correction is based on an elasticity of demand of 0.4 and a ratio of alternative transport costs to rail transport costs of 2.64.
[57] As is noted by Foreman-Peck, 'Railways', p. 77.
[58] Crafts et al., 'Total factor productivity', p. 618.
[59] In the last half of the twentieth century, it has been estimated that supernormal profits averaged only about 2 per cent of social gains from innovation with the remainder passed to consumers through lower prices; see W. D. Nordhaus, 'Schumpeterian profits in the American economy: theory and measurement', NBER Working paper No. 10433 (2004).

where δ is the rate of pure time preference, g is the rate of growth of real consumption per person and η is the elasticity of marginal utility of consumption with respect to the growth of consumption. HM Treasury works with an SDR of 3.5 per cent for today's UK based on $\delta = 1.5$, $\eta = 1$, and $g = 2$.[60] Other writers suggest that $\eta = 1$ is too low and SDR = 6 per cent is probably more appropriate and more consistent with observed savings behaviour.[61] Then again, $g = 2$ would be on the high side for Victorian Britain. In any case, there is no real doubt that the average social rate of return on railways far exceeded their opportunity cost.

That said, railways could have been better managed and the average social rate of return could have been higher. The estimates above do not rule out the possibility that marginal railway investment projects were undertaken that did not produce an adequate social return - the Great Central extension of its main line to London may well be a case in point. And, the evidence presented above in section II was that, at times, cost inefficiency was a serious problem.

To illustrate this last point, consider the median level of cost inefficiency across these railway companies in 1900 of 10.2 per cent. This implies that capital employed could have been about £84.6 mn. lower and operating expenditure about £5.7 mn., or 0.3 per cent of GDP, lower. If this capital had been deployed elsewhere in the economy it would have raised the overall capital stock by about 2.4 per cent and, using a standard output elasticity of 0.33, GDP by about 0.8 per cent.[62] Thus, losses from railway inefficiency, amounted to a little over 1 per cent of GDP in 1900.

Railways are an important qualification to the general exoneration of British management in this period that was proffered by the new economic historians.[63] The railway sector was characterized by a separation of ownership from control in which shareholders were weak, high barriers to entry and weak regulation at least prior to the freeze on freight charges. There was ample scope for management to fail at least until profits became too low for comfort in the early twentieth century. The neoclassical exoneration was largely based on investigations of industries where managers were exposed to much greater competition than was the case in railways.[64]

VI

So how good was the profitability of the major British railway companies in the years before World War I? In this paper, we have established several important new results which distinguish the profitability of the businesses from the returns to shareholders and the value of the railway in terms of a social cost-benefit analysis. Our main findings are as follows.

---

[60] HM Treasury, *The Green Book*, annex 6.

[61] Weitzman, 'The Stern Review'. The optimal savings rate based on equation (7) = $(r - \delta)/\eta r$ which for HM Treasury's parameters would imply 57 per cent!.

[62] Calculations based on aggregate capital stock estimate in Feinstein, 'National statistics', p. 428.

[63] McCloskey and Sandberg, 'From damnation to redemption'.

[64] For a fuller discussion of this point see Crafts et al., 'Were British railway companies'.

First, on the basis of cumulated capital expenditure, the return on capital employed fell from an average of 5.6 per cent in the early 1870s to about 4.5 per cent in the early 1900s after which it stabilized. After starting out at a level that was probably quite close to the cost of capital, the railway industry persistently failed to produce the required returns. This was the typical company experience but some companies had very low profitability throughout, e.g., London, Chatham and Dover.

Second, cost inefficiency was considerable in the 1890s and, had this been eliminated, most companies would have delivered a return on capital employed over 5 per cent. By the end of our period, there was no longer a possibility of achieving adequate returns from squeezing out inefficiency. the high level of cost inefficiency in the 1890s is symptomatic of a combination of weak competition, weak shareholders, and weak regulation in a non-traded service sector.

Third, returns to shareholders were quite attractive before the late 1890s. An optimal portfolio analysis indicates that a rational investor would have wanted a substantial weight in domestic railway shares - our estimate is that 27 per cent would have been justified in 1897. Thereafter downward pressure on profitability was reflected by a re-rating of share values which inflicted capital losses on shareholders and a rapid rush to the exits would have been appropriate.

Fourth, these outcomes are rather less bad than earlier writers have claimed. Our estimates of return on capital employed are generally around 1 percentage point higher than those recently published by Arnold and McCartney for a similar sample of companies.[65] While Goetzmann and Ukhov concluded that investors should have held no domestic railway securities in the 1870-1913 period we find that this only applies to the years from 1902 onwards and that as late as 1897 a sizeable holding would have been appropriate for these assets.

Finally, it is clear that, on average, railway investments delivered a high social rate of return - our estimate for 1890 is a rate in excess of 25 per cent. The reason for this is that the consumer surplus gains of transport users which accrued from cheaper and faster transport than was available from other modes dwarfed the profits available to be distributed to the owners of the railway companies. So, even though there was indeed waste and inefficiency on British railways in the late nineteenth century, nevertheless their contribution to economic welfare was massive.

[65] Arnold and McCartney, 'Rates of return'.

Footnote References

Aldcroft, D. H., *British Railways in Transition* (1968).

Arnold, A. J. and McCartney, S., 'Rates of return, concentration levels and strategic change in the British railway industry, 1830-1912', *Journal of Transport History*, 25 (2005), pp. 41-60.

Bodie, Z., Kane, A., and Marcus A.J., *Investments,* 7th edition (New York, 2007).

Cain, P. J., 'Railway combination and government, 1870-1914', *Economic History Review* 2nd ser., XXV (1972), pp. 623-641.

Cain, P. J., 'Railways, 1870-1914: the maturity of the private system', in M. Freeman and D.H. Aldcroft, eds., *Transport in Victorian Britain* (Manchester, 1988), pp. 93-133.

Crafts, N., Leunig, T. and Mulatu, A., 'Were British railway companies well managed in the early twentieth century?', *Economic History Review* (forthcoming).

Crafts, N., Mills, T. C., and Mulatu, A., 'Total factor productivity growth on Britain's railways, 1852-1912: a reappraisal of the evidence', *Explorations in Economic History*, 44 (2007), pp. 608-634.

Dimson, E., Marsh, P. R. and Staunton, M., 'The worldwide equity premium: a smaller puzzle', in R. Mehra (ed.), *Handbook of Investments: Equity Risk Premium* (Amsterdam, 2007), pp. 467-514.

Edelstein, M., *Overseas Investment in the Age of High Imperialism: the United Kingdom1850-1914* (New York, 1982).

Feinstein, C. H., 'National statistics, 1760-1920', in C. H. Feinstein and S. Pollard (eds.), *Studies in Capital Formation in the United Kingdom, 1750-1920* (Oxford, 1988) pp. 259-471.

Fogel, R. W., 'Notes on the social saving controversy', *Journal of Economic History*, 39, pp. 1-54.

Foreman-Peck, J., 'Railways and late Victorian economic growth', in J. Foreman-Peck (ed.), *New Perspectives on the Late Victorian Economy* (Cambridge, 1991), pp. 73-95.

Goetzmann, W. N. and Ukhov, A. D., 'British investment overseas, 1870–1913: a modern portfolio theory approach', *Review of Finance*, 10 (2006), pp. 261-200.

Grossman, R.S., 'New indices of British equity prices 1870-1913', *Journal of Economic History*, 62 (2002), pp.121-146.

Hawke, G. R., *Railways and Economic Growth in England and Wales, 1840-1870* (Oxford, 1970).

HM Treasury, *The Green Book: Appraisal and Evaluation in Central Government* (2003).

Irving, R. J., 'The profitability and performance of Britain's railways, 1870-1914', *Economic History Review* 2nd ser., XXXI (1978), pp. 46-66.

Irving, R. J., 'The capitalisation of Britain's railways, 1830-1914', *Journal of Transport History*, 5 (1984), pp. 1-24.

Jenkinson, T., 'Regulation and the cost of capital', in M. Crew and D. Parker (eds.), *International Handbook on Economic Regulation* (Cheltenham, 2006), pp.

Leunig, T., 'Time is money: a re-assessment of the passenger social savings from Victorian British railways', *Journal of Economic History*, 66 (2006), pp. 635-673.

Lowenfeld, H., *Investment an Exact Science*, (London, 1907).

Markowitz, H., 'Portfolio selection', *Journal of Finance,* 7 (1952), pp.77-91.

McClelland, P., 'Social rates of return on American railroads in the nineteenth century', *Economic History Review*, XXV (1972), pp. 471-488.

McCloskey, D. N. and Sandberg, L., 'From damnation to redemption: judgments on the late Victorian entrepreneur', *Explorations in Economic History*, 9 (1971), pp. 89-108.

Michie, R.C., *The London Stock Exchange: A History* (Oxford, 2001).

Mitchell, B.R., 'The coming of the railway and United Kingdom economic growth' *Journal of Economic History,* X (1964), pp.315-336.

Trebilcock, C., *Phoenix Assurance and the Development of British Insurance,* Vol. II. (Cambridge, 1998).

Weitzman, M., 'The Stern Review of the economics of climate change', *Journal of Economic Literature* 45 (2007), pp. 703-724.

Table 1. Return on Capital Employed: All 15 Companies

	Adjusted Paid-Up Capital	Cumulated Capital Expenditure	Net Traffic Revenue	% return Paid-Up Capital Basis	5-Year Moving Average	% return Capital Expenditure Basis	5-year Moving Average
1870	400549	361929	19646.0	4.90		5.43	
1871	412017	373585	21710.3	5.27		5.81	
1872	428946	389639	22720.5	5.30	5.11	5.83	5.63
1873	443372	401961	22769.3	5.14	5.13	5.66	5.64
1874	459202	417609	22651.9	4.93	5.05	5.42	5.58
1875	477197	433163	23819.8	4.99	4.95	5.50	5.49
1876	505173	450441	24670.5	4.88	4.88	5.48	5.43
1877	519964	464676	25107.9	4.83	4.83	5.40	5.39
1878	534625	479064	25528.8	4.78	4.82	5.33	5.39
1879	547911	489690	25661.0	4.68	4.82	5.24	5.38
1880	555461	498916	27395.4	4.93	4.84	5.49	5.39
1881	565516	509121	27612.1	4.88	4.87	5.42	5.42
1882	578793	519559	28440.7	4.91	4.89	5.47	5.43
1883	589510	533070	29118.7	4.94	4.83	5.46	5.35
1884	600980	544560	28821.0	4.80	4.78	5.29	5.27
1885	609431	556450	28304.5	4.64	4.73	5.09	5.19
1886	617302	564385	28478.4	4.61	4.70	5.05	5.14
1887	622509	572956	29113.8	4.68	4.74	5.08	5.16
1888	632304	582170	30202.1	4.78	4.78	5.19	5.18
1889	637104	591857	31761.6	4.99	4.81	5.37	5.19
1890	651308	603782	31530.7	4.84	4.80	5.22	5.16
1891	656014	618368	31364.8	4.78	4.44	5.07	4.76
1892	675906	630362	31053.6	4.59	4.35	4.93	4.65
1893	686224	642049	20661.4	3.01	4.29	3.22	4.58
1894	697654	653659	31557.5	4.52	4.29	4.83	4.58
1895	707484	663228	32326.4	4.57	4.32	4.87	4.59
1896	712864	671616	33945.2	4.76	4.64	5.05	4.92
1897	724770	688026	34355.0	4.74	4.67	4.99	4.93
1898	738433	702944	34188.4	4.63	4.64	4.86	4.87
1899	749680	718937	34980.7	4.67	4.53	4.87	4.73
1900	763695	734977	33669.3	4.41	4.46	4.58	4.65
1901	778536	749808	32802.3	4.21	4.41	4.37	4.58
1902	794616	762344	34793.8	4.38	4.34	4.56	4.51
1903	806370	780201	35278.5	4.37	4.34	4.52	4.51
1904	818790	787999	35598.2	4.35	4.39	4.52	4.56
1905	825358	797356	36391.1	4.41	4.41	4.56	4.57
1906	837313	805144	37308.6	4.46	4.38	4.63	4.55
1907	845157	815396	37636.0	4.45	4.39	4.62	4.55
1908	852528	821531	36128.3	4.24	4.42	4.40	4.58
1909	857390	827223	37553.3	4.38	4.45	4.54	4.61

1910	860097	829634	39253.1	4.56	4.46	4.73	4.62
1911	860982	833405	39866.1	4.63		4.78	
1912	866439	843596	39075.9	4.51		4.63	

Notes: the 15 companies are those that provided the fullest detail in the *Railway Returns* and were thus able to be subjected to the cost efficiency analysis reported in section IV. They are Caledonian (CR), Great Eastern (GER), Great Northern (GNR), Great Western (GWR), Lancashire & Yorkshire (LYR)London & North Western (LNWR), London & South Western (LSWR), London, Brighton & South Coast (LBSCR), London, Chatham and Dover (LCDR), Manchester, Sheffield & Lincolnshire (MSLR) which became Great Central (GCR) in 1897, Midland (MR), North British (NBR), North eastern (NER), South Eastern (SER), Taff Vale (TVR). These railways comprise about three quarters of the route miles in operation at the end of the period.
Sources: net traffic revenue from *Railway Returns*, paid-up capital and capital expenditures from company accounts held at the time the data were extracted (1962/3) in the British Transport Historical Archives in London, Edinburgh and York, see text.

Table 2. Rates of Return on Capital Employed
(5-year moving average centred on year shown %)

A) Adjusted Paid-Up Capital of All Lines Worked Basis

	1872	*1877*	*1882*	*1887*	*1892*	*1897*	*1902*	*1907*	*1910*
CR	4.73	4.78	4.29	4.38	4.14	4.48	4.07	3.93	3.89
GER	3.62	3.62	4.00	4.16	3.96	4.33	4.17	4.17	4.00
GNR	5.86	5.03	5.12	5.09	4.72	4.51	4.28	4.40	4.49
GWR	5.00	4.47	4.67	4.67	4.64	4.59	4.52	4.61	4.73
LYR	6.23	5.20	4.61	4.14	3.95	4.24	3.78	3.92	3.97
LNWR	6.23	5.52	5.64	5.35	5.17	5.33	4.84	4.97	5.11
LSWR	5.12	5.34	5.11	4.86	5.05	5.28	4.80	4.77	4.73
LBSCR	3.80	4.45	4.31	5.08	5.31	5.26	4.74	4.65	4.72
LCDR	1.75	2.11	2.40	2.34	2.43	2.73	2.70	2.67	2.84
MSLR	5.01	5.12	5.11	4.83	4.41	3.54	3.09	3.53	3.67
MR	5.85	5.31	5.34	5.17	5.02	4.99	4.56	4.48	4.69
NBR	3.56	4.14	4.15	4.40	4.12	4.51	4.57	4.36	4.29
NER	6.17	5.47	5.78	4.96	5.19	5.13	4.91	5.15	5.21
SER	4.56	4.99	4.96	4.80	4.53	4.47	3.46	3.38	3.59
TVR	7.61	7.30	9.05	8.01	5.93	5.78	5.92	6.57	6.24

B) Cumulated Capital Expenditure of All Lines Worked Basis

	1872	*1877*	*1882*	*1887*	*1892*	*1897*	*1902*	*1907*	*1910*
CR	5.31	5.19	4.65	4.65	4.37	4.60	4.09	3.88	3.79
GER	3.90	3.88	4.08	4.03	3.88	4.29	4.14	4.16	3.97
GNR	5.46	4.77	4.82	4.75	4.49	4.32	4.11	4.19	4.25
GWR	5.03	4.65	4.80	4.81	4.68	4.52	4.41	4.43	4.54
LYR	6.31	5.24	4.68	4.17	3.99	4.24	3.75	3.87	3.90
LNWR	6.15	5.56	5.65	5.29	5.06	5.18	4.68	4.76	4.87
LSWR	4.97	5.17	4.90	4.61	4.77	4.96	4.54	4.44	4.42
LBSCR	4.41	5.02	4.81	4.86	5.05	5.08	4.44	4.35	4.36
LCDR	2.03	2.54	2.85	2.78	2.87	3.17	3.05	3.08	3.33
MSLR	5.33	5.31	5.24	4.90	4.40	3.48	2.88	3.34	3.53
MR	5.94	5.42	5.53	5.32	5.19	5.09	4.55	4.40	4.54
NBR	3.58	4.18	4.19	4.38	3.99	4.20	4.24	4.03	3.97
NER	6.19	5.38	5.66	4.80	4.75	4.79	4.46	4.59	4.61
SER	4.53	4.91	4.80	4.63	4.34	4.30	3.32	3.26	3.46
TVR	6.73	6.37	8.04	7.24	5.40	5.21	5.37	5.82	5.49

C) Own Paid-Up Capital Including Nominal Additions and Deductions

	1872	*1877*	*1882*	*1887*	*1892*	*1897*	*1902*	*1907*	*1910*
CR	5.19	4.66	3.86	3.90	3.82	3.66	3.23	3.15	3.08
GER	4.17	4.01	4.15	4.19	3.97	4.34	4.03	4.05	3.90
GNR	5.70	4.72	4.58	4.37	3.75	3.47	3.34	3.42	3.48
GWR	5.32	5.40	5.55	5.54	5.33	5.07	4.92	5.10	5.30
LYR	6.20	5.24	4.55	4.11	3.90	3.74	3.29	3.43	3.46
LNWR	6.76	5.62	5.19	5.00	4.75	4.72	4.36	4.49	4.63
LSWR	5.42	5.50	4.86	4.54	4.57	4.38	4.00	3.81	3.72
LBSCR	4.01	4.99	4.94	5.06	5.34	5.37	5.02	4.99	5.08
LCDR	1.89	2.16	2.40	2.34	2.42	2.73	2.69	2.68	2.83
MSLR	4.83	3.89	3.90	3.80	3.51	2.92	2.60	3.08	3.27
MR	5.91	4.88	4.85	4.48	4.16	3.36	2.43	2.42	2.51
NBR	3.59	3.85	3.77	3.78	3.27	3.48	3.49	3.29	3.27
NER	6.20	5.45	5.77	5.01	5.04	4.77	4.45	4.66	4.71
SER	4.82	5.33	5.24	5.06	4.71	4.71	3.54	3.47	3.71
TVR	11.89	10.94	10.60	10.49	4.03	4.02	4.26	4.74	4.53

Note: MSLR became GCR from 1897
Sources: as for Table 1.

Table 3. Cost Inefficiency and ROCE, 1897 (%)

	Cost Inefficiency	*Actual ROCE*	*Counterfactual ROCE (1)*	*Counterfactual ROCE (2)*
CR	5.0	4.60	4.92	5.18
GER	5.7	4.29	4.71	5.00
GNR	8.3	4.32	4.88	5.33
GWR	14.9	4.52	5.43	6.38
LYR	3.6	4.24	4.39	4.55
LNWR	11.7	5.18	6.03	6.83
LSWR	4.3	4.96	5.47	5.72
LBSCR	2.5	5.08	5.19	5.32
LCDR	2.9	3.17	3.29	3.38
MSLR	19.0	3.48	4.44	5.49
MR	8.6	5.09	5.77	6.31
NBR	4.7	4.20	4.40	4.62
NER	15.1	4.79	5.91	6.96
SER	2.9	4.30	4.70	4.84
TVR	29.5	5.21	6.92	9.81

Note: ROCE on cumulated capital expenditure basis.
Sources: cost inefficiency from estimates made for Crafts et al., 'Were British railway companies', ROCE from Table 2 and counterfactual ROCE (1) based on adjusted profitability if cost inefficiency in operating expenditures eliminated. and counterfactual ROCE (2) based on adjusted profitability if cost inefficiency in both capital and operating expenditures eliminated.

Table 4. Cost Inefficiency and ROCE, 1910 (%)

	Cost Inefficiency	*Actual ROCE*	*Counterfactual ROCE (1)*	*Counterfactual ROCE (2)*	*Counterfactual ROCE (3)*
CR	5.7	4.09	4.11	4.35	3.89
GER	7.9	4.14	4.90	5.32	4.58
GNR	2.1	4.11	4.45	4.55	3.56
GWR	1.4	4.41	4.72	4.79	3.14
LYR	2.7	3.75	4.11	4.22	3.84
LNWR	1.2	4.68	5.15	5.22	3.78
LSWR	3.4	4.54	4.81	4.97	4.43
LBSCR	6.9	4.44	4.88	5.24	4.93
LCDR	4.7	3.05	3.65	3.83	3.57
MSLR	1.7	2.88	3.69	3.75	2.03
MR	1.7	4.55	4.84	4.92	3.87
NBR	7.4	4.24	4.40	4.75	4.27
NER	1.4	4.46	4.76	4.83	3.10
SER	4.7	3.32	3.85	4.04	3.77
TVR	1.5	5.37	5.58	5.66	2.69

Note: ROCE on cumulated capital expenditure basis
Sources: cost inefficiency from estimates made for Crafts et al., Were British railway companies', ROCE from Table 2; counterfactual ROCE (1) based on adjusted profitability if cost inefficiency in operating expenditures eliminated, counterfactual ROCE (2) based on adjusted profitability if inefficiency in both capital and operating expenditures eliminated, counterfactual ROCE (3) based on adjusted profitability if cost inefficiency in both capital and operating expenditures returned to 1897 level.

Table 5. Annual Total Returns to Ordinary Shares, Preference Shares and Debenture Stocks of British Railways, 1870-1913

Total returns are defined as capital returns in real terms plus the dividend yield for the calendar year. See text. All means are equally-weighted.

A) Railway Ordinary Shares

		EWMEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR
1870-1913	MEAN	4.1	4.1	4.1	3.4	5.6	2.5	4.3	4.5
	STDEV	11.0	14.8	14.2	9.0	14.5	9.0	8.0	9.0
1870-1897	MEAN	7.3	8.6	8.6	5.6	9.4	4.9	7.3	8.5
	STDEV	11.2	16.0	15.1	8.0	16.5	8.6	7.2	7.2
1898-1913	MEAN	-1.7	-3.8	-3.8	-0.3	-1.0	-1.8	-1.0	-2.6
	STDEV	8.4	7.8	8.2	9.8	6.2	8.3	6.7	7.4
		LBSCR	**LCDR**	**MSLR**	**MR**	**NBR**	**NER**	**SER**	**TVR**
1870-1913	MEAN	6.5	1.9	2.0	4.5	5.4	4.2	4.0	5.6
	STDEV	17.1	22.4	21.7	8.4	20.7	9.4	11.8	7.9
1870-1897	MEAN	11.2	3.6	4.5	6.7	9.1	7.0	7.9	8.0
	STDEV	18.7	24.1	21.0	6.7	23.8	9.9	10.4	7.5
1898-1913	MEAN	-1.6	-1.0	-2.5	0.7	-1.2	-0.8	-2.7	1.3
	STDEV	9.8	19.5	22.9	9.8	11.4	6.0	11.3	6.7

B) Railway Preference Shares

		EWMEAN	GERP	GNRP	GWRP	LNWRP	MRP	NERP
1870-1913	MEAN	3.7	4.2	3.7	3.8	3.5	3.6	3.3
	STDEV	5.7	6.7	5.9	5.9	5.6	5.7	5.4
1870-1897	MEAN	6.8	7.6	6.8	7.0	6.5	6.7	6.2
	STDEV	3.6	4.9	3.8	3.9	3.6	3.5	3.4
1898-1913	MEAN	-1.7	-1.8	-1.7	-1.8	-1.7	-1.6	-1.7
	STDEV	4.8	5.1	5.1	4.6	4.5	5.1	4.7

C) Railway Debentures

		EWMEAN	CRDB	GERDB	GNRDB	LYRDB	LNWRDB	LBSCRDB
1870-1913	MEAN	3.5	3.4	3.5	3.2	3.2	3.4	3.5
	STDEV	5.5	5.7	5.7	5.5	5.6	5.8	5.7
1870-1897	MEAN	6.3	6.4	6.5	6.0	6.1	6.4	6.5
	STDEV	3.4	3.5	3.6	3.5	3.9	3.9	3.9
1898-1913	MEAN	-1.8	-1.7	-1.7	-1.9	-1.9	-1.9	-1.8
	STDEV	4.6	5.0	4.8	4.8	4.6	4.5	4.5
		LCDRDB	**MSLRDB**	**MRDB**	**NBRDB**	**NERDB**	**SERDB**	**CONSOL**
1870-1913	MEAN	4.6	3.5	3.3	3.5	3.2	3.4	2.2
	STDEV	5.8	5.9	5.7	5.6	5.5	5.7	4.8
1870-1897	MEAN	7.4	6.3	6.2	6.4	6.1	6.5	4.6

	STDEV	4.0	3.8	3.7	3.4	3.7	3.2	4.9
1898-1913	MEAN	-0.4	-1.3	-2.0	-1.7	-2.0	-2.0	-2.0
	STDEV	5.2	6.0	4.7	4.8	4.4	5.0	5.0

Table 6: Railway ordinary share dividends paid (% par value), dividend yields, capital returns and total returns

Total returns are defined as capital returns in real terms plus the dividend yield for the calendar year. See text. In the case of LBSCR, NBR, GNR, and MR and MSL/GCR, the dividends from 1883, 1888, 1891, and 1897 are those received on deferred ordinary shares. Means are equally weighted.

A) Dividends paid (% par value) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	4.2	2.9	0.7	7.0	4.8	7.4	7.3	5.3	2.2	0.0	2.4	6.7	0.0	7.8	4.3	10.4
1877	4.8	5.6	0.8	5.7	4.0	5.7	6.6	5.6	5.3	0.0	2.5	5.6	1.4	7.1	5.5	11.0
1882	5.3	3.9	1.7	5.0	5.6	4.9	7.3	5.7	4.8	0.0	2.5	5.9	2.9	7.9	5.5	15.9
1887	4.7	4.2	2.2	4.5	5.7	3.9	6.6	5.3	4.1	0.0	2.0	5.1	3.1	6.0	4.9	13.6
1892	4.4	4.3	2.3	3.5	5.9	3.8	6.6	6.0	7.2	0.0	1.9	5.7	0.8	6.2	4.2	7.5
1897	4.3	4.9	3.0	1.9	5.2	5.0	6.7	6.5	6.5	0.0	0.7	4.7	0.9	6.3	4.5	7.2
1902	3.6	4.0	3.2	0.9	5.0	4.0	6.0	5.9	4.7	0.0	0.0	2.6	1.5	5.7	2.5	8.4
1907	3.6	3.5	3.0	1.6	5.3	3.9	6.1	5.8	4.5	0.0	0.0	2.6	0.9	5.7	2.6	8.7
1910	3.7	3.2	2.8	1.9	5.5	4.1	6.3	5.8	4.3	0.0	0.0	3.0	0.6	5.9	3.1	8.6

B) Dividend yields (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	3.6	2.9	1.6	5.1	4.4	4.9	4.9	4.9	2.7	0.0	3.2	4.8	0.0	4.6	4.2	5.9
1877	3.7	4.9	1.4	4.6	3.9	4.3	4.5	4.3	4.2	0.0	3.2	4.3	1.0	4.7	4.3	5.6
1882	3.6	3.7	2.4	4.1	4.1	3.8	4.3	4.3	3.7	0.0	2.9	4.3	1.7	4.6	4.3	5.8
1887	3.4	3.8	3.2	3.8	3.9	3.4	3.9	3.9	3.2	0.0	2.7	3.8	1.9	3.7	3.8	6.0
1892	3.1	3.6	2.7	3.0	3.7	3.5	3.8	3.5	4.7	0.0	2.7	3.7	0.5	3.9	3.5	3.9
1897	2.8	3.2	2.6	3.2	3.1	3.5	3.4	3.0	3.7	0.0	1.5	3.5	0.5	3.6	3.0	3.6
1902	2.9	3.5	3.3	2.0	3.6	3.6	3.7	3.5	3.8	0.0	0.0	3.9	1.0	3.8	2.7	4.7
1907	3.2	3.2	4.0	3.5	4.1	4.0	4.2	4.0	4.6	0.0	0.0	4.1	0.6	4.2	3.5	4.4
1910	3.5	3.9	4.3	3.9	4.5	4.4	4.6	4.3	4.6	0.0	0.0	4.6	0.4	4.6	3.9	4.5

Table 6: Railway ordinary share dividends paid (% par value), dividend yields, capital returns and total returns (cont.)

C) Capital returns (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	8.5	8.4	3.1	5.3	18.1	-2.6	4.4	5.0	19.4	14.3	10.8	2.4	17.9	7.1	9.1	4.4
1877	4.1	4.6	10.3	-0.6	2.0	-0.5	1.6	4.6	10.2	5.5	4.0	1.4	11.5	-0.5	4.0	2.9
1882	0.9	-0.1	3.8	-1.3	4.9	-1.2	2.8	-1.4	-1.2	-5.9	-0.7	0.1	5.3	2.5	-0.4	5.9
1887	4.2	6.0	5.5	2.7	5.4	1.9	2.3	5.1	7.2	5.2	5.4	2.7	10.9	2.5	2.4	-1.7
1892	-0.3	1.7	-0.5	-1.6	-3.5	-0.3	1.1	6.0	1.9	-2.3	-6.1	2.3	-5.8	0.3	1.6	1.2
1897	1.7	2.0	10.7	1.2	0.0	5.0	2.3	0.9	1.1	7.5	-9.6	2.2	2.4	0.7	1.1	-2.0
1902	-4.3	-6.9	-6.3	-7.1	-3.8	-5.4	-5.4	-6.1	-6.0	-6.7	3.7	-6.4	5.5	-5.7	-7.5	-1.1
1907	-5.6	-6.2	-9.0	-1.9	-4.3	-5.2	-4.3	-4.4	-6.1	-10.5	-8.5	-3.3	-9.9	-2.6	-7.6	-0.2
1910	-2.1	-7.1	-8.2	1.4	-5.0	-5.8	-4.5	-7.0	-4.3	12.5	2.6	2.4	2.0	-5.5	0.4	-5.3

D) Total returns (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	12.1	11.3	4.7	10.3	22.5	2.3	9.3	9.9	22.1	14.3	14.0	7.2	17.9	11.7	13.3	10.3
1877	7.7	9.4	11.7	4.0	5.8	3.8	6.1	8.9	14.4	5.5	7.2	5.6	12.5	4.3	8.3	8.5
1882	4.5	3.7	6.2	2.7	9.0	2.6	7.1	2.9	2.5	-5.9	2.2	4.4	7.0	7.2	3.9	11.7
1887	7.6	9.9	8.7	6.5	9.3	5.2	6.1	9.0	10.4	5.2	8.0	6.5	12.8	6.2	6.2	4.2
1892	2.8	5.3	2.2	1.4	0.2	3.2	4.9	9.5	6.6	-2.3	-3.4	6.0	-5.3	4.2	5.1	5.1
1897	4.5	5.2	13.3	4.4	3.1	8.5	5.6	4.0	4.8	7.5	-8.1	5.7	2.9	4.2	4.1	1.6
1902	-1.5	-3.4	-2.9	-5.0	-0.1	-1.8	-1.7	-2.6	-2.2	-6.7	3.7	-2.5	6.5	-1.9	-4.9	3.6
1907	-2.4	-2.9	-5.0	1.6	-0.2	-1.2	-0.1	-0.4	-1.5	-10.5	-8.5	0.8	-9.3	1.6	-4.1	4.2
1910	1.7	-2.9	-3.7	5.4	-0.2	-1.1	0.4	-2.4	0.4	12.5	2.6	7.6	2.7	-0.6	4.6	-0.1

Table 7. Weights (%) of railway securities included in optimal portfolios for periods beginning 1870

ALL and RAIL are the number of holdings. RAIL% and WRAIL% are domestic and foreign railway weightings respectively. Bootstrap standard errors are in parentheses.

	ALL	RAIL	RAIL%	WRAIL%	ORD%							DEB%					PREF%	
					GER	GWR	LNWR	LSWR	LBSCR	MR	NBR	LCDR	LNWR	LBSCR	MSLR	NBR	LNWR	NER
1884	21	10	9.56	9.30	0.86	0.23	0.18		0.56		0.97	1.60		0.21		0.37	0.24	4.34
					(0.64)	(0.46)	(0.42)		(0.78)		(0.68)	(1.61)		(0.45)		(0.84)	(0.54)	(3.41)
1885	27	12	7.74	8.20	0.91	0.13	0.28		0.44		0.99			0.21		0.25	0.50	4.03
					(0.72)	(0.27)	(0.55)		(0.60)		(0.77)			(0.59)		(0.63)	(0.80)	(3.06)
1886	27	12	9.87	18.66	0.71	0.18	0.26		0.71		1.28	2.44		0.13		0.40	0.39	3.37
					(0.58)	(0.37)	(0.53)	(0.26)	(0.73)		(0.90)	(1.89)		(0.39)		(0.81)	(0.62)	(2.81)
1887	27	12	19.30	9.32	0.76	0.27	0.45	0.21	0.62		1.34	3.09				2.06	0.71	9.79
					(0.59)	(0.37)	(0.68)	(0.41)	(0.61)		(0.84)	(2.23)		(0.29)		(1.67)	(1.01)	(3.55)
1888	25	10	21.31	9.76	0.66	0.13	0.34	0.24	0.44		1.00	3.71				2.29	0.72	11.78
					(0.49)	(0.25)	(0.54)	(0.42)	(0.46)		(0.55)	(2.42)				(1.68)	(0.88)	(3.65)
1889	27	12	22.87	10.14	0.72	0.14	0.37	0.13	0.44		0.92	2.76		0.19		1.27	0.56	15.37
					(0.46)	(0.23)	(0.52)	(0.28)	(0.56)		(0.54)	(1.79)		(0.53)		(1.16)	(0.70)	(3.82)
1890	25	13	16.28	19.30	1.28	0.12	0.13	0.28	0.50		0.55	3.30			1.26	0.93	0.27	7.66
					(0.69)	(0.22)	(0.23)	(0.44)	(0.51)		(0.34)	(1.99)			(1.35)	(1.00)	(0.55)	(2.86)
1891	25	13	20.36	20.88	1.31	0.13	0.22	0.19	0.24	1.28	0.29	2.32	1.77	0.48		1.25	0.33	10.55
					(0.68)	(0.24)	(0.37)	(0.46)	(0.35)	(0.83)	(0.23)	(1.59)	(1.32)	(0.78)		(1.10)	(0.57)	(3.13)
1892	25	13	27.24	20.11	1.00		0.23	0.69	0.33	0.91	0.21	5.45	1.83		1.01	2.53	0.23	12.82
					(0.51)		(0.36)	(0.56)	(0.38)	(0.67)	(0.18)	(2.36)	(1.37)		(1.06)	(1.63)	(0.44)	(3.34)
1893	25	13	23.76	19.71	0.55		0.15	1.83	0.49	0.64	0.15	5.47	3.11		0.39	2.46	0.26	8.26
					(0.33)		(0.28)	(1.02)	(0.46)	(0.51)	(0.16)	(2.33)	(1.74)		(0.58)	(1.59)	(0.52)	(2.58)
1894	23	11	17.47	20.19	0.76	0.35		2.21	0.58	0.42	0.12	3.78	3.76		0.27	1.34		3.88
					(0.40)	(0.34)		(1.14)	(0.53)	(0.39)	(0.13)	(1.81)	(1.79)		(0.60)	(1.05)		(1.84)
1895	22	9	14.90	17.19	0.82	0.32		2.56	0.91	0.53		3.43	3.33			1.17		1.83
					(0.47)	(0.29)		(1.19)	(0.78)	(0.52)		(1.72)	(1.87)			(1.05)		(1.13)
1896	22	9	16.36	21.13	0.75	0.44		2.84	0.98	0.68		3.35	4.26			1.79		1.27
					(0.45)	(0.37)		(1.20)	(0.66)	(0.59)		(1.76)	(2.07)			(1.32)		(1.02)
1897	22	9	16.37	19.14	0.93	0.49		5.50	0.58	0.87		2.58	3.50			1.08		0.84
					(0.52)	(0.42)		(1.66)	(0.48)	(0.68)		(1.46)	(1.82)			(0.98)		(0.77)
1898	22	9	11.70	24.42	0.73	0.20		5.39	0.93	0.82		1.43	1.38			0.41		0.41
					(0.43)	(0.25)		(1.67)	(0.61)	(0.58)		(1.16)	(1.11)			(0.54)		(0.60)
1899	21	8	4.93	22.33	0.57			2.00	0.58	0.37		0.57	0.28			0.23		0.33
					(0.41)			(0.95)	(0.45)	(0.38)		(0.64)	(0.38)			(0.43)		(0.45)
1900	21	8	2.21	33.01	0.20			0.71		0.11		0.24	0.30			0.43		0.22
					(0.20)			(0.54)		(0.17)		(0.36)	(0.44)			(0.54)		(0.29)
1901	16	3	0.97	32.31				0.33				0.41				0.23		
								(0.30)				(0.45)				(0.36)		

Figure 1. Total Real Returns to Railway Securities 1870-1913

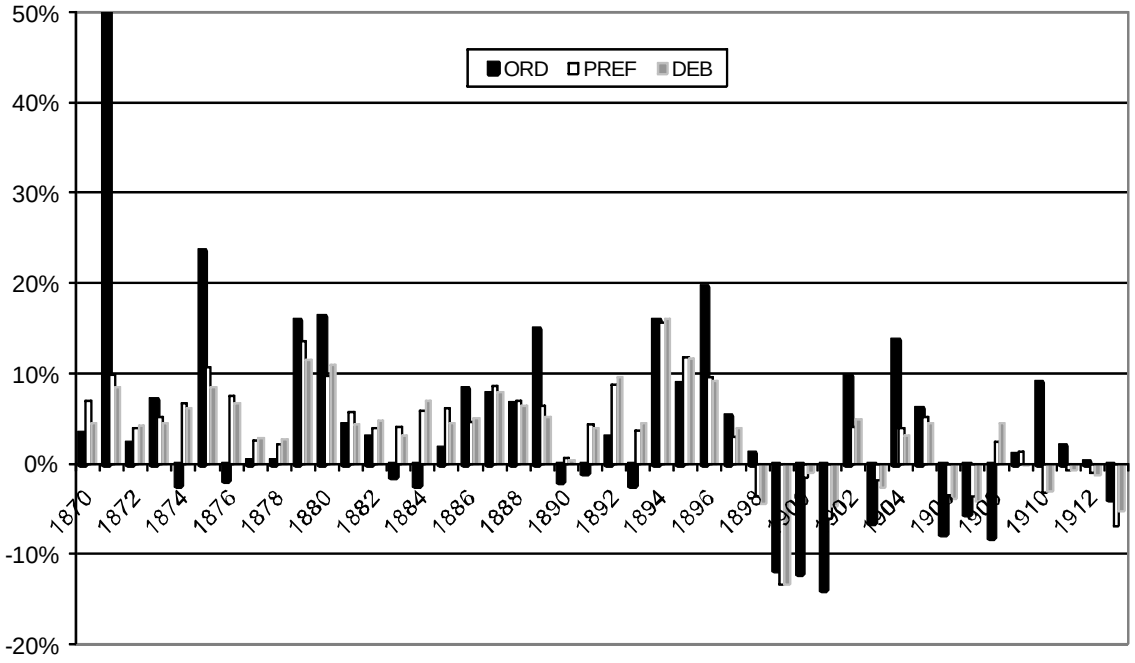


Figure 2. Efficient Frontier and Optimal Portfolio

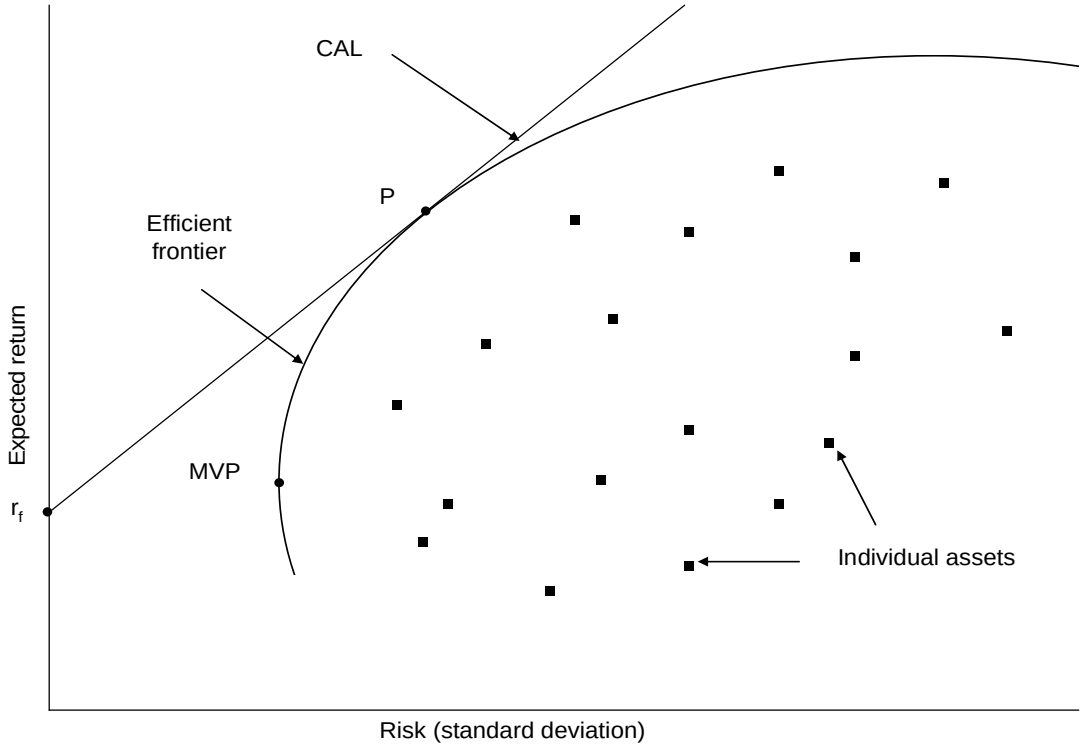


Figure 3. Sharpe ratios for periods beginning 1870

The Sharpe ratio is the excess real return of a security over the real risk-free rate divided by its standard deviation. RAIL (max) is the domestic railway security with the best such ratio. RAIL (mean) and NON-RAIL (mean) are the simple averages of the ratios of each domestic railway security and each non-domestic railway sector respectively. WRAIL is the ratio for the foreign railway debenture sector. OPTIMAL PORTFOLIO is the ratio of the optimal portfolio.

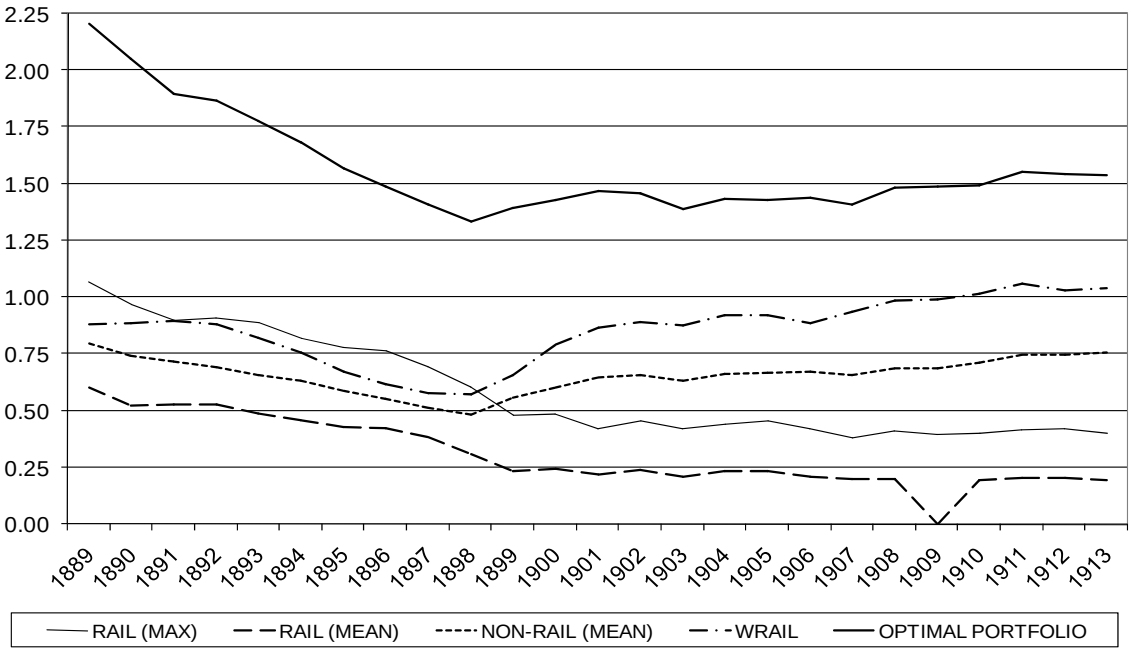
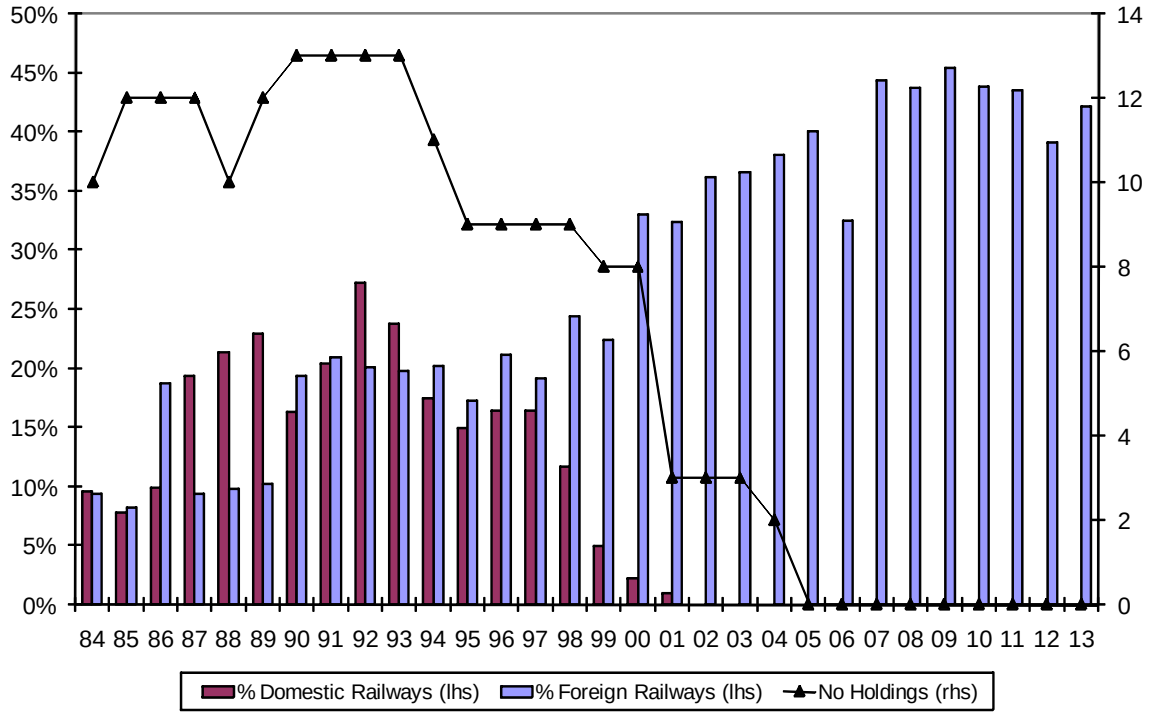


Figure 4. Total weighting in domestic railway securities

Domestic Railways represents the sum of the weights of the individual railway securities held in the optimal portfolio for various periods beginning in 1870 and ending in the year indicated on the horizontal axis. Foreign Railways represents the weighting in this sector in the optimal portfolio. The detail of individual railway weights is reported in Table 3. No. Holdings is the total number of domestic railway securities in the optimal portfolio.



Appendix 1. Quoted securities of Domestic Railway Companies

CODE	SECURITY
(i)	**ORDINARY SHARES**
CR	*Caledonian Railway*
GER	*Great Eastern Railway*
GNR	*Great Northern Railway*
GWR	*Great Western Railway*
LBSCR	*London, Brighton & South Coast Railway*
LCDR	*London Chatham & Dover Railway*
LYR	*Lancashire & Yorkshire Railway*
LNWR	*London & North Western Railway*
LSWR	*London & South Western Railway*
MSLR/GCR	*Manchester Sheffield & Lincolnshire Railway (Great Central Railway)*
MR	*Midland Railway*
NBR	*North British Railway*
NER	*North Eastern Railway*
SER	*South Eastern Railway*
(ii)	**PREFERENCE SHARES**
GERP	*Great Eastern Railway*
GNRP	*Great Northern Railway*
GWRP	*Great Western Railway*
LNWRP	*London & North Western Railway*
MRP	*Midland Railway*
NERP	*North Eastern Railway*
(iii)	**DEBENTURES**
CRDB	*Caledonian Railway*
GERDB	*Great Eastern Railway*
GNRDB	*Great Northern Railway*
LBSCRDB	*London, Brighton & South Coast Railway*
LCDRDB	*London Chatham & Dover Railway*
LYRDB	*Lancashire & Yorkshire Railway*
LNWRDB	*London & North Western Railway*
MSLR/GCRDB	*Manchester Sheffield & Lincolnshire Railway (Great Central Railway)*
MRDB	*Midland Railway*
NBRDB	*North British Railway*
NERDB	*North Eastern Railway*
SERDB	*South Eastern Railway*

Appendix 2. Optimization Procedure

The optimal weights resulting from this type of portfolio optimization technique are sensitive to minor changes in the expected returns of the assets. Consequently, to improve the precision of our estimates we employ a bootstrapping procedure, similar to Goetzmann and Ukhov (2006). According to this procedure, repeated and random draws from the distribution of returns are made for each asset or security. On each draw, the vector of expected returns and the variance-covariance matrix is estimated, and the optimal portfolio weights computed. From the resulting distribution of optimal weights, we calculate their mean values and the standard errors.

Goetzmann and Ukhov (2006) assumed that investors held a maximum of 7 assets in their portfolio, each asset consisting of a diversified portfolio of securities in a given sector. They then estimated optimal portfolios for all possible subsets of 7 assets drawn from a total of 19 assets in the investable universe. Finally, they ranked each of these portfolios by their Sharpe ratio. We depart from their approach in not assuming that investors held a maximum of 7 assets. This assumption seems less plausible once we allow individual railway securities into our investable universe such that the total number of assets rises from 19 to 48.

We therefore proceeded as follows. For each of the 30 periods beginning in 1870 and ending in a year between 1890 and 1913, we first optimised using all 48 assets, bootstrapping 1000 times. We then dropped those assets with a zero, or virtually zero weight, that is less than 0.1%. The remaining number of assets, including railway securities, varied between 14 and 26 assets (see col.2, Table 3). Using the expected returns and variance-covariance matrix of the remaining assets, we ran the optimisation once more, again bootstrapping 1,000 times. The resulting optimal weights for domestic railway securities and the foreign railway sector are those reported in Table 3. Due to lack of space, we do not report the weights for the other sectors. A minimum of 10 of these 15 sectors were always included. The sectors most frequently excluded because of their unattractive return and risk characteristics were domestic infrastructure equity and debentures, world infrastructure equity and colonial government debentures.

As a robustness check we ran the reduced form optimizations bootstrapping 10,000 times for 1884, 1889, 1894, 1899 and 1904. The resulting optimal weights were similar to those reported and are available on request.

Appendix 3. Taff Vale Railway

Taff Vale Railway was the smallest of the railways included in our universe in the first section of the paper. The next two smallest railways at the start of the period were the London Chatham and Dover, and the Manchester Sheffield and Lincolnshire. Both were at least twice as large as the Taff Vale, and all three were dwarfed by the other 12 railways. Taff Vale was an exceptionally attractive small stock in investment terms. It issued ordinary shares which were quoted on the LSE continuously throughout the period, and was the best performing security in the domestic railway sector as defined herein. The mean (standard deviation) of annual returns were 5.6% (7.9%), 8.0% (7.5%), and 1.4% (6.7%) in 1870-97, 1898-1913 and 1870-1913 respectively. Since its small size makes it unrealistic to assume that investors could have allocated anything other than a tiny portion of their portfolios to its ordinary shares, it was excluded from the results reported in the main body of the paper.

If we include Taff Vale Railway ordinary shares in the investment universe, the overall domestic railway sector weighting in the optimal portfolio is higher throughout. Hence, in 1884 the domestic railway weight was 33% compared to barely 10% without Taff Vale ordinary shares, of which the latter accounted for 26%. The latter attracted a weighting of at least 7.5% of the total portfolio until 1898, although thereafter it fell sharply to around 1.5%, a level which was maintained until 1913. Taff Vale ordinary was the only domestic railway security held after 1902. However, the evolution of the overall domestic railway weighting over time does not change dramatically to that reported above, and the main result, namely, that the rational investor exited domestic railways around the turn of the century, stands.