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

Brian Mitchell, David Chambers and Nicholas Crafts

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

BRIAN MITCHELL (Cambridge University)

DAVID CHAMBERS (Cambridge University)

NICHOLAS CRAFTS (Warwick University)

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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 cost inefficiency issues could have restored ROCE to an adequate level in the late 1890s but not in 1910. Declines in ROCE hit share prices and investors made little or no money in real terms after 1897. Optimal portfolio analysis shows that, whilst railway securities were attractive to investors before this date, they would have been justified in rushing to the exits thereafter.

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The profitability of British railway companies in the later-Victorian and Edwardian period has been much discussed over the years. Recent contributions to the literature have described rates of return as 'disappointing' and indicative of management failures.[1] The data recorded in the *Railway Returns* show declining rates of return on capital employed from the early 1870s. However, writers who take a more sympathetic view of railway management and profitability have pointed to constraints on management from actual or threatened regulation and have argued that the raw data on returns to capital are somewhat misleading.[2] Everyone agrees with Cain that there was 'waste and inefficiency' on the British railway system but when, how much, and how far it was management's fault has been obscure.[3] Similarly, although it is generally recognized that, at some point, the declining profitability of Britain's railways had adverse consequences for those who held their assets, the implications have not been spelt out clearly.[4] Finally, recent work has pointed to a rapidly rising contribution made by railways to national income even though their private profits declined.[5]

All this means that answering the question 'how good was railway profitability?' has several dimensions. The most obvious of these is to establish the profitability record at the individual company level, i.e., to measure profitability as carefully as possible taking proper account of the difficulties of the sources, especially with regard to nominal additions to paid-up capital. Beyond this, railway companies' profitability has to be evaluated against a number of criteria. These include addressing the following issues. First, to what extent could better management have delivered higher profitability? Second, was private profitability good enough to keep investors happy? Third, was the return to society a justification of the investment of so much capital in railways? On all these points, at the very least, both conceptual clarification and quantitative estimation is needed.

Management affects profitability through the quality of its investment decisions and its control of costs. Both have attracted criticism in the historiography, although much more the latter.[6] Irving, in particular, stressed inefficiencies in the operation of freight trains before 1900 but also argued that this was subsequently much improved.[7] While there is evidence on the extent of cost inefficiency at the company level the implications of this for profitability and beyond that for shareholder returns have not yet been explored.[8] Cost

[1] Arnold and McCartney, 'Rates of return'; p. 54; Crafts et al., 'Were British railway companies', p.864.
[2] Notably, Irving, 'Profitability and performance' and 'Capitalisation of Britain's railways' but also Cain, 'Railways, 1870-1914' and Gourvish, *Railways and the British economy*.
[3] Cain, 'Railways, 1870-1914', p. 120.
[4] See, for example, 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).
[5] Leunig, 'Time is money'.
[6] The most vociferous critic of railway investment decisions has been Aldcroft, 'The efficiency', but quantitative evidence of the extent of bad ex-ante decision making has not been provided despite plausible examples such as the Great Central's London extension.
[7] Irving, 'Profitability and performance'.
[8] Estimates of cost inefficiency for the period 1893-1912 were reported by Crafts et al., 'Were British railway companies'; these are consistent with Irving's position.

inefficiency means that actual costs are greater than minimum feasible costs and implies a failure to maximize profits; this is most likely to persist in a situation where there is a separation of ownership and control combined with weak competition. Evaluating management is, of course, not entirely straightforward. Past investments have a legacy effect and may mean a period of sub-normal profits where capacity is too high but is correctly retained because variable costs are covered so that low profitability is all that can be achieved. The hard question to answer is whether those investments looked reasonable ex-ante. Similarly, profitability may be constrained by the bargaining power of unionized labour or attempts to stave off regulation, both of which have resonance for late-nineteenth century British railways, and, here too, there are difficult judgement calls.

Profits made by an enterprise are the basis on which interest and dividends can be paid. The value of a security is the net present value of these expected cashflows; if this falls, investors suffer capital losses. Declining profitability of an enterprise hurts investors two ways, namely through lower interest and dividends and through capital losses on the value of their securities. The extent of the latter depends on whether a decline in profitability is believed to be temporary or permanent. The precise connection between returns on capital employed by railways in the real economy and asset values in the financial world remains to be established, although the general point is well understood.[9] However, a full understanding of the impact on investors requires that the implications for both return and risk are considered in the context of opportunities for diversification. In technical terms, this means investigating the behaviour of the Sharpe Ratio and, thus, the decline in the available rate of return for a given level of risk.[10] It can be expected that railway assets, which were very widely held at the start of our period, would on average have a smaller weight in portfolios but when this should have happened, how far it applied to all railway companies, and how much it cost investors has not been explained. Quantitative analysis has gone no further than looking at the sector and the period 1870-1913 as a whole with the conclusion that domestic railways would not have any place in an optimal portfolio.[11]

In the long run, companies need to make normal profits both to cover the opportunity cost of capital and for an efficient allocation of resources across the economy. Failure to do this will threaten the availability of external finance and future viability of the business. Arnold and McCartney suggest that, for some railway companies at least, this was in doubt by the end of the nineteenth century.[12] To judge the adequacy of profits from this perspective requires an estimate of and comparison with the supply price of capital. The ingredients of this are well known in the context of utility regulation but have not been

[9] See, for example, Cain, 'Railways, 1870-1914', p. 96.

[10] The Sharpe Ratio is defined as $(\mu - r_f)/\sigma_p$ where μ is expected return on the portfolio, r_f is the risk-free interest rate, and σ_p is the standard deviation of the portfolio return.

[11] This result is obtained by Goetzmann and Ukhov, 'British investment'.

[12] Arnold and McCartney, 'Rates of return', p. 54.

considered explicitly in this context; returns on capital employed need to be compared with the weighted-average cost of capital.[13]

Whereas private profitability concerns net revenue relative to capital employed, the social rate of return to railway investment (or 'social profitability') includes benefits to railway users in the form of cheaper and faster transport and is the sum of consumer surplus, net externalities, and private profits relative to capital employed, which can be further broken down into normal and supernormal profits.[14] This is interesting in two ways. First, the private and social rate of return can, of course, move in opposite directions and, in the context of the rapid expansion of passenger travel on Britain's railways, as Leunig points out but does not fully quantify, this is surely the story of the later-Victorian period.[15] Second, a comparison of supernormal profits and consumer-surplus gains can reveal the distribution of the benefits from investment in railway technology. To complete an evaluation of how good railway profitability was, an analysis of the social rate of return is required.

In sum, there are a number of related issues that are unresolved. This paper seeks to address them. Our discussion is formulated in terms of providing answers to the following questions, each of which is essential to an assessment of railway profitability but none of which has been adequately answered hitherto.

1) What was the rate of return on capital employed (ROCE) of major railway companies, how did this compare with the cost of capital and what impact did it have on stock market returns?

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

3) How attractive were railway assets to portfolio holders given that ROCE was falling and what did changes in investment returns on domestic railways imply for the overall rate of return at a constant level of risk?

4) What was the social rate of return on railways and how was it divided between transport users and capitalists?

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[13] The weighted-average cost of capital can be defined as $\lambda(r_f + dp) + (1 - \lambda)(r_f + \beta rp)$ where λ is the gearing ratio, dp is the debt premium, rp is the equity risk premium, and β is the covariance of the returns on the company's shares with those of the overall market divided by the variance of the market returns. Returns above this level can be thought of as supernormal profits and would represent a market failure with a deadweight welfare loss.

[14] Cf. McClelland, 'Social rates'; in practice it has been difficult to measure net externalities and these have not featured in estimates of social rates of return to railways; the consumer surplus is equivalent to the 'social saving', familiar from the new economic history of the railways but with due allowance for the price elasticity of demand.

[15] Leunig, 'Time is money', p. 669.

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 from company accounts. Next, we draw on 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 amalgamations. Estimates of ROCE at the level of the individual company are then related to holding returns on the companies securities using the data collected by Edelstein from the Investors' Monthly Manual.[16] 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. Finally, we make an analysis of the social rate of return in the late nineteenth century taking account of social savings as well as net earnings.[17]

I

This section presents evidence on the profitability or the return on capital employed (ROCE) of Britain's railways between 1870 and 1912. 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 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.[18]

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. However, we are primarily interested in returns to the total capital employed in the business, both equity and debt, with the latter in the case of late Victorian railways being largely in the form of debentures.[19] The two together constituted paid-up capital, Although data on paid-up capital is given in the *Railway Returns*,a more satisfactory source is the half-yearly accounts and reports to shareholders. This source enables us to correct the occasional error in the official figures, provides the possibility of assessing the

[16] These data were the basis of the research report in Edelstein, *Overseas investment*.
[17] Crafts et al., 'Were British railway companies'.
[18] 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. Since most of this "non-traffic" revenue was, in fact, derived from joint lines (with a small amount from shares in other companies), it is almost certain that the rate of profit on this branch of revenue was roughly similar to that on the traffic.
[19] Short-term borrowings, including bank loans were insignificant in relation to total capital.

expenditure side of the capital accounts and gives additional detail on paid-up capital, especially prior to 1890, the first year in which nominal additions to capital were noted in the *Returns*.

There are further 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 ne 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 and was the largest example we have been able to find prior to the 1880s, it made little difference to the aggregate of all companies. Moreover, it was nothing to what was to come later when the nominal additions, 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 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 of 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.[20] 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.[21] 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

[20] The curious may wonder what happened to the asset side of the balance sheet. The answer is that an item was added entitled "nominal additions on consolidation of stocks".

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

it is usually possible to subtract them from the figures of finance received.[22] 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.[23]

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 balance during the 1870s, whilst almost certainly this should apply to the London, Chatham & Dover too.[24]

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.[25] 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

[22] Nominal additions have sometimes been referred to as 'water' in the capital although this is not, of course, appropriate for those produced by relative valuations on amalgamation such as the LNWR in 1847. But most did not represent finance actually received and used. .

[23] 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.

[24] 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.

[25] 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.

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 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.[26]

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.

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.[27] The ROCE estimates in Table 1 decline by considerably less than those recently reported by Arnold and McCartney who appear not to have adjusted for nominal additions to paid-up capital.[28]

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 who found that the weighted-average ROCE fell from 4.8 per cent in 1872 to 3.85 per cent in 1892 and to 3.54 per cent in 1912.[29] 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

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

[26] 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 but 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. Fortunately, the great majority of the records of the lines leased by the GER, the GWR, and the Scottish companies have survived, these being the principal companies which operated leased lines in our period.
[27] Cain, 'Railways, 1870-1914', p. 110; Irving, 'Capitalisation of Britain's railways', p. 3, 17.
[28] Arnold and McCartney, 'Rates of return'.
[29] Ibid., Table 2 and Cain, 'Railways, 1870-1914', Table 4.

minimum feasible costs) for each major company in every year from 1893 to 1912.[30] 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 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 earlier year. Crafts et al. reported that for this sample of companies median cost inefficiency peaked at the turn of the century at 10.2 per cent but then fell sharply with a clear tendency for those with the most inefficiency to show the greatest improvement, as is reflected in Tables 3 and 4.[31] This is consistent with the picture presented by Cain and Irving of management responding to a potential profits crisis by improving efficiency, notably in the operation of freight trains, at a time when freight charges were frozen by regulation and input prices were rising.[32] The implication is that railway managers, who were not strictly disciplined either by competition or by shareholders, were taken out of the comfort zone and had to act.[33]

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.

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[30] Crafts et al., Were British railway companies'.

[31] Ibid., pp. 852-853. The most remarkable turn-around, which has been well chronicled by Harvey and Press, 'Management', was achieved by the Taff Vale. They point to the stimulus given by the opening of the Barry Dock & Railway Company, the consequent appointment of Ammon Beasley as General Manager, and the crushing victory in the strike of 1900 which dealt with what had been ' a sorry picture of inefficient working and inflated expenses' (p.70). The subduing of unionized labour resulting from the failure of the strike may have helped other companies to improve working practices.

[32] Cain, 'Railways, 1870-1914', p. 117; Irving, *North Eastern Railway Company*, p. 281.

[33] This is not to suggest that competition was completely absent but rather that its impact on management was relatively weak in the context of high barriers to entry and collusive behaviour; see the discussion in Cain, 'Railway combination', pp., 625-6.

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. The implication of the estimates in Table 4 is that railways were indeed operating in a more difficult environment in 1910; much of the fat had been cut out but still ROCE was generally below 1897 levels. The most obvious adverse change was in terms of regulation, in particular, the 1894 Railway and Canal Traffic Act which effectively prevented the raising of freight charges even though mild inflation was pushing up costs.

It has been suggested, notably by Arnold and McCartney, that railway management should have addressed the problem by pursuing company amalgamations.[34]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 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 too optimistic a view of the potential gains in profitability from amalgamation. First, although the Board of Trade was sympathetic to the view that costs would be lowered they would expect a quid pro quo through tighter regulation including of passenger fares.[35] Second, the hostility of traders and their support in parliament was such that there was no possibility in the last years before World War I of a deal on terms that would allow the companies to improve their profitability.[36] Third, when, in the context of their postwar financial plight, the railway companies were eventually amalgamated through the grouping introduced by the Railways Act of 1921, the legislation introduced the notion of standard net revenue at a level consistent with restoring the rate of return of 1913 but with charges to be reduced if this was exceeded.[37]

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[34] Arnold and McCartney, 'Rates of return', p, 55.

[35] This position was clearly articulated in the "Report of the Departmental Committee on Railway Agreements and Amalgamations", *British Parliamentary Papers* 1911 vol. XXIX.

[36] Cain, 'Railway combination', p. 119.

[37] Crompton and Jupe, 'Awkward fence', p. 441. The legislation did not guarantee that standard net revenue would be achieved but entailed that returns in excess of this amount were to be shared such that 80 per cent were returned to customers through price cuts. Crompton, 'Efficient and economical working', noted that contemporary estimates of the cost savings from the grouping were between £4mn. and £20mn. but there is

In other words, even if amalgamation did lower costs, the political reality both pre- and postwar was that the regulatory framework would ensure that the impact on profitability was negligible.

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.[38] 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.[39] 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.[40]

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 the LSE.[41] Investors could have earned a total return on any quoted security comprising a capital gain (or loss) and an income component. Hence, total real returns are defined as:

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

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no way of knowing what was actually the case. £20 mn. would be broadly consistent with the econometrics discussed in the text.

[38] Mitchell, 'The coming of the railway'.

[39] Trebilcock, *Phoenix Assurance*, pp.70.

[40] "British and Argentine Railway Debentures", *The Economist*, 10 June, 1893, pp.692; and "English and Foreign Railway Debenture Stocks", *The Economist,* 14 March, 1896.

[41] The 33 securities comprise the following: ordinary (or deferred) shares of all 15 companies; preference shares and debentures of GER, GNR, LNWR, MRP and NER; GWR preferences shares; and CR LBSCR, LCDR, LYR, MSLR/GCR, NBR and SER debentures.

where P_{ijt} = the sterling price of the security issued by the i^{th} company of the j^{th} type and j = 1 (ordinary shares), 2 (preference shares), 3 (debentures) published for the last week of December of the t^{th} year, D_{ijt} = the sterling cash dividend or interest payment by the i^{th} company on the j^{th} security type published for the last week of December of the t^{th} year, I_t = the annual price inflation for the t^{th} year.

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).[42]

The mean and standard deviation of the annual total real returns for each ordinary share, preference share, and debenture are summarized in Table 5.[43] 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 pattern of quinquennial returns reported by Kennedy and Delargy.[44] 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 +6.7%, +6.2% and +5.8% per annum, respectively, between 1870 and 1897. In the later period up to WWI, however, all three railway asset classes generated little or no real return and the ordinary shares of Taff Vale (TVR) were the only security to deliver a statistically significantly positive return to investors.

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[42] 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. Edelstein uses Phelps Brown's cost of living index as the deflator of the nominal returns series. We have elected to use throughout the more recent deflator from Feinstein, *National Income*, Tables 2 and 5. Any missing nominal return 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.

[43] TVR was considerably smaller than the other 14 railways. The next two smallest at the start of the period, LCDR, and MSLR which were at least twice as large as TVR, and all three were dwarfed by the other 12 railways, Kennedy and Delargy, 'Explaining Victorian entrepreneurship', Table 1. For continuity with the previous section, TVR is included here but excluded from the next section on optimal portfolios (see footnote 53).

[44] Kennedy and Delargy, 'Explaining Victorian entrepreneurship', Table 11a.

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 around 2 to 3% over the 4% annual real return on Consols (Table 5, Panel C). Subsequently, this premium shrank to 0.5% or less, when Consols averaged a negative real return of -0.5% per annum. 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.[45]

Investors receive their return on any security through price changes and income, either interest or dividends. A closer inspection of equation (2) indicates that the total real return in the case of ordinary shares is equal to the arithmetic sum of the capital return and the dividend yield, both in real terms. 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 1880s 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 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):

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

Nominal 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 chose not to reduce equity prices so as to maintain the dividend yield, but began to mark prices down in the 1890s up to the years immediately before WW1. This process of de-rating the shares generated negative real capital returns. Table 7 decomposes total returns on ordinary shares in real terms into the real dividend yield and the real capital gain or loss. Capital returns to the

[45] The mean return (standard deviation) of foreign railway debentures was 5.7% (3.8%) and 5.1% (2.9%) in 1870-97 and 1898-1913, respectively, based on Edelstein's nominal returns deflated by Feinstein's consumer price series.

15 railway ordinary shares fluctuated considerably more than their dividends, and losses first began appearing in the early 1890s (Table 7, Panel B). The dividend yield helped to keep the total returns on domestic railways in positive territory until the turn of the century. In the following decade, capital losses more than offset the dividend yield to push total returns into negative territory until there was a modest recovery from 1910 to 1913 (Table 7, Panel C).

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 disappointing total returns until the market in domestic railway securities stabilised around 1910.

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 thanks to such market commentators as Henry Lowenfeld, a London investment advisor and journalist, who wrote extensively about the merits of judiciously diversifying one's investments geographically and across industries.[46] 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.[47] Furthermore, investors prefer more return and less risk.

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:

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

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

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

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

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), i.e., the Sharpe ratio (S_p).

Sharpe 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), after the turn of the century.

The optimization problem confronting the rational investor now becomes:

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

$$\text{subject to} \qquad \sum_i w_i = 1$$

$$\text{and} \qquad w_i \geq 0 \text{ (short sale constraint)}$$

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.[48]

[48] Furthermore, according to the fund-separation theorem, any investor is able to hold any linear combination of the risk-free asset and the optimal portfolio,as described by the CAL. Risk-averse investors

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.[49] They found that rational investors on the eve of WWI would have made absolutely no allocation to the domestic railway sector at all.[50] This is, perhaps, unsurprising given the substantial deterioration in railway returns from the late 1890s 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.[51] 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

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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 optimal portfolio P 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 to take account of their risk preferences but simply shift the proportion of their wealth that they allocate to the optimal portfolio, P.

[49] Goetzmann and Ukhov, 'British investment'.

[50] 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.

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

similar to that utilized by Goetzmann and Ukhov.[52] 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.[53] This makes a total of 47 assets available for investment.[54]

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 return per unit of risk, or the 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. [55]

The weights of each railway security included in the optimal portfolio are summarized in Table 8.[56] There is a mixture of ordinary and preference shares and debentures, although ordinary shares predominate. Some of the weights such as the debenture holdings other

[52] 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.

[53] As discussed in footnote 41, TVR was a very small firm. 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 and it was therefore excluded from the results reported in this section. These are available on request.

[54] Of course, it would be preferable to include all individual securities in all sectors in the optimisations which follow. However, the considerable problems of data collection and computational complexity unfortunately rule this out. It is our contention that this restriction will tend to bias our results in favour of an allocation to railways other things being equal. Allowing an investor to choose a portfolio from the entire market of individual securities would be more likely to include individual non-rail securities with risk-return characteristics more attractive than those of the non-rail sectors which are just simple averages of their constituent securities.

[55] Employing a bootstrapping procedure, similar to Goetzmann and Ukhov, repeated and random draws from the distribution of returns are made for each asset or security such that 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 standard errors. We depart from Goetzmann and Ukhov in not restricting investors to a maximum of only 7 assets, an assumption which becomes somewhat unrealistic as once we admit individual railway securities and our investable universe rises from 19 to 47. 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 47 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. Using the expected returns and variance-covariance matrix of these remaining assets, we ran the optimisation once more, again bootstrapping 1,000 times. As a robustness check we ran the reduced form optimizations bootstrapping 10,000 times for 1884, 1889, 1894, 1899, 1904, 1909 and 1913. The resulting optimal weights were similar to those reported and are available on request.

[56] We do not report non-railway sectors weights. At least 10 of the 15 other sectors were always included. The domestic infrastructure equity and debentures, world infrastructure equity and colonial government debentures were the sectors most frequently excluded due to their unattractive risk-return characteristics.

than those of London Chatham and Dover (LDCRDB) and London and North Western (LNWRDB) in certain years are very small and 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 the ordinary shares of London and South Western (LSWR), London Brighton and South Coast (LBSCR) and London and North Western (LNWR) all of which featured among the stronger economic performers in the sector. The largest holding was the LSWR ordinary share which occupied almost 15% of the portfolio in the period to 1897-98. Although the ordinary shares of a poor economic performer such as MSLR (GCR) were included in the portfolio the holdings were extremely small and not statistically significantly different from zero.

Edelstein concluded that foreign assets earned superior risk-adjusted returns, and that domestic railway ordinary shares were a particularly poor investment.[57] 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 8), a clear picture of the decline in the domestic railway allocation emerges (Figure 4). The total weight begins at approximately the 15% level in 1884, rising to a peak of 43% in 1892, thereafter falling away sharply to around 5% just before WW1.[58] 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 35% on the eve of WW1 (WRAIL, Table 8). Thus, in contrast to Edelstein's findings, the rational investor would have selected a portfolio with some, albeit modest, exposure to domestic railways in 1913. Furthermore, when considering the earlier period not dealt with by Edelstein, investors would have allocated funds to domestic railways well in excess of those to foreign railways up to the late 1890s.[59]

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.

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

[58] 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.

[59] Our results are 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 weighting in the optimal portfolio over time is similar to that portrayed in Figure 4, with the exception that the weightings are higher throughout. Beginning around the 30% level in 1890, the weighting peaked at slightly over 60% in 1897 and declined to 15% in 1913. We prefer to report full results in the main body of the paper based on the returns from 1870 because of the longer run of data that is available in estimating optimal portfolios from 1890 onwards.

The question arises as to whether the subsequent decline in the weighting of domestic railways in the optimal portfolio is driven by the deterioration in their returns or an improvement in other returns. The previous discussion of the pattern of returns would suggest the problem lay in the deterioration of railway returns. Whereas the simple average of annual domestic railway returns fell sharply from the 5 and 6 per cent level to nothing, real returns in other sectors declined by only 1.5 percentage points to 6.2 per cent in the period 1898-1913 from 7.7 per cent in 1870-1897. To confirm this view, we constrain the mean return for each domestic railway security in 1898-1913 to fall by the same margin of 1.5 percentage points compared to the earlier period and leave standard deviations and correlations unchanged. We then re-run the optimization procedure for the whole period to 1914. In this counterfactual case, the total domestic railway weighting would have amounted to over 50 per cent. It would appear that poor domestic railway returns rather than improvement in the returns of other sectors led to the downgrading of their importance in the optimal portfolio.

Furthermore, this shortfall in domestic railway returns was costly. Investors had to forgo an extra 1% of annualised return for the same level of risk. Assuming this counterfactual of higher domestic railway returns in 1898-1913, the rational investor in 1913 can select an optimal portfolio with a better Sharpe Ratio, rising from 1.34 to 1.57. Applying the latter ratio to the level of portfolio risk originally chosen by investors and adding the risk-free rate, their expected annual return would rise to 8.8 per cent from the 7.8 per cent previously anticipated.[60]

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.[61] 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."[62]

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[60] Intuitively, this exercise shifts the efficient frontier in Figure 2 to the north-east, and the estimated incremental return of 1 percentage point represents the vertical shift in the plot of the optimal portfolio, P, whilst holding portfolio risk on the x-axis constant.

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

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

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, and their general lack of business acumen.[63] Yet, as late as 1909, the magazine despaired of the vast majority of investors investing the time and effort to understand the degree of mismanagement taking place.[64]

Notwithstanding this selling, domestic railways still accounted for 20% of the entire London market in 1913, half their index weighting in 1870.[65] One implication of the foregoing analysis is that investors would have been well advised to have rapidly reduced their exposure to railways from the late 1890s onwards and in aggregate remained somewhat overexposed to domestic railways on the eve of WW1. However, having seen the sector de-rated and the dividend yield recover in the first decade of the new century, investors did witness the ordinary shares revert towards their mean long-run performance and deliver a more attractive return of almost 4% per annum between 1910 and 1913. Hence, a second implication is that having shunned these shares in the late 1890s when their ratings were propelled by the irrational exuberance of others, the well-informed investor would have waited until dividend yields had returned to a level at which investment once more became attractive in the years immediately preceding WW1.

Nevertheless, it seems clear that the weight given to domestic railway securities by a rational investor would have been considerably 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 and notwithstanding the bottoming out of railway security prices in the run-up to WW1, the scope for 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

[63] *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. 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".

[64] *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."

[65] This weighting applies to all three security types and is estimated from the *Stock Exchange Daily Official List* figures quoted in Michie, *The London Stock Exchange*, Table 3.3. British government and foreign government stocks, as the risk-free asset, are excluded. Any change in weights, of course, reflects both the relative amount of new issues as well as relative price changes. In the case of ordinary shares alone, the railway sector, including sterling-denominated foreign railway shares, represented 15% of the total equity market in 1913, compared to 76% in 1870, Grossman, *New Indices,* Table 1.

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. The ex-post equity risk premium for 1872-1913 based on the difference between equity and consols returns was 4.5 per cent.[66] This would imply that the average cost of capital for the railway sector was 6.1 per cent. If railways are thought to have eventually become more like utilities, then an assumption that β = 0.8 might be justified.[67] This would put the average cost of capital at 5.75 per cent which we believe is a reasonable benchmark.

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 ex-post, especially since by the end of our period there was no scope to reach the benchmark by addressing issues of cost inefficiency. Quite probably, by then, regulation was too tight. It seems unlikely that any substantial supernormal profits were made by these railways after 1870 except by the (tiny) Taff Vale

Trends in 'social profitability' were very different from those in private profitability. Benefits to transport users grew steadily driven by continuing TFP growth and increased traffic volumes. In this context the appropriate comparison is with the social discount rate. A reasonable approximation to the average social rate of return can be written as

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

[66] Grossman, 'New indices'..

[67] The average utility sector beta is now about 0.8;
see http://pages.stern.nyu.edu/~adamodar/New_Home_Page./data.html

This formula is the social equivalent of ROCE and recognizes the value of lower transport costs to users captured by the social savings, i.e., consumer surplus gains from cheaper and faster transportation.[68]

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 are that the passenger social savings were 3.0 per cent of GDP in 1870, 4.4 per cent of GDP in 1890 and 6.1 per cent in 1912.[69] The starting point for freight social savings is the estimate made by Hawke for 1865.[70]

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.[71] Accepting this correction, implies a freight social saving of 2.58 per cent of GDP in 1865. This can be converted into an estimate for 1890 and for 1912 by taking account of the extra volume of traffic in these years and the further reduction in transport costs in line with TFP growth.[72] The latter is taken to be 0.8 per cent per year in line with the estimates given by Crafts et al.[73] This results in freight social savings of 5.0 per cent of GDP in 1890, and 6.4 per cent of GDP in 1912.

Using the net revenue and capital expenditure estimates of Table 1, this implies that, the average social rate of return on railways in 1870 was 23 per cent, in 1890 was 28 per cent and in 1912 was 35 per cent. This is a classic example of a technological innovation whose benefits accrue to consumers rather than proprietors.[74] 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. For comparison, estimates of the social rate of return to investing in 3 years of schooling to deliver basic literacy for grooms of all classes are 19.6 per cent in 1840 and 15.2 per cent in 1868.[75]

The standard formula for the social discount rate (SDR) is

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

[68] 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.
[69] Leunig, 'Time is money', figure 6; data kindly supplied by the author.
[70] Hawke, *Railways and economic growth*, p. 188.
[71] 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.
[72] As is noted by Foreman-Peck, 'Railways', p. 77.
[73] Crafts et al., 'Total factor productivity', p. 618.
[74] 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).
[75] See P. H. Lindert, 'Revealing Failures in the History of School Finance', paper presented to World Economic History Congress, Utrecht, 2009.

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.[76] Other writers suggest that SDR = 6 per cent is probably more appropriate and more consistent with observed savings behaviour.[77] 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.[78] Thus, losses from railway inefficiency amounted to a little over 1 per cent of GDP in 1900.[79]

Railways are an important qualification to the general exoneration of British management in this period that was proffered by the new economic historians.[80] The railway sector was characterized by a separation of ownership from control in which shareholders were ineffective, high barriers to entry, and weak regulation, at least prior to the freeze on freight charges. There was ample scope for management to fail until profits became too low for comfort in the early twentieth century.[81] The neoclassical exoneration was largely based on investigations of industries where managers were exposed to much greater competition than was the case in railways.[82]

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

[77] Weitzman, 'The Stern Review'. The optimal savings rate based on equation (7) = $(r - \delta)/\eta r$. Reasonable values for Victorian Britain might be $\eta = 4$ and $\delta = 2$ so if $r = 6$, the savings rate would be 16%, close to what is observed.

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

[79] This estimate appears similar to that of 0.75% of GDP in Foreman-Peck, 'Natural monopoly', p. 716. However, he attributes all the inefficiency to excess capital whereas our reading of the evidence is that operating costs were a big part of the problem which was subsequently addressed especially with regard to freight trains.

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

[81] As Cain, 'Railways, 1870-1914', pp. 112-7, pointed out. Railways were outliers in the degree of separation of ownership and control at this time and shareholdings were typically very diffuse, see Hannah, 'The divorce', pp. 408-9.

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

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 from the value of the railway in terms of a social cost-benefit analysis. Our main findings are as follows.

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. Towards the end of our period, there was no longer a possibility of achieving adequate returns by 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 security holders 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 securities - our estimate is that around 40 per cent would have been justified in the mid-1890s. Thereafter downward pressure on profitability was reflected by a de-rating of share values which inflicted capital losses on shareholders and a rapid rush to the exits would have been appropriate around the turn of the century.

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.[83] While both Edelstein and Goetzmann and Ukhov concluded that investors should have held no domestic railway securities in 1913 period, we find that up to the late 1890s a sizeable holding would have been appropriate for these assets and that following a substantial decline investors would still have retained a very modest exposure to domestic railways in 1913. Declining profitability of Britain's railway companies hurt investors; we estimate that it implied a fall of 1 percentage point on the expected annual return for a given level of risk.

Finally, it is clear that, on average, railway investments delivered a high social rate of return. 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

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

the profits (and even more so the supernormal profits) available to be distributed to the owners of 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.

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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 the companies' accounts. These were extracted by Brian Mitchell in 1962/3 in connection with a Cambridge University Department of Applied Economics project on long-term capital formation in the U.K. directed by Phyllis Deane. Aggregates of capital expenditure based on them were published in Mitchell, "The Coming", and were incorporated in Feinstein, *National Income* but the individual company data were not then published. The accounts were held at that time in the British Transport Commission Historical Archives in London, York and Edinburgh. These are now held in the Public Record Office References are as follows: Caledonian RAC 1/44-45, Great Eastern RAC1/144-149; Great Northern RAC1/155-157; Great Western RAC1/171B-J; London Brighton and South Coast RAC1/248-250 and RAC(Y)1/25; London Chatham and Dover RAC1/256-257; Lancs and Yorks RAC1; London and North Western RAC1/233-236; London and South Western RAC1/245-A247; Manchester Sheffield & Lincolnshire RAC1/141 and 1/267-268 and Great Central RAC1/141-142; Midland RAC1/264, 1/290; North British RAC 1/312A&B; North Eastern RAC1/315-321; South Eastern RAC1/377-381; Taff Vale RAC1/400-402.

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 in real terms are defined as the arithmetic sum of capital returns and the dividend yield in real terms for the calendar year. See equation (2) in text. All means are equally-weighted.

A) Railway Ordinary Shares

		EWMEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR
1870-1913	MEAN	4.3	4.2	4.2	3.6	5.7	2.6	4.4	4.6
	STDEV	9.4	13.7	13.3	8.7	13.5	7.9	6.8	7.9
1870-1897	MEAN	6.7	7.9	7.8	4.9	8.7	4.2	6.6	7.8
	STDEV	9.7	15.3	14.3	7.8	15.8	7.8	6.3	6.7
1898-1913	MEAN	0.1	-2.3	-2.2	1.3	0.6	-0.2	0.6	-1.1
	STDEV	7.4	6.8	8.5	10.0	5.5	7.4	6.3	6.5
		LBSCR	**LCDR**	**MSLR**	**MR**	**NBR**	**NER**	**SER**	**TVR**
1870-1913	MEAN	6.6	2.1	2.0	4.7	5.4	4.3	4.2	5.8
	STDEV	16.1	22.0	20.5	7.8	19.7	8.2	10.9	6.9
1870-1897	MEAN	10.4	2.9	3.8	6.0	8.4	6.3	7.2	7.3
	STDEV	18.0	23.3	20.1	6.3	23.0	9.0	9.7	6.9
1898-1913	MEAN	0.0	0.7	-1.1	2.3	0.3	0.8	-1.2	3.0
	STDEV	9.4	20.2	21.6	9.6	10.7	5.2	11.0	6.3

B) Railway Preference Shares

		EWMEAN	GERP	GNRP	GWRP	LNWRP	MRP	NERP
1870-1913	MEAN	3.9	4.4	3.9	4.0	3.7	3.8	3.5
	STDEV	4.5	5.7	4.8	4.7	4.4	4.4	4.2
1870-1897	MEAN	6.2	7.0	6.2	6.3	5.9	6.0	5.6
	STDEV	3.6	5.0	4.1	3.9	3.6	3.5	3.4
1898-1913	MEAN	-0.2	-0.2	-0.1	-0.2	-0.2	-0.1	-0.1
	STDEV	2.6	3.5	3.0	2.5	2.4	2.7	2.6

C) Railway Debentures

		EWMEAN	CRDB	GERDB	GNRDB	LYRDB	LNWRDB	LBSCRDB
1870-1913	MEAN	3.6	3.6	3.7	3.3	3.4	3.6	3.6
	STDEV	4.2	4.3	4.4	4.3	4.3	4.7	4.5
1870-1897	MEAN	5.8	5.7	5.9	5.4	5.5	5.8	5.8
	STDEV	3.3	3.4	3.6	3.5	3.6	4.1	3.7
1898-1913	MEAN	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.2
	STDEV	2.6	3.0	2.8	2.7	2.6	2.7	2.9
		LCDRDB	**MSLRDB**	**MRDB**	**NBRDB**	**NERDB**	**SERDB**	**CONSOL**
1870-1913	MEAN	3.4	3.7	3.4	3.6	3.4	3.6	2.4
	STDEV	4.3	4.5	4.4	4.1	4.2	4.5	3.9
1870-1897	MEAN	5.5	5.6	5.6	5.8	5.5	5.9	4.0
	STDEV	3.6	3.5	3.7	3.2	3.3	3.3	3.0
1898-1913	MEAN	-0.3	0.3	-0.4	-0.2	-0.4	-0.4	-0.5
	STDEV	2.6	4.1	2.8	2.3	2.6	3.2	3.6

Table 6: Railway ordinary shares: nominal dividends paid (% par value) and nominal dividend yields

Dividends paid (% par value) are in nominal terms. Means are equally weighted.

A) Nominal 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	4.6	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
1911	3.9	3.3	2.7	2.1	5.7	4.1	6.5	5.8	4.4	0.0	0.0	3.4	0.7	6.0	3.5	9.9

B) Nominal 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
1911	3.7	4.1	4.3	4.0	4.7	4.6	4.8	4.5	4.6	0.0	0.0	4.9	0.6	4.8	4.2	5.3

Table 7: Decomposition of railway ordinary share returns: real dividend yields, real capital returns and total real returns

Dividend yields, capital returns and total returns are all expressed in real terms. See equation (2) in 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.

A) Real Dividend Yields (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	2.5	1.7	0.4	3.9	3.2	3.8	3.7	3.8	1.6	-1.1	2.1	3.6	-1.1	3.4	3.0	4.8
1877	5.7	6.9	3.4	6.7	5.9	6.4	6.6	6.4	6.3	2.0	5.2	6.3	3.0	6.8	6.3	7.6
1882	3.7	3.8	2.5	4.2	4.1	3.9	4.4	4.3	3.8	0.1	3.0	4.4	1.8	4.7	4.4	5.9
1887	4.1	4.5	3.8	4.5	4.6	4.0	4.5	4.5	3.9	0.6	3.3	4.5	2.6	4.4	4.5	6.6
1892	3.4	3.9	3.0	3.3	4.0	3.7	4.1	3.7	5.0	0.3	2.9	4.0	0.8	4.2	3.8	4.2
1897	2.5	3.0	2.4	3.0	2.9	3.2	3.1	2.8	3.4	-0.2	1.3	3.3	0.3	3.3	2.8	3.4
1902	1.8	2.4	2.2	0.9	2.5	2.4	2.6	2.4	2.7	-1.1	-1.1	2.7	-0.1	2.7	1.5	3.5
1907	2.7	2.7	3.4	3.0	3.6	3.5	3.7	3.5	4.0	-0.5	-0.5	3.5	0.1	3.6	2.9	3.9
1911	2.9	3.3	3.4	3.2	3.9	3.8	4.0	3.7	3.8	-0.8	-0.8	4.1	-0.2	3.9	3.4	4.5

B) Real Capital Returns (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	8.3	8.3	2.9	5.3	17.8	-2.5	4.3	5.0	19.0	14.0	10.5	2.5	17.4	7.1	9.0	4.4
1877	2.7	3.1	9.0	-2.0	0.7	-1.9	0.2	3.2	8.8	4.3	2.6	0.0	10.1	-1.8	2.6	1.6
1882	0.3	-0.6	3.3	-1.8	4.3	-1.6	2.3	-1.8	-1.7	-6.7	-1.4	-0.4	4.7	1.9	-0.8	5.3
1887	4.0	5.9	5.2	2.5	5.2	1.6	2.1	4.9	7.0	5.1	5.0	2.5	10.7	2.2	2.2	-1.9
1892	-1.9	0.0	-2.0	-3.2	-5.0	-1.9	-0.6	4.3	0.3	-4.0	-7.7	0.7	-7.4	-1.3	-0.1	-0.5
1897	2.1	2.2	11.0	1.5	0.5	5.3	2.7	1.2	1.5	8.4	-9.2	2.6	2.7	1.1	1.3	-1.4
1902	-3.3	-5.9	-5.2	-6.0	-2.7	-4.4	-4.4	-5.1	-4.9	-5.7	4.5	-5.4	6.3	-4.7	-6.5	0.1
1907	-4.3	-4.9	-7.7	-0.6	-3.0	-3.9	-2.9	-3.1	-4.9	-9.3	-7.3	-2.0	-8.7	-1.2	-6.2	1.2
1911	1.1	-2.8	-4.3	3.3	-1.4	-1.4	-0.4	-3.0	-0.1	12.2	4.6	5.9	2.2	-0.9	4.6	-2.6

Table 7: Railway ordinary share dividends paid (% par value), real dividend yields, real capital returns and total real returns (cont.)

C) Total Real Returns (%) – 5 year moving average.

	MEAN	CR	GER	GNR	GWR	LYR	LNWR	LSWR	LBSCR	LCDR	MSLR	MR	NBR	NER	SER	TVR
1872	10.8	10.0	3.4	9.2	21.0	1.3	8.1	8.8	20.6	12.9	12.6	6.1	16.3	10.5	12.0	9.2
1877	8.4	10.0	12.5	4.6	6.6	4.5	6.8	9.6	15.1	6.3	7.9	6.3	13.1	4.9	9.0	9.2
1882	4.0	3.2	5.8	2.4	8.4	2.3	6.6	2.5	2.1	-6.6	1.6	4.0	6.6	6.6	3.5	11.2
1887	8.1	10.4	9.1	7.0	9.8	5.6	6.6	9.4	10.9	5.8	8.4	7.0	13.3	6.6	6.7	4.7
1892	1.5	3.9	1.0	0.1	-1.0	1.8	3.6	8.1	5.3	-3.7	-4.8	4.7	-6.6	2.9	3.7	3.7
1897	4.6	5.2	13.3	4.5	3.3	8.6	5.9	4.0	5.0	8.2	-8.0	5.9	3.0	4.4	4.2	2.0
1902	-1.6	-3.5	-3.0	-5.1	-0.2	-2.0	-1.8	-2.7	-2.3	-6.7	3.4	-2.7	6.2	-1.9	-5.0	3.6
1907	-1.6	-2.2	-4.3	2.4	0.5	-0.4	0.7	0.4	-0.8	-9.8	-7.8	1.5	-8.6	2.4	-3.3	5.0
1911	3.9	0.4	-0.8	6.5	2.5	2.4	3.6	0.7	3.7	11.4	3.8	10.0	2.0	3.1	8.0	1.9

Table 8. 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. Standard errors are in parentheses.

PERIOD	RAIL	WRAIL	ORD									DEB							PREF		
			GER	GWR	LNWR	LSWR	LBSCR	MSLR	MR	NBR	NER	CRDB	LCDRDB	LYRDB	LNWRDB	LBSCRDB	MSLRDB	NBRDB	GERP	LNWRP	NERP
1884	18.3	8.7	3.6	1.9	1.5		3.2			4.4	1.2	0.4	1.1			0.5				0.5	
			(2.1)	(1.6)	(1.7)		(2.0)			(1.8)	(1.1)	(1.1)	(1.6)			(1.3)				(1.4)	
1885	17.2	7.5	3.1	2.0	1.4		3.4			4.8	1.1	0.4	0.7			0.2				0.2	
			(1.9)	(1.6)	(1.6)		(2.2)			(1.7)	(1.1)	(0.9)	(1.0)			(0.7)				(0.7)	
1886	16.9	19.2	3.3	1.7	1.2		3.4			4.6	0.8	0.4	0.9			0.5					
			(1.8)	(1.4)	(1.3)		(2.0)			(1.7)	(0.8)	(0.9)	(1.1)			(1.0)					
1887	24.8	4.5	2.5	2.0	2.3	0.3	4.0			4.8	1.0	0.5	2.7	0.5				1.0		0.4	2.8
			(1.5)	(1.6)	(1.9)	(0.7)	(2.1)			(1.5)	(0.9)	(1.1)	(2.1)	(1.1)				(1.4)		(0.8)	(2.4)
1888	26.4	4.7	2.4	1.8	2.4	0.4	3.4	0.1		4.4	1.0	0.5	3.0			0.2		1.8		0.6	4.3
			(1.3)	(1.5)	(1.8)	(0.7)	(1.8)	(0.0)		(1.3)	(0.9)	(0.9)	(2.2)			(0.6)		(1.9)		(1.0)	(2.8)
1889	31.3	7.3	2.8	2.6	3.6	0.3	3.2	0.2		4.4	1.3	0.5	3.2	0.1		0.3		1.2		0.7	7.0
			(1.3)	(1.7)	(2.3)	(0.6)	(1.7)	(0.3)		(1.3)	(0.9)	(0.9)	(2.1)	(0.3)		(0.7)		(1.3)		(1.1)	(3.3)
1890	24.5	14.5	3.9	2.1	1.2	0.7	3.3			3.6	0.6	0.4	3.6				0.5	0.9		0.2	3.4
			(1.4)	(1.4)	(1.2)	(1.0)	(1.9)			(1.1)	(0.6)	(0.9)	(2.3)				(1.0)	(1.3)		(0.4)	(2.4)
1891	28.0	19.2	3.5	2.3	2.2	0.3	3.1		2.3	2.2	0.5	0.7	2.5		3.1		0.4	0.4		0.5	4.0
			(1.3)	(1.3)	(1.6)	(0.5)	(1.8)		(1.4)	(0.8)	(0.5)	(1.1)	(1.9)		(2.3)		(0.9)	(0.7)		(0.9)	(2.4)
1892	43.4	14.6	2.5	2.8	1.9	4.6	2.6		1.5	1.0	0.4	0.7	11.8		3.1		2.0	2.4	0.1	0.7	5.1
			(1.1)	(1.4)	(1.5)	(2.1)	(1.5)		(1.0)	(0.6)	(0.4)	(1.1)	(3.9)		(2.2)		(2.0)	(1.9)	(0.3)	(1.1)	(2.7)
1893	41.0	14.1	2.0	2.0	1.5	6.3	3.5		1.0	0.9	0.2	0.7	11.6		4.5		1.1	2.7		0.4	2.7
			(0.9)	(1.1)	(1.2)	(2.2)	(1.6)		(0.8)	(0.5)	(0.3)	(1.0)	(3.6)		(2.5)		(1.4)	(2.0)		(0.7)	(1.7)
1894	39.0	12.7	1.9	1.7	1.3	7.4	3.5		1.1	0.9	0.2	0.6	10.8		4.4		0.6	1.7	0.2	0.3	2.7
			(0.9)	(0.9)	(1.0)	(2.3)	(1.7)		(0.8)	(0.5)	(0.2)	(1.0)	(3.3)		(2.5)		(0.9)	(1.5)	(0.3)	(0.5)	(1.7)
1895	38.2	9.5	2.2	1.3	1.1	7.6	3.6		0.9	1.0	0.2	0.4	11.0		4.9		0.3	2.2			1.7
			(0.9)	(0.7)	(1.0)	(2.5)	(1.6)		(0.7)	(0.5)	(0.2)	(0.8)	(3.4)		(2.5)		(0.6)	(1.8)			(1.4)
1896	35.8	8.4	1.9	1.3	1.0	7.3	4.2		1.0	1.1	0.1	0.4	9.7		5.2		0.6	0.7			1.5
			(0.8)	(0.7)	(0.8)	(2.3)	(1.7)		(0.8)	(0.5)	(0.2)	(0.6)	(3.1)		(2.7)		(0.8)	(0.9)			(1.3)
1897	35.1	6.9	2.7	1.1	0.6	14.5	2.6		1.7	0.7	0.1	0.3	5.8		3.3			0.4			0.9
			(1.0)	(0.7)	(0.7)	(3.1)	(1.4)		(1.0)	(0.4)	(0.2)	(0.6)	(2.4)		(1.9)			(0.7)			(1.0)
1898	28.4	7.8	2.4	0.4	0.4	14.7	3.0		2.3	0.6	0.1	0.3	2.5		1.3			0.1			0.3
			(0.8)	(0.4)	(0.5)	(3.0)	(1.4)		(1.2)	(0.4)	(0.2)	(0.6)	(1.5)		(1.2)			(0.3)			(0.5)
1899	23.0	11.8	2.5	0.5	0.4	10.6	2.4		2.3	0.7			2.8		0.7						0.2
			(0.9)	(0.4)	(0.5)	(2.3)	(1.1)		(1.2)	(0.4)			(1.5)		(0.7)						(0.4)
1900	14.3	17.0	1.8	0.3	0.2	6.5	1.1		0.8	0.7		0.1	1.4		0.8			0.3			0.3
			(0.7)	(0.3)	(0.4)	(1.8)	(0.7)		(0.7)	(0.3)		(0.4)	(1.1)		(0.8)			(0.5)			(0.5)
1901	12.2	19.2	1.7	0.2	0.2	5.0	1.0		0.4	0.6		0.2	1.0		1.0			0.4			0.4
			(0.7)	(0.3)	(0.3)	(1.4)	(0.6)		(0.4)	(0.3)		(0.4)	(0.8)		(0.8)			(0.5)			(0.5)
1902	13.4	19.4	1.3	0.2	0.3	5.7	1.0	0.3	0.7	0.8			1.7		0.7			0.4			0.1
			(0.6)	(0.2)	(0.4)	(1.6)	(0.6)	(0.2)	(0.6)	(0.4)			(1.1)		(0.7)			(0.6)			(0.2)
1903	10.4	20.1	1.0	0.3	0.3	2.8	0.8	0.2	0.7	0.9			2.2		0.7			0.4			
			(0.5)	(0.3)	(0.3)	(1.2)	(0.6)	(0.1)	(0.6)	(0.4)			(1.3)		(0.6)			(0.5)			
1904	11.4	21.2	1.2	0.3	0.2	3.0	0.8	0.3	0.7	1.1			2.2		0.6		0.7	0.2			
			(0.5)	(0.3)	(0.3)	(1.1)	(0.5)	(0.2)	(0.5)	(0.4)			(1.1)		(0.5)		(0.7)	(0.3)			
1905	12.7	19.7	1.0	0.4	0.2	3.6	0.9	0.2	1.2	1.1			3.0		0.6		0.3	0.1			
			(0.5)	(0.4)	(0.3)	(1.2)	(0.6)	(0.1)	(0.7)	(0.4)			(1.3)		(0.6)		(0.4)	(0.2)			
1906	11.4	20.3	0.9	0.3	0.2	3.6	0.7	0.3	1.2	0.7			2.5		0.4		0.4	0.1			
			(0.4)	(0.3)	(0.3)	(1.2)	(0.5)	(0.2)	(0.6)	(0.3)			(1.2)		(0.5)		(0.5)	(0.2)			
1907	8.5	32.4	0.6	0.3	0.2	3.5	0.3	0.2	1.0	0.7	0.1		1.1		0.3		0.2				
			(0.3)	(0.3)	(0.3)	(1.1)	(0.3)	(0.2)	(0.5)	(0.3)	(0.2)		(0.8)		(0.4)		(0.2)				
1908	7.5	33.8	0.6	0.3		2.5	0.4	0.2	0.6	0.4			2.2		0.3		0.0				
			(0.3)	(0.2)		(0.9)	(0.4)	(0.1)	(0.4)	(0.2)			(1.0)		(0.4)		(0.0)				
1909	6.9	33.2	0.4	0.3		2.3	0.6	0.1	0.6	0.4			1.9		0.2		0.2				
			(0.3)	(0.2)		(0.8)	(0.4)	(0.1)	(0.4)	(0.2)			(1.0)		(0.2)		(0.3)				
1910	8.0	34.8	0.5	0.3	0.1	2.7	0.3	0.2	0.8	0.4	0.1		1.9		0.2		0.2	0.2			
			(0.3)	(0.2)	(0.2)	(0.9)	(0.4)	(0.1)	(0.4)	(0.2)	(0.2)		(1.0)		(0.3)		(0.3)	(0.2)			
1911	7.4	37.1	0.4	0.3	0.2	2.2	0.3	0.2	1.2	0.4			1.8		0.2		0.3	0.1			
			(0.2)	(0.2)	(0.2)	(0.8)	(0.2)	(0.1)	(0.5)	(0.2)			(0.8)		(0.2)		(0.3)	(0.1)			
1912	6.0	33.2	0.3	0.3		1.3	0.2	0.3	1.4	0.3			1.7				0.2				
			(0.2)	(0.3)		(0.6)	(0.2)	(0.2)	(0.6)	(0.1)			(0.8)				(0.2)				
1913	5.7	35.0	0.3	0.3		1.3	0.3	0.3	1.0	0.4			1.8				0.1				
			(0.2)	(0.2)		(0.6)	(0.3)	(0.1)	(0.5)	(0.2)			(0.8)				(0.2)				

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

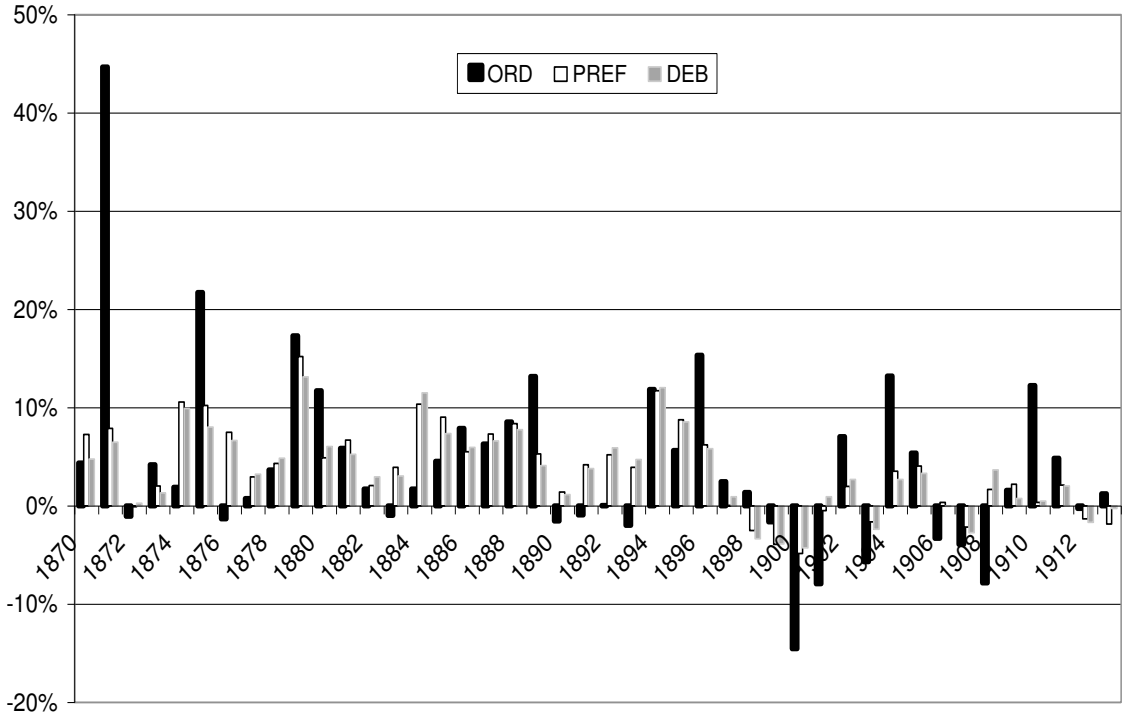

Figure 2. Efficient Frontier and Optimal Portfolio

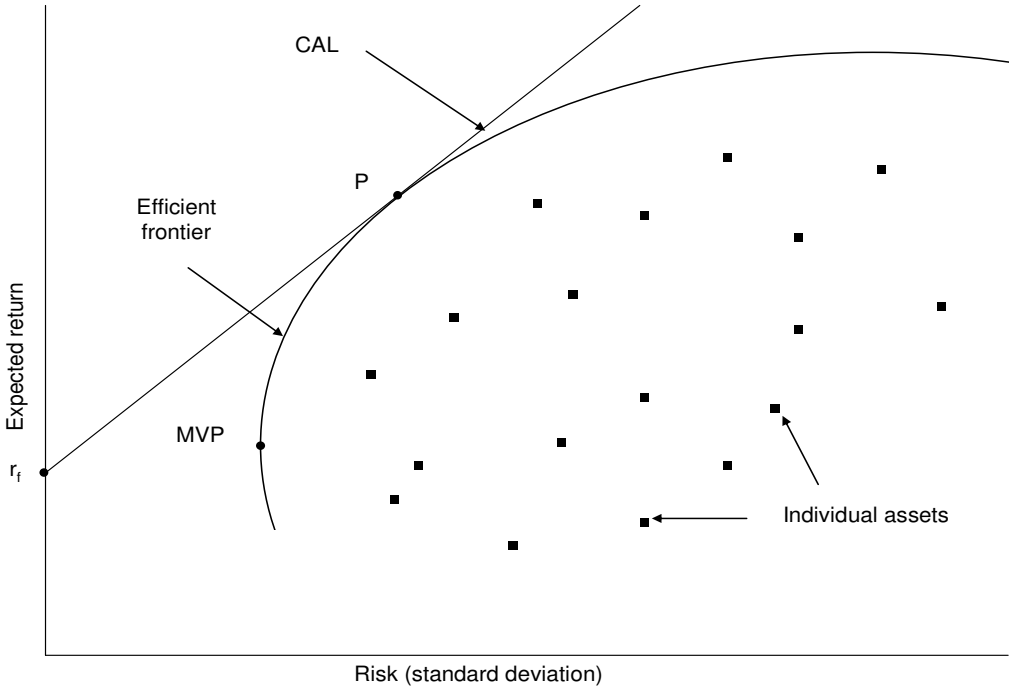

Figure 3. Sharpe ratios for periods beginning 1870

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.

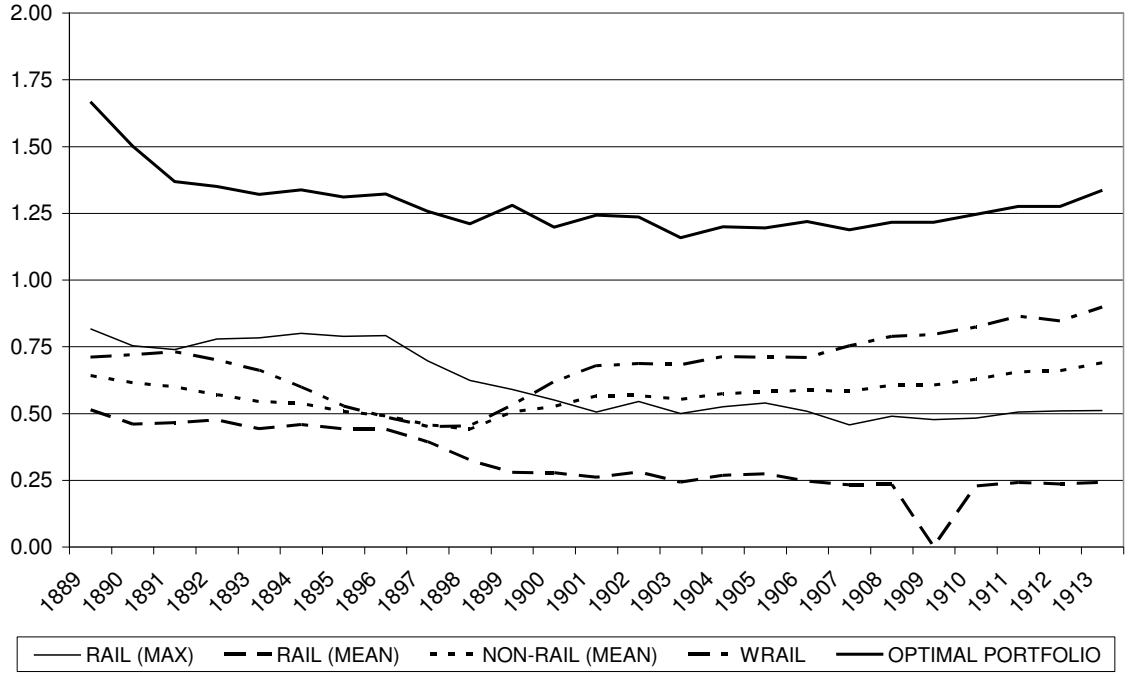

Figure 4. Total weighting in domestic railway securities

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.