The Comparative Development of Urban Electric Railways in Britain and the U.S.A., 1880-1914

'Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by

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ABSTRACT

The commercial development of electric traction in the late nineteenth century permitted the development of underground or overhead railways to meet ever increasing demands for efficient urban transport. The high costs of constructing such railways means that they were confined to a handful of the largest cities. But the same high costs meant that the capital formation associated with them was considerable and the companies themselves were of major significance for the expansion of the electrical industry generally, playing a major role in technological innovation.

This work examines the development of such urban railways through both technological innovation and the supply of capital to the companies. The emphasis is on urban railways as business organisations, with comparisons drawn between performance and development on both sides of the Atlantic.

Chapters Two and Three show that while the development of new technology permitted the expansion of urban railways, it was not by itself the over-riding factor in such expansion. Indeed, the apparent reluctance of some companies to convert to electric traction was a logical decision as, initially at least, electric traction did not reduce operating costs as much as anticipated.

Contrary to experiences in other industries, companies in Britain were not significantly slower in adopting new technology than were their American counterparts. But very different rates of growth of traffic in the two countries led to different philosophies: in Britain innovation was for defensive reasons of maintaining market share; in the USA it was for dynamic reasons of expanding capacity to keep pace with demand. But the attitude of company managers in the two countries was the same. They were sales maximisers rather than profit maximisers and operated their companies accordingly.

In Chapter Four the financing of electrification and new urban railway construction is examined and it is shown that British lines faced great difficultes in raising sufficient capital. These difficulties reflected the poor financial prospects of the individual railway companies as much as the workings of the London capital market. In America lines were either controlled by large financiers or received financial backing from municipal authorities.

American capital also played a significant role in the development of the British industry. But as Chapters Five and Six show, Americans enjoyed no more success in operating British urban railways than did British managers. While most lines made operating profits, the returns paid on capital were never particularly impressive in Britain. In

America capital was easier to obtain and this led to a substantial expansion of some companies to the point where here, too, the railways were unable to pay proper returns on the capital invested.

This reinforces the idea of a dynamic industry in the USA and a defensive one in Britain. In turn, this difference reflects more fundamental differences between the two economies, the relatively poor performance of the British urban railways being due at least in part to over optimistic expectations of traffic growth based on American, not British, experience. This in turn tends to reflect the overall differences in performance of the two economies at the time.

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CHAPTER 1

INTRODUCTION

By the late 1870s, the commercial use of electricity for lighting had become possible. With further development, electricity was shown to be a viable and attractive form of power in factories and by 1880 commercial electric traction was shown to be feasible. Offering as it did a cleaner, quieter and faster mode of power for transportation than steam or horse traction, it was quickly adopted by most European and American tramway enterprises.

Developments in the electrical industry also provided a new source of power for railways. As with any new technology, adoption of the innovation was most rapid where it could show the greatest advantages. In the case of railways and electricity, the capital cost and physical burden of providing electric power meant that these advantages were greatest where journeys were short and traffic heavy. Such conditions were primarily found on the suburban railway lines surrounding the largest cities. But the advent of electricity also meant that entirely new lines, within the cities themselves, in the form of underground or overhead railways, were practical.

The development of electric tramways, involving as it did the search for new technology to replace horse traction and the financing and development of new tramways has been thoroughly covered, especially in Europe.[1] The development of urban electric railways has also been well researched. But studies of this have generally been less concerned with the specific economic issues surrounding the application of electricity to

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1. J. P. McKay: Tramways and Trolleys - The Rise of Urban Mass Transport in Europe, Princeton, 1976.

railways. For example, in his study of urban transit development in major American cities, Cheape focused on the public policy issues that promotion of urban railways entailed, examining the political arguments surrounding such development.[1] Other studies have concentrated on general transport development in specific cities, examining both political and economic factors. Thus urban electric railways formed only one part of the comprehensive study by Barker and Robbins of the development of public transport in London.[2] Reflecting the way in which the rapid growth of urban population and the consequent growth in the size of cities fuelled demands for improved forms of transportation, such works have focused on the social and political issues involved.

Similarly, within industry studies, the position of electric railways has been examined, not in isolation but as part of a wider analysis. Thus the most comprehensive study to date of urban electric railway development in Britain forms only part of Byatt's exhaustive documentation of the development of the entire British electrical industry.[3] Alternatively, the subject has been seen as one part of the wider issues facing railway management generally, as in Irving's analysis of British railway managers' approach to suburban railway electrification.[4]

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1. C. W. Cheape: Moving the Masses. Urban Public Transit in New York, Boston and Philadelphia, 1880-1912, Cambridge, Mass., 1980
2. T C Barker & R. M. Robbins: A History of London Transport, London, 1963
3. I. C. R. Byatt: The British Electrical Industry, 1870-1914, Oxford, 1979
4. R. J. Irving: 'British Railway Investment and Innovation, 1900-1914, with Special Reference to the NER and LNWR' Business History, XIII, 1971

But urban railways were a significant industry within their own right. As Cheape has explained, their development reflected two dominant themes:

> the constant pressure of rapid growth in city population and area and the requirements of the technology developed to service that growth.[1]

There was a third major factor. The substantial costs of construction work under or over city streets and the provision of equipment required for operating an intensive service meant that the capital formation associated with urban railways was considerable and cannot therefore be excluded from any economic analysis of their development.

The role of urban growth in railway development has been covered in other studies. Cheape for example analyses the interaction of political, social and geographical factors in rapid transport development.[2] The definitive work on the development of Chicago clearly shows the close inter-relationship between the expansion of first streetcar lines and later the elevated railways, and fluctuations in land prices and real-estate development.[3] Other works have demonstrated the close links between urban growth and transport development in both Boston and London.[4]

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1. Cheape: op. cit. p.1.
2. ibid.
3. H. Hoyt: One Hundred Years of Land Values in Chicago, 1830-1933, Chicago, 1933
4. S. B. Warner: Streetcar Suburbs - The Process of Growth in Boston, 1870-1900, Cambridge, Mass, 1962;
   A. A. Jackson: Semi-Detached London, Suburban Development, Life and Transport, 1900-39, London, 1973.

But urban growth was not the sole determinant of urban transit development. Equally important were the technological innovations that led to newer, more rapid forms of transport and the organisation of capital to finance these developments. This work concentrates on these two key issues of capital and technology, analysing their role in the development of the industry on both sides of the Atlantic. Until now, studies which have included the financial aspects of the development have focused on a specific company, such as Latta's study of investment in the New York Subway.(1) But the demand for urban rapid transit, as represented in the growth of cities was a constant factor. Examination of the response to this demand, both through technological innovation and the supply of capital, should say more about the late nineteenth century economic structure and business organisation. Yet until now, there has been no comparison of financial performance and technical innovation within the industry, much less a trans-atlantic comparison, even though the structure of the industry invites one.

Confined to the largest cities in both Britain and America, the individual companies shared common problems and circumstances which by their very nature were unique to urban electric railways. Continuing research and development in the electrical industry led to a sustained flow of improvements to make electric traction steadily more attractive and financially viable. The diffusion of such technology was rapid, the bulk of the major urban railways being constructed in a period of little

1. C. M. Latta: The Return on the Investment in the Interborough Rapid Transit Company, Ph.D thesis (unpublished), Columbia University, 1975.

more than fifteen years. This was stimulated by a close interchange of ideas, development and, as will be shown, even capital and management skills throughout the industry. Inevitably therefore, technology, operating patterns and even managerial attitudes showed great similarity between the companies.

But while the industry was a homogenous one, the two economies in which it operated were very different. In America, concern about the growth of big business reflected the dynamism of the economy which stimulated the rapid application of new technology, continuing growth of output and the rise of the 'robber barons', the new breed of big business financier and entrepreneur. In Britain concern reflected the lack of dynamism in the economy. Possibly for the first time, anxiety was being expressed about the country's economic performance and the apparent slowness in adopting new methods of technology. The role of the capital market was beginning to be questioned, the attention paid to foreign loans being seen as unhelpful for domestic enterprise.

This work is an examination of the rise of the urban electric railway industry against this background of two different economies, in an attempt to gauge the impact of varying economic performance on entrepreneurial decision making. The economic aspects of the introduction of new technology and the financial aspects of company promotion and development are key features of this analysis. Assuming entrepreneurs to be rational, comparison of the timing of technological innovation, the raising of capital and the medium term financial management of the companies should provide a further insight into the performance of the two economies.

The contrast between Britain and America is central to this analysis for electric traction was adopted in the two countries for different reasons, which mirrored more wide ranging aspects of the two economies. In Britain, a low rate of growth of both urban population and income meant that electricity was adopted by railways as a defensive measure, in an attempt to maintain existing market share after the electrification of tramways had made inroads into traffic levels. But in America the rapid expansion of the cities and the inexorable rise in passenger traffic meant that electrification was a dynamic measure which permitted a significant increase in capacity for existing infrastructure, or made new projects such as the New York Subway feasible. The different reasons for adopting electric traction serve to emphasise the similarity of approach of entrepreneurs in both countries. They were sales maximisers rather than profit maximisers. This is highlighted in the later part of the work where the return on the investment in the companies and the impact of electrification on operating costs is analysed.

The contrast between defensive and dynamic approaches is consistent with other aspects of economic development in the two countries at the time. In industry generally, electric power provided a relatively cheap way of increasing output by using existing resources more intensively or by re-organising productive methods. But slow growth of output in Britain reduced the attractions of this. Also, the gas industry in Britain was extensive and efficient and this reduced the incentive for introducing electric lighting.(1) Thus other

1. Byatt: op. cit. pp.3, 4.

industries had less of an incentive for switching to electric power. Railways had an incentive but it was different from the incentive for railway electrification in America. But the contrast between the defensive and dynamic approach was not confined to the introduction of new technology. Slower growth in Britain meant that on the whole managers were always searching for ways of reducing costs while in America they were more concerned with expanding capacity. While this inevitably led to differences between the companies in terms of performance, these differing performances reflected not so much the varying individual abilities of railway managers as their adaptation to the wider economic circumstances within which they had to operate. At a company level, there was a high degree of consistency in entrepreneurial performance.

The Role of Technology

British entrepreneurs have often been criticised for their slowness in adopting new technology.(1) But the development of urban electric railways in the two countries does not reveal any significant time lag. This suggests that where the advantages of new technology were apparent, entrepreneurs would not linger in adopting it.

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1. This idea is subsumed within a more general theory of poor British entrepreneurial performance in the latter nineteenth century. The clearest expositions of this are in:

   D. S. Landes: The Unbound Prometheus, Cambridge, 1969, esp. pp. 326-358;
   D. H. Aldcroft: 'The Entrepreneur and the British Economy, 1870-1914', Economic History Review, vol. XVII (1964)

   It is not intended to suggest that this view is in any way universally accepted. A different assessment is forcefully expounded in:

   D. N. McCloskey (ed): Essays on a Mature Economy: Britain after 1840, London, 1971.

The early advances in electrical technology were made in Europe but the basic innovations for electric traction were all made in the United States in the late 1880s and by the 1890s America had indisputably taken the lead, never to lose it.(1) More rapid advance in America emphasised the generally slower growth in demand for electrical products in Britain which in turn was a reflection not only of slower growth in Britain but also of the more highly developed infrastructure there. Not until 1933 did British consumption of electricity reach the level attained by the USA in 1907 and in 1927, when California's annual per capita consumption of electricity was 1,200 units and Chicago's 1,000, that of Britain was only 110. Yet as early as the 1890s it was estimated that replacing steam engines in manufacturing industry by electric power from an outside source could cut power costs by seventy to eighty per cent.(2)

However, the structure of industry in Britain was not always suited to the rapid adoption of electric power. Coal mining and the cotton industry did not lend themselves readily to electrification and these industries were proportionately much more important in Britain than in the USA. These two industries between them accounted for about half of all power used in British industry in 1907. In a textile mill, the layout of machinery and its constant use during the day meant an efficient central steam engine driving the machinery by shafts offered the greatest advantage.(3) In coal mines, big economical engines

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1. H. C. Passer: The Electrical Manufacturers, 1875-1900, Cambridge, Mass, 1953.
2. Ministry of Transport: Report of Committee on National Electrical Energy Situation, 1927;
   R. DuBoff: 'The Introduction of Electric Power in American Manufacturing', Economic History Review, vol. XX, 1967.
3. Byatt: op. cit. p.90.

were used for winding and ventilation and the low opportunity cost of coal meant that fuel saving was not of a high priority. Electricity offered greater advantages underground but the fire risk made it unpopular.(1) Electric power provided a way of increasing output by making more intensive use of resources. But in Britain, where output was growing relatively slowly, such advantages were less obvious.

In almost every other new industry, America demonstrated a marked superiority compared to Britain in the exploitation and marketing of new ideas. In 1904 there were 8,000 motor cars in the UK compared to 55,000 in the US and by 1912 the figures were 88,000 and 901,000 respectively.(2) The chemical industry in Britain failed to adopt the Solvay process of alkali manufacture, relying instead on the traditional Leblanc method.(3)

There were exceptions in Britain. The shipbuilding industry for example adopted electric power fairly quickly. Given the size and importance of shipbuilding at the time, by implication other industries would also have switched to electric power if the investment and return justified it. But a significant proportion of the shipbuilding industry was concentrated in the North East of England, and much of the reason for its adoption of electricity there was due to the influence of Charles Merz, who was primarily responsible for the more rapid utilisation of electricity in that region than elsewhere in Britain.(4)

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1. ibid: p.92.
2. B. R. Mitchell & P. Deane: Abstract of British Historical Statistics, Cambridge, 1962, p.230; US Bureau of Census: Historical Statistics of the United States, Colonial Times to 1970, Washington DC, 1975, part II, p.716.
3. D. S. Landes: The Unbound Prometheus, Cambridge, 1969, p.273.
4. Byatt: op. cit. p.115 et seq.

Logically, one might expect this disparity to extend to electric railways and to see a clear time lag between their development in America and development in Britain. This was certainly the case with the electric tram, development of which in Britain was not only relatively late compared to the United States but also when compared with Germany.[1]

Such expectations would be reinforced by the difficulties that early electrical manufacturers had in developing a market in Britain. Like their American counterparts, such companies had small beginnings. But in America the technological flair of electrical pioneers was matched by considerable commercial acumen. Research and development in electric traction could be financed through sales of electric motors for industrial use. Initially small companies grew rapidly but, as a result of takeovers and mergers, by the late 1890s the American electrical manufacturing industry was dominated by just two companies - GEC and Westinghouse. But in Britain early electrical contracts were piecemeal and insufficient to sustain the pioneering manufacturers. This was not only because of lack of demand. Unlike their American counterparts, there is only limited evidence of the early British companies taking much of an initiative to develop a market.[2] Of the two leading pioneer electrical companies in Britain one, Mather & Platt, was involved in electrical traction as something of a sideshow. Although it tried to stimulate demand by offering guarantees to purchasers of its equipment, such attempts were half-hearted and the company had already decided to withdraw from

1. ibid.: pp.29-30.
2. ibid.: p.33; J. P. McKay: Tramways & Trolleys, op. cit. Ch.5.

the electrical industry before demand for the industry's products started to increase. The second pioneer company, the Electric Construction Corporation was also prepared to offer guarantees in a limited fashion but it was beset by problems with both its directors, one of whom was arrested for fraud, and with its electrical engineer who left to set up his own company.(1)

Such difficulties did nothing to encourage the spread of electric power and electric traction in Britain. But in spite of the setbacks, and in contrast to the development of electric tramways, development of urban electric railways in the two countries was broadly contemporaneous, with Britain actually enjoying a head start.

In support of the argument that this reflected rational decision making by entrepreneurs who would not linger in adopting new technology when they perceived a benefit by doing so, some analysis of coal price movements in the UK was undertaken to determine whether increases in the cost of coal made electric traction relatively more attractive, thereby acting as a spur to the changeover. While the evidence is inconclusive, it does show that work on the major electrification schemes in Britain was preceded by rises in the cost of coal, indicating that relative costs of differing forms of traction were at least a factor in the timing of electrification. If applicable to other industries, this suggests that the advantages of electric traction in Britain, at least initially, may not have been obvious and that delays in

1. I. C. R. Byatt: The British Electrical Industry, 1875-1914, D.Phil. thesis, (unpublished) Oxford, 1962, p.352.

adopting electric power reflected not entrepreneurial inefficiency but entrepreneurs' expectations of the expected returns on capital and the extra profits that might or might not accrue from adopting new technology. Slower growth generally in Britain than America accentuated this by lengthening the lag before returns could be expected. This is consistent with the hypothesis of defensive and dynamic reasons for electrification.

The Role of Capital

The contrast between dynamic and defensive attitudes extended to the raising of capital but again a consistent performance pattern emerges of urban railways being marginal investments and, at least in Britain, only marginally profitable. This was reflected in the difficulty most companies had in raising adequate capital.

In spite of the importance of technology, electrification of urban railways was not an unavoidable occurrence. It was the availability of capital and the demand for transportation which dictated construction, not the mode of operation, for the application of electricity in transport and industry required considerable capital resources. To obtain this, the electrical industry and the urban railways had to compete, at least in Britain, not only with other domestic capital formation but also with overseas investment. A clear order of priorities existed for channelling investment through the British capital market in which new industries came a poor third behind foreign bonds and investment in staple industries.(1)

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1. H. W. Richardson: 'Retardation in Britain's Industrial Growth, 1870-1913', Scottish Journal of Political Economy, vol. XII, 1965, p.148.

Although the period 1896-1904 saw a peak in railway investment in Britain, urban railway companies faced great difficulty in raising capital. This inevitably leads to the question of whether urban railways were deprived of capital as a result and whether the British capital market was thereby allocating resources inefficiently, especially when compared to American capital formation. In fact, in direct contradiction to the general trend of the nineteenth century, through much of which British capital had acted as a catalyst for a significant proportion of American d evelopment, British urban railway companies were heavily dependent on American capital. This provides a useful link in the international comparison of the industry; more generally, it was part of a much larger outflow of capital from the USA at the time. Henry Ford's investment in the British motor car industry, American investments in British tramways and the entry of Westinghouse and GEC into the electrical manufacturing industry are other examples.(1) Critics of the performance of the British capital market and of British entrepreneurial performance would argue that in general terms this investment was in precisely those areas where British entrepreneurs, with backing from the British capital market, should already have been making inroads. But American investment in Britain was not always successful. Westinghouse's entry into the British electrical industry provided a boost to urban railway electrification but was otherwise a failure. Nowhere was this lack of success more clearly demonstrated than in American investment in urban railways in London.

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1. British financiers were not the only ones to make mistakes. When Henry Ford sought $100,000 to establish the Ford Motor Company in 1903, he was able to raise only $28,000 in cash. The great investment boom in America at the time was in inter-urban railways. As an industry, they had the worst financial record for their size. G. W. Hilton & J.F. Due: The Electric Interurban Railways in America, Stanford, 1964, p.3.

The difficulties that urban railways faced, at least in Britain, in raising capital were compounded by the problems of having to raise capital on a declining market and by competition from tramways, not only for passengers but also for funds. A major difference in America was that tramways and urban railways were generally controlled by the same company, so that this problem did not arise. Nevertheless, the capital intensive nature of most lines in both countries made them especially susceptible to economic fluctuations. If to this is added the degree of risk entailed in investing in the new technology of electric traction, the reluctance of British investors and the initial hesitance of American investors to finance lines in their own country is understandable.

As urban railways were marginal investments, and as the capital intensive nature of most lines made them particularly susceptible to economic fluctuations, firm control of expenditure was essential if the companies were to be profitable. But this was not always forthcoming. Promoters were unduly sanguine in their expectations of traffic, leading in a number of cases to overbuilding of lines. This was especially so in Boston where the involvement of the municipality in funding development removed constraints on expansion that might otherwise have applied, and also in London where American investment in unjustified expectation of traffic levels being comparable to t hose in America, meant that after the initial burst of construction no new underground lines were built until 1968.

In America generally, efficient transport structures were created but promoters with their

> haste for personal profit, their techniques of finance and their underestimation of capital costs saddled city transit systems with excessive fixed charges (which) drained funds, discouraged additional investment ...

and contributed to the collapse of many systems after 1914.(1)

While there was no evidence of similar haste for personal profit in American investment in British lines, such investment was singularly unsuccessful. This was despite the use of the best available managerial talent and access to ample American funds in the form of share capital rather than more burdensome fixed interest loan stock. In general, locally financed projects fared better than other lines and this suggests that imperfect investor knowledge was a factor to be taken into consideration in examining the poor performance of some companies.

In the medium term, companies in both countries experienced severe difficulties in sustaining payments on capital. But the reasons were different. In America, overbuilding and underestimation of capital costs reflected a dynamic economy where it was casually assumed that increased fixed costs would be more than covered by increased traffic. While this approach was also a factor in the failure of American investment in British urban railways, the marginal nature of most British lines suggests there was more to the relative stagnation of the British economy than entrepreneurial shortcomings or an inefficient capital market and supports the argument of those who see the overall problem of the

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1. C. W. Cheape: Moving the Masses, op. cit. p.215.

British economy as a structural one in which more rapid change was possible but did not occur. Inevitably, in such circumstances, the approach of entrepreneurs was cautious or 'defensive'.

Electrification and Operating Costs

Once companies adopted electric traction they were quick to apply operating patterns which utilised it to maximum advantage. This suggests awareness of the importance of fixed costs, which formed a much higher proportion of total costs under electric working than under steam working. On the other hand, the companies were, for the most part, in the forefront of innovation but frequently unable to cover capital charges.

Analysis of operating performance under electric traction shows that once adopted, it was primarily seen as a way of stimulating passenger growth. Railway managers were more concerned with sales than with costs. In America in particular, there was a strong assumption based on past performance that traffic would continue to grow and that continuing investment and increased traffic would mean costs would continue to decline as a proportion of revenue.

But an increase in passengers did not necessarily lead to a reduction in costs and urban railways proved to be more successful at increasing the overall number of passengers than they were at reducing the proportionate cost of carrying them. Lines in both countries were faced with rising cost indices but, for different reasons, static fares. In America in particular, flat-rate fares meant that line extensions often produced little in the way of extra revenue, as the length of journeys, rather than the number of passengers, increased. In Britain tramway competition led companies to improve and expand services when financial returns suggested they should be seeking to reduce costs.

The greater concern shown for sales rather than net returns meant that close control of costs came second to capacity improvements. Provided funds were available, investment would frequently take place without detailed calculations of the likely financial benefits. Furthermore, in cost terms, particularly in Britain, the initial difference between steam and electric traction was probably overstated, once the extra capital costs of the latter are taken into account. Over time, however, this difference would be reduced as companies sought to utilise to the full the extra advantages and flexibility of electric working.

Thus analysis of the development and operating patterns of the urban railways reveals that the significance of structural differences in the two economies was mixed. These differences had only a marginal impact on the rate of technical innovation. The interchange of ideas and information across the Atlantic was rapid, so that once a particular innovation had been shown to be practical and economic, the great majority of the companies did not hesitate in adopting it unless there were sound reasons for doing so. Furthermore, analysis of year by year performance of the companies reveals no discernible overall difference between British and American lines although differences between individual companies are apparent. This conformity in operating performance reflects the similarity of operating and traffic conditions for urban railways. Such similarities were less likely to be apparent elsewhere in the two economies, so it is perhaps not surprising that structural differences were of marginal direct importance, although they clearly affected the approach of managers to everyday operation.

With the exception of urban railways, the evidence in the electrical industry generally for much more rapid uptake of new technology in America than in Britain is unambiguous. Part of this delay in Britain reflected structural factors but it also reflected scientific attitudes. The key to factory electrification was alternating current power but British electrical engineers concentrated primarily on direct current development. Industrial application of this was limited but it was more suited to traction requirements.(1) The direction of research did not therefore affect the rate of electrification of railways in Britain although it may have hindered other applications. But in America, electrification in industry played a more positive role, for earlier development of industrial electric motors gave electrical suppliers more outlets and greater turnover, thereby facilitating continuation of expensive development work for electric traction requirements. This apart, the spread of electric power into industry had no significance for, or impact upon, the electrification of urban railways. In both Britain and America, for the most part urban railways built their own power stations, so the existence or otherwise of public electric supply networks also played no part in urban railway electrification.

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1. Byatt: op. cit. p.69.

The role of municipal authorities

It is hard to argue that municipal control of most urban railway lines would not have been more appropriate. The detailed arguments for this have been made elsewhere but municipal control did have some bearing on companies' economic performance.(1)

In both Britain and America, the thrusting of the lines out into undeveloped suburban areas brought with it rapid development of these previously rural areas. This was achieved much more rapidly in America because of the existence of uniform fares which were the same, irrespective of the length of the journey. The existence of these was a reflection of the interest in rapid transit projects shown not just by real estate developers, financiers, traction magnates and shopkeepers but also by local political organisations. The natural outcome of this political support in America was the municipal backing given to the subways in New York and Boston, where private enterprise would have happily built elevated railways but baulked at the cost of subway construction.

In Britain on the other hand, the underground railways were granted powers by private Act of Parliament and there was no question of municipal operation.(2) The only control the London County Council had was insistence on an adequate number of cheap and convenient trains. The basic aim of Parliament was to establish a formula which would stop the abuses of monopoly without further interference, as in theory, was the case with municipal control of electricity supply in general and tramways.

1. Cheape: op. cit.
2. Byatt: op. cit. p.200.

The then newly formed London County Council had wanted to influence the original underground railway Acts, seeking the most direct routes, bigger tunnels and cheap trains for workmen. But it had no way of ensuring that its suggestions were adopted. On the other hand, through obstructive intervention it ensured that costs could be kept up.(1)

In America, where traditional preference for private enterprise was just as strong, municipal transit commissions in New York and Boston planned and built new lines financed and owned by the city, with the facilities leased to private enterprise for operation. But in each case the initial decision for public construction was an ad hoc response to the city's need for improved transit. Public enterprise was envisaged as a temporary measure until private initiative could resume responsibility. Provided controls were established, Americans continued to rely on the profit motive as the best incentive for efficiency.(2)

Thus it was left to market forces in Britain to provide the necessary capital while municipal backing in America showed a more far sighted approach but also reflected the growing anti-trust mood and public concern over the rise of big business. Within this fundamentally different structure, the day to day control and operation of the various companies showed only minor differences.

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1. ibid. p.201.
2. Cheape: op. cit. p.216.

The Case Studies

The cities that could justify the investment required for an urban railway were few. Required to make it worthwhile were

> a well defined central business district, densely populated middle to low income tributary areas and water or other natural barriers to define the areas so as to prevent admixture of residence and employment.(1)

The growing transport needs of the great majority of cities were met by tramways - first horsecars, then cable cars and finally the electric tram. The high population densities and geographical conditions required for urban railways meant that they were confined to the four largest cities in the USA and the three largest in Britain. These were New York, Chicago, Philadelphia and Boston in the USA and London, Glasgow and Liverpool in Britain. The lines in Philadelphia and Glasgow are not considered in this work. In Philadelphia the lateness of development of the transit system places it outside the scope of this work while, unique in the development of urban railways, the directors of the Glasgow Subway opted for cable power. Not until 1935 did Glaswegians enjoy the luxury of electric traction on their underground railway.(2)

Of the cities covered, London presents both the most complicated and most interesting study. As Table 1 shows, there were no fewer than nine companies here, although three enjoyed

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1. G. W. Hilton: 'Transport Technology and the Urban Pattern', Journal of Contemporary History, vol. III (1969), pp.129-135.
2. Population figures for the cities were: New York 4.6m, Chicago 1.8m, Boston 1.2m (all 1900 census), London 7.2m, Liverpool (including suburbs) 1.1m (both 1911 census).

TABLE 1

RAILWAY SYSTEMS COVERED IN THE TEXT

a.	London:	Metropolitan Railway Metropolitan District Railway City & South London Railway Waterloo & City Railway Central London Railway Great Northern & City Railway Baker St. & Waterloo Rly. Great Northern, Piccadilly & Brompton Rly. Charing Cross, Euston & Hampstead Rly. (The latter three were the original members of the Underground Electric Railways of London Group.)
b.	Liverpool:	Mersey Railway Liverpool Overhead Railway
c.	New York:	Manhattan Elevated Railway Interborough Rapid Transit Company Brooklyn Rapid Transit Company Hudson & Manhattan Railroad
d.	Boston:	Boston Elevated Railway
e.	Chicago:	Chicago South Side Railway Lake Street Elevated Northwestern Elevated Metropolitan West Side Elevated Railroad Chicago Union Loop

See also Appendix I.

common ownership from the start of operations. The earliest lines - the Metropolitan and Metropolitan District - dated from the 1860s and were the last to accommodate electric working in the capital. While primarily an urban railway, the Metropolitan had a long main line out into the depths of the Buckinghamshire countryside, some 60 miles from its Baker St. headquarters. At the other extreme, the Waterloo and City Railway was the shortest of all the urban lines, serving only two stations and providing nothing more than an under river shuttle service. Conditions in London were further complicated by the difficulties associated with construction. The Metropolitan and District Railways were both built by excavating city streets and constructing the railway lines just beneath the surface. The cost of this, and the congestion that resulted while major streets were turned into construction sites, meant that subsequent lines were built as deep level 'tubes' taking advantage of new tunnelling methods. Even so, construction in London remained expensive, while legal complications meant that lines still had to follow the course of streets which did not necessarily provide the most obvious or easiest routes.

Liverpool provides a marked contrast. There were only two lines here, the underground Mersey Railway and the elevated Overhead. The Mersey was an excellent example of a line built primarily to overcome a geographical barrier by linking two substantial communities on either side of the River Mersey, while the Overhead was a modest but profitable link along the s everal miles of Liverpool dockland.

In America, the steady growth of New York meant that, as in London, rapid transit predated electric technology. In this case, however, it was provided not by subsurface lines but by the elevated lines of the Manhattan Elevated Railway. The continued expansion of the city and controversy over environmental disfiguration by elevated steam trains made an underground railway only a matter of time. But in contrast to London, where development was left primarily to individual enterprise, the Subway in New York was a careful combination of both municipal and free enterprise. Brooklyn also had an elevated system, which in the period under view, developed independently of the Manhattan lines. There was also a short link across the Hudson River which, as with the Mersey Railway, was constructed first and foremost as a means of overcoming a geographical barrier.

Boston was the first major city in the USA to have an electrified tram system and was also the first city in America to boast an underground railway, although intitially this was simply a tunnel for tramcars. Cheape has observed that in Boston

> a strong tradition of public control, a peculiar political alliance, and the location of a hallowed landmark, the Boston Common, were important determinants of technology and public policy.[1]

These factors helped to make Boston unique among the case studies in being the only city in which all public transport was provided by a single enterprise, the Boston Elevated Railway. As in New York, the geography of the city was an important determinant of the pattern of railway construction.

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1. Cheape: op. cit. p.17.

Alone among the studies, in Chicago rapid transit was provided entirely by elevated railways, which were more suited to Chicago's wide streets and favourable geographical circumstances, there being no water barriers as in the other American cities. Unlike Boston and New York, development was left to individual promoters rather than the municipality. This led not only to the construction of competing lines but also meant that the stability essential for sound development was lacking and stock watering and receivership were prominent features of early development in Chicago.

Further details of the individual companies are given in Appendix I. The geography of each ofthe cities featured prominently in electric railway development as is apparent from a study of the maps in Appendix III. The topography of New York, Boston and Liverpool, which helped to explain the pattern of urban railway development in these cities is noticeable, as is the wide variation in the size of the cities, which helped to account for substantial variations in the basic characteristics of the individual companies, such as the length of the lines and the volume of passengers carried. Despite these variations, the industry was a remarkably homogeneous one. The technical requirements of an urban electric railway were fundamentally the same from one line to another while the requirement of a rapid, frequent interval service meant that operating conditions were also similar. Compared to other forms of transport, the capital requirements were consistently high, while the geographical barriers that were sometimes the _raison d'etre_ of urban railways further helped to distinguish them from other forms of transport.

Undoubtedly there were differences between the individual urban railway companies both within a country and even more so if all the individual lines in the two countries are compared. How, one may argue, are lines such as the Mersey Railway and the New York subway comparable? Above all, the unified centrally controlled lines that were effective transport monopolies in the major American cities were non-existent in Britain. Nevertheless, all the lines shared to a large extent common problems. They were pioneers in the use of electric traction, and all of the lines studied had either opened for business or converted to electric traction in less than two decades from electric traction being shown to be a practical proposition. Despite differing economic conditions, in both countries elevated railways are shown to have been practical propositions for private enterprise while, due to the large amounts of capital that had to be mobilised, underground railways were not.

Technologically at least, urban electric railways had been a response to growing urban pressures. Solving these through alternative systems such as steam or cable operated railways was shown to be practically or politically unacceptable. Thus electricity was the only viable solution but the way in which it was adopted reflects the existing arguments in economic history about the pace of technical change and innovation in Britain and America.

It is apparent that the overall economic environments were substantially different, as indeed a number of Americans found to their cost. In America the importance of municipally controlled public utilities was grasped, whereas in Britain it was left to a not very efficient form of free-market allocation of resources for essential utilities to be developed in a much more haphazard way. In spite of this, the true achievement was that work of this nature, calling for the mobilisation of large amounts of capital and the adoption of a revolutionary form of traction, and which depended for its success on continual growth of a city's population, should have been achieved as quickly as it was.

CHAPTER 2

ELECTRIC TECHNOLOGY AND THE URBAN RAILWAYS

> The application of electricity to the propulsion of street cars in the U.S. is unparalleled in the world's history in the rapidity of its growth, in its attractiveness as an investment, in the revolutionary changes which it has made in the character and methods of local transportation and in its influence as a redistributor of urban and suburban population.
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> W. J. Clark: 'Cassier's Magazine', 1899, p.518.

Obviously, one of the more significant variations in development was in the actual timing of the opening of electric railways. In addition to the patterns of consumer demand, these variations were affected by both technical and cost considerations. From the technological point, the adoption of electricity in multifarious forms and for varied uses was, in America at least, unprecedented. In Europe, and Britain especially, the adoption of electricity was considerably slower. No full attempt to explain this difference will be made here, primarily because it is being argued that the urban railway industry was a rather specialised industry, the peculiarities of which were the major factors in dictating development.

To test this hypothesis, the relative patterns of technological development in the two countries are being examined. This is not as straightforward as it may appear. Firstly, there was a basic difference in the adoption of electric railway technology by existing, steam operated, urban railways and in its use by the new railways, in that where a line was planned for electric operation from the outset, different engineering methods could be employed and different assumptions made, as will be shown. Secondly, as with other industries, exogenous factors such as the availability of capital, economic conditions and local political factors, had a bearing on the adoption of technology. For the new underground railways there was, with the arguable exception of cable haulage, no practical alternative to the adoption of electricity as a form of motive power.

For existing steam workad lines, however, the situation was different for electricity would presumably have to demonstrate a convincing reduction in operating costs or produce an increase in revenue before being adopted. Furthermore, as with any new technology, the established companies would be slower to adopt it than the new companies, partly because of its unproven nature and partly because of the need to write off substantial amounts of existing capital.

Basically, prior to electricity there were two alternative forms of technology suitable for train haulage - cable power and steam power. Although cable power ultimately proved moderately successful in Glasgow, where traffic was light and trains never more than two carriages, and was adopted on some five hundred miles of street railway in America, other experiments were less successful. In London the Tower Subway opened in August 1870, a Receiver was appointed in November 1870 and the railway was removed shortly thereafter. In New York cable operation on the first elevated line had demonstrably failed by 1870.(1) Although it was eventually

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1. C. E. Lee: Railway Magazine, vol. LXXXIX (1943); J. B. Walker: Fifty Years of Rapid Transit - 1864-1917, New York, 1918, pp.78-80.

proved to have possibilities, it is extremely unlikely that cable operation of a twenty mile long subway with heavy trains at short intervals could ever have been successful. The problems with steam engines, as regards the adequate ventilation of tunnels, were similarly insoluble, despite claims to the contrary. However, lines which had initially, some years previously, commenced operation with steam traction, could be expected for a number of reasons to be slower in adopting electric traction, if only because of the necessity of writing-off capital equipment. It makes sense therefore, to consider the two types of company separately, rather than side by side.

The first electrically operated urban railway and the world's first electric underground railway was the City & South London Railway (CSLR) which opened in London in 1890. Although not the first electric railway, it was the most significant one at the time of opening and its pioneering nature must not be under-estimated. Proposals for an electric railway in London had been made as early as 1882 when the Charing Cross and Waterloo Electric Railway had been formed, with one of the Siemens brothers as electrical engineer. This scheme was abandoned in July 1885, electricity being considered impractical still but in 1884 the City of London & Southwark Railway was formed, to be worked by cable traction. In 1888, when electric traction was still very much in its infancy, the shareholders approved a proposed change to the new form of power, and a change of name to the CSLR.(1)

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1. T. S. Lascelles: City & South London Railway, Lingfield Surrey, 1955; City & South London Rly. Shareholders Minute Book No. 1.

At about the same time, the large West End Street Railway in Boston had become the first major American organisation to opt for electric traction. From then on, the comparative rate of diffusion of the new technology in Britain and America is of interest. At first sight, a notable change appears to have taken place in that up to 1890 or so electrical engineering appeared to be more advanced in Europe but from then on the U.S. established itself as the clear leader. For example, while the diffusion of the Gramme dynamo into Britain in the early 1870s was rapid, in America the curiosity of university science professors was initially more important than industrial application. However, in the 1880s the failure of many of the early entrepreneurs in Britain may have done much to discourage further research and innovation there.(1)

From then on, the 'propensity to innovate' was more marked in the U.S.A. in that it had the two most successful electrical manufacturing companies in the form of Westinghouse and G.E.C. and in Frank Sprague the leading inventor as far as electric railways were concerned. There were notable individuals in

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1. J. E. Brittain: 'The International Diffusion of Electric Power Technology', Journal of Economic History, vol. XXXIV (1974), p.108; H. J. Habakkuk: American and British Technology in the 19th Century, Cambridge, 1967, p.212. The early development of electric power was largely a matter of relative costs. While the battery had been developed in the early 1840s, into the 1850s coal cost 9d per cwt or less, while zinc for batteries cost at least 2/6d per cwt. In the early 1860s the Italian Pacinotti and later Siemens (of Germany) made big improvements in electrical generators, which obviated the need for expensive zinc, and Gramme then showed that the generator could also be run as a motor. M. Mac Laren: The Rise of the Electrical Industry during the 19th Century, Princeton, 1943, Ch.IV.

Britain but the problems were greater. The market for electrical products in general was growing more slowly, which made the risks of adventure greater. In addition, the more highly developed infrastructure of the British economy made innovation more difficult and therefore change came more slowly. One example of this was that on the eve of the introduction of electric lighting, England was better lit than the U.S.A., largely because the English gas industry was more efficient than its U.S. counterpart and the high cost of American coal made gas prices higher there.(1) A more direct and relevant example was the problem of tramway electrification. The considerable opposition to overhead wires prolonged the research into battery power. As far as railways were concerned, this was an irrelevance - unlike tramways, they could take their power from a live rail beside the track (for obvious reasons this was hardly practical for tramways in the middle of the public highway) and such a method had been proved effective as early as 1883 when it was adopted on the Giant's Causeway line at Portrush in Northern Ireland.(2)

As opposition to overhead wires faded, so did research into battery power. However, contemporary observers claimed that a further disincentive to innovation in electric traction lay in the 1870 Tramways Act. The chief objective of this Act had been to facilitate tramway construction by reducing the cost of obtaining Parliamentary authority but under the terms of the Act,

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1. H. J. Habakkuk: op. cit. p. 209. In fact, as will be shown later, evidence of comparative coal prices for railways suggests that coal was cheaper in the U.S.A.
2. J. H. McGuigan: The Giant's Causeway Tramway, Lingfield Surrey, 1964.

local authorities were given powers of compulsory purchase at current value at the end of twenty-one years after the date of opening of a tramway and thereafter every seven years. Many operators in the 1890s blamed this clause with bringing the industry to a state of stagnation at a time when the tram companies should have been proceeding with electrification but this allegation has since been shown to have been

> more of a public relations exercise than a sound business grievance ...(1)

Nevertheless, restrictions in the Act meant that tramways were laid out in a manner wholly unsuitable for subsequent conversion to electric traction.(2) Furthermore, the clause for takeover by local authorities was included as a way of defraying the rates through the acquisition of profitable tramways. Thus municipal socialism meant the further development of proven successes, rather than experimenting with new and possibly expensive ideas. The net result of this, it was felt, was that

> many perfectly honest and profitable schemes would have failed but for the aid of American capital.

As early as 1901 the backwardness of the English electrical manufacturers was attributed to this lack of opportunity and they were expected to take at least a decade to catch up with American manufacturers.(3)

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1. A. D. Ochojna: 'The Influence of Local and National Politics on the Development of Urban Passenger Transport in Britain 1850-1900', Journal of Transport History, vol. IV, (1978) p.138.
2. For example, land could not be taken compulsorily for widening roads to accommodate tramways. Promoters tried to overcome this problem by single line systems and sharp curves, which were totally unsuited for electric tramway systems.
3. E. F. Vesey Knox: 'Economic Effects of the Tramways Act of 1870', Economic Journal, vol. III (1901), pp.492-510.

This argument is made more plausible if explained in the more general terms of slow economic growth and innovation in Britain at the time, of which it is but one more aspect, so that Britain, while keeping pace with France, lagged behind tramway electrification in Germany and the U.S.A., although the relative growth of electric tramway mileage after 1900 was much faster in Britain than in the U.S.A.(1) Although the slow growth of the British tramway system in the 1890s was painfully apparent, of even more significance is the comparative rate of adoption of electric power in industry generally, prior to the 1890s, for it was this that laid the foundation of the electrical industry. Thus the Sprague Electric Railway and Manufacturing Company was formed in 1884 and while Sprague proceeded to concentrate on tests on the New York Elevated, until 1887 sales of motors were almost entirely for industrial use.(2) Meanwhile the capital of the firm grew from $100,000 in 1884 to $1m in 1886. By American standards, Sprague's was not even a large company, eventually merging in 1889 into the newly formed Edison General Electric.(3) The early British firms were very small in comparison. Mather and Platt was a partnership until 1892, when it became a private company with a capital of £400,000. It was not the only British electrical manufacturer but in 1888 total output of the industry did not reach £200,000. Even by 1892, output does not appear to have been much over £500,000.(4)

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1. By 1897 88% of American tramway mileage was electrically worked, compared to only 9% in Britain. I. C. R. Byatt: op. cit. p.163.
2. H. C. Passer: The Electrical Manufacturers 1875-1900, Cambridge, Massachusetts, 1953, p.238.
3. ibid. p.248.
4. I. C. R. Byatt: op. cit. p.333; L.E. Mather: Sir William Mather 1838-1920, London, 1920, Ch. 2.

The slow growth of the electrical industry in Britain has been noted frequently enough elsewhere - all that is being noted here is that whereas the American firms had a substantial demand usually from small firms at this stage for electric motors, such demand was not apparent in Britain. The problems that such lack of demand would cause are apparent and in the traction field the slow electrification of tramways can only have compounded them. Quite apart from limiting the inflow of funds, the low level of demand in Britain hindered companies in other ways. For instance, in the U.S.A., guarantees which shifted the risk of innovation on to the manufacturer, notably in the case of Sprague financing the introduction of electrification on the Chicago South Side Railway, were an important reason for the rapid increase in electric traction.(1) However, British entrepreneurs did likewise. British Thomson Houston (BTH) was formed in 1894 from the British agents for GEC of America who had been agents for the Thomson-Houston Electric Company of Massachusetts since 1886 and they took responsibility for the ownership of five tramway installations in Britain.(2) BTH subsequently became the major traction equipment company in Britain but growth of electric traction was still much slower than in the U.S.A. Despite this early inroad into the British traction market by an American firm, the first two electric railway projects of significance in Britain were both handled by British firms. The third contract (to Siemens and Halske) was part British but thereafter American subsidiaries held sway.

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1. H. C. Passer: op. cit. p.343.
2. J. H. Cansdale: Electric Traction Jubilee, 1896-1946, BTH Co., 1946, pp.7, 25. Significantly, although BTH was formed from an existing British company, additional finance came from Germany and staff from America, I. C. R. Byatt: op. cit. pp. 172-3.

The predominance of the American subsidiaries followed on from their expansion into the British market in the late 1890s. This highlights in many ways the problem faced by British electrical manufacturers in that while the market remained small they themselves were severely constrained in size and profit but as soon as an expansion of the market appeared probable, the larger and better established American firms quickly gained a foothold, effectively restricting further expansion by British firms. This is a gross over-simplification of the circumstances - for one thing the entry of the American firms into the British market was stimulated by a domestic depression in the U.S. - but it is worth considering whether the earlier development of electric tramways and urban railways in Britain might not have helped the domestic British electrical industry.(1)

Part of the explanation must lie in the different reaction to electric traction for tramways and railways. In the U.S.A., electrification of the Boston streetcar system marked commercial acceptance of its feasibility for urban tramways. However, Boston at the time was the largest American city still relying entirely on horse cars. Steam trams were rejected as being too dangerous in the congested streets and the topography meant that cables were also unsuitable. Experiments with storage battery power proved unsuccessful and work had actually begun, somewhat

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1. The British industry quickly began to fall technically behind the American and German industries in the mid 1890s, but prior to then it may be asked why the British companies did not make greater efforts to gain access to the European market. In fact, at least one company - Cromptons - tried hard to win European orders without success. The company blamed this on the credit policies of British banks, compared to those of German banks. I. C. R. Byatt: op. cit. p.329.

reluctantly, on preparations for installing a cable system before electricity was deemed practical. Overhead wires were at first opposed strongly and a conduit system was used in central Boston until its failure quietened critics and led to its replacement by overhead wires.[1] In this respect, developments in Boston were similar to those in many European cities a decade or so later. From an American viewpoint, the success of the Boston conversion established firmly the viability of electric traction for tramway use. Its applicability to railways was established, as far as Americans were concerned, in 1892 when the Baltimore Belt Line Tunnel was opened. The locomotives here were required to take a 1,200 ton freight train up a 1 in 100 gradient at 15 m.p.h. and up to 200 trains were expected to use the tunnel each day.[2]

By this time, however, the feasibility of electricity for railway traction purposes had been demonstrated in Britain by the CSLR which opened in 1890 and it was reinforced when the Liverpool Overhead Railway (LOR) opened in 1893. Meanwhile, tests and experiments regarding the feasibility of electric traction had already been carried out by established urban railway companies, without any progress being made. In London, the Metropolitan had been conducting trials since 1887, in theory at least. With its own right of way, the Metropolitan would have had no difficulty in adopting either overhead wires

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1. C. W. Cheape: The Evolution of Urban Public Transit ... op. cit. p. 200. Under the 'conduit' system, instead of using overhead wires for the power supply the electric current was passed beneath the street in an iron channel, through which a contact 'shoe' on the tramcar passed.
2. Baltimore News: 26th May 1892.

or the 'third rail' system of electrification. Instead, the early trials were meant to be with battery, or 'accumulator' locomotives. Nothing ever came of these - indeed the trials never actually took place and the same was the case with proposed trials of a 'direct' system. In each case, the failure was on the part of the syndicates supposedly conducting the trials and the only result was to reinforce the scepticism of the Metropolitan Railway directors concerning the expediency of electric power.(1)

Although the Metropolitan had not been prepared to make any financial contribution to these abortive trials, they did take the subject seriously enough to send their manager, John Bell, to the United States to report on electric traction progress there. Two visits were made, the first in 1885, from where the idea of electrifying the Metropolitan appears to have stemmed. At the time of Bell's second visit, the West End company was just about to spend $4.5m on electrification and a number of smaller electric lines were operating successfully, notably Sprague's in Richmond, Virginia. The only railway electrification, however, was an experiment by Leo Daft on the New York Elevated.(2)

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1. Correspondence between Metropolitan Rly. directors and Lord Bury of Electric Traction Co., 1889, GLC.Acc1297/MET 10/49.
2. Leo Daft (1843-1922) came to U.S.A. from England 1866. "1884 his firm built the first complete central station on a commercial scale for electric power generation and distribution. He began railway experiments in 1883 and in 1885 (sic) built the first commercially operated electric railway in the U.S. in Baltimore." Scribner's Concise Dictionary of American Biography, 2nd ed., New York, 1977, p. 222.

After trials, the elevated company claimed that the test locomotive achieved a speed of only ten m.p.h. and cost at least twice as much to operate as the steam engines. 85% of power generated was estimated to be lost through friction and wet weather supposedly had an adverse effect on operation. Not unnaturally all these claims were denied by Daft, who through his company had invested $100,000 in the experiment. He claimed that electricity was quicker and 30% cheaper than steam power. An alternative explanation was that Jay Gould had a violent dislike of electricity, arising from a severe fright he had received when a fuse blew on an earlier experimental locomotive on which he was travelling, and for a long time afterwards he refused to have anything to do with electric traction.(1) This had happened when Sprague was carrying out tests on the 34th Street line in May 1886. However, to other observers these tests were so impressive that Edison considered buying out Sprague there and then.(2) It was another ten years before electrification of the elevated finally began and even longer before the Metropolitan was electrified.(3)

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1. Report of John Bell on visit to U.S.A. 1889 - Acc 1297/MET 10/49. Jay Gould (1836-1892) was a financier who achieved notoriety in 1869 in his attempt to control the gold market. At one time controlling the Erie Railroad, by 1890 he owned about half the railway mileage in the South Western States, by 1886 he was practically the full owner of the New York elevated lines and he also controlled the Western Union Telegraph Co. Scribner's DAB, op. cit. p. 364.
2. H. C. Passer: op. cit. p. 242.
3. In view of subsequent developments it is worth noting that the Metropolitan Railway was a British pioneer in the use of electric lighting, having adopted it as early as 1882. I. C. R. Byatt, op. cit. p. 318.

Meanwhile, neither of the firms involved in the two early electrification contracts in Britain established themselves in the traction market and diffusion of technology was primarily a result of American efforts. This raises further doubts about the attitude of British entrepreneurs to electric traction, especially in the light of the pioneering approach of the CSLR directors. In view of the original plan to use cable haulage, an unspecified sum was paid to the Patent Cable Tramways Corporation for the cable rights. This company went into liquidation in January 1888 and this undoubtedly precipitated the decision to consider electric traction.(1) Exactly where the idea of electrification originated is not clear but it appears that Mather and Platt approached the Board, who were probably already contemplating a change, with a suggestion for electric working.(2) Given that the cable company had gone into liquidation in early 1888 and that details of the agreement with Mather and Platt were not published until 1889, it is possible that tenders for electrification were invited by the CSLR board; if so no details appear to survive. At the time, the Mather and Platt partnership was enjoying a modest success in the field of electricity. In 1883 they had acquired the British licence to the Edison dynamo and in the same year Dr. Edward Hopkinson, formerly chief assistant at Siemens, joined them. In 1885 he built the electrical equipment for the Bessbrook and Newry line in Northern Ireland.(3)

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1. Barker & Robbins: op. cit., vol. I, p. 307.
2. Railway News, vol. LI (1889), p. 316.
3. Metropolitan Railway records: GLC Acc 1297/MET 10/49.

Whether it was the CSLR board or Mather & Platt who first suggested electric working of the CSLR, Mather & Platt were confident enough to offer guarantees to the railway company, with regard to operating costs under electric traction. Such guarantees were common enough in the U.S.A., most of Frank Sprague's contracts for innovatory installations being obtained by such an approach, but were less common in Britain. By offering these guarantees, electrification of the CSLR could go ahead and was looked forward to with anticipation:

> If the plan of Messrs. Mather & Platt ... proves successful ... there can be no doubt that a most important departure will take place in the traffic facilities of large towns ... The iron tubular subways can be constructed at a very much lower figure than an ordinary tunnel ... According to their estimates, the locomotive expenses on an English steam railway vary from 7½d. to 1s. per train mile: with the electric power Messrs. Mather & Platt take the figure for the subway at 3d. ... To show their belief in the 3d. a mile cost, Messrs. Mather & Platt have guaranteed that should it exceed 3½d. they will pay the excess for a period of two years ...[1]

While these guarantees were important, it is also worth noting that the CSLR had sought out experience in its directors. In 1885, after two initial nominees had declined the invitation, Charles Mott and Alexander Hubbard of the Great Western Railway and Mersey Railway boards joined the CSLR, with Mott being

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1. Railway News, vol. LI (1889), p. 316.

elected chairman.(1) As Mott was also the director in charge of the Severn Tunnel project for the GWR, his experience was presumably considered invaluable by the CSLR. Certainly he seems to have regarded the new project with considerable enthusiasm, moving from Birkenhead to London in 1886. He became an early advocate of a unified London underground system and was actively involved in trying to raise capital for the Brompton & Piccadilly Circus line.(2) The importance of Mott in advocating electric traction is unclear but overall the decision to opt for electric traction was a bold one.

Unsurprisingly, there were initial problems with the electric system. The principal early fault, apart from the problem of limited physical size which was a reflection of the early plans for a cable line and the need to limit costs, was concerned with the burning out of the armatures on the motors, partly because of the winding used and partly because of overloading. However, the physical limitations soon showed themselves to be a severe hindrance. The insufficiency in reserve of electric power meant that gas lighting was used in the stations. Although the original scheme had been for motor driven coaches, the Board of Trade insisted on having separate locomotives. In an attempt to increase the passenger-handling capacity experiments were made with a motor coach train in 1894, with subsequent approval from the Board of Trade. In service, however, time was lost as the driver and assistant had to push through crowds at the City terminus and

1. CSLR, Minute Book No. 1, (30.12.85) p. 32: GLC Acc 1297/CSL 1/1.
2. A. A. Jackson & D. F. Croome: Rails Through the Clay, London, 1962, p. 31. Both Mott and Hubbard resigned from the Mersey Railway board after joining the CSLR, partly because of opposition to them from Mersey Railway shareholders, who felt local interests only should be represented. Originally from Plymouth, Hubbard was various times director of a number of small West Country Railways.

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no further trains were adapted in this manner.[1] Although technically successful, the restricted size of the tunnel and other aspects of the system greatly increased operating costs, as will be shown later.

More significantly, the initial impact of the CSLR was only limited. There were a number of bills before Parliament for new underground railways in London, which led to the setting up of a Select Committee in 1892 to consider the issue of transport in the city.[2] This committee was to consider six tubular railways (that is, similar in design to the CSLR), two being extensions to the CSLR and the Central London Railway (CLR) - another 'tube' railway, the original Act for which had been passed in 1891. The others were the Waterloo & City, the Baker St. & Waterloo (BS&W), Hampstead, St. Pancras & Charing Cross (Hampstead) and the Great Northern & City (GN&CR). This sudden surge in applications for underground railways had little to do with electric traction, however, despite the fact that the original Act for the CLR specified this as motive power.[3] One James Henry Greathead was engineer for all the projects and had originally been involved in promoting the abortive London Bridge to Elephant & Castle subway scheme in 1884.[4] Greathead had patented the shield method of

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In addition, until 1892 he was a Trustee for the Hudson Tunnel Bondholders. He was a director of the GWR from 1878 to 1907 (Deputy Chairman 1891-1906) and died in 1910. GWR: Directors' Portraits, RAIL 253/487.

1. T. S. Lascelles: op. cit.
2. Report from Joint Select Committee: Electric & Cable Railways (Metropolis), 23.5.1892.
3. Central London Railway Records: GLC Acc 1297/CLR 4/1.
4. J. Simmons: 'The Pattern of Tube Railways in London' Journal of Transport History, vol. VII (1965-66), pp. 234-9.

tunnelling construction which bore his name and provided a practical method of tunnelling through the London clay. This was of major significance, for

> the prospect of new cut and cover lines for central London had by the middle 1880s become financially and politically impossible ... Fortunately for London, the underlying stratum of blue clay was the ideal working medium for a method of tunnelling which offered an escape from the impasse - tube tunnelling with shields.(1)

Thus the tube design was a direct result of Greathead's innovation which in turn was initially more significant than electric traction. That this was so can be seen from the initial plans for cable operation of the CSLR. More particularly, however, even after the successful opening of the CSLR, although plans were made for electric working of most of the new tube lines, these were by no means firm. Most notably, it was intended to work the Hampstead line by cable on account of the heavy gradients.(2) Otherwise, electricity was intended as the motive power although the precise reasoning appears somewhat confused. Electricity was held to be particularly advantageous in the haulage of heavy trains at relatively infrequent intervals, as, for example, in the Baltimore tunnel in the U.S.A. Given that the cost of any tunnel was felt to be so great that the only justification lay either in public necessity or in operating economy, the advantages of electric traction in providing a frequent service do not appear to have been fully understood.(3) While it was appreciated that the cost of cable

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1. Jackson & Croome: op. cit. p. 26.
2. Select Committee - Electric & Cable Rlys. op. cit. pp. 1307-9.
3. ibid. pp. 1038-45, Brunton & Davis: Modern Tunneling, London & New York, 1922, p. 424.

traction was very largely a fixed cost, the same fact in relation to electric railways does not appear to have been realised, contemporary technical literature showing very much more concern with running costs.(1)

This attitude was reinforced by the evidence of electrical engineers. Hopkinson felt that running costs for steam and electric traction at this time were 'about the same' and although he foresaw a number of advantages in electric traction, Alexander Siemens did not envisage any great reduction in running costs as a result of the introduction of electric traction.(2) It was another ten years, at a time when the electricity supply industry was expanding rapidly in North East England, before a consulting engineer in that part of the country argued forcefully that there had been too little concern with capital costs in the industry.(3) Meanwhile, evidence was given to the Select Committee that although cable traction was probably less expensive than electricity, it was hardly as effective.(4)

Such a view can only have been reinforced by the opening of the Liverpool Overhead Railway (LOR) under electric traction in 1893. When construction started, it was still intended to operate by steam but the decision to electrify was taken in 1891 and reduced the estimated cost from £585,000 to £466,000. The experience of the CSLR was cited as the deciding factor. The contract of 1891, like that for the CSLR, went to a British

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1. Byatt: op. cit. p. 143.
2. Railway News, vol. LIX (1893) p. 356; Select Committee - Electric & Cable Rlys. op. cit. pp. 834-836.
3. Byatt: op. cit. p. 143.
4. S.C. - Electric & Cable Rlys. op. cit. pp. 1103-1106, 1202.

firm - the Electric Construction Corporation of Wolverhampton - who agreed under the terms of the contract to operate the LOR for two years for $3\frac{1}{2}$d. per train mile.(1) It will be noted that these terms were almost identical to those on which Mather & Platt had agreed to work the CSLR.

Thus the first two British urban electric railways were electrified by British companies, who agreed to shoulder most of the risk involved in electrification (in financial terms at least). From then on, however, most of the electric traction contracts of any note went to the British subsidiaries of foreign firms. For example, BTH was formed in the mid 1890s and quickly won orders for tramway projects in Bristol (1895) and Dublin (1896).(2) From this period the British industry began to fall noticeably behind the Americans and Germans and after 1900 all the major traction contracts went to the American firms, or their British subsidiaries. The change may have been affected by rapidly falling prices of electrical products from 1891 to 1895 but English manufacturers made no attempt to develop traction equipment after 1891.

The CSLR stayed loyal to the early British firms, placing orders for further locomotives with Siemens (1891), Electric Construction Corporation and Thames Iron Works (1897-8) and a total of thirty-one from Cromptons and Co. between 1897 and 1901.(3) Such orders were hardly sufficient to sustain the

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1. C. E. Box: <u>The Liverpool Overhead Railway</u>, London, 1959.
2. Byatt: op. cit. p. 173.
3. T. S. Lascelles: op. cit.

British electrical industry, however. Part of the problem was that after the LOR opened in 1893, there was a five year gap before the next urban railway, the Waterloo & City, opened. There was a similar delay in tramway electrification, reflecting the working of the trade cycle which was making the raising of money for new schemes difficult. Therefore, the manufacturers would have had to create a demand for one to exist but most of them had capital difficulties themselves. This was not always their own fault. Cromptons noticed that whereas the German banks would back their own manufacturers, British banks refused to give credit that could be extended to customers.(1)

The workings of the capital market also left much to be desired but this in part reflected earlier speculation and over-optimism which had led, in 1882, to losses by shareholders and this made lenders very cautious where electrical enterprises were concerned. This meant that electrical manufacturers had to borrow at least some of the money they required at fixed interest rates even in boom years. However, this was a situation that others, notably the railway companies, were also facing.(2)

The general speculative nature of ordinary shares in the new companies encouraged financial manipulators and the Electric Construction Corporation suffered particularly badly in this respect. The firm had originally had the idea of providing

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1. Byatt: op. cit. pp. 170, 329.
2. ibid. p. 342.

finance for electrification in a way similar to that adopted by American innovators but preference shares and debentures were issued to pay for alleged increases in business. Its chairman was one Jabez Spencer Balfour, who had built up a large financial empire based on the Liberator Building Society, which went bankrupt in late 1892. The E.C.C. was reconstructed but in 1894 its chief engineer Thomas Parker left to set up his own company. This too he later left in order to become consulting electrical engineer to the Metropolitan Railway.(1) Thus although the structure of the capital market helped to cause problems of illiquidity for Brush, E.C.C. and Cromptons, the problem was not purely one of an inefficient capital market. Mather & Platt did not become a public company until 1899 but had withdrawn from much of the electrical industry in 1891.(2)

Mather & Platt's withdrawal highlights the arrested development of the early industry. Originally a textile machinery manufacturer, they had quickly realised the potential of electric power and in 1883 acquired the English patent rights to the Edison dynamo but did not linger in the electrical industry when it failed to develop. Siemens on the other hand were one of the earliest dynamo manufacturers, having started in the late 1870s and in the early 1880s were enormously profitable. However, these profits largely came from their

1. The impact of the Liberator crash is discussed in more detail in Ch. 4.
2. L. E. Mather: op. cit. Ch. 2; Byatt: op. cit. p. 352.

sales of submarine cables and were not ploughed back into the development of the industry. For example, 1881 dividends formed 80% of profits and exceeded the paid up capital of £300,000. This was followed by a 95% dividend in 1884, with the result that when the slump came in 1886, the company was in a weak position and by 1893 was losing money. Largely because of indecision by the Berlin board, the company kept plodding on, so that it was still manufacturing by 1900, and able to take advantage of the upturn in the British market.(1) When this happened, however, the company, with the help of its German parent, was able to compete with the big American manufacturers. Other British companies however, were generally too small and under-capitalised, or like Mather & Platt, had already decided to look to other fields.

After 1895 there was a major boom in electrical manufacturing in line with the general recovery throughout the economy. However, the surge in demand was not met by the British manufacturers. Whereas from 1891 to 1895 there had been no significant demand in the U.K. for traction motors, the traction boom in the U.S.A. had seen the price of two-motor equipment (for tramcars) fall from $4,500 in 1889 to $2,600 in 1891, $1,650 in 1893 and $750 in 1895. Between 1891 and 1895 the price of a typical 1,500 kw. railway generator also fell, from around $48,000 to about $26,000 (or by about 46%, compared to the 71% fall in the price

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1. L. E. Mather: op. cit. Ch. II, J. D. Scott: <u>Siemens Brothers, 1858-1958</u>, London, 1958, p. 64.

of motors). Between 1890 and 1898 Westinghouse sold about 20,000 motors and from 1893 to 1898 General Electric (GEC) sold about 30,000.(1) By 1895, however, the American economy was considerably less buoyant and the traction boom there was largely over. The early traction boom in the U.S.A. took place in spite of depressed economic conditions, in contrast to the same years in the U.K. After a brief recovery in 1895, there was a renewed depression coinciding with the 'Silver Campaign' and it was in this period that the two largest American electrical manufacturers established themselves in the British market. Both of them (GEC and Westinghouse) had had sales agencies in Britain for some time - GEC's predecessors since 1886 and Westinghouse since 1889. In the 1890s both of these agencies (BTH for GEC and British Westinghouse Electric & Manufacturing - BWEM - for Westinghouse) were established on stronger lines but still selling American-produced equipment. Later in the decade the decision was taken to establish large manufacturing plants by both companies and in 1901 Siemens of Germany also started building a plant, after discussions had been held in earlier years with BTH about a possible merger.(2)

The construction of plants by three foreign firms has frequently been seen as evidence of the failure of British entrepreneurs and the British capital market in meeting the demands of the new industry. Solely from the viewpoint of

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1. H. C. Passer: op. cit. pp. 264, 269.
2. J. D. Scott: op. cit. p. 64.

electric traction, several points can be noted. Firstly and most obviously, electric traction was never so important in the U.K. in terms of investment as in the U.S. The peak year for gross investment in electric traction was 1904, when £12.87m. was invested in electric tramways and the London Underground. (The cumulative total would be somewhat higher because of investment by the Lancashire & Yorkshire and North Eastern Railways in their own systems. This amounted to about £0.7m. before 1904.) This represented over 64% of total investment in fixed capital in the industry in 1904 but this was the peak year, with electrical investment in general comprising about 10% of gross investment in the U.K., the peak year for this being 1903, when it was 11.3%.(1) In sharp contrast, in 1897, when gross investment in the electrical industry was only £4m., or 3.1% of gross U.K. investment, some 34.5% (£1.38m) went on electric traction. Prior to 1897 it is safe to assume that investment was even less, yet there were five firms (Brush, Siemens, Crompton, E.C.C. and Mather & Platt) competing for very limited orders, which were especially infrequent for traction purposes. From 1896 Brush began to work in association with British Electric Traction who were gradually taking over and electrifying tramway systems in a number of towns. Excluding tramways, and the pioneer Irish lines at Portrush and Bessbrook, the combined demand for railway traction equipment before 1900 was that from the CSLR, LOR and Waterloo & City Lines. The latter opened in 1898 using Siemens equipment in

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1. I. C. R. Byatt: op. cit. p. 465. In 1904 tramway investment alone accounted for 6% of gross domestic investment. Deane & Cole: British Economic Growth ... Cambridge, 1964.

American built rolling stock. As with the CSLR, there were teething troubles which appear to have had more to do with the rolling stock, the engineering of the tunnels and Board of Trade restrictions than with the electrical equipment.(1) The Waterloo & City was the last new line on which the original electrical equipment came from a British source. This was partly because of the paucity of subsequent demand, for although demand from tramways was somewhat greater than that from the railways, the limited size of the traction market was a major factor in Mather & Platt's withdrawal from the market at an early date.

The limited size of the British traction market is emphasised if output is compared with American firms. Although between 1893 and 1898 GEC sold 30,000 motors in the U.S.A., in fifty years from 1896 to 1946 their British subsidiary BTH supplied only some 22,000 motors.(2) Criticisms have been levelled against the British industry in that prices were initially high, limiting demand (although as shown, this was also the case in the U.S.A. where long term demand was not affected) yet it has been shown in Britain that firms did not work together to keep up prices but cut prices as soon as there was a possibility of working under capacity.(3) It is probably in the field of the capital market that criticisms were most justified but here again the situation was not necessarily straightforward. The output of the electricity industry was in effect a derived demand,

1. Letter from W.H. Preece to J. Wolfe Barry, 16.11.98 - Acc 1297/MET 10/70.
2. J. H. Cansdale: op. cit. p.16.
3. Byatt: op. cit. p. 340.

dependent upon other companies. However, neither railways nor tramways were particularly favoured investments in this period. Even the electrical companies themselves were at fault here. The problems of E.C.C. in 1892 can have hardly endeared themselves to investors, while other companies such as the Electric Traction Syndicate revealed little in the way of tangible results.(1) Such factors may help to explain why Brush and Cromptons had such difficulty in raising capital.

Certainly the capital market does not appear to have been well disposed towards the electrical industry, in Britain anyway. After reaching a respectable peak in the years up to 1886, the yields on electrical equipment manufacture declined steadily to 1913 by when it was, for example, half the yield available from investment in food processing. It has been claimed that this reflected badly upon the capital market since electrical engineering opened up new production possibilities throughout the economy, whereas advances in food processing affected only a small part of the economy and that this should have been reflected by an efficient capital market.(2) In contrast to the

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1. This was a financing, rather than manufacturing, company although it had intended carrying out tests on the Metropolitan in 1887 and around the same time had an experimental battery operated tramway scheme in the East End of London as well as some electric cabs on the London streets. Correspondence between Metropolitan Railway and Electric Traction Co.: GLC Acc 1297/MET 10/69.
2. M. Edelstein: 'Realized Rates of Return on U.K. Home & Overseas Portfolio Investment in the Age of High Imperialism' - Explorations in Economic History, vol. XIII (1976), pp. 292, 302-3, 318.

position faced by the British manufacturers, the large German firms of AEG and Siemens Schuckert were strongly supported by the capital market and the large investment banks. In addition, scientific knowledge, technical skill and high standards of performance were felt to weigh more heavily than capital availability alone.(1)

Technical skills were undoubtedly important, for innovation was a key aspect in urban railway development. At a general level, the strong competition between GEC and Westinghouse led to a steady improvement in the quality and durability of the motors produced, which in turn helped to finance the development of suitable railway motors. Whether the British capital market would have been any more benevolent to a Westinghouse or a GEC is not clear. All the ordinary share capital of BWEM was held entirely by the American parent company and the British market was called upon only for preference and debenture issues.(2) Although there is no clear evidence of 'dumping' on the British market by the American firms, they rapidly achieved a significant market penetration, boosted by the upsurge in British demand. The necessity for this was emphasised by the severity of the American slump, GEC's 1893 sales figures not being passed until 1899. However, a new British firm was formed at this time, with Dick, Kerr buying a factory in Preston in 1897 initially to build electric tram bodies although the company quickly won a contract to supply additional motor cars to the Waterloo & City Line.

1. D. S. Landes: The Unbound Prometheus, Cambridge, 1969, p. 290.
2. Railway News: vol. LXXVIV (1900), p. 754. The London capital market was, as pointed out, geared more to the issue of fixed interest securities than to ordinary share capital.

Management and finance were British, the technical director was American.[1] With the two American subsidiaries, Brush and Siemens, Dick, Kerr were subsequently responsible for almost all traction equipment orders placed in Britain.

The next underground line to open after the Waterloo & City was the Central London Railway (CLR) which opened in 1900. In 1895 this company had signed a contract with the Electric Traction Company for construction work. The latter was a subsidiary especially created for this purpose by the Exploration Company, which was the driving force behind the CLR project. As with the CSLR, James Greathead was the engineer and his basic tubular, iron clad tunnel design was used in both cases. However, the tubes on the CLR were larger than those originally used on the CSLR, being 11 ft. 6 in. in diameter as opposed to 10 ft. 6 in. on the CSLR. The contract specifications called for thirty-two electric locomotives capable of conveying a train seating 336 people at 14 m.p.h. on a 2½ minute frequency. In contrast, CSLR trains held about 100 passengers. The carriages were to be

> at least equal in quality to the carriages put upon the New York Elevated Railway in 1892.[2]

The line opened in 1900 with locomotives from the Schenectady works of GEC in America; the rest of the equipment was by BTH and this was to set the trend for future lines.

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1. Byatt: op. cit. p. 364; Jackson & Croome: op. cit. p. 52.
2. Central London Railway: <u>Contracts</u>: GLC Acc 1297/CLR 4/1.

The remaining tube lines in London adopted, for the most part, BTH equipment too. Indeed, in the case of the Underground Electric Railways of London (UERL) lines, all the initial stock, not just the electrical equipment, came from abroad. The Baker St. & Waterloo (Bakerloo) line used American stock, the Piccadilly line stock from France and Hungary and the Hampstead line American stock assembled in Manchester.. This is less surprising than in the case of any other lines, if only because the UERL lines were American owned.(1) As a result, not only was foreign equipment adopted but many features of the original working were taken from contemporary American practice although the initial plans for an American-style uniform fare and round-the-clock operation were not adopted.(2)

With the opening of the Hampstead line in 1907, the construction of new urban railways in Britain came to an end. Ignoring the lines which had converted from steam to electric operation for the time being, these divide neatly into two groups: those lines opened before 1900 (the CSLR, LOR and Waterloo & City) and those opened subsequently (CLR, GN&CR and the UERL lines). Those in the latter group all used American equipment whereas the earlier lines were more reliant on British equipment.

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1. The same group had by this time also acquired control of the Metropolitan District Rly. This is discussed in more detail in Ch. 5. Although the use of American and German equipment was commonplace, there is no apparent reason why the UERL should have ordered stock from France and Hungary.
2. Interview with C. T. Yerkes: Railway News, vol. LXXVII (1902), p. 20.

This apparent split between the 'old' and 'new' was accentuated by the collapse of the German electrification boom in 1900, which led to a considerable fall in prices and profit margins after 1901. Over-capacity in Britain was particularly concentrated in BWEM and Siemens, both of whom, trying hard to achieve full capacity helped to drive prices down.[1] By 1907 the railway electrification boom - or what there was of it - in Britain was largely over and manufacturers would have to rely on traffic expansion and stock replacement for future orders.

One of the reasons that British companies were not strongly placed in this fight for future orders lay in the workings of the British capital market, as has been suggested and partly discounted . These constraints that had apparently been a factor in giving the long term advantage to the American suppliers had also affected the railway companies themselves. In their anxiety to keep costs to a minimum, faced as they were with severe problems in raising adequate capital, they had adopted the 'tube' pattern of tunnel construction. It was quickly realised that this actually caused new problems. By 1905 the Royal Commission on Transport in London felt that so far as public convenience was concerned

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1. Byatt: op. cit. p. 374.

> the facilities which "shallow" railways afford, for all descriptions of traffic, are much greater than those which can be given by "tube" railways ... wherever the "shallow" form of construction can be satisfactorily employed in London, preference should be given to it.(1)

The Commission thus felt that while from a technical standpoint Greathead's shield method of construction was successful, it was of too constricting a nature to permit an adequate service and furthermore that the construction of deep-level lines was inadequate, primarily because the extra time entailed in reaching the platform, not to mention the not insubstantial cost of lift operation, deterred the short distance travellers who were precisely the people Yerkes had sought to encourage. Such a conclusion overlooked the fact that the raison d'être of the small bore tubes was financial. The 1892 Select Committee had revealed that if the tubes were built to a diameter of 16 ft. thereby being able to accommodate standard size trains, instead of 11 ft. 6 ins., the additional cost would be in excess of £100,000 per mile.(2) The 1905 Commission did recognise this fact, insofar as it was accepted that it would be even more difficult to raise capital for new lines if they were to be built immediately below the surface, in the fashion of the Inner Circle. To circumvent this, it suggested that the local authorities might be authorised to give assistance, either through the remission of rates or in the form of a direct contribution to the capital costs.(3)

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1. Royal Commission on Transport in London 1905, pp. 73, 148.
2. S.C. - Electric Railways (Metropolis), 1892, op. cit. pp. 366-68.
3. Royal Commission - London Transport, 1905, op. cit. pp. 104, 216.

The Greathead shield was a technological answer to two problems. The political and economic difficulties in digging up the narrow London streets to construct a tunnel, as had been done for the Metropolitan and District lines necessitated deep level working and the London clay necessitated the shield method of construction, whereby the most forward part of the working was dug out from within the 'shield', the unsupported gap left when the shield advanced being filled by tubular iron casing. A similar method of tunnelling was used in the Hudson tunnel in New York from 1889, where the river silt was thought to be of the softest kind.(1) The shield was only suited to working in such conditions. In contrast, the Mersey Railway was tunnelled through soft sandstone rock using the Beaumont drilling machine.

Clearly, given the external constraints in London, the method of tunnelling could be an important factor in the overall financial viability of a company and in the same way that the Greathead shield made relatively economic construction possible in London, so the Beaumont machine did for the Mersey Railway. The machine was originally patented in 1864, prior to when there had been but three patents (all American) for tunnel drills. Between 1864 and December 1865 a further seven American patents and three British patents were granted, the value of them being reflected in the progress achieved in constructing the Mersey Railway.(2) With the exception of the Hudson tunnels, however, such factors were far less important in America. The first

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1. Brunton & Davis: Modern Tunneling, op. cit. p. 545.
2. ibid. p. 189.

subway opened was under Tremont St. in Boston, in September 1897 and was about 1.1/3 miles in length.(1) However, the example of New York best demonstrates the differences between Britain and the U.S.A. In New York, a section of the roadway would be opened up to allow a trench giving access to be dug, the road would then be restored with a temporary surface while work proceeded underneath on the subway. This was made possible partly by more favourable geological conditions than existed in London but more particularly by better geographical circumstances. Upper Broadway in New York was between one hundred and one hundred and fifty feetwide and lower Broadway eighty feet wide. In London, on the other hand, barely twelve streets were over eighty feet wide. Furthermore, property rights were rigorously protected, which was a further reason for building deep level lines. Even at a deep level, however, the London lines were forced to follow the streets because of problems with wayleaves. In the case of the CSLR in particular, this led to an abundance of sharp curves and steep gradients, increasing working costs unduly. Thus there was an apparent paradox in construction costs, with the short Waterloo & City line and the CLR, both of which had relatively favourable routes in terms of construction, costing £483,000 per mile and £631,000 per mile respectively, while the 25½ mile long, four track New York subway cost about $50 million, or barely £400,000 per mile.(2)

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1. 50 Years of Unified Transportation in Metropolitan Boston, Boston, 1938, p. 33.
2. Electric Railway Journal, vol. XXXIII (1909), p. 358.

In the case of the Inner Circle in London, less than one-third of which ran under the streets, about half the total expenditure was estimated to have been for land and indemnities, whereas in New York it was felt that by placing as much of the line as possible under the streets the direct costs for land would be minimised and the sand, gravel and rock through which the New York line would run was considered to be very much easier material in which to work than the London clay.(1)

The earliest proposals for underground lines in New York almost always involved a line underneath Broadway, which was considered too fine a street to be disfigured by elevated lines and too important to be dug up for tram tracks to be laid. The first Bill for such a line was introduced in March 1864, by someone who had seen the opening of the Metropolitan in London but it was another forty years before the subway was finally opened in New York. Although it was claimed by the subway promoters that electricity had made it possible it was also claimed that

> it was not power but politics and the war for franchise rights which postponed the building of the first underground railway.(2)

In fact, a Bill was passed in New York in 1873 for the construction of a steam operated subway but no progress was made because by then the first elevated line was in operation and no

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1. W. J. McAlpine: Report on Comparisons between the Proposed Arcade Railway and London Underground Railways, New York, 1884.
2. J. B. Walker: Fifty Years of Rapid Transit - 1864-1917, New York, 1918, p. 14.

capital was forthcoming for the subway. The political changes that eventually brought about the subway in New York were inspired by the 1891 Rapid Transit Act which was amended to permit cities to use their own capital for subway construction, followed by the 1894 referendum in New York when a large majority voted in favour of public ownership.(1) In addition to changing political attitudes, the growth of traffic on the Elevated was such as to demonstrate the need for additional transit facilities. The steady increase in traffic, not only in absolute terms but as a proportion of total population meant that there was little doubt about the need for a subway as well as elevated railways. To take the example of only one route - that along Third Avenue - the journeys per head of population had increased from 47 in 1880 to 70 in 1890. The increase for the elevated line alone was even more noticeable - from 30 to 73 over the same period. As early as 1891, representations were being made to the Rapid Transit Commissioners over the desirability of electric traction in any new subway. It is difficult to assess how far technical factors were the cause of the delay although by the time work started in 1900, there was no doubt that electricity was the only practical motive power. The steady growth in traffic on both the elevated and the horse trams was by 1890 calling into question their ability to cope with such large amounts of traffic. On Third Avenue alone, by 1890 there were over 106 million journeys by the two modes of transport and with such an enormous traffic the conditions in a steam worked subway would have been appalling.(2) Equally, the problems of attempting successful

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1. Walker: op. cit. pp. 140-146.
2. Central London Railway records: GLC Acc 1297/CLR 4/1.

cable operation with such a volume of traffic would have been immense.

From a technical aspect, however, of more direct relevance than the delay in starting work on a subway in New York was the opening of the early Chicago elevateds. The South Side line opened in 1892 and the Lake Street line the following year but both initially relied upon steam locomotives. Even so, by this time considerable progress had been made in the electric traction field in America. In 1890 Westinghouse had brought onto the market a double reduction motor and in the same year the single reduction motor made its first appearance.(1) The effect of such progress was to greatly reduce many of the early problems such as the pounding of motors corrugating the track between the sleepers.(2) In this respect, these American motors were probably in a more advanced state than those initially used on the CSLR. However, these motors were primarily for trams, as railway electrification was non-existent at this date in America. The feasibility of electric traction for railways was amply demonstrated when the Baltimore Belt Line Tunnel was electrified in 1892 but the first electric urban line was the Metropolitan West Side Elevated in Chicago which opened in 1895.

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1. The earliest electric motors had worked at a high speed which was totally unsuitable for tramway operation and was reduced to a reasonable level through a triple reduction gearbox. By progressively developing double and then single reduction motors, with fewer revolutions per minute, the power needed to start an engine was reduced, thereby reducing the demands on the power station at the start of each day's operations, the size of the gearbox was reduced and therefore the total weight and loss of energy was reduced and general efficiency was increased.
2. <u>Cassier's Magazine</u>: vol XVI no. 4 (1899), p. 362.

Although GEC motors were used on this line, additional equipment was provided by Siemens and Halske who had opened a branch office in Chicago in 1892.[1] This recourse to foreign equipment may have simply reflected competitive tendering by Siemens, or it may in fact have reflected limitations in the supply capabilities of the American suppliers, at least as far as railway electrification was concerned. Support for this possibility comes from the introduction of the revolving field alternator into the United States in 1896 after being originally used in Frankfurt in 1894; while America undoubtedly had the major market for electrical supply equipment, the Europeans at this date were still competing in terms of product development.[2] The Metropolitan line in Chicago used motor coaches of a design similar to those in use on the LOR, only larger. With this system of operation, one coach in a train would be fitted with motors of a necessarily restricted size in order to accommodate passengers. The length of the train was therefore governed by the number of coaches a motor coach could pull. In the case of the LOR this was usually two, so that trains were generally three coaches in length, while on the West Side line they were slightly longer. The Waterloo & City line also adopted such a system which was ideal where traffic was light, or of a steady pattern, but unsuitable where there were large variations in the traffic flow. It was also ideal for elevated railways, where the weight of electric locomotives on the structure would have increased maintenance costs.

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1. H. C. Passer: op. cit. pp. 270, 321.
2. J. E. Brittain: op. cit. p. 114.

Two further points about the Metropolitan line in Chicago are of interest. Firstly, although the first two elevated lines in Chicago both opened with steam traction, they were also the first urban lines to subsequently change from steam to electric traction, secondly opening of the Metropolitan coincided with the first overhead wire electric tram lines in Chicago city centre. As in Boston earlier and most other city centres in due course, opposition to the overhead wires was strident. The newspapers, while avowedly in favour of rapid transit opposed the overhead wires and advocated storage battery power instead. This delayed the opening of the first electric line in the city centre until November 1895.(1)

Although public opposition has often been cited as a reason for the delay in electrification, the cable system in Chicago was already extensive. Once the Metropolitan had opened, however, the situation changed rapidly and this was reflected in the electrification of the other urban lines - the Lake St. in 1896 and the South Side in 1897-8. Thus the Lake St. line wrote off a fleet of almost new steam engines, it having been open only two years. In both cases, significantly, the changeover to electric traction also came after a change in management.(2)

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1. R. D. Weber: Rationalizers & Reformers: Chicago Local Transportation in the 19th Century, Ph.D. (unpublished), University of Wisconsin, 1971, p. 109.
2. Cassier's Magazine: op. cit. p. 450.

The impact on elevated railways overall was impressive. Elevateds reached the height of their popularity in America about 1901, by when there were some 340 miles of line, all of it either electrically operated or in the process of being converted. Half of the total was in New York and Brooklyn, most of the remainder was in Chicago and Boston, with short stretches in Baltimore, Kansas City and Jersey City.(1) In all cases the scheme had been approved, or work had started, before electricity was necessarily a practical proposition yet the conversion was rapid. This reflects the peculiar operating conditions of the elevateds. The steam locomotives used had to be much lighter than standard steam locomotives but suited to far more intensive use. They also had to comply with air pollution regulations.(2) That such developments should take place and be so quickly discarded would clearly imply that they were only really practical as long as there was no alternative. This compares with, for instance, the use of cable power by street railways or more specifically with the use of steam trams which only lasted until electrification had been adequately proved. Nevertheless, the speed of the changeover is significant, the South Side Railway having to dispose of forty-six almost new locomotives. The Manhattan Railway had to write off some 330 locomotives, with an approximate value of $1,650,000, so the delay in electrifying its lines is to some extent understandable.(3)

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1. Electric Railway Journal, vol. XXXVII (1911), p. 249.
2. The New York Rapid Transit Commission estimated that an ordinary railway locomotive vitiated the air to the same extent as 87,000 people but an elevated railway locomotive only to the same extent as 25,000 people. New York Rapid Transit Commission, reprint from Boston newspapers of 20 February 1895.
3. Railway News, vol. LXIX (1898), p. 165.

The importance of electric traction in bringing about changes in attitude cannot be underestimated. Although it was initially opposed for tramway operations in city centres, for elevated railways its attraction was apparent when compared with existing operations. Thus, the conditions on existing lines could be thought of as tolerable until there was plainly something better. For example, the Boston newspapers, in writing about the ventilation in the proposed Tremont St. subway, noted that

> In the Mersey tunnel, which is operated by steam locomotives and lighted by gas, but which has artificial ventilation similar to that proposed for the subway, the air is reasonably good.(1)

In fact, as the next section will show, the quality of air in the Mersey tunnel was felt to be a major problem and the Tremont St. subway was to be electrically operated (by streetcars) anyway. The point was that the quality of the air in the Mersey tunnel was such that there can be little doubt that steam power was only used because of the lack of suitable alternatives at the time of opening. The failure of the original cable driven elevated in New York has already been mentioned, similarly the first plan for an elevated line in Boston called for the use of compressed air.(2) Approval for an elevated in Boston was originally granted in 1890 but suspended the following year, to enable a complete study of the rapid transit needs of the city to be made.(3) It is not

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1. Reprints from Boston newspapers, 20 February 1895, p. 13, Scudder Library File 252.
2. 50 Years of Unified Transportation in Metropolitan Boston, op. cit. p. 33.
3. ibid. p. 35.

without significance that in both New York and Boston, such commissions were set up about the same time and that this was also the time when electric traction was proving to be practical. Although the Chicago experience strongly suggests that even if these lines had been operated by steam power initially, the change would not have been long delayed, in Boston various alternative schemes were mooted. Most notably, the Meigs Elevated Railway was incorporated in 1884 and a full size test track was operated in Cambridge in 1886. Although the Boston Elevated Railway was again incorporated by an Act of 1894, the Meigs plan failed, presumably because of lack of capital.(1) Proposals for a Meigs line in Chicago had also been unsuccessful and the technology must have played an important part in this. Steam power would still be used but the line was to be designed as a form of monorail, its principal attraction supposedly being the reduced capital outlay this would entail. In all cases, however, both subway and elevated, it is apparent that the schemes which were most successful in attracting capital were those where the technology had been sufficiently proved to be the simplest but most adequate form available. In New York, Boston and Chicago there were strong reservations as to whether electricity met such a requirement. By 1897 attitudes had altered sufficiently to lead to a new Act for the Boston Elevated under which steam power was specifically excluded.(2) When the line opened in 1901, therefore, the rolling stock bore marked similarities to that in use on other elevated railways

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1. ibid. p. 45.
2. ibid. p. 47.

at the time. The coaches were wooden bodied, with two 150 hp. motors and initially operated in three coach trains, soon increased to four.[1] From 1906 steel bodied stock was used with larger motors but of greater note is that multiple-unit operation was used from the outset although the stock did not differ markedly from that in use on the earlier lines, which were not yet using multiple-unit trains.

With multiple-unit operation, every carriage in a train had a motor or motors (or one carriage in every group of carriages) which could all be controlled from the driving cab. The advantages of such a system were numerous. If trains were locomotive hauled, the locomotive had to be heavy enough to provide the necessary traction weight for the heaviest trains likely to be in service. This meant outside the peak hours for traffic the engines were not fully utilised but of greater concern was the wear and tear imposed on the track, and the superstructures in the case of elevated railways, by the passing of heavy locomotives. By using motor coaches, as the LOR and other lines did, this problem was overcome but only at the expense of severely restricting the size of trains, thereby imposing rigidities in the operating pattern. The major advantage of the multiple-unit was that such rigidities could be overcome. Because each carriage conveyed its own power source, the length of trains was no longer limited by the capabilities of a locomotive or motor car. Long trains could be run in busy periods and short trains at quieter times. As each carriage could be self powered, the entire weight of the

1. ibid. p. 58.

train, including passengers, could be used as traction weight. With individually powered cars there was much faster acceleration and greater economy in energy consumption.[1]

Other things being equal, the invention of the multiple-unit clearly made electric operation of urban railways an even more attractive proposition, given the greater operating flexibility which it offered. Furthermore, the multiple-unit system reinforced the advantage in terms of research and innovation that lay indisputably in America, largely because of the much higher demand for electric traction equipment there.

Although this superiority was reflected in the size of GEC and Westinghouse, the bulk of early successful research in electric traction was the work of one man - Frank Sprague. It was he who invented the multiple-unit and earlier demonstrated the practicality of electric traction in America.[2] The development of Sprague's reputation as the premier electric traction engineer reflects the importance of easy access to information in both Europe and America. Up to about 1883, what progress there was in the commercial development of electric traction had been almost entirely in Europe but from then on it was more and more significant in America. It has been suggested that this was because Sprague (who at that time was an engineer in the U.S. Navy) had been in London in 1882 for the Crystal Palace Exhibition and while there obtained information on electrification progress in Europe. Sprague himself appears to

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1. H. C. Passer: op. cit. p. 271.
2. H. C. Passer: op. cit. pp. 273-5.

have admitted that some of his ideas about the potential of electric traction were developed whilst travelling on the Metropolitan District Railway while in London.(1)

He was subsequently the first person to demonstrate what was an essential feature of railway and tramway traction - the use of motors suspended under the body, over the axles, with positive gearing to the axles. This idea was originally developed for his abortive trials on the New York Elevated in 1885-6. While Sprague was without doubt a gifted inventor, of equal significance was his commercial success. While he was primarily concerned with developing electric motors for traction purposes he established a company which in its early years was devoted to sales of small motors for industrial use. The success of this company, which was due at least in part to the fast growing demand for electric power in America, financed Sprague's tests and experiments. This was vital to his long term success, for his New York Elevated trials were expensive, but, in terms of orders, unsuccessful. His first commercial breakthrough was in winning a contract to electrify the tramway at Richmond, Virginia in 1888. Here again, the importance of having a sound company to provide financial support was apparent for Sprague almost certainly lost heavily on this contract, receiving $90,000 but spending about $160,000.(2)

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1. Cassier's Magazine: op. cit. pp. 339, 362. In a similar fashion, the Metropolitan Railway thought it worth their while to send their manager to America twice in a few years, in order to investigate electrification progress.
2. J. P. McKay: op. cit. Ch. 2.

However, the long term gamble paid off, for the success of the conversion enabled him to win many orders, not least that for the Boston West End Railway conversion shortly after. Such risk bearing was by no means confined to Sprague. In New York, when a new cable railway was proposed along Lenox Avenue, GEC offered to equip it for electric conduit operation and if operation proved unsatisfactory after twelve months, GEC would remove it at their own cost, without compensation.(1)

The comparison with Britain is apparent. Both Mather & Platt and the E.C.C. offered financial guarantees on their early contracts but new orders were not forthcoming. This reflected not only the limited state of the traction market, because of the myriad restrictions both real and imaginary, but also the limited industrial demand for electric motors. Thus while Sprague could concentrate on long term electric traction prospects, Mather & Platt and E.C.C. were in the position that while

> No doubt both firms were outstanding ... electric traction ... was the primary concern of neither ...

this above all reflected the lack of an adequate market in which to specialise.(2) The restrictions of the capital market only added to this. It is interesting to speculate, for example, whether any of the British electrical manufacturers were in a position to offer financial guarantees to the promoters of the Glasgow subway to persuade them to adopt electric, instead of cable, traction. With the much larger market in America, Sprague continued to specialise in electric traction, ultimately

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1. Cassier's Magazine: op. cit. p. 276.
2. McKay: op. cit. Ch. 5.

developing multiple-unit control which was subsequently adopted almost universally with electric traction. However, as with his earlier inventions, the breakthrough for Sprague with multiple-unit control did not come overnight. As before, he offered generous financial guarantees to the South Side management which were vital but more significant was the fact that it had taken him about seven years to persuade a company to adopt it.

The first references to it appear in January 1891 when George Westinghouse was busy preparing an estimate for electrification of the Manhattan Elevated in New York. In connection with this, he claimed to have examined Sprague's 'Unit Control System' closely for possible application in New York but dismissed it as involving too great additional complication and cost.

> The 1,100 cars of the Elevated Railway in New York will occupy eight miles of track and it therefore has become apparent that the fitting of all the cars of the Elevated Railroad with motors and complicated apparatus is entirely out of the question, without taking any note whatever of the great additional cost ... Mr. Sprague is an ingenious and clever engineer and tackles very complicated problems. I am confident, however, that in such cases as the Manhattan Elevated of New York, or the Metropolitan Underground of London, his system is entirely impracticable.(1)

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1. Letter from George Westinghouse to Captain Francis Pugh of the Metropolitan Rly. and Westinghouse, England, 1 January 1898.

Sprague thus had to fight not only against the basic conservatism of railway management but also against the scepticism of fellow engineers who were also rivals chasing the same contracts. That he triumphed is testimony to his determination and ability.

Notwithstanding early scepticism, the multiple-unit became a very successful refinement in railway operation and this success raises interesting questions not only about the rate of diffusion of the multiple-unit but also about the early development of electric trains in general. Any attempt at calculating the precise importance of the multiple-unit is difficult for the simple reason that once it had been invented and adopted, very few urban systems did not adopt it. This is hardly surprising if, as Sprague claimed, it lowered initial costs and overall costs thereafter. Furthermore, in America at least, the rapid increase in electric traction was in part a function of the guarantees which shifted the risk of innovation on to the manufacturer. This alone was a strong incentive to adopt the most up to date form of technology available. In addition, adoption of multiple-unit operation tended to be a function of the overall market penetration by the relevant supply firms. Trying to derive overall adoption rates based on lines which were initially electrified but converted to multiple-unit operation would be meaningless because the companies involved were so few. After its introduction on the South Side elevated, the only line not to use it from the outset was the CLR although this quickly changed. It is interesting to note that while the CLR soon changed, the already established electric lines (CSLR, LOR, Waterloo & City and the Metropolitan West Side in Chicago) were much slower to do so. The major limiting factor in any overall study, however, reduces itself to the fact that the number of firms is so limited, bearing in mind that most models of diffusion theory have considerably larger samples.

As already explained, the advantage of multiple-unit operation lay in costs. Instead of the costs of operation being represented by a series of short run cost curves, these could be 'evened out' by a single long run cost curve. Although smaller train units cost more to operate, the flexibility in size permitted through the multiple-unit enabled fluctuating traffic conditions to be more precisely catered for and by doing so, had a long term benefit on costs. With locomotive operation, costs would be optimised at a certain level of traffic but as traffic increased, extra units (trains) would have to be made available, thereby increasing costs. With mutliple-unit operation extra cars could be added, initially doubling capacity, then increasing it by fifty per cent and so on. The unit could then be split into two trains, thus minimising short run costs and allowing additions to be made to capacity at a lower marginal cost. Thus inflexibilities in operation could be minimised and it became more realistic to attempt to equate optimal frequency with passenger demand.

While the multiple-unit invention was undoubtedly important, it is difficult to say whether it made any difference to the plans of companies for electrification. For example, the South Side line in Chicago had already taken the decision to convert to electric traction and had received tenders from GEC, Westinghouse and Siemens & Halske before being approached by Sprague.[1] Of more interest, therefore, is the impact that Sprague's invention had on the other supply companies, particularly on their success in winning orders for future projects. This is a subject which is better examined in the light of its impact on the older companies, however, and is therefore left to the next chapter.

Before considering this, it is worth taking stock of the general developments in the urban railway field and assessing the significance of the opening of each line. Leaving aside, for the time being, the existing lines - the Metropolitan, District, Mersey, Manhattan and Brooklyn systems - the CSLR led the way by being the world's first electric underground railway. Like most pioneers, it paid the price of innovation. The restricted size of the tunnels caused problems and the electric equipment was rather rudimentary. Nevertheless, it was a technical success, made possible not by the development of a suitable form of electric traction but by Greathead's patent form of tunnel construction, which set the pattern for all subsequent underground lines in London.

Three years later the LOR became the first electric elevated railway in the world. Again, electric traction was not vital to its success but a noteworthy innovation was the introduction of fully automatic signalling, which would subsequently become an essential feature of most urban railway operations.[2] The

1. H. C. Passer: op. cit. p. 272.
2. C. E. Box: op. cit.

timing of railway electrification in these years invites speculation about the diffusion of technology, for despite the Baltimore tunnel electrification and the opening of elevated railways in Chicago between 1890 and 1893, the first electric line in that city and the first urban electric line in America was not opened until 1895 and, as noted, some of the equipment came from a German firm. In the next few years, however, the balance of innovation swung firmly in favour of the U.S.A. This was demonstrated amply by the introduction of electric traction on the Chicago South Side Railway in 1898, using the multiple-unit system.(1) In marked contrast, the next line to open in Britain, the CLR in 1900, initially used locomotives in the fashion of the CSLR.

The CLR had benefitted from the mistakes of the CSLR and the line was constructed on a more adequate scale as a result but the decision not to adopt multiple-unit traction is curious, for although this was an American invention, the CLR used American equipment supplied by GEC who had acquired the patents to the multiple-unit invention.(2) The decision may have been due to Board of Trade reservations about the use of motor cars in tunnels although this is unlikely as this practice had by then been sanctioned on both the CSLR and the Waterloo & City. A more likely explanation is that the order for locomotives was placed prior to the successful demonstration of multiple-unit

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1. Cassier's Magazine: op. cit. p. 450.
2. H. C. Passer: op. cit. p. 343.

working on the Chicago South Side Railway, given that the CLR was originally due to open in 1898, and that the success of locomotive working on the CSLR encouraged the CLR to adopt a similar policy. Whatever the reasons, the decision was an expensive one. The desired 2½ minute frequency was simply not attainable with the locomotives, which provoked numerous complaints from householders about excessive vibration. Multiple-unit control was introduced from 1903, the CLR having the peculiar distinction of being the second and last electric underground line to rely exclusively on locomotives and the first British line to adopt multiple-unit control.(1)

After the opening of the CLR, the pattern of innovation took a less dramatic form. All the London lines used the Greathead shield method of construction and the principle of restricted size tunnels to keep costs down was also adhered to. Similarly, after 1898 all the new lines used multiple-unit control from the outset although, interestingly enough, it was not adopted on the LOR or Waterloo & City and only on the CSLR after that line was completely rebuilt after the First World War. While subsequent innovations did not have the same fundamental importance, they were significant, without materially affecting operating patterns. Thus steel coaches were introduced shortly after opening by the Boston Elevated Railway and were readily adopted by the New York Subway when it opened in 1904 and gradually introduced on other lines as operating conditions warranted.

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1. Barker & Robbins: op. cit. vol. II, p.46; Jackson & Croome: op. cit. p. 55.

Within this overall pattern, two points stand out. Firstly, innovation not only had to be successful, it had to appear as conventional as possible, if the necessary capital was to be forthcoming. The Meigs elevated railway was an excellent example of an apparently technically sound idea failing because its novel approach (which did not appear to offer significant operating advantages compared with conventional theories) frightened off investors. In turn, for an innovation to be acceptable, someone had to take the initial risk to finance the prototype. This in turn leads to the second point which is that there was a steady two way flow of ideas and information across the Atlantic, so that diffusion of proven ideas was rapid.

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The question of electrification of the older urban railway lines was rather different from that for the new lines. It has been the aim of the preceding section to show that while electricity was eventually shown to be the most practical method of operating the new urban railway lines, potential alternatives did exist, except in the case of New York Subway. Demand factors and the availability of capital dictated construction, rather than the mode of operation. However, as soon as it had been shown to be practical there was little advantage in not adopting it, especially as the adoption of electric traction either complemented other technical developments (the 'tubes' in London) or permitted economies in construction (the LOR). With existing steam-worked lines such considerations did not apply. Firstly, electricity would be useless if it did not show economies in operation. Even if it did, conversion might involve the writing off of substantial amounts of capital. Secondly, there were problems with converting lines to electric operation without interfering with traffic. As with the new lines, the money to pay for the conversion had to be found.

This area therefore offers the possibilities of international comparisons on a more meaningful basis than in the case of the new lines. Arguments about relative factor costs and relative entrepreneurial ability, frequently made for other industries, ought to be applicable here. The examination of the steam-worked lines is therefore subdivided. Firstly there is a straightforward survey of the pattern of development while a more analytical approach to examine the implications of the timing of electrification follows in the next chapter.

Reference has already been made to the early abortive attempts at trials on the Metropolitan and the trials on the New York Elevated. These trials took place as early as 1886 but it was ten years more before electrification of the elevated began and even longer before the Metropolitan and District Railways introduced electric working. A further point is that the last lines to open with steam power and therefore those with the newest capital equipment, were the first to write off this investment and introduce electric working (the Chicago elevated lines and the Mersey Railway) in their respective countries. Admittedly there were other factors than mere technical feasibility to be taken into account but it seems strange that the delay in electrification, in some cases at least, should have been relatively so long. As far as the Metropolitan was concerned, part of the problem lay in the utter failure of the early trials. These had concentrated on the use of 'accumulator' locomotives, where the power was supplied from batteries within the locomotives. They were unreliable, lost some 70% of the power generated and depreciated at 25-40% annually. After abortive attempts at trials with battery locomotives by Radcliffe Ward and the Electric Traction Syndicate in 1889-90, no further trials or experiments took place until 1896.(1) Much of the infant British electrical industry had been obsessed with trying to develop a practical form of battery locomotive, even when 'direct current' was proving practical. This involved the supply of current to the train either by overhead wires, or by a live rail beside the track.

The unsuccessful trials on the Metropolitan were closely linked with experiments in battery traction on the North Metropolitan Tramways, where tests had taken place in 1882 and again in 1887. To be fair, such tests at this time could be seen as legitimate experiments in trying to find the most suitable form of power to replace horses on tramways. Other attempts were made in various European cities with steam power and compressed air.(2) The 1887 tests on the North Metropolitan system were apparently successful and a licence for electric operation was obtained from Parliament and the London County Council. Plans were thwarted by the objections of West Ham Corporation, however, and an attempt to secure Parliamentary support through a special bill was refused

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1. Metropolitan Railway Records: GLC Acc 1297/MET 10/49.
2. J. P. McKay: op. cit. Ch. 1.

> as an attempt on the part of the tramway authority to override the local authorities.(1)

Failures such as this served to heighten the prejudices of many of the Metropolitan Railway directors, leading one to tell the company manager that

> You know I have not the slightest belief in its (electrification) being done, except at two or three times the cost of working in our present way, with Coal, but the information may be worth having ...(2)

Such a view was not unrealistic for subsequent research in the mid-1890s clearly showed that a battery powered tramcar required considerably more power to operate than a standard tramcar where the power was taken from overhead wires and also required larger investment in generating machinery. The greater unreliability of battery cars led one engineer to counsel

> unless some form of battery be discovered with entirely different characteristics from the lead battery, I should advise leaving such experiments to those who enjoy spending money on this kind of hobby.

The same observer went on to say that the use of batteries

> would not commend itself to any practical railroad manager, except as a makeshift in such Government ridden cities as exist in Europe.(3)

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1. ibid. Ch. 5.
2. Letter from Pochin to J. Bell, Manager, Metropolitan, 7th January 1893, GLC Acc 1297/MET 10/49.
3. C. Hewitt in paper to American Street Rly. Assoc. in Railway News, vol. LXVII (1897), p. 741.

The most obvious explanation of why trials with battery power should have ever been contemplated by the Metropolitan appears to have been that other parties suggested the trials and were prepared to bear the costs of them. The Metropolitan duly paid a price in that the failure of attempts at trials increased the scepticism of many of the directors and delayed progress for some years. This must have been exacerbated by the all-embracing nature of these failures; the Electric Traction Syndicate had been given twelve months for trials in 1887 but nothing happened until October 1888, when they admitted that 'accumulator locomotives' would be impossible. They were then given approval for trials of a 'direct system' but negotiations were ultimately closed in April 1889 with nothing tangible having been achieved.(1)

This complete failure to undertake any tests, irrespective of the type of power system, can only have had an adverse impact on further trials. In February 1889 the Company received a letter from William Mather (whose firm was responsible for the electrical installations on the CSLR) in which he said:

> I am of the opinion that working underground trains by electrical motive power is not only quite feasible, but from my point of view the most economical and simple method that can be at present conceived of - I do not think any new underground lines will be worked by steam locomotives.(2)

1. Metropolitan Rly: Correspondence on Electric Traction, GLC Acc 1297/MET 10/49.
2. ibid.

With recent experiences very much in mind, the Metropolitan directors made much of the technical problems of electric traction although many of these were resolved by the time the CSLR opened in 1890. A further factor to be taken into account was that any electrification of the Inner Circle would have to be executed in conjunction with the District Railway (MDR) and this considerably exacerbated the problem. The MDR's directors were no less reactionary than those of the Metropolitan but its finances were in such a parlous condition that raising capital for electrification would have been difficult.

The generally difficult conditions for raising capital that existed in the early 1890s may also have been in the minds of Metropolitan directors. In any event, the next signs of progress with electrification came in 1896 when the Thames Iron Works Co. were commissioned to produce a report on a possible conversion. This report estimated the total cost of electrification of the Inner Circle as £1.033 m., no credit being taken for the obsolete steam engines. It was suggested that this could be raised on an issue of 3% Debentures. If immediate action on the report had been taken it would have been advantageous, as the money market would not be so benign again. The cost of coal for the power station was estimated at 15s. per ton, or £21,600 annually and driver costs at 6s. per day each, or £12,960 for a year, assuming 120 drivers for 100 locomotives.(1) As Table 2 shows, the cost of electric energy used was actually expected to be greater than that for an equivalent mileage under steam power -

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1. Electric Traction Proposal of Thames Iron Works Co. 1896, GLC Acc 1297/MET 10/65.

TABLE 2: COMPARATIVE COST OF LOCOMOTIVE POWER FOR TRAIN MILEAGE OF 2,312,000 PER ANNUM (THAMES IRON WORKS ESTIMATE OF INNER CIRCLE WORKING)

	METROPOLITAN		DISTRICT		INNER CIRCLE ESTIMATE FOR ELECTRIC OPERATION		
	Total (£)	Per train mile (pence)	Total (£)	Per train mile (pence)		Total (£)	Per train mile (pence)
Coal & water used on locos.	39,111	4.06	36,798	3.82	Electric energy used, including power station maintenance	40,820	4.24
Wages (2 men per locomotive)	29,863	3.10	25,238	2.62	Wages (1 man per loco.)	12,960	1.34
Oil & loco. stores	3,564	.37	2,119	.22	Oil & loco. stores	2,400	.25
Repairs & cleaning (excluding depreciation)	22,059	2.29	24,082	2.5	Repairs & cleaning (excluding depreciation)	17,500	1.82
TOTAL	94,957	9.82	88,237	9.16	TOTAL	73,680	7.65

Source: Electric Traction Proposal of the Thames Ironworks Co., 1896, GLC Acc 1297/MET 10/65.

by 10.93% over the District's costs and by 4.36% over the Metropolitan's own costs. In all other aspects of locomotive operation electric traction would show a substantial saving.

The most spectacular saving would be in wage costs, where the report suggested a likely saving of 56.6% over Metropolitan costs or 48.65% over District costs. The other most significant saving would be in the field of repairs and cleaning where savings were estimated at 20.67% over existing Metropolitan costs or 27.33% over MDR costs. Overall running costs on an annual basis were calculated to show a saving of 22.41% on the basis of Metropolitan costs and 16.5% on the basis of MDR costs. The report thus clearly highlighted the potential cost saving, which was either £14,557 p.a. or £21,277 p.a., depending on the company on which the costs were examined. It is apparent that the areas in which most costs would be saved were those directly associated with the replacement of labour intensive operations connected with steam locomotives by capital intensive electric traction. This point will be examined in more detail in the next chapter, in the meantime it is worth recalling Habakkuk's hypothesis, that where an innovation promised a reduction of labour at the cost of an increase in capital, the Americans had a sharper incentive than the British to adopt it.(1)

Despite the apparent advantages of electric traction that the Thames Iron Works report apparently revealed (which were of course dependent on suitable conditions in the capital market for raising the money for conversion), there was the difficulty

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1. H. J. Habakkuk: op. cit. pp. 40-54.

that through trains from the Great Western and London & North Western Railways ran on to the Inner Circle. All electrification schemes up to this time had conveniently overlooked this difficulty but it was important, firstly because the financial benefits of electric operation would be restricted while steam trains continued to run over the Inner Circle, secondly because one of the hoped for improvements from electrification was an improved atmosphere in the stations and tunnels and this would not be possible while 'foreign' steam engines were allowed to work over the Metropolitan.(1)

Thus despite the apparent financial benefits that would be achieved, the Metropolitan Railway directors were not yet convinced of the overall advantages. In October 1897, their general manager claimed that the problem was still a technical one - while admitting that plenty of suitable electric locomotives existed he claimed that there was a difficulty in finding sufficient power to start two or three trains simultaneously. The Chairman was concerned at the effect the capital expenditure would have on the dividends although he claimed that as soon as a 'responsible syndicate' could be found to undertake the work at a 'reasonable rate', the company would 'jump at the offer'.(2)

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1. Correspondence on electric traction between Pochin and Francis Fox, consulting engineer, 19 May 1893, 29 January 1894.
2. Morning Leader, 9 October 1897; Daily Telegraph, same date.

The Thames Iron Works' findings supported earlier opinions that the actual costs of power for steam and electric haulage were fairly similar althoughthe Thames Company's calculations were based on a figure for coal costs for electric power of 15s. per ton which in view of subsequent figures seemed excessive. Overall, however, some saving in cost is apparent, without allowing anything for reduced ventilation costs or the cleaning costs of stations and stock, and before allowing for any increase in passenger traffic.

If traffic grew by 5% as a result of electrification, receipts would be £50,000 higher and the total increase in revenue £75,000. If the £1 m. capital needed for electrification was raised on 3% Debentures, as suggested, this would have left a balance of profit of £45,000 p.a. In practice, Railway Debenture issues at this time were more likely to be paying 5% interest, where they could be sold at all, and this would have left a balance of profit of only £25,000. While the Thames Iron Works Co. were prepared to spend £25,000 on experiments to demonstrate the practicability of Inner Circle electrification, and to form a power company to find the necessary capital, the District Railway remained extremely sceptical of such evidence.(1) Given the joint nature of the Inner Circle, MDR support for conversion was necessary and this impasse highlights the difficulties of the early British electrical industry and makes it even less surprising that most British companies forsook the traction field for more promising pastures. Mather & Platt had

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1. Letter from T.I.W.Co. to Met. Rly., 18 December 1897.

offered generous guarantees to win the CSLR contract but did not achieve any significant further orders by doing so. The same applied to the E.C.C. with the LOR and now there was the case of the Thames Iron Works, who could not obtain a contract even by offering guarantees and without facing competition. As the British electrical market was showing signs of awakening at this time, a successful contract for electrification of the Inner Circle might have led to the name of Thames Iron Works being more widely known. At a national level, this suggests structural difficulties within the British economy; at a company level it suggests entrepreneurial shortcomings - or more specifically shortcomings in company directors.

There can be no doubt that in this particular case the problem was aggravated by the animosity between the Metropolitan and District Railway boards, which was one reason for the MDR's decision to carry out its own tests in early 1898. The Metropolitan, however, agreed to join on equal terms, with each company contributing £10,000 towards the cost. Meanwhile, immediately following the Thames IronWorks report, the Metropolitan commissioned a further report to investigate possible conversion of the Inner Circle. The findings of this report, presented in early 1898, suggested that a service of steam and electric trains could be run if necessary but 'the one great advantage of electricity ...' - the purity of the air - would be lost.(1) The evidence within the report contradicted this to some extent pointing out that trains would be faster,

1. Metropolitan Rly: Report on conversion of Inner Circle to electric operation, W. H. Preece & T. Parker, 26 March 1898.

traffic capacity would be increased and operating costs would be reduced but this rather betrays thinking about the value of electric traction, it being seen as a way of increasing traffic through providing pleasanter travelling conditions, rather than a means of reducing costs.

After receiving this report, the two railways agreed to hold their own trials of electric operation and a test train eventually entered service in April 1900. As a benchmark of progress, the CSLR had by then been open almost ten years, the CLR was on the point of opening and the first section of the Paris Metro which like the CSLR was electrically operated from the outset, had opened to the public. The slow progress on the Inner Circle was typified by the compromise of these latest trials which came to an end in November 1900 with little having been achieved. Indeed, the Joint Committee on Electric Traction which the Metropolitan and District companies set up appears to have demonstrated the worst features of such organisations. The test train produced was little better. It weighed 164 tons compared to the 54 tons of a Liverpool Overhead train yet its carrying capacity was no greater. The result was higher fuel consumption, heavier wear and tear and generally less impressive performance. Unsurprisingly, the committee concluded that such a train would be unsuitable for Inner Circle working. Furthermore, while the advantages of multiple-unit control had not been forgotten it was felt that the utilisation of existing stock was initially at least, of paramount importance and outweighed any possible advantages that multiple-unit control could offer.[1]

Despite this, real progress appeared to have been made for the committee pursued its intention of inviting tenders for the electrification of the Inner Circle and by the end of 1900 nine such tenders had been received.[2] After the years of lack of progress, ostensibly on the grounds of technical difficulties, the committee rather surprisingly accepted the tender of a Hungarian firm, Messrs. Ganz & Co. of Budapest.[3] The surprise was due to the fact that the form of power to be used by Ganz was unconventional. All previous railway electrification projects had used the direct current system where electricity was fed, at a level between 400 and 700 volts, to the train, usually by means of a third rail beside the track from where it would be picked up by a shoe on the motor coach or locomotive.

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1. Metropolitan and Metropolitan District Rly. Electric Traction Joint Committee: Minutes 13.6.1900, Acc 1297/M+DJ1/53.
2. ibid. Given that criticism has been made of the early British electrical industry for lack of co-operation between manufacturers, it is interesting to note that Mather & Platt, Siemens and Thames Electrical Engineering Works submitted a joint tender. Tenders were also received from E.C.C., Q.L. Kummer & Co. of Dresden, BTH, Brush, Dick, Kerr, B.W.E.M. and J. G. White & Co., in conjunction with F. J. Sprague.
3. Ganz & Co. were a well established firm in the electrical industry, said to be the strongest industrial house in Hungary with a labour force of 6,000, paying average dividends of 25% and backed by the Hungarian Credit Bank - "virtually a branch of Rothschilds of Vienna". - Report by Messrs. Preece & Parker following visit to Budapest, 7.2.01, Acc 1297/MET 10/78.

The current returned either through the running rails or through an insulated fourth rail, the two systems being very similar. It was a very simple system and very effective but one of the major drawbacks was that at such relatively low voltages the voltage drop in transmission was high, necessitating the use of substations every few miles. On the other hand, great economy could be obtained by alternating between series and parallel control, the demand for power being much lower when the motors were wired in series but adequate power being available by switching to parallel wiring for starting and accelerating.

The Ganz system, however, used alternating current. The major advantages of this were that the much higher tension (3,000 volts being the current) meant that the power loss was much smaller and as this was the normal lighting frequency it could be taken from an external power station if need be. The major objections to using alternating current were firstly that two insulated conductors were needed - this would be objectionable on a public street but of little consequence on a private right of way; secondly the frequency did not give high efficiency or sufficient torque and finally the great economy possible through series/parallel control was unattainable with three phase motors which were necessary with alternating current systems, because of the large current required for starting and acceleration.

The first of these objections was hardly applicable to the Inner Circle and the other two were both overcome by Ganz. By designing motors for a much lower frequency, they were of an efficiency equal to that of direct current motors and with a high torque. By arranging the motors in pairs in 'cascade' the problem of series/parallel switching was overcome. Furthermore, the motors had no commutators or brushes, these being two of the main problem areas with early dc motors, and no sparking. The transformers that would be needed to reduce the current pressure would occupy no more space '... than Smith's book-stall at possibly five stations' and the maximum current needed in starting and accelerating would be 250 amperes, whereas 500 volts dc would require ten times that. The motors would be lighter in weight than equivalent dc motors and would maintain uniform speed up grades and with varying loads. Given that the novel features in the system were all familiar in other areas of electrical engineering, it was felt that there would be no problem in obtaining Board of Trade sanction for the system.(1)

Before the contract could be referred to the Board of Trade for approval, however, the District Railway was taken over by the American financier Charles Tyson Yerkes. Yerkes was anxious that the District should be electrified as soon as possible but was unconvinced about the utility of three phase operation. The MDR therefore insisted that their portion of the Inner Circle be fitted with their own system in addition to the Ganz system, the problem being that it was highly unlikely that the Board of Trade would agree to two separate systems on any portion of the line and the Inner Circle section only formed 26% of the total District system. Following a request from the two companies to the Board of Trade to receive a joint deputation, the Joint Committee broke up in June, 1901.(2)

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1. Report by Messrs. Preece & Parker on Inner Circle working, following visit to Budapest, 7 February 1901. Acc 1297/MET 10/78.
2. Acc 1297/M&DJ 1/53.

Eventually the Board of Trade ruled in favour of a direct current system, which was what the American backers of the District wanted. Although technically the Ganz system may have been superior it was still in a somewhat experimental stage, it was less practical and less easy to maintain than the more straightforward direct current system, especially in conditions felt to be the most complicated in Europe and experience certainly vindicated the Board of Trade's decision. The whole dispute gave the Railway News more ammunition for its claim that

> What really clogs the wheels of action in London is the host of different authorities and vested interests that exist.(1)

Their claim that the importation of business energy from abroad was not needed was wide of the mark, however. Yerkes had actually visited Budapest to inspect the Ganz system, which would at least imply that he approached the affair with an open mind but the Board of Trade concluded their report by saying that the Metropolitan were fully justified in going to arbitration, as the manner in which the District had conducted preliminary negotiations was most embarrassing to the Metropolitan.(2)

After this the two companies effectively went their own separate ways. In July 1901 the Metropolitan District Electric Traction Company was formed for the purpose of electrifying the MDR. The capital issue was £1 m., none of this being publicly offered. Yerkes subscribed £336,000 and only one subscriber was not an American.(3) The District proceeded to hold tests between

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1. Railway News, vol. LXXVI (1901), p. 566.
2. ibid. vol. LXXVII (1902), p. 855.
3. ibid. vol. LXXVI (1901), p. 144.

Westinghouse and GEC equipment before awarding the contract for train equipment to the latter company in late 1903. Earlier in the year the Metropolitan had placed an order for stock with British Westinghouse.

By this time the Mersey Railway - the only other British urban line to convert to electric operation - had commenced electric working. The Mersey was already something of a pioneer. Opened in 1886, it was the first deep-level underground railway line, with an impressive but not very successful system of ventilation. The steam locomotives designed for it were the most powerful in the country, similar designs not appearing elsewhere in Britain for another fifteen years. Unfortunately, the various heavy expenses for ventilation, drainage, locomotives and lift operation meant that the line was soon in Receivership. While this created severe financial difficulties, it also led to an early search to reduce the costs of operation, including the suggestion that

> we must seriously consider whether we cannot work the tunnel by electricity and do away with ... artificial ventilation, for if this was so there is no doubt we could increase our fares considerably both in summer and winter and reduce our costs for the ventilation in itself comes to something ... per mile per train ...(1)

An enabling bill for electrification was approved by the proprietors in March 1895 but nothing further happened until October 1898 when the Receivers reported that

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1. Letter from G. Waddell, director, to Earl of Iddesleigh, receiver, Mersey Railway Co., 14 November 1892 Northcote Papers 51/24/21.

> we have not seen our way, with the present system of traction ... to effect any substantial reduction (in operating costs) ... We think that the time has come when your Board might with advantage consider the advisability of substituting cable or electric, for locomotive traction ...[1]

The argument for electrification had now switched from improving the atmosphere to the need to reduce costs, although it was recognised that the unpleasant atmosphere was a factor affecting the high operating costs. Total receipts had risen from £70,748 in 1895 to £74,172 in 1898 but over the same period working expenses rose by 10.71%, leading to a 5.7% fall in net receipts. As ventilation accounted for nearly 10% of expenses, the benefit that could be derived from electrification was obvious.[2] It is interesting to note, however, that as late as 1898 cable traction was still being suggested as a viable form of power.

A report published the following year concluded that for the Mersey Railway the saving in working expenses as a result of using electricity would be £11,540 annually and the increase in gross receipts after one year £18,943. With the existing net revenue that made a total of £41,873. The maximum new capital required was estimated at £428,750. Interest on this at 4% would involve an annual charge of £17,510, giving a net improvement after one year of over £24,000, rising to over £41,000 after three years.[3] A new mood of optimism came over the Company after an Act was passed in 1900 giving the necessary

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1. Mersey Railway: <u>Board Minutes</u>, 31 October 1898, p. 141.
2. Board of Trade: <u>Railway Returns</u>; Mersey Railway: <u>Annual Reports</u>.
3. Mersey Railway: <u>Board Minutes</u>, vol. VII, 29 September 1899, p.175.

powers for raising capital for electrification. The exact nature of developments after this is unclear but on 15th July 1901 a contract for the electrification of the railway was sealed with the British Westinghouse Company (BWEM).

The terms of the contract were onerous. Although the total price payable to BWEM was set at £635,303, £620,000 of this was to be paid in 4% perpetual 1st debentures and the rest in cash. BWEM were to operate the line for a twelve month trial period for a cost of not more than 6.75d. per train-mile, against the existing 1s. 3d. per train-mile.(1) Given that the Metropolitan, without the exceptional operating costs of the Mersey (primarily pumping but also lift operation and ventilation which taken together were around 18% of total operating expenditure) had not been offered anything better than 6.62d. per train-mile, the offer of BWEM was clearly very tempting. The exact rôle of BWEM must remain hypothesis rather than hard fact, however. That BWEM were anxious to sign as many contracts as possible to obtain work for their new Trafford Park plant is clear. It is also clear that the expected rush of orders was simply not materialising and it was now looking unlikely that BWEM would be awarded the Inner Circle contract in view of the confusion reigning there. The Mersey Railway had obtained sanction for electrification but had no money to pay for conversion and there is no evidence that any firms were ever invited to submit tenders for the work. The financial aspect of the BWEM contract was obviously important but would not have been impossible for

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1. Railway News: vol. LXXVI (1901), p. 465.

other consortiums to match. One can only conclude that BWEM approached the Mersey with the scheme and, given their parlous financial situation, they were delighted to accept. Electric working on the Mersey started in May 1903.

Thus after comparing the switch to electric working on the British lines, a number of factors are apparent. Firstly, capital was a problem but by no means an insuperable one. Political difficulties were also apparent, whether they were the animosity between the Metropolitan and District companies or the time consuming process of obtaining Parliamentary and Chancery Court approval for progress in the case of the Mersey. Meanwhile, in the field of technical competence, ideas still appeared to be in a state of confusion. After procrastinating for over ten years about making any decision, ostensibly on the grounds of the technical problems of electric traction, the Metropolitan opted for the newest, least tried, least known and least practical method of traction, before the Board of Trade intervened. Similarly, although battery power was finally - apparently - out of favour, cable power was actually suggested as a possible form of traction for the Mersey in 1898 (admittedly further studies suggested it would be impractical).

Running like a thread through the arguments for electrification as the major factor for its adoption was not its cost saving attraction but its value in producing a cleaner atmosphere. While this was no doubt a good reason - the argument was that cleaner tunnels would produce more traffic and therefore more revenue, it does not appear to have been wholly sound. Ventilation was not, of course, a problem for the

American elevateds, but the Americans were apparently prepared to build steam operated subways, if necessary, and seemed to think that the ventilation in the Mersey tunnel was adequate for such purposes as studies for the Boston subway showed. In contrast, one of the reasons for electrification of the Inner Circle was the pressure being brought to bear on the companies over the problem of ventilation. This pressure intensified after 1897, when the Board of Trade issued a 'blue book' on the ventilation problem in which it was declared that electric traction was the only real cure for the foul air.(1) The Board of Trade were prepared to accept a temporary compromise, urging the companies in 1900 to improve ventilation by constructing more 'blow holes' to allow smoke to escape from the tunnels. The Metropolitan were reluctant to agree to this, citing early electrification as the excuse. In the case of the District, one journal asked if

> the shareholders really believe that - other matters being equal - a traveller would pass a District Railway station, and reach his destination by some other means, merely because the trains are propelled by steam locomotives?(2)

By this time the evidence was that passengers were doing just that. Indeed, this was an exceptional view for it was frequent complaints in the Press about the quality of air on the Inner Circle that led to the Board of Trade inquiry in the first place. Nevertheless, visitors from the Boston Rapid Transit

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1. Metropolitan Railway Records: Acc 1297/MET 10/69.
2. 'Electrification of the District', Railway Magazine: vol. VIII (1901).

Commission in 1891 complained of a 'buried alive' feeling and noise

> like the roaring of the ocean after a storm

on the (electric) CSLR and actually found the air fresher on the Metropolitan.(1) This may suggest that the issue was exaggerated in Britain but a more probable explanation is that it was an attempt at reassuring Bostonians if, for any reason, a steam worked subway was built in that city. Maybe the visitors were potential sufferers of claustrophobia for the conditions on the CSLR remained unchanged until after the First World War, without apparently provoking much adverse comment. It is also worth noting that most of the adverse publicity about conditions on the Inner Circle came after the opening of the CSLR provided the public with a more favourable comparison and that Sprague's ideas about electric traction received a boost from his travelling on the lines of the District Railway, while in London.

The invention of the multiple-unit does not appear to have had a great impact on these companies although it was adopted by all of them when they commenced electric working. The reason for this is fairly straightforward. The Mersey Railway was already committed in principle to electric working before Sprague's invention was shown to the world but it was anxious to operate heavy goods traffic and through expresses (it never did) for which such an invention was inappropriate. For local traffic, motor coaches like those on the LOR would have sufficed. The advantages of multiple-units would have been more obvious on the

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1. C. W. Cheape: op. cit. p. 162, quoting Report of the Rapid Transit Commission to Massachusetts Legislature, 5 April 1892.

Inner Circle but here one of the major problems was the 'foreign' trains, for which electric locomotives were obtained. In no case, therefore, did the invention of the multiple-unit make a crucial difference.

The same was true even of the pioneer line in this respect - the Chicago South Side. Like the Mersey, this line had quickly gone into receivership and after reorganisation the decision was taken to electrify in spring, 1897, by which time the other steam operated Chicago line - the Lake St. - was changing to electric working. The South Side received tenders from GEC, Westinghouse and Siemens & Halske, all of whom advocated the use of powerful motor cars, before Sprague's offer to convert to multiple-unit operation with the risk borne by himself, was received. Sprague only provided the technical services and equipment for the control system, the remainder of the equipment coming from GEC and Westinghouse, but the success of his conversion meant that by 27th July 1898 the steam service had been entirely abandoned.(1)

Including the Chicago 'Loop', 19.44 miles of track were operated and the average duty of the equipment was claimed to be more intensive than on any other elevated railway. The total operating expenses per car in November 1898 were less than 7.5 cents for an average schedule of 15 m.p.h. with stations every 0.4 miles. Based on this performance, the Manhattan elevated could have been operated at 16.5 m.p.h. for not more than nine cents per car, a saving (after deducting interest charges) of $0.75 m. each year. As Table 3. shows, within one

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1. Cassier's Magazine: op. cit. vol. XVI, pp. 439-462.

year of having started electric working, net earnings of the South Side Railway had increased by over 270%, reflecting both increased traffic and reduced operating expenditure.

TABLE 3.

CHICAGO SOUTH SIDE RAILWAY: COMPARATIVE PERFORMANCE UNDER STEAM AND UNDER ELECTRIC OPERATION

	Ratio of expenses to earnings including 'Loop' rental, taxes & licences	Ratio of expenses excluding 'Loop' rental, but including taxes & licences	Net earnings
STEAM			
November 1897	87.3	77.7	$10,603.80
December 1897	83.6	73.8	$14,691.69
ELECTRIC			
November 1898	57.3	47.7	$39,448.56
December 1898	55.0	45.4	$45,355.68

Source: Cassier's Magazine, Vol. XVI, No. 4 (1899), p. 460.

While the information in Table 3 is somewhat limited, it does clearly demonstrate the immensely improved returns that could be gained from electric traction. Sprague was paid $300,000 for his South Side work and the stock, which before reorganisation was $32 per share, rose to $105 after electrification.(1) With the success of multiple-unit operation in Chicago, similar systems were soon afterwards adopted on the Brooklyn and Boston elevated, the latter being a new line and the former a steam-worked line where preliminary conversion work for electric traction had already started.

1. ibid.; Passer: op. cit. pp. 272-5.

While the rest of America took to the multiple-unit, progress towards electrification of the Manhattan elevated in New York was so slow as to be effectively non-existent. The conditions certainly warranted it. The Third Avenue line alone was carrying some seventy-three million passengers each year by 1890 and after 1889 the total system never carried fewer than 180 m. passengers in any one year. The volume of traffic was causing increasing congestion which was not helped by the general unpopularity of the steam locomotives as cinders, oil, water, tyre shavings and, at least once, a locomotive, fell into the streets below.(1) Public pressure was certainly strong in New York in advocating electrification but reports in 1895 that the company had signed a contract with Westinghouse proved to be nothing more than rumour.(2) Eventually, in January 1898 George Gould was forced to make a statement. In reply to a demand from Mayor Van Wyck that the Manhattan Railway Company change to electric working without delay and 'continue the present routes to the more sparsely settled and distant localities' he said

> We have decided to introduce electricity on the elevated system and we will now proceed to effect a general installation with as little delay as possible.

As Sprague had made offers to instal electric trains on the Second Avenue line in 1891, 1895 and 1896, all of which had been refused, it would have been reasonable to treat Gould's remarks sceptically.(3) However, tests duly took place in 1898, not of

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1. Railway News: vol. LXI (1894), p. 365.
2. ibid., vol. LXIV (1895), p. 100.
3. ibid., vol. LXIX (1898), p. 165; Passer op. cit. p. 272. George Gould (1864-1923) was the "son and unsuccessful successor of Jay Gould". Scribner's DAB, op. cit. p. 364.

direct current or even alternating current equipment but of battery locomotives. Why this form of traction, which by this time had been seemingly discredited as inefficient and costly, should have even been considered is surprising in the least as until then batteries had proved constant failures. Its likely practicality was summed up by one observer thus:

> No results of this experiment have been made public yet, but it is difficult to see how much is expected ... It subjects the battery to usage which history has proved to be disastrous to its life and efficiency.(1)

Nothing more was heard of this trial and surmise would suggest the only reason it ever took place was because of Jay Gould's earlier dislike of conventional electric traction. Alternatively, it might have been a way of pacifying the public and thereby paving the way for new franchise agreements without actually taking any irrevocable steps towards electrification.

That this seems reasonable is apparent from another statement by George Gould the following year when he informed stockholders that electrification would be delayed 'in view of the large expense' and the 'uncertainty as to the practicality of electricity as a motive power'. The cost of changeover at this time was estimated at $7-10 m. and would have also involved writing off 330 steam engines worth $1.65 m. On the credit side coal costs and track repairs would be reduced by 50% and the speed increased by 33%.(2)

The issue of electrification was connected with efforts to improve the overall service of rapid transit in New York and build new extensions but the Rapid Transit Commissioners and the railway

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1. C. Hewitt, op. cit. p. 742.
2. Passer, op. cit. p. 272.

management repeatedly failed to reach agreement. George Gould and Russell Sage were prepared to expand only with guarantees against risk which the Rapid Transit Commission could not give.(1) Thus although the public were informed of the intention of electrifying, actual practice was different. Not two months after George Gould announced the decision to introduce electric operation, a committee of the Rapid Transit Commissioners heavily criticised the Manhattan Company for their lack of precision in applications and tardiness in commenting on suggestions and recommended that the city should not grant the company an open-ended option to build. In particular, the committee observed that

> It has been public understanding for a long time past that the Manhattan Company proposed to substitute electricity for steam, and we were disappointed that such change was not mentioned in the Manhattan application (for new routes) ... it will be best not to insist on the condition of a change of motive power ... because in our opinion it will very soon be to the plain interest of the Manhattan Co. to make the change without regard to the great advantage to the public.(2)

Little more appears to have happened until the Vanderbilts were rumoured to have taken a leading interest in the company in mid 1898, with the appointment of a new vice president long identified with them. It was widely expected that this would

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1. Cheape, op. cit. p. 113; To the Stockholders of the Manhattan Railway Co., 20th February 1899, p.2. Russell Sage (1816-1906), financier, Whig congressman, business associate of Jay Gould, "was one of the shrewdest and most conservative money manipulators of his time" with an estimated fortune on death of $70 m. Scribner's DAB, op. cit. p. 886.
2. Collection of Documents and Reports submitted to the N.Y. Rapid Transit R.R. Commissioners. Committee report of 17 March 1898.

lead to an improvement in the service, presumably because their opinions of electric traction were more advanced than those of George Gould.(1) Whatever the precise facts, at almost exactly the same time that Gould was advising the shareholders of the expense and uncertainty of electrification, an associate went on record as saying that a saving of 2½ cents per mile, equivalent to a saving of $1 m. p.a., as a result of electrification would be a 'conservative estimate'. As such a saving would make it possible to pay 5% on new capital and an additional 1% on existing capital thereby raising the interest on it to 5% as well, without one new passenger being carried, it is difficult to explain Gould's pronouncements to the shareholders. The fact that speed would be increased by 16% to 18% and rush hour capacity by 20%, due to a 1½ minute headway between trains being possible instead of the existing 6 minutes, makes his attitude even less understandable. Whatever Gould's personal opinion, however, at a meeting on 28th February 1899, at which 80% of the stock was represented a vote to increase the capital stock from $30 m. to $48 m. was carried.(2)

Once this decision had been taken, work progressed more quickly. By August, Westinghouse had been awarded the contract for the stationary power plant - the eight 6,650 hp generators would be the largest in the world.(3) One factor which was undoubtedly important in the decision to proceed with

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1. Railway News: vol LXX (1898), p. 802.
2. ibid. vol. LXXI (1899), p. 323; Manhattan Railway file, Scudder Library. There were 1,418 stockholders in all.
3. Railway News: vol. LXXII (1899), p. 885.

electrification was the imminent awarding of a contract for the rapid transit subway. Otherwise, the conservatism of the controlling group remained much in evidence - most notably in the initial decision not to adopt multiple-unit control. Instead, it was planned to use a 'double-end' system with a motor car at each end of six car trains although this decision was later changed in favour of multiple-unit control prior to the changeover.(1) As by that time multiple-unit control was in use in Boston and Brooklyn, as well as in Chicago, it could hardly be said to show any great adventurous enterprise by the Manhattan board. It is hardly necessary to add that the electrical equipment was considered an 'unqualified success'. As passenger traffic was growing at an average annual rate of 12% prior to electrification, its precise effect is not as clear as it might have been but the first three months of electric working showed a daily average increase of over 92,000 in the number of passengers carried.(2)

Immediately prior to electrification an important development became public. This was the leasing of the Manhattan Elevated by the Interborough Rapid Transit Company for 999 years from 1st April 1903. After January 1906 an annual rental of 7% on the $60 m. capital stock was guaranteed. The Gould and Rockefeller families acquired large interests in the IRT through the transaction but the net effect was to make August Belmont and his associates the major power in New York

1. ibid. vol. LXXIII (1900), p. 970.
2. ibid. vol. LXXVII (1902), p. 134; vol. LXXX (1903), p. 342.

transit. As he had earlier been active in the promotion and organisation of the Brooklyn elevated, he could claim to be the most influential figure in New York transit development.(1) The takeover can also be seen as marking the decline of the Gould interests as they had effectively forsaken the possibilities of risk taking and innovation, and the rewards therefrom, in exchange for an assured annual income although the doubling of the capital stock in the previous four years could be seen as a way of ensuring this. The delay in electrification was an important factor for this, along with the years of argument with the Rapid Transit Commission, meant that once the subway was opened the position of the Manhattan Company would become considerably less secure.

On the other hand, the huge annual growth in per capita journeys in the city meant that it would only be a matter of time before any temporary shortfall in the elevated's prosperity was recovered. How far the Gould interests were prepared to accept this is not clear. However, even as late as May 1900, senior management of the company appeared to be almost totally ignorant of the advantages of electric operation, at a time when the Manhattan was still negotiating for the possibility of a share in the new transit contracts.(2) As the possibility of this became increasingly unlikely with opposition, especially in the Bronx, to it, so the long term independence of the Manhattan must have appeared increasingly in doubt. The leasing

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1. ibid. vol. LXXVIII (1902), pp. 787, 850; J. B. Walker: op. cit. pp. 167, 185-90.
2. William Barclay Parsons: Diaries, vol. 1, 22 May 1900, 4 June, 1900.

could then be seen as an astute move by the Gould faction so as to maximise their long term income. Whatever the reasons behind the leasing, it brought unification of all rapid transit lines in Manhattan and the Bronx - a situation that was barely beyond the stage of wishful thinking in London.

This appraisal of attitudes to electrification of the Manhattan suggests that the directors were more cautious as regards electrifying their property than the directors of other elevated railways in America were. The result was that in both Britain and America the largest urban railway systems were the last to electrify - an unsurprising conclusion, given that the complexities of electrification would obviously be greater in these cases. This relative slowness was not merely due to technical factors. In both cases directors expressed strong personal reservations about the likelihood of electrification. Sometimes this was straightforward scepticism - as in the case of the Metropolitan director who told his general manager that he had

> no belief that railways will be worked by Electricity in either your lifetime or mine.(1)

Such views did not prevail for by 1903 - thirteen years after the opening of the world's first electric underground railway - all the significant urban railways in Britain (excluding, as ever, Glasgow) and America had either converted to electric traction, or were at an advanced stage in doing so. In the intervening years there had clearly been a change in attitude,

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1. Letter from Pochin, director, to J. Bell, manager, Metropolitan Railway, 3rd February 1894.

hastened by the opening of several new electrically worked urban railways. These changes in attitude developed at almost identical times on both sides of the Atlantic and as a result, the actual changeover followed a similar timing in both countries. Such a pattern is not always found in other industries and here it probably reflects the specialised conditions of the urban railway industry.

The change also came about through the combination of external pressures: the unpleasant atmosphere on the Inner Circle was apparently driving passengers away and the Manhattan Railway was operating at very near full capacity. Frank Sprague suggested that a reduction in the age limit of British railway directors might have increased the pace of the changeover to electricity and this is one key to the issue.(1) The change was made but could, technically, have been made earlier. If the change had been made earlier, might electricity have been more widely applied on British railways? This is not merely a question of the age of directors. The Habakkuk thesis was that, other things being equal, Americans had more to gain than the British from capital-intensive investment and others have reached the same conclusion.

Therefore we must ask whether British urban railway companies were justified, on financial grounds, in using electric power. Did the fact that they adopted it so quickly reflect more enlightened management ideas or merely that the

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1. Frank Sprague, in speech at International Electrical Congress, St. Louis, 1904 - papers published in New York, 1907.

the special conditions of urban railways warranted it? Could they have made the change earlier? Similar questions can be asked of the 'new' urban railways. For example, did the CSLR pay a price for pioneering, were the later lines able to utilise to full advantage cost-reducing technical developments? The next chapter will try to develop some elementary theoretical ideas on the timing of electrification and analyse the benefits that technical developments offered.

CHAPTER 3

INNOVATION AND PRODUCTIVITY ON URBAN RAILWAYS

> It is easy to overlook the absence of appreciable advance in an industry. Inventions that are not made, like babies that are not born, are rarely missed.
>
> J. K. Galbraith: The Affluent Society

Through all the permutations of electric traction research and development covered in the previous chapter - from trials with battery locomotives to the abortive attempt to introduce the Ganz system on the Inner Circle - two innovations can be seen as having an importance outweighing others - the actual development of commercially viable electric traction and Frank Sprague's invention of the multiple-unit system. Subsequent to these developments, however, there was a myriad of less obvious but almost as important innovations such as automatic signalling, automatic carriage doors, steel bodied carriages and escalators at stations. As with electric traction itself, such inventions could not be expected to be adopted unless they yielded commercial returns. Before examining them, therefore, further analysis of the timing of electric traction development is in order. After all, if Sprague was right and the age of British railway directors had an adverse effect on electric traction diffusion in Britain, then British urban railways would presumably demonstrate a permanently slower rate of innovation, with presumably adverse financial consequences, than their American counterparts.

In seeking to develop a theoretical approach to analyse electric railway development, the initial idea has been taken from David's work on grain prices and the adoption of the mechanical reaper in the American Middle West.[1] His thesis established a link between the cost of labour, the rate of mechanization and the size of the farm, showing that as the price of grain rose, so the size of farms expanded, increasing the demand for mechanical reapers and reducing the demand for labour. The approach for electric railways is somewhat different. Firstly, considering the conversion of existing lines, the factors to be accounted for are the increase in coal costs, the saving in ventilation costs (in Britain) and in labour costs and the burden of new capital costs. Although ventilation costs were not a direct problem for the Manhattan Elevated, there was the attraction of increased capacity as a result of the change (this probably being the major reason for the change) and, if Sprague's multiple-unit system was used, reduced maintenance costs for the elevated structure as a result of the lower weight of the electric stock.

In developing the hypothesis it has been assumed that costs are related to revenue per passenger mile. Figure 1 depicts the hypothesis in terms of long run cost curves for both steam and electric operation. In both cases - curve CsCs for steam traction and curve CeCe for electric traction - fixed costs represent the cost of motive power but the additional fixed cost of power station investment causes curve CeCe to continue to fall after costs begin to rise under steam traction. The rise in unit costs results from the limitations not so much in line capacity (although this was the case for the Manhattan Elevated)

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1. P. A. David: 'The Mechanization of Reaping in the Ante-Bellum Midwest' in Industrialisation in Two Systems: Essays in Honor of Alexander Gerschenkron, H. Rosovsky ed., New York 1966, pp. 3-39.

as in the utilisation of available steam locomotives. At a larger scale of operation the CeCe curve would also rise as the limits in either line capacity or power station capacity were reached. In the graph, the railway operating under steam traction is taken to be at equilibrium performance at Mo with passenger revenue equal to minimum costs at Po. Mt lies beyond Mo and is the threshold mileage at which unit costs under steam are equal to those under electricity. In other words, it is a point of indifference. Unless the company can operate at least Mt miles per year at a revenue level of Po, the interest on the extra capital cost that would be incurred by electrification would not be covered.

The precise location of Mt is determined by the various cost and revenue factors which will influence the relative position of the two curves. Thus in Figure 1 curve $\overline{C}e\overline{C}e$ represents the cost curve for electric operation for a conventional railway. For an underground railway, however, with the additional prospect of reduced ventilation costs and other costs associated with underground steam working, curve CeCe represents the position, the additional incentive reducing the point of indifference. For British lines, the contention is that the rise in coal prices at the turn of the century drove the threshold mileage down so that electrification became feasible at a lower annual mileage. This is shown in Figure 1 as a downward shift in the long run electrified cost curve relative to CsCs, lowering the threshold size to the optimum mileage under steam operation, although it is not actually suggested that the rise in coal costs was ever great enough to reduce it to this level.

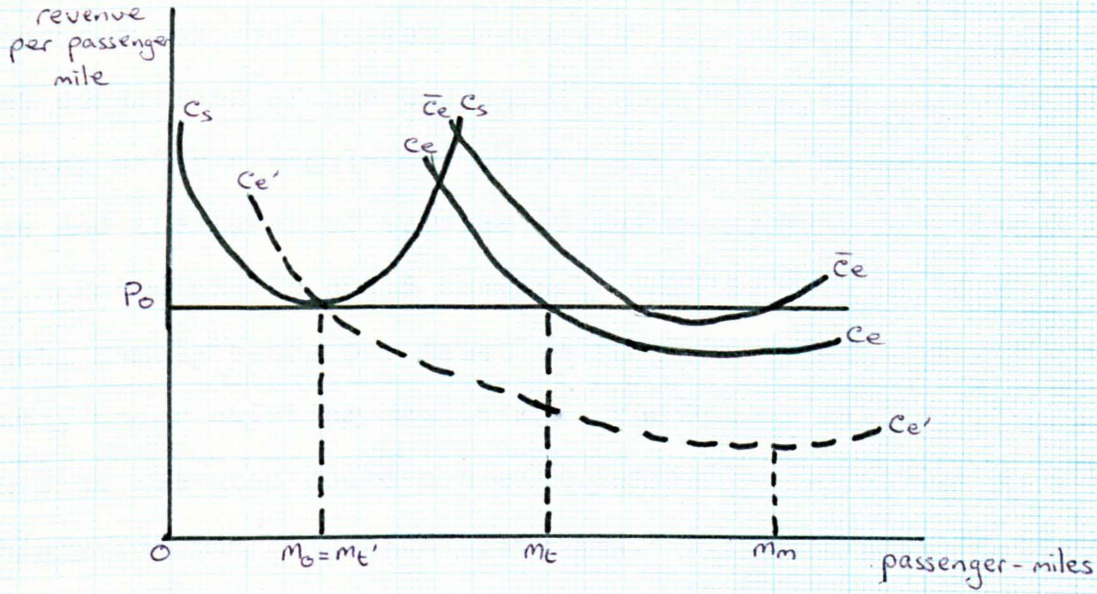

Figure .1.

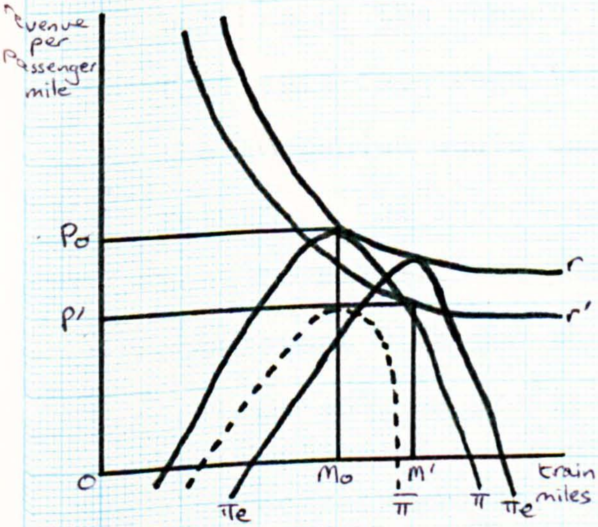

Figure .2a

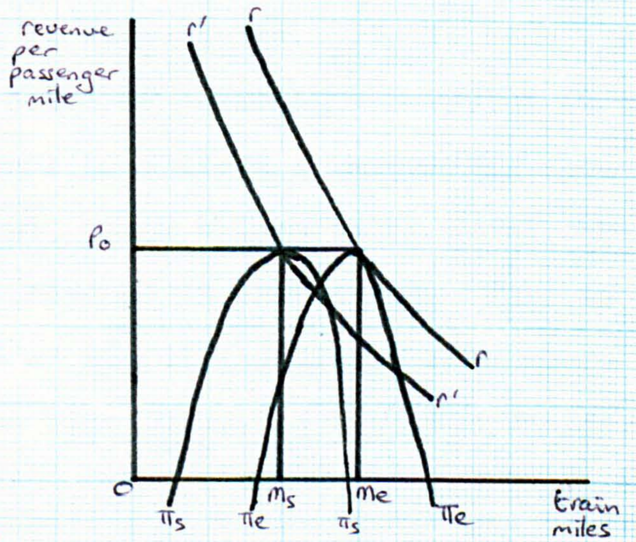

Figure .2b.

The main drawback with this graphical representation is that it does not take sufficient account of the widely differing market conditions of the companies. The Manhattan Elevated was operating under a regulatory constraint on the fares it could charge and the level of service it had to provide but within these constraints it could seemingly sell as many units of product, namely seats per mile, as it could offer. At the other extreme, under existing conditions, the Mersey Railway and the South Side Elevated could not earn sufficient income to meet the necessary returns on capital invested. Although none of the lines were competing amongst themselves for traffic, most were in an oligopoly or duopoly position, sharing traffic with some other form of transport.(1) What the companies did have in common was regulatory control over the fares they were allowed to charge although the Mersey was unable to charge these fares because of the competition it encountered. It has been assumed that this fare regulation acted as a profit constraint in that the companies would endeavour to achieve a reasonable rate of return on the investment and, other things being equal, then seek to maximise passenger revenue at that level. This is consistent with the theory of the oligopolistic firm where

> So long as profits are high enough to keep stockholders satisfied and contribute adequately to the financing of company growth, management will bend its efforts to the augmentation of sales revenues rather than to further increases in profits.(2)

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1. In London the position was more complex for the growth of motor bus companies in the early 1900s, with few restrictions, led to a situation more akin to imperfect competition.
2. W. J. Baumol: <u>Business Behavior, Value & Growth</u>, New York 1959, p. 50.

The graphical illustration of this is shown in Figure 2a. π is the profit curve of the company and r and r' are rate of return curves, showing the profit and output levels at which those rates of return can be achieved. Thus a company with profit curve π can either seek to maximise profits by aiming for rate of return r, in which case it will operate at Po Mo, or it can seek to maximise passenger traffic, subject to a minimum return of r', in which case it will operate at P'M'. (Although revenue per passenger mile is lower, fare levels are the same in both cases.) Curve $\bar{\bar{\pi}}$ would represent the position of the Mersey and District Railways, where minimum rates of return were not being attained.

Assume that the company is operating along profit curve π, giving a rate of return of r', with annual train mileage of M'. If it is to contemplate electrification two conditions will be apparent. Firstly, its profit curve must shift so as to meet a higher rate of return curve, to account for the interest charges on the capital to pay for electrification. Secondly, because of the much higher element of fixed costs present with electric traction, the profit curve will move to the right. Thus the curve π_e represents the new situation. In this particular case M' is once again shown to be the threshold, or point of indifference, because r is the minimum rate of return curve at which the costs of electrification can be met. Therefore, unless circumstances change, a change to electric traction is unlikely.

If, however, there is a rise in coal costs, these circumstances will be altered. If it is assumed that the company's prior objective will be to earn an adequate rate of return, then the train mileage will fall. The new situation is shown more clearly in Figure 2b. If Po is constant (fares do not change) the higher fixed cost element of electric traction means that a higher rate of return can be achieved and at a higher mileage (attempting to maximise sales) than is possible under steam. The important criterion for the company is that the difference between r and r' (Δr) should be large enough to pay for the annual charges on the cost of electrifying. To accept this and the first graph of the threshold, shown in Figure 1, it must be assumed that there was a relationship between passenger receipts and train mileage. If the figures in Table 4 are examined this can be seen to be reasonable - what is readily noticeable from the figures is the significant increase in train mileage but not in receipts following electrification. Thus the relationship would appear to hold. Similarly, in the case of the Manhattan Elevated, passengers rose from 194 million in 1900-01 to 215 million in 1901-02 (when the system was partially electrified) and 248 million in 1902-03 and thereafter grew steadily. (See Appendix 2 Table 2.) Before electrification they had never been higher than 219 million, reached in 1892-3. Such a growth in traffic would obviously imply increased train mileage and this lends credence to the argument given for electrification in New York; what is now needed is evidence to support the view that changes in costs accelerated or justified the change in Britain.

TABLE 4: PASSENGER RECEIPTS AND TRAIN MILEAGE UNDER STEAM AND ELECTRIC OPERATION FOR MAJOR BRITISH URBAN RAILWAYS

	MERSEY		METROPOLITAN		M.D.R.	
	Receipts	Mileage	Receipts	Mileage	Receipts	Mileage
1891	£62,637	238,488	£655,456	1,855,020	£416,803	1,367,686
1892	76,102	297,822	662,688	2,070,448	422,037	1,367,864
1893	72,856	290,981	654,730	2,142,309	406,163	1,351,343
1894	67,520	273,272	672,491	1,938,810	423,533	1,367,243
1895	68,504	279,166	672,201	1,980,781	421,762	1,377,604
1896	71,078	282,309	694,689	2,057,280	425,481	1,386,257
1897	71,537	283,702	724,825	2,196,383	439,528	1,385,984
1898	71,576	290,854	717,081	2,308,887	426,920	1,401,088
1899	73,867	307,966	743,648	2,278,738	428,402	1,401,647
1900	75,817	313,505	735,026	2,295,640	410,319	1,380,996
1901	70,051	311,360	681,746	2,276,486	372,416	1,346,722
1902	58,491	309,109	685,502	2,336,643	386,732	1,368,187
1903	66,864*	619,354*	696,006	2,398,838	385,334	1,539,584
1904	79,743	827,308	703,880*	2,535,524*	382,321	1,615,669
1905	84,025	829,898	711,377*	2,698,487	379,118*	1,885,055*
1906	90,643	829,188	669,397	2,806,189	413,252	2,426,317
1907	96,974	827,553	666,604	3,526,751	416,954	2,452,260
1908	99,946	811,773	709,903	4,097,371	483,758	3,022,128
1909	103,264	722,492	718,508	3,911,429	526,712	3,206,257
1910	105,555	662,785	741,883	4,077,737	573,935	3,415,514

*electric traction introduced over a significant portion of mileage.

Source: Board of Trade: Railway Returns

TABLE 5: ESTIMATED VALUE OF COAL (PRICE PER TON) BASED ON PITHEAD PRICES IN U.K., 1890-1911

1890	£0.41	1898	£0.32	1905	£0.35
1891	£0.40	1899	£0.38	1906	£0.36
1892	£0.36	1900	£0.54	1907	£0.45
1893	£0.34	1901	£0.47	1908	£0.44
1894	£0.33	1902	£0.41	1909	£0.40
1895	£0.30	1903	£0.38	1910	£0.41
1896	£0.29	1904	£0.36	1911	£0.41
1897	£0.29				

Source: Statistical Abstract for the U.K., nos. 52, 59 (1905, 1912)

TABLE 6: Threshold mileage for conversion of Metropolitan Railway to electric operation, assuming annual interest and depreciation charges of £112,000.

1895	2,149,712	1900	1,992,882
1896	2,814,070	1901	1,908,006
1897	3,002,680	1902	1,854,304
1898	3,284,457	1903	2,166,344
1899	2,466,960	1904	2,580,645

Source: Metropolitan Railway Records.

One factor would be coal costs as a rise or fall in the price of coal would affect the relative attractiveness of steam and electric power. While this contradicts Table 2 on page 85 which shows costs of power for steam and electric haulage to be similar, as did earlier evidence on the subject, by 1910 the Mersey Railway was able to produce figures showing that with electric traction one pound of fuel costing 8s. 9d. per ton moved one ton 2.29 miles at an average speed of 22¼ m.p.h. while with steam power the same weight of coal, but costing 16s. per ton moved one ton 2.21 miles at an average speed of 17¾ m.p.h.(1) Discounting the attractions that electric traction showed in energy utilisation and speed, the cost of coal showed a distinct advantage in using electric traction. Therefore, if coal prices generally were rising, as long as the cost of relatively cheap power station coal was not rising disproportionately, electric traction would look more attractive. Even if the price rise were only temporary it is feasible that management and directors, believing the rise to be of a longer term nature, might commit themselves to converting to electric traction.

While Table 5 shows a marked rise in coal value and therefore presumably cost, in 1900 and 1901 it seems highly dubious that this alone can have led to the decision to electrify. On the other hand, there is no evidence that, in Britain, high wages or substantial savings in the labour force were ever considered to be important on an overall basis. Indeed the total labour force of any given British company fell only marginally

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1. Joshua Shaw, Mersey Rly. Manager: <u>Electric Railway Journal</u>, vol. XXXV, 1910.

with electrification but their productivity would rise in terms of train-miles produced.[1]

In Britain at least, what would be important, rather than fluctuations in coal costs, would be the cost of electrification in terms of annual interest charges. If it is assumed that the net cost of electric operation was less than that of steam operation which is rational, for otherwise railways would be unlikely to consider a change then the threshold mileage will clearly be related to annual interest charges and the savings as a result of the change. Obviously any rise in coal costs would make electrification more attractive while any rise in the cost of borrowing would possibly delay it and evidence for both has been suggested in the previous chapter. The relationship can be expressed concisely in the simple form

$$k = M_t(s - e) \qquad (1)$$

where k = annual interest charge on capital for electrification

s = per train-mile running costs under steam operation

e = per train-mile running costs under electric operation.

s and e are functions of a whole series of costs such as coal and water used, wages, power station maintenance, repairs and cleaning.

1. For American companies the position was different. While one must be cautious about trying to make international cost comparisons, the proportion of costs going in labour charges was much higher in the U.S.A. while power costs were significantly less. On a direct comparison at any given time, wage rates for all classes of employees were usually twice as high as in Britain, whereas power costs - that is, the cost of coal - were only about half as much. (E. B. Dorsey: English and American Railroads Compared, New York, 1887; G. R. Blanchard: Address on Railway Pooling, Convention of the New York Board of Trade and Transportation, New York 26.10.1897). This should come as no surprise, given the Habakkuk thesis, but its implications will be discussed later.)

The attraction of the equation's simplicity is that it can be easily adapted to fit any company. The major flaw is that electric running costs will include a far higher element of fixed costs and will therefore continue to decline on a train-mile basis after steam running costs have started to rise and this will not be sufficiently taken into account.

However, if the model is used on the basis of forecast costs, the results are quite effective. For the Mersey Railway, the equation is

$$£24,800 = M_t(15 - 6.75) \qquad (2)$$

$$\text{or } M_t = \frac{5952000^*}{8.25}$$

This gives a threshold mileage of 721,454, which although considerably above the mileage operated at any time under steam traction, was exceeded in every full year of electric operation. This implies that not only was the company operating as near to the optimum mileage as possible previously but also that the high fixed cost element of electric operation was appreciated. The equation makes no allowances for any increases in passenger receipts but for urban railways an increase in the frequency of service such as this obviously demonstrates would in itself attract more passengers. The main limitation of the equation is that no account is taken of the depreciation of the equipment. Three different factors must be accounted for here: wear and tear resulting from the level of use, wear and tear due to exposure to the elements, which is essentially a function of time but related to the maximum capacity for which the equipment is provided, and anticipated changes in future demands.(1)

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* Railway News: Vol. LXXVI (28.9.01), p. 465.

1. Ponsonby: 'Depreciation with Special Reference to Transport', Economic Journal 1956.

No satisfactory rules exist for electric railway depreciation though tramway depreciation was adequately covered. In Britain track was written down at differing levels depending on the intensity of service, rolling stock could be depreciated at 7% annually and general plant and machinery at 5%. In the U.S.A. however, rolling stock was depreciated over twelve to thirty years, with the scrap value of the car varying from 20% of cost to nothing.(1) However, the British depreciation rate of 7% for tramway rolling stock is insufficiently precise for our purposes although equipment can probably be written down over twenty years in a straight line - that is, at a constant level of depreciation. For rolling stock some allowance must be made for the intensity of its use and this is done by using the 'load factor'. This is a constant figure defined as the average load per train and varies therefore from company to company. The problem with its application is in gauging the total proportion of capital affected by it - should it only be applied to the cost of rolling stock or also to the cost of generators and other equipment? A further problem is in seeking to ascertain its value, as to be accurate it should be based on the average occupancy level of all trains. Ideally, using the load factor, the equation for establishing the threshold would be

$$r\left(K + \frac{kM}{\lambda}\right) = M_t(s - e) \qquad (3)$$

where K is the new fixed capital, kM is the new capital which would be affected by the load factor λ and r is the rate of interest. The idea of the load factor is important, for as it becomes smaller, so the savings in working costs through the use of highly efficient

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1. Electric Railway Journal: vol. XXXIV (1909), pp. 476, 839.

plant would become steadily less important. Unfortunately, however the issue of depreciation is treated, the effects are very different. Any increase in the actual annual cost for the Mersey Railway would increase the threshold to impractical proportions, although in the case of the Metropolitan it would take the figures to a higher level but nearer the actual annual mileage after electrification. The problem is that no account is taken in the model of anticipated growth in passenger revenue, which would help to reduce the difference. Although this can obviously be made on an ex-post basis there can be no real indication of the accuracy or otherwise of ex-post estimates. As it stands therefore, the model is crude and limited but fairly effective. If, for example, the figures for the Thames Iron Works' proposals for Inner Circle electrification are used, the threshold mileage is 3,317,972, on the basis of Metropolitan Railway costs. For all its limitations, the model does reveal the effect of changes in coal prices on the threshold, as Table 6 shows.

The annual capital charge was arrived at as follows. Although the actual increase in capital over the period was over £3 m. the net cost of electrification was approximately £1.3 m., £352,000 of which represented the cost of motors and generating equipment.(1) All new capital was raised on 3½% Debentures. For depreciation, the km/λ notation was used for the £352,000 on capacity affected stock. The remaining capital was depreciated

1. Metropolitan Rly. Records, Acc. 1297/MET 1/66.

in straight line form, using David's method over a twenty year period.(1) The somewhat clumsy equation used, therefore, was

$$(d + 0.5(r))\, K_o + r.\frac{kM}{\lambda} = M_t(s - e) \qquad (4)$$

where d is the rate of depreciation. With figures for charges substituted, the equation becomes

$$(0.0675)1000000 + \frac{0.035.352000}{0.275} = M_t(s - e) \qquad (5)$$

The figure of 0.275 for the load factor was derived by multiplying train mileage by average train length and dividing by number of passengers for the observed results in the first year of electric operation. The figures for (s - e) have been substituted by taking the actual train mile operating costs for the relevant year and subtracting the nearest contemporary estimate of electric operation. If the figures are compared with the actual annual mileage shown in Table 4 the result appears reasonable.

In the U.S.A. the effect of coal costs was much less significant. In 1904 about 86% of the total cost of moving a ton-mile went in investment and fixed charges represented by the equipment and maintenance of a single mile of railway and for steam railways, of every $100 in earnings, only about $7 went in fuel.(2) By itself, this would greatly extend the threshold for existing railways, demonstrating further that the reason for the change on the Manhattan was due to increasing the capacity. In the first six months of electric operation, traffic grew by 13.8% where it had previously stagnated. In addition to a growth in receipts, however, operating expenses fell by $115,921 in the

1. P. A. David: op. cit. p. 30.
2. H. Ward Leonard: Electric Railways - International Electrical Congress 1904, op. cit.

same six months. The changeover was estimated to have cost $7.2 m. and the overall improvement in results was equal to 28% on this additional capital. The new capital was all raised on ordinary stock, so that calculating the actual cost to the Manhattan company is impossible, but earnings were equivalent to 8.56% on the capital stock of $55.2 m. as opposed to 6.93% on $48 m. in 1902.(1)

The relatively low fuel costs in America would tend to make the threshold idea of limited relevance there and this tends to be borne out by evidence from the early experimental electric lines. In 1896, for example, the New Haven Railway equipped its Nantasket Beach Line with electric traction using General Electric equipment. While the railway company was pleased with the success of the trials, no significant saving in the overall use of coal was achieved. Previously the two steam locomotives on the line used four tons of coal each day and the same amount was consumed in generating electricity for the branch.(2) Coal costs may have been a factor in the timing of the changeover certainly, but not a major one - certainly not in America. If it was a factor, it was certainly more important in Britain but even there it cannot be used to defend railway management and directors from the traditional accusations of conservatism. The clearest example of this, insofar as it directly affected urban railways, was in a discussion over the positioning of conductor rails on electrified tracks.

1. Railway News: vol. LXXX (1903) p. 775.
2. ibid. vol. LXVI (1896) p. 68.

In early 1903 - by when the commitment to electrification had already been made by the urban companies - the (English) Great Northern Railway announced that it was actively considering electrifying its suburban lines and contacted the Metropolitan Railway for details. The Metropolitan's reply did not exactly support the theory that close analysis of fuel costs might have influenced the company's directors in their decisions:

> You will understand that we are committed to electricity for a certain portion of our line whatever it may cost ... We have no very precise information of what the cost altogether of equipping the line will be but as you know we are bound to have electricity and the only thing we can look after is to get it as economically as possible.(1)

The Great Northern went on to suggest that a conference should be held of all railway companies with electrification plans, so as to adopt a uniform system, common to all the companies. They suggested that the Metropolitan should arrange such a meeting, so it was duly arranged to coincide with the District Railway's half yearly meeting, somewhat limiting its effectiveness. In due course another meeting was arranged at which discussions centred round the positioning of conductor rails as the other key features - current and voltage - were already unofficially taken as standard. At yet another meeting twelve companies being basically all those interested in electric traction, between them suggested three different positions for the conductor rail, all of which differed from that on the Mersey, which was the only one of the companies actually to have commenced electric working.

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1. Letter from A. C. Ellis of Metropolitan to Sir Henry Oakley of G.N.R., February 1903, Acc 1297/MET 10/68.

The Metropolitan's engineer pointed out that even if common measurements were adopted, differences between the various companies would still prevent through running of trains. The conference did conclude with a recommended position for the live rail but it differed from the position adopted on the Mersey Railway whilst the Metropolitan, District and two other companies refused to adopt it, despite the fact that the Metropolitan's consulting engineer and contractors both supported the recommended measurements. The Great Western Railway attempted a compromise by suggesting the use of a moveable contact shoe, enabling their stock to work over both systems but this was rejected by the Metropolitan as potentially time-consuming and dangerous. Unsurprisingly the conference was hailed in the press as a vindication of railway managers' lack of enterprise and antipathy to moving with the times.(1) In fairness to the British managers, however, American practice in this matter was equally diverse.

Thus, while evidence for the often argued conservatism of British railway boards it apparent, it would also appear, from the figures available, that investment in electric traction would have brought about only a marginal reduction, if any, in power costs before 1900. On the other hand, the significant reduction in other costs, not to mention the likely increase in passenger traffic, should have been sufficient to demonstrate the value of electric traction. In the U.S.A. however, power costs were much lower for both steam and electric traction. Here it appears to have been the development of multiple unit control that inspired

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1. Letter to A. C. Ellis, 2.3.03 - Acc 1297/MET 10/68.

the change, both for the tremendous improvement in operational flexibility and the reduction in costs it brought. In Britain, the multiple unit system, while welcomed, does not appear to have been important in the change. Instead, there was a general feeling that electricity was still impractical and would show few savings in costs and this feeling undoubtedly delayed development, even if only marginally. In addition, there were two very important factors. One was the growth in surface omnibus and tram traffic and the other was the actual availability of electrical equipment from suppliers. It was no coincidence that the major electrification programmes in Britain should have followed so soon after the two major American electrical manufacturers had established works in the country. This therefore suggests consideration of two further issues: firstly the success or otherwise of the electrical manufacturers, secondly the attitude of railway management to further innovation after electrification - was electrification merely a 'once for all' innovation or did it pave the way for a series of subsequent improvements in operation?

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Taking the first of these, the success or otherwise of the electrical manufacturers is worth analysing for a successful manufacturer would obviously influence railway management more easily and would presumably have easier access to capital markets for finance. More noteworthy still is the success that General Electric (GEC) of America, as subsequent owner of the Sprague multiple unit patents, had as opposed to its rivals.

By 1903 there were still only four lines in Britain (the CLR, GN&CR, Mersey and the North Eastern Railway) with a firm commitment to multiple unit operation. In all of these cases except the Mersey, GEC equipment was used. In the whole of Europe at this time, five railways were being equipped with GEC multiple unit equipment while in the U.S.A. no fewer than twenty-one lines had adopted such operation, only one of them using equipment produced by GEC's major rival, Westinghouse. This company was the Brooklyn Elevated, which chose its equipment after conducting tests of a rather rudimentary nature, which engineers from both Westinghouse and GEC agreed were unreliable but which the general manager of the Brooklyn Rapid Transit sytem insisted upon. These involved races between cars equipped with different motors and then a tug of war between them. The Westinghouse motor had the better gear ratio, better commutation and better temperature characteristics for tests of this nature and they were awarded the contract. Having equipped their street cars thus, the company were presumably content to equip their elevated trains with motors from the same source.(1) Both the District Railway in London and the IRT in New York conducted tests of rival equipment before opting for contracts with GEC but no details of these tests appear to have survived.(2)

While the majority of the American lines that had ordered multiple unit equipment were little more than glorified tramways the seven most important lines had a total of 1823 multiple unit fittings, of which only 74 (4.05%) were by Westinghouse.(3) All

1. H. C. Passer: op. cit. p. 270.
2. Barker & Robbins: op. cit. Vol II, p. 107 et seq.
3. Railway News: vol. LXXIX, (March 1903), p. 528.

these were accounted for by the single Brooklyn order. The breakdown of American and European orders for multiple unit equipment at this time is given in Table 7. As almost 50% of major orders in America were accounted for by the Manhattan Elevated, the significance of this contract is apparent. Even if all the American lines are taken together, they represent far from all the American electrification projects, and if European projects are taken, their importance is further reduced. In the case of the Prussian Railways the equipment was provided by the main contractors (UEG) but in all other cases listed here, the local Thomson Houston company (Thomson Houston being the subsidiary in the relevant countries of GEC) was awarded the contract.

However, the relative importance of multiple unit control in Britain is to some extent a reflection of the low overall rate of electrification, which was mainly confined to urban and suburban conditions where multiple unit control also happened to be most valuable. A study of developments in electric traction in Europe to 1907 revealed not only the dominance of European firms (Ganz, Brown Boveri, Oerlikon, AEG, UEG and Siemens & Halske) but also the relative absence of multiple unit control systems in the schemes.(1) This tends to underline the fact that although nominally equipment might be similar in terms of motors and power supply, the needs of lines varied enormously and unlike tramways, where standard motors could be supplied, contracts were still largely filled on an individual basis. This is underlined by the comparative data for various railways given in Table 8.

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1. Parshall & Hobart: Electric Railway Engineering, London 1907, p. 375.

TABLE 7: ADOPTION OF MULTIPLE UNIT SYSTEM IN U.S.A. AND EUROPE, 1903
(only major American lines are included but all other American lines adopted the GE system)

General Electric			Westinghouse
Interborough R.T., New York	-	340 units	Brooklyn Elevated - 74 units
Manhattan Elevated, New York	-	900 "	
Boston Elevated	-	150 "	
South Side El., Chicago	-	200 "	
North Western El., Chicago	-	67 "	
Brooklyn Elevated	-	54 "	
Aurora, Elgin & Chicago Rly.	-	38 "	
Central London Rly.			Mersey Rly.
Great Northern & City Rly.			
North Eastern Rly.			
Prussian Rlys.	-	18 units	
Western Rly. (France)			
Orleans Rly. (France)			
Mediterranean Rly. Co. (France)			
Athens-Piraeus Rly. (Greece)			

In addition, the Metropolitan District Rly. in London was conducting trials with both Westinghouse and GEC equipment (it subsequently ordered GEC equipment) and the Metropolitan Rly. in London initially ordered Westinghouse equipment.

Source: Railway News, March 1903, p. 528.

TABLE 8: COMPARATIVE ROLLING STOCK DATA, ELECTRIC RAILWAYS

Line	Seats per Train	Length of train (feet)	Weight (Tonnes) (Loaded)	Seats per foot	Loaded Weight per foot	Seats per Tonne (Loaded)
Mersey Railway	292	300	138	0.97	0.46	2.10
Manhattan Elevated (4 motor cars, 2 trailers)	286	282	125	1.01	0.44	2.29
GN & CR 7 car train	422	355	195	1.19	0.55	2.16
CSLR 4 car train & loco.	128	141	41	0.91	0.35	3.12
Liverpool Overhead Rly.	57	45	38	1.27	0.84	1.5
Metropolitan El. Chicago	40	40	-	1.00	-	-
CLR 7 car train	324	330	133	0.98	0.41	2.42
Met. (London) 6 car train	322	320	165	0.99	0.52	1.95
District Rly. 7 car train	328	347	160	1.06	0.49	2.05
Waterloo & City 4 car train	220	164	72	1.34	0.44	3.06

Source: Parshall & Hobart: Electric Railway Engineering, London, 1907, p. 14.

TABLE 9: CONTINUOUS CURRENT MOTOR EQUIPMENT EMPLOYED ON TYPICAL RAILWAYS

Line	Scheduled speed, mph, inc. stops	Stops per mile	Weight of Train (Tonnes)	Rated Horse-power of Motors per Tonne Weight of Train
Metropolitan District	15.7	2.1	175	6.8
Manhattan Elevated	14.7	3.0	127	7.9
Interborough RT	16.2	2.6	162	7.4
Liverpool Overhead	19.0	2.5	55	7.3
Central London	14.0	2.1	120	4.2

Source: Parshall & Hobart: Electric Railway Engineering, London, 1907, p. 91.

The different designs of stock for each railway are apparent from the varying figures although it is noticeable that the highest seat to weight ratio was achieved by two of the earlier lines, the CSLR and Waterloo & City. However, it should be noted that seat capacity bears little relation to overall capacity and in this sense the figures are only a rough guide. Indeed, fewer seats in a coach would - usually - mean more room for standing passengers, thereby maximising loading capacity during peak travelling hours. Taken with the figures in Table 9 however, the operating differences of the various railways are underlined. Table 9 alone would tend to suggest that conditions were similar, but of the lines in Table 8, only the L.O.R. did not use GEC equipment. The evidence would suggest that GEC were probably nearer to the production of standard railway equipment than other manufacturers. This would be partially explained by their early success and would help to explain their continuing successes. It is significant that although the New York subway did hold trials between GEC and Westinghouse equipment, the contractors and engineers were having discussions with GEC as early as 1900.(1)

Subsequently, evaluation tests of a more sophisticated nature than those undertaken in Brooklyn were carried out in London in 1911 between District and Metropolitan Railway trains to establish each company's current consumption over the Inner Circle, for the purposes of compensation and payment. Tests in 1909 had shown that the Metropolitan trains, which mostly used Westinghouse equipment, used rather more of the current than the

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1. W. B. Parsons: Diaries, 29 May 1900.

GEC equipped District ones and this led the manager of the Metropolitan to suggest that the issue should be dropped. As the question had arisen through their claim for compensation following the apparent revelation that District locomotive-hauled trains consumed up to 12.3% more current than Metropolitan trains did on Circle trips, the District, not unnaturally, refused to drop the matter.

Therefore detailed consumption tests were carried out in late 1911, the results of which are shown in Table 10.[1] In terms of energy consumption alone the British Westinghouse (BWEM) trains were inferior, using up to 20% more current than a standard District train. The reasons for the District adopting GEC (British Thomson Houston) equipment are not known, but if their earlier equipment trials had produced similar results, this alone would have been a powerful reason. Apart from the Mersey Railway, the Metropolitan was the only British company to order Westinghouse train equipment, although several (including the District) did order Westinghouse generating equipment.

In terms of energy consumption, the superiority of BTH (GEC) equipment over Westinghouse equipment, at least on the Inner Circle, is apparent. However, if this superiority manifested itself in other ways, one might reasonably ask how Westinghouse managed to obtain orders at all. Part of the explanation lay in GEC's holding of the Sprague patent for multiple unit control -

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1. Metropolitan Rly.: Inner Circle Current Consumption Tests; Acc 1297/MET 10/104.

TABLE 10: INNER CIRCLE CURRENT CONSUMPTION TESTS OCTOBER-NOVEMBER 1911

	METROPOLITAN		DISTRICT
	BTH train 1 motor, 3 trailers	BWEM train 2 motors, 2 trailers	Standard train 2 motors, 2 trailers
Weight of train	112.65 tons	124.65 tons	97.16 tons
Total running time	45m. 48 secs.	42m. 57 secs.	42m. 50 secs.
Average stops (signals)	20 secs.	24 secs.	23 secs.
Total current consumed	103.2kw. hrs.	115.2kw. hrs.	83.38kw. hrs.
Mean current consumed (2 trips)	100.7kw. hrs.	118.28kw. hrs.	93.97kw. hrs.
Watts/ton-mile	70.0	70.5	65.7
Kw.hrs./car-mile	1.971	2.198	1.595
Mean Kw.hrs/ car-mile	1.921	2.257	1.794

Source: Metropolitan Rly.-Inner Circle current consumption tests, Acc 1297/MET 10/104.

while Westinghouse would be unlikely to admit it, their own control system was generally accepted to be somewhat inferior - but in Britain at least, Westinghouse obtained orders by quoting tenders that were consistently cheaper, with quicker delivery dates promised, than those of other companies and even, as in the case of the Mersey, by providing the capital for electrification. Unfortunately, the BWEM contracts were usually of a substandard quality and the company soon acquired a reputation for late delivery and shoddy workmanship. Having built new works at Trafford Park, Manchester, twice the size of the original plant in Pittsburgh, the company was naturally anxious to obtain orders to fill the new plant. Before the plant was even complete, however, the problem of late deliveries had arisen. While the Pittsburgh plant was still supplying the British market an upturn in the American economy at the turn of the century had led to a waiting list for overseas orders. By the time the Trafford Park works were open, any boom in the British economy from tramway electrification (in anticipation of which the enormous works had been planned) was largely over. Therefore, in a desperate attempt to obtain orders, BWEM quoted contracts which undercut those of other suppliers. Desperate to improve their cash flow, the work was turned out as quickly as possible, almost always to the general dissatisfaction of the purchaser. The Mersey, the Metropolitan and Underground Electric Railways of London (UERL), in whom the District was amalgamated, all had complaints against BWEM which ended in arbitration and in the Metropolitan's case very nearly to the complete cancellation of the contract.(1)

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1. Metropolitan Rly.: Electric Traction Committee Minutes Books 1-3, Acc 1297/MET 1/66.

In the first five months of electric working on the Mersey alone, 134 faults caused delays to trains. Particularly serious was the faulty working of the Westinghouse multiple unit control system which on six occasions failed to switch off the current, leading to at least one fairly serious accident. Similarly, the Metropolitan gave formal notice in late 1905 that unless the motors and trailers were brought up to standard in three months, they would be rejected. (This notice was subsequently extended by three months.) The Mersey eventually opened for electric working on 5th May 1903 and electric working on the Inner Circle was partially inaugurated on 1st July 1905, although the Metropolitan had by then been running electric trains between Baker St. and Harrow for some months.[1]

Westinghouse's difficulties in Britain were compounded by the relative slowness of the adoption of electric traction in other sectors of the railway industry, where the uptake of electric traction would provide a further market. Indeed, Westinghouse was quite successful in winning such orders in the American market and had such orders been forthcoming in Britain, their position might have been easier. In America, the original 96 ton locomotives of the Baltimore and Ohio Railway were joined in 1903 by a 150 ton version which GEC claimed was the largest electric railway engine in the world. It was, in effect, two separate engines, with a total of four motors, joined together as an articulated unit and run on Sprague's multiple unit system.[2] Although such a design incorporated little, if anything, in the way of new technology, existing GEC production

1. ibid.; Barker & Robbins: op. cit. II, p. 107; Mersey Rly. Reports on BWEM contract; ERJ vol. XXXVII (1911) p. 218.
2. Railway News: vol. LXXX (September 1903) p. 474.

line motors being used, by 1910 over sixty such locomotives had been supplied by GEC to railways in the U.S.A., and one to France. Westinghouse, who favoured alternating current, had provided some 73 locomotives, using one or other current systems, to three American companies by the same date.(1) In Europe too, companies were tending to become identified with a specific form of traction, the most notable example being Ganz and the three phase system. Single phase was one of the more popular systems, with AEG having provided 245 such motor cars or locomotives and Siemens 188 by 1911.(2) Although single phase and three phase systems did not survive long in terms of popularity, they are a reflection of the steady technical progress that was taking place in the electric traction field. In turn this is a reflection of the initial demand for railway traction equipment, leading to further developments, and of the ensuing demand for further electric traction equipment.

After the electrification of high density urban rail systems, the next major field for electrification was seen as main line tunnels or mountain worked lines. Thus, in America, with the notable exception of the main line electrification of the New Haven Railway, most other orders were for short stretches of electrified line, either in and out of major termini or through tunnels. In Europe, there was much greater electrification of main lines but in Britain main line electrification before 1914

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1. Electric Railway Journal: vol. XXXVI (July 1910) p. 13.
2. ibid. 'Single Phase Railways in Europe', vol. XXXVIII (1911).

was almost non-existent. This is clearly revealed in the rate of adoption of single phase traction. By November 1908, including interurban installations, there were 966.5 miles of single phase electrified line in the U.S.A., 662.5 of them equipped by Westinghouse, operating 236 motor cars and 66 locomotives. In Europe there were 877.5 miles of such line but only 18 of these were in England.(1) Even by 1911, only seventy-five of the 433 single-phase traction units in Europe were used in Britain, on just two lines - the Midland Railway and the London, Brighton & South Coast Railway. Thus the market for traction equipment generally in Britain was considerably smaller than in any comparable country, for whereas in the U.S.A. the early success of electric traction on urban railways was rapidly followed by at least limited main line electrification, this was not the case in Britain.

When electrification was undertaken in Britain, it was usually suburban in nature and frequently in response to the growing competition from short distance electric tramways, this being the case both with the North Eastern Railway's Tyneside electrification, started in 1902, and the London, Brighton & South Coast's South London scheme of 1909. Both these were successful, yet uptake of electric traction was limited. To some extent this must have been a reflection of the increasing export of capital, making the raising of new capital a problem

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1. ibid. vol. XXXII (November 1908) p. 1423.

of timing, as has been suggested.(1) It is noteworthy in this respect that the rate of electrification was beginning to grow again, prior to the outbreak of World War I but other factors are also important. Although British railway management conservatism is a likely (and popular) factor, the Lancashire & Yorkshire Railway was one of the earliest 'main-line' companies with a large-scale electrification project - that from Liverpool to Southport. However, apart from some short distance projects in the Manchester region, the company embarked upon no further schemes. Although boardroom divisions in the N.E.R. may have delayed further progress there, especially after Sir George Gibb left to join the UERL group in early 1906, there is no evidence that such a situation also prevailed on the L. & Y.R.(2) Clearly, further study of the factors behind early railway electrification in Britain is needed. Before leaving this subject, it is worthwhile noting that contemporary attitudes towards it felt that in America

> in many if not most cases, electrification is looked upon in the light either of a necessity to avoid combustion in tunnel operation or of a luxury for which the suburban passenger or the city resident must pay ... But by the steam railroads in the British metropolis electrification is considered

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1. R. J. Irving: 'British Railway Investment & Innovation 1900-14, with special reference to the N.E.R. & L.N.W.R.' - Business History, vol. XIII (1971) p. 57; B. Thomas: Migration & Economic Growth, 1954, pp. 22-30.
2. George Gibb, as manager of the North Eastern Railway, was one of the most progressive railway managers in the country and was largely responsible for the N.E.R.'s electrification schemes. His resignation in 1906 was apparently at least partially due to tensions between himself and the Board over improvements.

> more as a means of salvation from present difficulties, involving sacrifices it is true, but providing perhaps the only way by which these roads can win back the fickle commuter and the short distance rider and can restore the suburban traffic to its old standards.(1)

Another possible factor in the reasons for the slower rate of adoption of electric traction in Britain may have been the price of coal. After the rise in prices around the turn of the century, the price of coal fell somewhat, although subsequent price increases, coupled with improvements in power generation technique meant that by 1914 the relative attraction of electric power was increasing, as was the number of new electrification schemes. Coupled with relatively low labour costs compared to America, the overall advantages to be gained from electric traction may not have appeared too obvious to most British railway directors. However, the rate of electrification was lagging not only if compared with the U.S.A. but even, as one engineer pointed out, compared to Germany, Japan and even the colonies.(2)

Again, some of this progress could be explained by the cost and availability of coal. Italy, for example, was an early leader in construction of single-phase electrified railways largely because the lack of natural resources meant that all

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1. Electric Railway Journal: vol. XXXVII (1911), p. 362.
2. Railway News, vol. LXXII p. 709 - Sir Douglas Fox in an address as President of the Institute of Civil Engineers.

coal had to be imported, whereas electrified lines could use domestic hydro-electric supplies. One other significant factor was the availability of capital. The next chapter covers this in more detail, but basically by 1900 it was becoming increasingly difficult for railways to borrow in the capital market and therefore there was increasing reluctance to commit money for new projects. Against this, prior to 1900, rapid increases in passenger growth had led to the railways spending large amounts of money on improving passenger services.(1) Much of this was spent on improvements in suburban traffic operations and it might have seemed logical to electrify a number of lines as part of these overall improvements. That it did not appear so, especially at a time when coal prices were rising, means that the finger of blame returns once again to the railway directors.

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Development of suitable equipment was not confined to electrical engineering but included factors such as rolling stock design. The changes in attitude regarding what was considered to be the best form of design are important. In Britain, the adoption of the American style cars, with gates at either end of each carriage, opened and closed by conductors travelling on the cars, was adopted initially on the CSLR and subsequently copied by every other line, except the LOR, where

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1. R. J. Irving: The North Eastern Railway Co. 1870-1914, Leicester 1975; A. K. Cairncross: Home and Foreign Investment, 1870-1913, Cambridge 1953.

the traditional series of doors along each carriage side was adopted. Initially, the intention was undoubtedly to follow a similar pattern on the Interborough subway, and to run trains of a size similar to those then in use on the Manhattan Elevated. Had this been the case, many of the advances made possible through the building of a large subway, with adequate public capital, designed for intensive operation, would have been negated. If platforms had been designed for five car trains, as was at first mooted, the capacity of the subway would have been greatly reduced, owing to the limited train length and the time taken in loading and unloading at stations. Fortunately, largely through the foresight of the city's engineer, Parsons, this was avoided. He successfully made representations to omit the end platforms for the gates from the cars and to instal sliding doors in the sides of each car instead.(1) Similarly, the proposed length of trains was increased from five to eight cars, despite which there were soon capacity problems, leading to further alterations.

Parsons' far-sighted attitude was also influential in persuading the subway to use carriages built of steel from an early date although steel cars also quickly found favour for the London lines, because of the reduced fire risk that they represented. Parsons' influence notwithstanding, however, the New York subway, along with the Boston Elevated, used wooden

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1. W. B. Parsons: <u>Diaries</u>; op. cit. 13 November 1900, 30 December 1901. W. B. Parsons (1859-1932) was chief engineer of New York City Transit Commission 1894-8 and subsequently engineering consultant for the Panama Canal and several other projects. Scribner's <u>D.A.B.</u>, op. cit. p.758.

bodied cars originally, although a prototype steel car was produced for the subway in December 1903. They were not adopted at the outset in New York because of the refusal of American works to construct them at the time, due to congested order books.(1)

Despite this, the urban railways generally were pioneers in the use of steel carriages and this development, in its way, was of almost as much significance as progress in electric traction. This is shown in the weight of electric trains, which although in some cases was a function of the strength of the elevated structure, was even more a function of early electric technology. The first trains on the CSLR weighed 35 tons, while those on the first three electric elevated railways - the LOR, the Metropolitan (West Side) and the Lake St. all weighed 40 tons. The impact of multiple unit control is apparent, with the overall weight of South Side trains jumping over 50% of this figure to 65 tons. Reflecting the much greater passenger demand, the Manhattan trains were heavier still, at 85 tons. In contrast, weight problems for the underground lines were far less of a problem, jumping from the 35 tons of the CSLR to 105 tons for the Waterloo & City and 150 tons for the original CLR trains.(2)

The weight of the original CLR trains is mainly a reflection of the heavy and unpopular locomotives used initially,

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1. Interborough Rapid Transit: The Subway in New York - Its Construction and Equipment; New York 1904, pp. 131-2.
2. Metropolitan Railway: Acc 1297/MET 10/74 (April 1900).

but the adoption of steel cars made such a weight seem almost trivial. A 5 car train of steel bodied coaches on the IRT would weight 150 tons, while the more usual 8 and 10 car trains weighed 242 tons and 312 tons respectively.(1) Even on elevated lines there was a marked increase in weight, the Brooklyn Rapid Transit operating 6 car trains weighing 158 tons, and when it won the contract for building and operating a new subway system in New York in 1914, the new designs called for the operation of 8 car trains weighing 304 tons over the elevated structure.(2) The significance of steel cars lay not only in the weight, however, but also in the cost and design of cars.

At first glance the cost of steel cars appeared enormous, a Chicago Elevated steel car costing some $11,000 in 1914 and one of the new New York cars of the same year $15,000. Against this have to be set the not insubstantial savings that accrued. Steel stock could be expected to have a longer life and maintenance costs were also reduced, the average car maintenance costs on the Hudson & Manhattan being just 1.48 cents per car mile for the years 1910-13.(3) However, of greater significance was the change in design permitted by the new material. The greater strength of the material meant that doors could be incorporated in the body without unduly weakening the structure. As a result, a movement away from the end gates, in line with Parsons' original thinking, was possible. In the period under review, the ultimate in car design was reached with the new cars

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1. Electric Railway Journal: vol. XLIII (1914) p. 1266.
2. ibid. vol. XLIV (1914) p. 1234.
3. ibid. vol. XLIV (1914) p. 159.

for the New York Municipal Railways (thenew Brooklyn Elevated subway system) introduced in 1914. There was the additional advantage here that in planning an entire system from first principles, larger stock than hitherto used could be designed, and full advantage wastaken of this. Thus cars with an overall length of 67 feet were designed for this new subway, soon to be followed by cars of 69½ feet for the new Cambridge subway in Boston. This compared with existing car lengths of 49 feet on the Brooklyn Rapid Transit, 52 feet on the IRT and 48 feet on the Hudson and Manhattan.[1]

By using side doors instead of end doors the car could be split up into sections to take passengers more evenly. The overall results of such planning were that a car could be designed with higher passenger capacity, but a greater number of doors giving faster entry and exit. Comparisons are given in Table 11, which shows the considerable progress made by the 1914 design cars, compared with earlier cars. A much greater number of passengers were carried, whilst actually reducing the distance from the entrance. The most significant saving in this respect was over the Brooklyn stock, where the traditional car-end entrances were still used. The greater capacity of the cars could mean the adoption either of trains of fewer carriages or of reduced frequency, leading, it was estimated, on comparisons with existing Brooklyn stock, to savings of about $200,000 annually in train wage costs, whilst increasing the ultimate track capacity by 20% to 25%. It was further found that the maximum capacity of six hundred of the new cars,

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1. ibid. vol. XLIII (1914) p. 1263.

costing $9 m., would require 1070 Brooklyn Rapid Transit cars which would cost $13.4 m., or about 900 IRT cars costing $10.98 m.(1) Effectively there would also be a saving in the energy consumption per passenger carried.

Because of the increased width and length of the cars such a car design could only be incorporated at the planning stage of any new line, another example being the large cars built for the opening of the Cambridge subway in Boston. However, the rather conservative design of the Hudson and Manhattan cars prompts further examination of this particular company. The adoption of such relatively small cars is in large measure explained by the earlier work on the tunnels, which at one stage had been planned for tramcar use. By adopting multiple unit trains instead, higher speeds were possible but this was countered by heavier gradients and sharper curves than would have been the case had the tunnel alignment been planned for railway operation from the start.(2) The major innovation in tunnelling adopted for the Hudson tubes involved the use of shields and high pressure jacks. It was found that using high pressure jacks, the shield could be pushed forward at a rate of one-half of an inch per minute, without the need to excavate any silt.(3) This considerably increased the rate of progress. However, the general construction techniques did not differ markedly from existing practice. As with all other new electric lines, automatic signalling was adopted by the Hudson & Manhattan.

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1. ibid. vol. XLIII (1914) p. 1267
2. C. M. Jacobs: 'The Hudson River Tunnels of the Hudson & Manhattan R.R.Co.', Minutes of the Proceedings of Institution of Civil Engineers, vol. CLXXXI, 1910, p. 10.
3. ibid.

TABLE 11: COMPARATIVE CAR DESIGN, 1914
(Latest Stock in Each Case)

Company	Total Passengers per Car	Per Cent of Train Length taken by doors	Average Distance to doors per passenger (ins.)
Boston Elevated	266	16.2	91.6
New York Municipal Rly.	270	22.8	83.6
Brooklyn R.T. Elevated*	154	12.2	146
Interborough	169	24	90.5
Hudson & Manhattan	158	20.4	87

*Wooden bodied, steel framed, stock.

Source: Electric Railway Journal, vol. XLIII (1914) p. 1263.

TABLE 12: HOURLY CAPACITY COMPARISONS, VARIOUS RAILWAYS, 1910

Company	Cars/Train	Trains/Hour	Total Cars/Hour
Manhattan Elevated	7	60	420
IRT Subway	8	32	256
Hudson Tunnels*	8	40	320
Brooklyn Elevated	6	60	360
Boston Elevated*	8	35	290
Union Loop, Chicago+	5	85	388
Bakerloo[1]	6	36	216
Piccadilly[1]	6	30	180
Charing Cross[1]	5	40	200
District[2]	10	42	420
CSLR	5	24	120

*Ultimate capacity
+Some trains less than 5 cars, due to traffic conditions.
1 - rush hour service. Actual capacity 40 trains of 7 cars per hour.
2 - rush hour service at Earls Court.

Source: Electric Railway Journal, vol. XXXV, p. 291, vol. XXXVI, p. 213, vol. XLIII, p. 299.

First adopted by the LOR, such practice was considerably improved on the New York Subway. More than any other aspect, however, the intricacy of the signalling system adopted was a direct function of the level of train service and the complexities of operation although on the elevated in New York prior to electrification signalling was almost non-existent, with trains following one another by sight.

Meanwhile, carriage design displayed a far more standardised pattern, with the American end-door design becoming universal in Britain, except on the LOR. This was a radical change in procedure. The Metropolitan, District and Mersey lines in steam days, and the LOR always, used the traditional British pattern of a series of doors along each side, opened and closed by the passenger. To change so readily to a design which necessitated an increase in the staff on each train, as the doors were opened and closed by gatemen, and reduced the number of doors per carriage, yet apparently worked well, is a tribute to the spread of American ideas and British receptiveness to them, rather than to the success of the design as such. Admittedly, this was essentially practical for the 'tube' railways, where the narrow width of the carriages made longitudinal seating necessary and prevented the use of a series of side doors. Its adoption by the Mersey, Metropolitan and District lines was partly a result of this, partly a reflection of the American influence. Either way, they do not appear to have been popular, the Mersey at any rate replacing them with sliding doors within a few years.[1] On the 'tube' lines, trials with centre-entrance cars commenced in 1913, although centre-entrance cars (with the doors operated manually by the passengers) had been in use since the start of regular electric service on the Metropolitan and District lines. However, even in 1913, cars for the District line were predominantly wooden bodied, rather than steel, the first orders for steel cars coming in 1910.[2] UERL cars were built of steel, the average train weight not exceeding 121.2 tons, this being the weight of trains used in Bakerloo peak hour services.

District trains, which were of ten coaches in length, were rather heavier.[3] However, in most respects the similarity between London and American operations was readily apparent, down to the use of identical General Electric motors by most companies. The major differences between companies reduced themselves to that of varying hourly capacity. The capacity of the various lines is shown in Table 12 for 1910 (by when capacity on some of the London lines had been increased). The table does not give seating capacity per coach, although the reduced dimensions of the 'tube' rolling stock undoubtedly also reduced total capacity, particularly because at this stage the motors on the carriages were carried within the body, whereas on the larger systems they could be carried underneath the body.

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1. J. Shaw: 'Notes on the Mersey Rly.' paper to Liverpool Engineering Society, 1st December 1915.
2. Electric Railway Journal, vol. XXXVI pp. 212-3, vol. XLIII pp. 298-9.
3. ibid. vol. XXXVI pp. 212-3.

The Liverpool lines have been left out of the table because the evidence suggests they were never operating at this date anywhere near capacity. Even in peak hour periods by 1910, the Mersey was filling only 66% of its seating capacity.(1) The apparent high capacity of the older elevated systems is a reflection of operating conditions, average speeds being much lower than on the underground lines. Similarly, the District figure is high, representing total departures in two different directions. Actual capacity would be nearer half the figure given. Ignoring the different size of coaches, however, and using the UERL capacity figure of 280 cars per hour, it can be seen that, with the exception of the original CSLR, physical capacity of the various underground lines did not vary as widely as the overall figures would suggest. Furthermore, the limited capacity of the CSLR demonstrates clearly that the ultimate operating capacity was a function of the original design for a railway. This is apparent in every case. For example, the design weight of an elevated structure limited both train weight and train frequency while on an underground line capacity was set by the overall size of the tunnels, which dictated the maximum carriage size. As with the CSLR, after the opening of the first subway, subsequent lines were built with larger tunnels, which thereby could take larger coaches, with larger doors, which would occupy longer platforms. Thus automatic signalling could allow improved frequencies of train operation and escalators could improve the flow to and from the platforms of passengers but such innovations were only of value where they yielded a benefit in

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1. J. Shaw: 'Notes on the Mersey Rly.' op. cit.

terms of overall operations, which were dictated by the original design and any attempt to measure technical progress, particularly in underground railways, must take account of this.

This is particularly important if any attempt is to be made at developing a theory of diffusion for underground electric railways. Indeed, it can easily be seen that such an attempt is scarcely practical, the overall importance of style of railway construction being the limiting factor. Nevertheless, there are a number of new innovations which would have been practical in most cases, the problem here is that the number of companies is so limited that an attempt at measuring diffusion is clearly pointless. Such ideas as the hypothesis that the probability of a firm introducing a new technique is an increasing function of the proportion of firms already using it and the profitability of doing so but a decreasing function of the size of the investment required are barely applicable.(1) It would be interesting to test the rates of innovation between the different companies to test the hypothesis that the rate of imitation is faster in more competitive circumstances but again, the results would not be general conclusions but specific instances for the respective firms.

Even over such a short period, the actual list of innovations is impressive, even if electric traction is taken as the factor which made underground railways feasible, rather than as a major innovation in urban railways. To reiterate, the other innovations would include multiple unit control, automatic

1. E. Mansfield: 'Technical Change and the Rate of Imitation', Econometrica, Ocobter 1961, pp. 741-66.

signalling, steel bodied carriages and sliding doors instead of gates, to be followed by automatic sliding doors, on the railway side. In addition, a number of improvements were made to the design of turbines and generators throughout the period, increasing the overall efficiency and economy of power station working. This last aspect clearly demonstrates economies of scale. The original CSLR power station was producing electricity by 1913 at a gross cost of 0.538d. per kilowatt hour and producing about 9.5 m. Kw. hours annually, compared to the CLR generating station cost of 0.380d. which was producing about 18.8 m. Kw. hours annually.(1) Yerkes and his advisers were aware of this - hence their decision to build one large power station to supply all their lines and other users if need be - but this was also a reflection of a more general lack of concern with capital costs. Although investment decisions may have been deferred by high interest rates, there was little attempt to reduce these by purchasing electric power from an outside supplier. This was not helped by the technical literature which showed much more concern with running costs than with capital costs.

The first company to move away from having its own power station was the North Eastern Railway, for its North Tyneside electrification. The NER had employed Charles Merz as a consulting engineer and he was a great opponent of railway generated power - to him one of the main virtues of electric traction was that it eased the load problems of large central power stations but this advice was generally ignored until an

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1. City & South London Rly: Power Station Comparisons, Acc 1297/CSL 4/1.

Act of 1919 prevented further duplication of power generating facilities.(1) All the independent urban lines however, in both Britain and the U.S.A., provided their own power station facilities. In some cases, notably those of the Manhattan, the CSLR and the CLR, there was little alternative. For the NER to buy power from a central company was admirable but it was fortunate in having a local company in a position to sell it power. Thus, although the output of electricity sold by supply undertakings rose fifteen-fold between 1899 and 1914, very little of this growth was attributable to railway demand.(2) A major exception, in America, was the Brooklyn Rapid Transit system, which was the major buyer of outside power among the urban railways.

Despite this factor, the improvement in the efficiency of use of electricity by the railways was marked. The improvement in generating costs, with regard to power station construction over time, has been observed already. In overall terms, however, there was also an increase in the proportion of train-miles or car-miles obtained for a fixed amount of electric power used, as is revealed by Table 13. This shows only the total number of Board of Trade Units of electric energy used by the railways, for total car mileage and train mileage and therefore does not reveal any intra-company improvements but the

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1. I. C. R. Byatt: op. cit. p. 143; R. A. S. Hennessey: The Electric Revolution, Newcastle on Tyne, 1971. Charles Merz was born in 1874, joined BTH in 1894 and in 1899 became a consulting engineer in the partnership of Merz and McLellan. Byatt, p. 136.
2. E. H. Phelps-Brown & S. J. Handfield Jones: 'The Climacteric of the 1890s' - Oxford Economic Papers, 1952, p. 276.

overall improvement is still apparent. This can be seen if the figures in columns 3 to 5 in Table 13 are converted to index form, with 1906 as the base year. Passenger train mileage grows from 70.6 (1905) to 197.04 in 1913 and car-mileage from 100 (1906) to 181.51 in 1913, while electricity used grew only from 63.28 in 1905 to 168.12 in 1913. Thus, this reveals not only an increase in the efficiency of use of electricity but also of train operation in general. This was further tested by regressing logarithmic values for the ratio of train mileage to car-mileage against those of electricity used. The results of this showed that over the period in question, for every one per cent growth in electric power used, the ratio of train mileage to car mileage increased by 0.16%. This suggests not only that power was being used more effectively but also that rolling stock was being used more efficiently, shorter, more frequent trains being operated and therefore better advantage of multiple-unit operation being obtained. From 1906 to 1913, the average train length fell from 4.14 cars to 3.82 cars, although it did fall as low as 3.75 cars in 1909. By itself, however, this is an insufficient guide to improvement in productivity and must be compared with the growth in the number of passengers carried and, ideally, the distance they were carried, and with changes in the labour force.

A similar method of comparing passenger figures with both train mileage and car mileage was then undertaken. Again, this was rather a limited approach as passengers were only one variable and no account was taken of passenger miles travelled, which would be a better comparison but for which figures are

TABLE 13: ELECTRIC WORKING, ALL U.K. ELECTRIC LINES, 1905-1913

Year	(1) Track mileage wholly electric worked	(2) Mileage partly* electric worked	(3) Passenger train-miles	(4) Car-miles	(5) Electric energy used (BofT units)
1905	140¼	170½	9,640,921	-	100,977,467
1906	197¼	157½	13,653,771	56,581,060	159,581,401
1907	196¼	182¼	18,742,535	74,468,969	213,675,447
1908	204½	200½	21,632,149	85,110,845	249,287,308
1909	204½	229¾	22,919,653	86,048,316	253,294,628
1910	205	229¾	23,724,344	89,984,526	235,933,706
1911	206¾	258	24,214,484	93,860,790	250,296,470
1912	210¾	281	24,981,766	95,758,532	252,925,833
1913	205¾	314½	26,903,376	102,698,032	268,289,293

Source: Board of Trade, Railway Returns, relevant years, p. 96 (1913, p. 148).

*The table includes mileage of all electric worked lines in the U.K. However, all urban railway mileage was included in Column 1, with the exception of 16-17 miles of the Metropolitan Railway and a short section of the Hammersmith & City Railway (worked as a branch of the Metropolitan). The remaining mileage in Column 2 belonged to the NER, L&YR, Midland Railway and LB&SCR. In Column 1, apart from 15 miles of the Blackpool & Fleetwood Tramroad, 9 miles of the London, Tilbury & Southend Railway, 3 miles of the Bessbrook & Newry Railway and (1913 only) 8½ miles of the Great Central Railway, all the mileage was worked by urban railways. By 1914, 153,919,644 units of electricity - 57.37% of the 1913 total - were used by four London lines - the MDR, UERL, CSLR and CLR.

unavailable. Table 14 gives the indices for the relevant data (these figures are for urban electric railways only, unlike those in Table 13 which were for all electric railways) from which it appears that the overall increase in both train mileage and car mileage was greater than the growth in passengers. A major problem with this is that much of the growth in train mileage and car mileage reflects longer running distances as extensions were opened and existing traffic going further over such extensions is not revealed by the data as it stands. Even if this problem is altered slightly, by examining train miles per passenger carried, as in Table 15, no discernible trend is apparent, although there is a slight movement towards a more favourable ratio between car miles and passengers. However, it should be remembered that in all these cases, all that is being looked for is an improvement in productivity (in its broadest sense) after electrification. Although not typical, train miles per passenger on the Mersey Railway fell from .044 in the last year of steam operation (1902) to .033 in 1913, while overall train mileage rose from 310,944 to 556,906 over the same period.(1)

Although such noticeable changes were not obvious purely under electric traction, specific cases of improvements in productivity through technical innovation are numerous. Again in the case of the Mersey Railway, it was estimated that

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1. J. Shaw: 'Notes on the Mersey Rly.' op. cit. To give a very rough guide to the Mersey's relative importance, in 1906 it consumed approximately 30% of total railway-used electrical energy and accounted for some 27.5% of car mileage.

TABLE 14: URBAN RAILWAYS - MILEAGE WORKED BY ELECTRICITY AND PASSENGERS PER ANNUM, 1900-13.
Index Nos., 1906 = 100

Year	Train Mileage	Car Mileage	Passengers
1900	20.5	-	14.89
1901	31.51	-	28.05
1902	34.47	-	32.35
1903	40.71	-	35.79
1904	41.96	-	35.83
1905	64.67	-	91.67
1906	100	100	100
1907	148.78	138.37	112.49
1908	175.71	158.88	137.82
1909	187.33	160.06	142.21
1910	190.81	164.92	142.46
1911	192.08	169.02	150.08
1912	193.69	166.47	147.92
1913	206.97	177.14	162.15

Source: Board of Trade returns, relevant years, p. 96 (1913 p. 148)

TABLE 15: URBAN ELECTRIC RAILWAYS IN U.K. TRAIN MILES PER PASSENGER AND CAR MILES PER PASSENGER, 1900-13.

Year	Train Miles/Passenger	Car Miles/Passenger
1900	0.0606	-
1901	0.0494	-
1902	0.0469	-
1903	0.0500	-
1904	0.0515	-
1905	0.0310	-
1906	0.0440	0.1996
1907	0.0582	0.2455
1908	0.0561	0.2301
1909	0.0579	0.2246
1910	0.0589	0.2310
1911	0.0563	0.2248
1912	0.0576	0.2246
1913	0.0561	0.2180

Source: As for Table 14.

although enclosing the platform ends of cars would cost £750 to £800, the annual saving in conductors' wages would be £350.(1) The burden of wage costs of conductors and gatemen can be gauged from the District Railway's figures. In 1906 the wages of its conductors and gatemen, on average 4.76d. per hour, were equivalent to a cost of 0.417d. per car mile and would incidentally be more directly proportional to any increase or decrease in car mileage than those of motormen. In comparison, electric energy used cost some 1.810d. per car mile but motormen's wages were only 0.197d. per car mile (8.52d. per hour).(2) The effect of the introduction of passenger-operated or semi-automatic sliding doors is revealed in the District's wages bill. While the wage bill for motormen rose from £12,768 in 1906 to £19,051 in 1914 (up 49.21%) for conductors and gatemen it fell from £27,042 to £25,772 (a drop of 4.7%). This should, however, be treated with some caution for changes in the methods of calculation made the figures for 1914 not strictly comparable with earlier years. The overall wages bill for trainmen, no distinction between the groups being made, rose by 22.75% from 1906 to 1913 - from £39,810 to £48, 868. For 1914 the figure was given as £44,823, representing only a 12.6% increase on the 1906 figure. As a comparison, also from 1906 to 1914 the number of electricity units used per train mile fell from 13.98 to 13.91, while from 1906 to 1913 the amount used per car mile increased from 2.793 to 3.233 units.(3)

1. Mersey Railway: PRO RAIL 475/11 p. 180, 11 December 1913.
2. Metropolitan District Railway: Acc 1297/MDR 4/3.
3. ibid. Acc 1297/MDR 4/3; MDR 4/14; LER 4.

The cost of employing conductors and gatemen, while not insignificant, was a burden borne by all the urban railways in both Britain and the U.S.A., except for the LOR. However, only four systems (UERL, CLR, CSLR and Mersey) had to employ liftmen and here again there was scope for innovation with the introduction of escalators. The UERL group, for instance, was spending almost as much on lift staff wages (£17,304 in 1914) as on gatemen (£17,657) as was the CLR (£6,296 and £6,307 respectively, in the same year). While the CSLR did not distinguish between conductors and gatemen, even its lift staff wage costs at £5,995 in 1914 were not insignificant.(1) Again there are problems with comparing earlier figures but the wages of liftmen cost the UERL about £17,180 in 1908, compared to £18,980 in 1907. Individual average earnings for liftmen were also higher than those of conductors and gatemen, which in turn were lower than those of all other categories except porters.(2) Although in monetary terms the performance may have been good, in terms of total expenditure there was little change in the proportion spent on lift operation and maintenance. Despite this, use of escalators remained extremely limited. The LOR did instal one as early as 1901 which was only the second in the U.K. but this was taken out of service in 1906.(3) The London lines did not instal an escalator until 1911 and even by 1914 few had been installed. However, the proportionate savings in

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1. ibid. LER 4/1.
2. Board of Trade: Earnings & Hours Enquiry - VII - Railway Service 1907, Electric Railways, p. xxvii.
3. C. E. Box: The Liverpool Overhead Railway, London 1959.

labour costs were substantial. In 1914, the UERL group used some 625,000 units of electricity to drive its escalators, compared with some three million units for its lifts, yet the staff costs were £401 and £17,300 respectively.(1)

However, the slow adoption of escalators can be explained largely by the capital costs involved. The original Mersey Railway lifts had cost some £24,000 (£3,330 each) and the cost of working them was £1,800 annually in 1894.(2) Furthermore, these costs excluded the initial capital cost of constructing a lift shaft. If escalators were installed, the lift shafts would be unsuitable and new shafts would have to have been sunk. On a line like the CLR, with a minimum depth below the surface of twenty feet, the cost of escalators at every station would be clearly substantial and not justify the large scale replacement of lifts, unless it could be shown that more passengers would be attracted by escalators, which is doubtful. Thus, as with carriage design, installation of escalators largely depended upon the original design of the stations. The only line which was in a position to incorporate them in the design stages was the IRT but here also costs appear to have been important. Most of the stations were just below surface level but in a few cases lifts were installed. The Manhattan Elevated also had lifts at its 116th St. station. Here there were four hydraulic lifts, each with a capacity of fifteen people plus operator.(3) In comparison, the hydraulic lifts on

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1. Underground Electric Railways of London: Acc 1297/LER 4/1.
2. Letter from Fox brothers to H. Oakley of CLR, May 1894. Acc 1297/CLR 4/1.
3. W. B. Parsons: Diaries, op. cit. 22/6/1900.

the Mersey Railway had a capacity of 150 people.(1) Such a design seems to have been generally accepted as being far too large for economical working - the James St. station lifts had a maximum capacity of 3532 passengers per hour which was almost identical to that of the Manhattan lifts. On the IRT subway, it was decided to instal lifts at the deeper underground stations, although at the 125th St. station, which was on a viaduct over the street, an escalator was installed - further evidence that the cost of constructing shafts was the major determining factor. However, the possibility of installing escalators at the underground stations was certainly discussed. Originally lifts costing between $12,000 and $15,000 had been suggested but some months later plans for installing an escalator in a lift shaft of the CLR were explained to the city's engineer, Parsons. The intention was to use two lift shafts, each having a thirty foot diameter. This was not possible in the IRT stations which had only one shaft, fifteen feet by thirty-two, and it was not considered possible to instal an escalator in such a space.(2) This discussion appears somewhat curious, firstly because there is no record of the CLR contemplating the installation of escalators at this time (1901) and secondly because the level of achievement in construction of the subway at the time would have made enlarging the lift shafts a comparatively straightforward matter, given that the

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1. British Westinghouse Electric & Manufacturing: The Electrification of the Mersey Railway, 1903.
2. Parsons: Diaries, op. cit. 25/6/1900, 5/3/1901.

precise station designs had not been finalised. Thus the only escalator on the subway in New York was at 125th St. and here August Belmont refused to allow the projected cost of $10,000 to be spent on it and accused the architects of having 'positively silly ideas'.(1)

Such attitudes aside, the diffusion of this particular innovation was slower than that of any other relevant improvement. By 1905-6 automatic signalling in one form or another was being or had been introduced by every line in Britain and every line in Britain (with the arguable exception of the CSLR) had, by 1913, introduced major changes in either train motors (the CLR, LOR and the Metropolitan) or in generating station facilities (the District, UERL, Mersey and Metropolitan) which although in some cases were the consequences of unsatisfactory original equipment were always introduced in an attempt to improve efficiency.

How far can such progress be quantified? As has been shown, this can be done in several different ways, none of them particularly satisfactory. Ideally, a production function should be used to attempt to obtain a measure of technical progress but any attempt at using this runs into problems of comparability, given that there is no satisfactory measure of output. Passenger mileage is the most obvious measure but there are problems in measuring it where no records of it are kept, notably in the case of companies employing a flat fare, as in America.

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1. Belmont papers: 4/11/1904.

Passengers per car mile, or miles run per passenger, would be possible alternatives. However, as Table 15 has shown, with the data available it is difficult to draw any meaningful conclusions. The only valuable way of analysing miles per passenger would be to examine traffic flow between specific stations, and the corresponding train service. This would be difficult to do for British lines, and impossible for American ones, where the statistics are not available. The figures for car-miles per passenger are similarly unpromising but in a later chapter this problem is examined in a slightly different way by comparing the optimum train service with the actual train service. While this has been analysed on the basis of equating supply and demand for profit considerations, it would give an indication of improvements in overall productivity, if comparisons were made over time.

In the meantime, measurement of labour productivity would give at least some indication of relative progress, although even here there are problems with accurate statistics being comparable over time. In 1907 the average total workforce on U.K. electric railways was 6,859 but this excluded station-masters, booking clerks and salaried staff.(1) However, it was the latter category - salaried staff - which seems to have shown the most apparent growth up to 1914. Where it was feasible to do so, staffing levels appear to have been reduced in other sectors. The advent of automatic signalling, for

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1. Board of Trade: Wages & Hours Enquiry, 1907, op. cit. p. 237.

instance, meant that as early as 1907 more liftmen were employed in the U.K. industry as a whole than signalmen (383 to 203). Even the disparity between motormen and other train staff was not so great as might have been expected - 604 to 1199 - suggesting either that conductors and gatemen worked longer shifts or that an excessive number of motormen were employed.(1)

How far labour productivity improved or deteriorated over the period cannot be said with any accuracy, although for the British railway industry as a whole the average annual rate of labour productivity fell by 0.58% from 1900/01 to 1904/5. From 1905/6 to 1909/10 it grew by about 0.78% per annum.(2) For the U.S.A. output per worker figures are given in Table 16. The different methods of calculation serve to emphasise that the columns are complementary rather than comparable. What is of immediate note in the table is the column 3 figures, showing very little increase in the number of passengers per worker. If the comparison was made in terms of passengers per mile operated per worker, the figures would show a steady and marked decline from 1890 onwards. The problem with the figures is that this decline would be a reflection of the state of interurban railways in America, rather than urban rapid transit companies, although the same problem applies to the rapid transit lines, especially because any extensions built relied solely on new passengers for increased revenue, given their

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1. ibid. p. xxvii.
2. D. H. Aldcroft: 'Efficiency & Enterprise of British Railways 1870-1914', Explorations in Economic History 1967-8, vol. V/II p. 159.

TABLE 16: OUTPUT PER WORKER, U.S.A.

	(1) N.B.E.R. Output per Worker, All Transportation	(2) N.B.E.R. Output per Worker, Railroads	(3) Passenger per Worker, Electric Railways
1890	42.3*	47.5*	62.13
1902	56.6	61.4	73.70
1907	59.6	64.4	73.03
1912	64.3	70.2	73.44

*1899

Columns 1 & 2: index numbers, 1929 = 100, column 3 index, 1927 = 100.

Source: U.S. Bureau of Census: Historical Statistics of the United States, Colonial Times to 1970; Bicentennial Edition, Part II, Washington DC, 1975, pp. 727, 952.

(Electric Railways in column 3 includes all electrically operated railways but not electrified sections of steam railroads, in the U.S.A.)

fixed fare structure. Indeed, given that the index is unweighted, that passenger figures are merely the aggregate of figures for all U.S. electric lines and that the companies in this study were among the five largest U.S. electric railway companies, the figures are perhaps not too inaccurate. If this is the case, the stagnation after 1902 makes an interesting comparison with contemporary circumstances in Britain.

In this respect, it must be seen that in terms of technical innovation, for newly built lines, the similarities in rate of uptake were greater than the differences and the timing was fairly rapid. Obviously there were major differences, conditioned largely by design limitations at the construction stage, most notably in the design of high capacity cars. In all other respects, however - the adoption of multiple unit control, of automatic signalling, of steel bodied cars and sliding doors, progress was both substantial and widely dispersed, although initially the two lines on which innovation was least were the CSLR and LOR - the two earliest lines. In both these cases the relative lack of progress can be explained in fairly straightforward terms - for the CSLR the original tunnel design was the major restricting factor, in the case of the LOR traffic conditions never justified alterations such as sliding doors or steel bodied carriages, although the line had had automatic signalling from its opening and installed up to date equipment in a successful attempt to meet the competition from electric trams when that arose. What is noteworthy about innovation in general here is that it has been claimed that for American railways in general, in the early 1900s the possible influence of innovations was overpowered by the great demand for increased capacity.[1] This was obviously the case for both the Manhattan Elevated and the IRT but less so for other lines, yet there is no evidence of any major difference between the IRT and other lines in investment in innovative ideas, as opposed to investment in increasing capacity alone. Conversely, investment by British lines could, in many cases, be seen as a response to competitive pressure.

In conclusion, one idea - that of the conservatism and ability of entrepreneurs - is worthy of consideration. It has, after all, been claimed that the speed with which a particular firm begins using a new technique is directly related to its size and the profitability of its investment in the technique but that a firm's rate of growth, its profit level, its liquidity, its profit trend or the age of its management seem to have no consistent or close relationship with how rapidly a firm adopts an innovation.[2] The evidence for railway electrification would, on the whole, bear this out although the cases of individual directors who were sceptical about its practicality are certainly numerous enough to question the claim, without necessarily agreeing with Frank Sprague's view that the problem lay in the average age of British railway directors. There were directors of the Metropolitan, Mersey and District who were opposed to electric traction at some stage although there is no evidence that their opposition alone would have prevented electrification at any given time. Similarly, the first two elevated railways in

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1. K. T. Healy: 'Regularization of Capital Investment in Railroads' in Regularization of Business Investment, NBER Special Conference, Princeton, 1954, p. 162.
2. E. Mansfield: Transportation Economics, NBER Conference, New York, 1965, p. 187.

Chicago were initially steam operated and it took a change of ownership or management for electricity to be introduced while the opposition of Jay Gould to electrification of the Manhattan Elevated has been noted.

The contrast with lines electrically operated from the outset is marked. The CSLR led the way by employing people who were then recognised experts in their fields and this pattern was expanded by the CLR, which regularly sought advice from leading railway managers and electrical experts. In Britain the pattern reached its logical conclusion with the experts employed by the UERL. Men such as Albert Stanley from the Public Service Corporation, New Jersey, and George Gibb from the North Eastern Railway were sought for their proven ability. In the same way, Theodore Shonts became manager of the Interborough Metropolitan Company in New York. However, (and it is not intended to impute any significance into technical innovation from this) rapid transit enterprises appear to have held considerable appeal to affluent and eminent American businessmen, for public prestige as well as financial motives. The most obvious example of this was C. T. Yerkes, his nearest British equivalent being perhaps Charles Mott, although in earlier years Edward Watkin of the Metropolitan and James Forbes of the District were prominent. In comparison, the Interborough Metropolitan had directors such as August Belmont, Cornelius Vanderbilt, Seth Low and Solomon Guggenheim.(1) This active participation by prominent local

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1. Edward Watkin and James Forbes were prominent British railway directors who apparently held a certain antipathy towards one another. Cornelius Vanderbilt, August Belmont, Seth Low and Solomon Guggenheim were all prominent New York bankers or financiers. Seth Low was also at one time Mayor of New York.

businessmen in transit affairs was largely lacking in Britain. It is important not for any direct implications for technical innovation but for its significance in raising capital which in turn must obviously have an impact on innovation. How far technical innovation can be attributed to the policies of management or directors cannot be determined precisely but it is significant that overall innovation on both sides of the Atlantic followed a closely defined pattern which must be largely attributable to the influx of American technology and capital into Britain at the turn of the century.

If a picture is tending to emerge then, it is one of no obvious differences in the rate of innovation on either side of the Atlantic. Given the Habakkuk thesis, this is perhaps surprising, even more surprising if the criticisms of British railway management are accepted. Even more important, however, is that if the British urban railway companies, having decided to electrify, were then proceeding with further innovations, this is an apparent exception to the possible existence of a major structural impasse in the British economy at the time. That such innovation may have been undertaken out of necessity, in an attempt to reduce operating costs is a point which will be examined in a later chapter. Meanwhile, it is appropriate to turn to an examination of the capital organisation of the urban railways, and the functioning of the capital market in supplying them with funds.

CHAPTER 4

THE RAISING OF CAPITAL

> There is nothing on earth so inert and gullible as the average American stockholder. He lacks the most primitive instinct of self-preservation. The same group of financial buccaneers can exploit him with impunity, just as often as they choose, by a trifling shift in the scenery each time. The whole equipment consists of a few names of men who represent financial power and a press bureau.
>
> Anonymous New York lawyer.

As has just been shown, technological innovation on the railways spread far beyond the introduction of electric traction - indeed, at times one may wonder whether some of the innovations were of real significance. Certainly there appears to have been no lack of desire to introduce a steady series of improvements most of which were more concerned with railway operation from the technical and practical side, rather than from the financial side. In some ways this is surprising, as for most of the lines the problem tended to be one of raising sufficient capital, rather than being able to operate effectively. Before asking how well the companies used their capital, however, it is more appropriate to turn to the actual problem of raising capital.

This ought to be one of the most interesting and fruitful areas of comparison between Britain and America as one of the dominant features of the British capital market in the nineteenth century was the outflow of funds abroad, which has led to continued argument as to whether domestic projects were starved of capital. However, it is not simply a matter of domestic investment versus foreign investment. Before 1914 34% of all British overseas investment went to North America (£1,400 million), while at the same time 41% of the total went into railway investment.(1) Admittedly, most of this was directed towards the major rail network but the size of the investment meant that British investors were at least familiar with American geography and American economic fluctuations.(2)

The link went far beyond this. As Habakkuk put it

> The argument is that the periods of most rapid growth and intensive use of resources in the two economies were inversely related to each other ... this alternation was established because there existed a common stock of resources, so that when one area drew rapidly on the stock it was at the expense of the other.(3)

Taking this argument to its extreme, one would expect a high degree of interdependence between urban railways in both countries, as was apparant in the field of technology. In fact a disproportionate amount of capital for lines in both Britain and America came from America. This may have been due to differing ideas about the value of investing in urban railways or to differences in the relevant capital markets.

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1. M. Simon: 'The pattern of New British Portfolio Foreign Investment, 1865-1914' in A. R. Hall (ed): The Export of Capital from Britain. 1870-1914. London, 1968, pp. 23-25.
2. For 1913 total British overseas investment has been estimated at £3,780 m., of which £755 m. went to the United States (exceeded only by Latin America - £760 m.) - S. B. Saul: Studies in British Overseas Trade, 1870-1914, Liverpool, 1960, p. 67.
3. H. J. Habakkuk: Fluctuations in House-Building in Britain and the United States in the 19th Century. - Journal of Economic History, Vol. XXII, No. 2 (1962).

This importance of American capital in urban railway construction played a crucial role in some cases and this chapter examines this role, both in general terms and from more specific aspects. The latter include comparing economic conditions at given times in the two countries and analyses of shareholdings and the sorts of funds that companies had access to. The aim of the chapter is to show that while economic conditions were one factor, the over-riding one was the predominance of American capital on both sides of the Atlantic, which was the result of a combination of rational decisions by British investors and the role played by American financiers.

The predominance of American capital reflected a change in existing capital flows for in the years after 1870 the American railroad market had become fully developed on the London stock exchange. This interest in American railroads was one result of the financial crash and panic of 1866 which had

> put an end to the ascendancy of the contractor, of Railway Finance, of Cosmopolitan Enterprise, in the London money market.(1)

The panic hit railways badly, one of the worst affected being the then under construction District Railway which because of the crash was faced with having to raise a disproportionate amount of capital through expensive fixed interest loans. The Mersey Railway Company, which had just been formed, was also badly affected as it lay dormant for nearly twenty years and even when

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1. L. H. Jenks: <u>The Migration of British Capital to 1875</u>, New York, 1927, p. 262.

construction did start, progress was only possible through the Contractor receiving payment in share capital.[1]

The interest in American railroads that succeeded the panic was sustained throughout the 1880s during which decade a preference for shares rather than bonds developed. The market value of total British investment in American railroads grew from £160 m. in 1881 to £300 m. in 1890, when it was brought to a halt by the Baring crisis.[2] This crisis effectively brought major British interest in American lines to an end as London investors sold their American railroad investments so as to maintain their South American investments through the crisis.[3] Even after the end of the crisis, interest in the American lines did not revive.

The Baring crisis and subsequent contraction in Britain affected capital exports just as it did domestic investment patterns while in America commercial bank failures and a Wall Street panic in 1893, coupled with a lack of confidence in the maintenance of the gold standard, exacerbated the effect. Partly in consequence, world gold prices fell by some 11% between 1891 and 1897.[4]

In Britain, the Baring crisis shook confidence in foreign securities and overseas investment consequently fell to a low ebb

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1. Mersey Railway: Board Minutes, 27.7.81 (RAIL 475/4 p. 1)
2. P. L. Cottrell: British Overseas Investment in the Nineteenth Century, London 1975, pp. 36-38.
3. ibid. p. 39.
4. M. Friedman & A. J. Schwartz: A Monetary History of the United States 1867-1960, Princeton, 1963, p. 105.

in the 1890s. This was reinforced by domestic American economic difficulties. Coupled with the falling off in capital imports substantial exports of gold from the United States had started in 1888, largely due to distrust of American intentions in maintaining the gold standard.(1)

The silver campaign in the States led to a run on the banks and to a move to hold cash rather than deposits, currency held by the public being 6% higher in June 1893 than a year earlier, while deposits had fallen 9½%. In July the Erie Railroad called in a Receiver, the stock market suffered a severe decline and the economy stagnated for the next three years.(2) This period also saw the growth of populist discontent with 'Big Business' and the growth of a rich group of monopolists. This discontent was particularly directed against the power of the railroad 'robber barons' and the Erie bankruptcy did nothing to quell it.

In sharp contrast to the American economy there was a considerable improvement in British economic performance dated from about 1894. In that year the percentage of unemployed trade unionists was 6.9, compared to 7.5 in the previous year. By 1896, it was 3.3% and by 1899 only 2%. Similarly, figures for trade, railway freight and capital issues all show a 'low' in 1893 with improvement thereafter. At the same time, British overseas investment fell from the peak which it had reached in 1890 to less than half that level in 1894 and remained depressed until 1904.(3)

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1. ibid. p. 102.
2. ibid. p. 109.
3. E. M. Sigsworth & J. Blackman: 'The Home Boom of the 1890s', <u>Yorkshire Bulletin</u> vol. XVII, 1965, p. 74.

Of new capital issues in Britain in 1895, £39.7 m. was for home investment and £58.5 m. was for overseas investment. By 1901 the respective figures were £118.4 m. and £38.3 m. This was the peak year - from then on overseas investment grew while domestic investment declined.(1)

There appears to be little doubt that within this period the building industry predominated in new capital issues but the availability of 'cheap money' must have helped other sectors. This included increased expenditure by local authorities on, for example, electricity and tramways. Although as a percentage of Gross Domestic Fixed Capital Formation railway investment peaked at 10% in 1895, the actual money spent on investment increased to 1900, as it did for electrical engineering, although this only formed 2.8% of Gross Domestic Capital Formation in 1900.(2)

Given the increase in domestic investment relative to overseas investment in the years 1895 to 1901 the increase in railway investment in this period is not unnatural. This increase supports the thesis that throughout the period 1886-1903, massive outflows of funds abroad notwithstanding, money was more readily available for suburban development, especially land transport.(3) If money was in fact more readily available, a substantial proportion of it was accounted for by tramway projects. Between 1890 and 1901, a total of £199 m. was invested in such operations,

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1. A. R. Hall: 'A Note on the English Capital Market as a Source of Funds for Home Investment before 1914', <u>Economica</u> vol. XXIV, February 1957, p. 62.
2. Sigsworth & Blackman: op. cit. p. 84.
3. A. K. Cairncross: <u>Home and Foreign Investment, 1870-1913</u>, Cambridge, 1953.

the bulk of it in private companies. Over the same period total tramway mileage increased from 954 to 1,184, the real growth in mileage coming after 1900, reaching 2,720 miles by 1913.(1) The increase in paid up capital of all railway companies over the period was £184.6 m.(2)

Undoubtedly some of this was spent on suburban traffic but it is not likely to have been substantial given the supposed conservatism of British railway directors, who argued that suburban traffic was at best barely profitable - something that the underground railways' profit figures tended to support. However, the years 1896-1904 were a period of peak railway investment for both urban railways and their main-line counterparts. Like the earlier railway investment peak in the mid 1870s this was a period in which the yield on railway capital was stationary or declining but both these peaks succeeded periods in which profits were abnormally high. According to Cairncross the railway companies had the encouragement of past profits, expanding revenue and a favourable stock market and continued to invest even when capital was not so cheap. The price of railway stock was at its highest in 1897-8 and had fallen at least 20% below the peak by 1903; yet railway investment was higher in the later years.(3)

None of the reasons that Cairncross outlined for this seem particularly applicable to urban railways. These reasons were the intractable nature of new construction; once started new work would

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1. J. P. Mckay: Tramways & Trolleys - The Rise of Urban Mass Transport in Europe, Princeton, 1976, pp. 69, 83.
2. C. Douglas Campbell: 'Cyclical Fluctuations in the Railway Industry', Transactions of the Manchester Statistical Society, 1929, p. 39.
3. A. K. Cairncross: op. cit. pp. 139-141.

have to be finished and new rolling stock acquired. For evidence he cites the large increases in new mileage in 1883 and 1891. Secondly receipts were increasing rapidly in the two periods, with an increasing volume of traffic being carried at fixed prices. Throughout the 1890s there was a substantial rise in debenture prices, the yield on which fell from about 3½% in 1888 to 2¾% in 1896 and did not return to the 1888 level until 1904. Consequently, even on a falling market, the terms on which capital could be raised were comparatively favourable. Finally, Cairncross draws attention to the rapid increase in passenger traffic which he attributes largely to the growth of population and of suburbs.(1)

None of these factors would have affected new urban railway projects. Nevertheless, promoters thought it a favourable time for raising capital as in 1893 four new underground lines were authorised in London. These were the Baker St. & Waterloo, the Charing Cross, Euston & Hampstead, the Great Northern & City and the Waterloo & City railways. Of these, the Waterloo & City was promoted by the London and South Western Railway to provide access from their Waterloo station south of the Thames to the heart of the city. Although promoted as a separate company, the L&SWR was able to guarantee payment of 3% on share capital during construction.(2) After opening in 1898 the line was fully integrated into the L&SWR.

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1. ibid. pp. 139-141.
2. This was specifically authorised by the 1893 Companies Act, but restrictions on doing so had been lifted in 1886.

This was an exceptional case as the other companies formed at this time faced great difficulties in raising capital which in part were a reflection of the financial difficulties of earlier urban railway schemes, the Mersey Railway in particular having been quick to go into receivership. The City & South London Railway, which opened in 1890 had also faced difficulties in raising capital and like the Mersey and District Railways before it, it had to resort to paying its contractor partly in stock. Prior to its opening a succession of earlier schemes for electric or cable-powered underground railways in London had all failed through an inability to raise sufficient capital.(1) While the C&SLR avoided the fate of the Mersey Railway, its early financial performance was unspectacular.

The generally disappointing returns from early projects such as this, coupled with prevailing trends and conditions in the capital market meant that this was not a good time to be seeking capital for an urban railway, where the prospect of good returns was limited. The Central London Railway, authorised in 1890 with a capital of £3.6 m. had by 1894 succeeded in raising only £600.(2)

Apart from the C&SLR the only other line to open in the first half of the decade was the Liverpool Overhead Railway which opened in 1893. Cheaper to construct than an underground line, using electricity which was now proven in its effectiveness, with a large traffic flow already existing and some financial support from the Mersey Docks and Harbour Board, the company had few problems.

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1. CSLR: Directors' Minute Book No. 1, 1886, Acc 1297/CSL1/1.
2. Board of Trade: Railway Returns, 1891-1895.

As overseas investment declined and domestic railway investment increased so after 1895 did circumstances become more favourable for urban railways. In that year the C&SLR increased its paid up capital substantially and the CLR's capital leapt from £600 to over £0.5 m., enabling work to start on the project.(1)

The upturn did not immediately affect the 1893 schemes. In March 1894 the Charing Cross, Euston and Hampstead line had invited subscriptions for the entire £1.41 m. authorised as its paid-up capital but only £802 was raised. This was insufficient to justify allotment and was returned. In 1897 an extension of time was obtained. Similarly, the Baker St. and Waterloo lay dormant until 1900.

The performance of the early railways generally appears to have been sufficiently questionable to deter investment in new schemes. Of the three companies formed in 1893, although their combined authorised capital was £5.55 m., increasing to £5.68 m. in 1897, total paid up capital in the latter year was only £902.(2)

Nevertheless, these dormant London schemes were joined in 1897 by the Brompton & Piccadilly Circus Railway, with authorised capital of £800,000. Considering that the paid up capital of the Liverpool Overhead at this time was £740,000, this appears to have been a somewhat optimistic figure but it succeeded in raising £4,100 by 1898. By the same year the Great Northern and City (G.N. & C.) had also raised £244,738.(3) In 1898 also the Waterloo

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1. Board of Trade: Railway Returns, 1891-1895.
2. ibid.
3. ibid.

& City opened under the control of the London & South Western and the partial success of the G.N. & C. was due to similar factors. The Great Northern Railway encouraged its promoters to plan a railway with larger and more expensive tunnels so that it could operate through suburban trains to the heart of the city but having supplied two directors for its board, the Great Northern's enthusiasm for the project waned and it declined to guarantee dividends. By paying dividends out of capital, however, enough was raised to enable the line to be opened in 1904. Presumably a substantial amount of this was in the belief that the Great Northern would eventually take over the line. In fact relations between the two companies steadily deteriorated and the Great Northern & City was never profitable.(1)

Towards the end of the century, as domestic investment grew, so did investment in urban railway projects. By 1900 the subscribed capital of the Baker St. & Waterloo had grown to £184,000 and construction work had started, the Brompton & Piccadilly Circus had raised £29,000 but the Charing Cross, Euston & Hampstead had raised just £902.(2) June of 1900 saw the opening of the Central London Railway, which by that time had raised £2.85 m. but the same year saw work on the Baker St. & Waterloo halted. Much of the investment in this line was made by the London and Globe Finance Corporation, which with twenty-seven associated companies announced its insolvency in December.

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1. T. C. Barker & R. M. Robbins: A History of London Transport, op. cit., vol. II, p. 48.
2. Board of Trade: Railway Returns.

Thus, despite the steady increase in domestic investment up to 1900 which made access to capital easier, capital remained a problem for a number of lines. In theory the raising of capital should have been even more difficult after 1900 as domestic investment fell off and as the economic boom came to an end. As money spent on investment was increasing to 1900, some expansion of new facilities might have been expected up to 1902 or 1903, reflecting the lag between raising money and the completion of new facilities.

Cairncross claimed that after 1900 a good deal of the capital expenditure of the railways was incurred for electrification and for the building of underground railways. The number of main line companies which undertook electrification projects was minimal and the problems of underground railways during the 1890s have been outlined. Despite investment peaking in 1900 and these difficulties, the peak years for investment in this field were 1903 and 1904, with the completion of the four outstanding London projects and the electrification of the old steam lines - the Metropolitan, District and Mersey Railways. In 1903 11% of capital spent by all British railway companies went on underground railways and in 1904 the proportion was 15.95%. Although capital spending was not actually in a trough at this time the peak year of 1901 was past and annual new spending was falling dramatically.(1)

The answer to why investment should have reached its peak at a time when domestic investment levels were falling rapidly is simple. A large proportion of the capital came from America.

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1. Board of Trade: Railway Returns, op. cit.; C. D. Campbell: op. cit., p. 39.

Between 1900 and 1902 the Chicago traction magnate Charles Tyson Yerkes bought the Charing Cross, Euston and Hampstead line for £100,000, the Baker St. & Waterloo for £360,000, the Piccadilly line and the District Railway. With mainly American backing he proceeded to spend £2½ m. on the electrification of the District Railway.(1) Also in this period the British subsidiary of Westinghouse of America financed the electrification of the Mersey Railway, this costing them something in excess of £600,000.(2)

This influx of American capital reflected a dramatic reversal in the position of the United States' capital account as it became a net exporter of capital from 1897 to 1902. This sudden switch to exporting capital by the United States, which until 1896 had been a traditional capital importer, was due to a number of factors. These included the repatriation of foreign held funds in stocks and bonds following the improvement in stock market prices after 1896, the war with Spain in 1898 and the outbreak of the Boer War in 1899, the latter leading to a recall of British held American investments. In addition, fortuitously large agricultural exports in 1897 and 1898 plus the Dingley Tariff may have boosted capital exports further. The difference in the yield between American and British bonds also narrowed considerably, making American investments less attractive to the British and British investments more attractive to the Americans.(3)

After the electrification of the District and Metropolitan Railways, there was no further major investment in British urban

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1. T. C. Barker & R. M. Robbins: <u>A History of London Transport</u>, op. cit. vol. II, pp. 75-84.
2. Mersey Railway: <u>Directors' Meeting Minutes</u>, 475/8, pp. 141, 201, 220, 274.
3. Friedman & Schwartz: op. cit. pp. 147-8.

railways prior to 1914 although investment for specific projects such as improvements and extensions did continue. The bulk of the investment occurred over a nine year period which encompassed a boom in domestic investment and a surge in outflows of capital from America. The latter appears to have been especially important as a source of finance for more marginal projects, that is those which were not able to raise sufficient capital during the immediately preceding period of heavy domestic investment during the 'Home Boom'. As a result, investment in urban railways peaked slightly later - in 1903 and 1904 - than most other indicators for domestic capital formation.

How does this compare with the American experience? While American urban railway development was spread over a rather longer period, certain key years stand out. The first half of the 1890s saw the expansion of the elevated railways in Chicago and the turn of the century witnessed more significant expansion, with the electrification of the New York elevated lines, opening of subways in Boston and New York and general consolidation of existing systems.

The expansion around the turn of the century fits into the general pattern of the American economy where cyclical contraction from 1882 to 1885 was followed by relative stability to 1891 and then by the 'disturbed' years of 1891 to 1897. From 1897 to 1902 came a sharp recovery, with relatively stable growth from 1903 to 1907. In the years between 1893 and 1896 prices declined, especially relative to those in Great Britain, but from 1897 to 1900 prices in the two countries rose at about the same rate. This rise in prices was accompanied by a sharp reversal in business activity, per capita output between 1896 and 1902 growing almost 4½% per year.[1]

This latter period is particularly interesting for it coincided with the large outflow of American capital which has already been noted. At least until this time, it has been suggested that with anything up to 80% of American securities sold overseas being either state and municipal bonds sold for transport development, or railroad stocks and bonds, trade deficits generated in a period of rapid growth would be financed by development of the transport network which in turn was related to rates of income and output growth.[2] Not only did this lead to the full development of the American railroad security market in London in the 1870s and 1880s but the 1880s and 1890s saw record proportions of British exports going to the United States, with the marginal share of British exports going to the United States reaching a peak in the 1890s.[3] British capital exports to the U.S. had peaked earlier, the overall peak in American capital imports coming in the late 1880s. By the time of the Baring crisis, the level of such imports was already falling. There were two recoveries in the years after the Baring crisis but after 1896 it was almost ten years before the U.S. capital account showed a surplus. This was followed by sustained and heavy capital imports in the years 1907-10.[4]

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1. Friedman & Schwartz: op. cit. pp. 138-9.
2. J. G. Williamson: 'The Long Swing: Comparisons and Interactions between British and American Balance of Payments, 1820-1913', in A. R. Hall, ed: <u>The Export of Capital from Britain, 1870-1914</u>, London 1968, p. 60.
3. ibid. p. 73.
4. ibid. p. 79.

One could immediately deduce from this that whatever the overall importance of British capital for American railways, the timing of urban railway development was wrong for British capital to have had much impact in this field. Indeed, this would also apply to the initial phase of elevated railway construction in America, for in the period 1875-1880 America was also a net capital exporter.(1) It should come as no surprise then that the only British investment of any note in an American urban railway project came in 1889. In that year, the Hudson and Manhattan Railroad, upon which work had earlier come to a stop, floated $1.5 m. of bonds in Britain. This enabled further work to start on the project, only for this to come to a halt in August 1891, as an almost direct result of the Baring crisis.(2)

While this was the only notable exception to the general absence of foreign funds from American urban railways, other attempts to attract such funds were made, all of which appear to have been unsuccessful. Chief among these were an unsuccessful appeal by Chicago elevated railway promoters in the early 1890s and a vain attempt by the Interborough Rapid Transit Company in 1913 to obtain funds from the Rothschilds in London.(3) The early 1890s saw the collapse of interest in American railway securities following the Baring crisis while 1913 saw a short term deficit in the American capital account but as British capital exports remained high it is not immediately apparent why Rothschilds were unable to oblige.

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1. ibid. p. 79.
2. Railway News, vol. LXI (1894), pp. 158, 801, vol. LXXII (1899), p. 8.
3. H. C. Harlan: Charles Tyson Yerkes & the Chicago Transportation System, 1886-1901, Ph.D. (unpublished), University of Chicago, 1975, p. 161; Belmont Papers, October 1913.

Logically, therefore, if foreign capital was neither sought nor forthcoming, American lines were primarily dependent on domestic capital. The early 1890s were a particularly unpropitious period, with bank suspensions, the Erie Railroad receivership and populist agitation over 'big business' and the Silver Question. Obviously this was not a good time for raising capital. This clearly affected the early elevated railway schemes in Chicago on most of which construction started in the early or middle 1890s. Even in the more favourable circumstances prior to 1891 these projects experienced extreme difficulty in raising capital and most of what was raised was highly speculative. Between 1894 and 1898, when the elevated lines were at last showing signs of progress, there were further panics on the Chicago stock exchange.(1)

These panics reflected the particular local conditions of Chicago as much as national circumstances in that there was intense speculative excitement concentrated on real estate development. The end of the World Fair in 1893 led to an immediate depression in land prices which intensified as the decade wore on, the trough coming in 1897 when land values declined 25% and real estate was felt to be a liability rather than an asset.(2)

Chicago was especially hard hit in the real estate market, which was closely tied to the viability of new transport links. When the crowds who had flocked to the 1893 World's Fair but who had failed to come in the numbers expected had gone, the almost empty

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1. Homer Hoyt: One Hundred Years of Land Values in Chicago, op. cit. p. 179.
2. ibid. pp. 180-1.

flats and hotels near the fairgrounds quickly passed into the hands of receivers. The rapid increase in unemployment as factories curtailed operations reduced the demand for housing whilst the termination of World Fair projects and the contraction of firms into smaller quarters reduced the demand for office space at the very time when its supply was being greatly increased by the completion of a number of new skyscrapers.(1) Such local difficulties made life very difficult for the elevated railway companies but the only one which was actually unable to raise sufficient capital to open was the Northwestern line, which remained in a half-completed state for two years from August 1896.(2)

In New York the depression of the mid 1890s was marked by a steady decline in stock exchange quotations of the Manhattan elevated company, from a high of 174¾ in 1893 to 113 in 1897. However, not until the financial year 1896-7 was there any reduction in interest payments - from 6% to 4½% - which would support the idea that the effect of the depression would be felt most notably in attempts to raise new capital. Nevertheless, in 1896 and 1897 some $19.8 m. of bonds were retired by the company, largely in advance of the upturn in business activity.(3)

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1. ibid. p. 179.
2. R. D. Weber: Rationalizers and Reformers: Chicago Local Transportation in the 19th Century, Ph.D. (unpublished), University of Wisconsin, 1971, pp. 83-91.
3. Manhattan Railway file, no. 2691.07, Scudder Library.

Thus the impact of the recession appears to have been varied, Chicago being very badly hit, New York rather less so. Nevertheless, even in Chicago new elevated lines were able to open in the earlier part of the recession, the Lake St. line opening in 1893 and the Metropolitan West Side in 1895. This suggests that urban railways in America did not have the same difficulties in raising funds which seemed to be apparent in Britain.

A major exception appears to have been the projected New York subway. In New York a Board of Rapid Transit Railroad Commissioners was established in 1891 under a State Act of that year and proceeded to draw up plans for a subway. It was agreed at this time that the most difficult problem was that of capital, the Commissioners saying that hardly a single good system had been proposed that could be built cheaply enough to attract capitalists.(1) In a 1894 referendum a large majority voted in favour of municipal ownership of the projected new subway.(2)

Progress after 1894 appears to have been hindered by the possible preoccupation of the Rapid Transit Commissioners in fruitless negotiations with the Manhattan Railway over the construction of elevated railway extensions.(3) By 1898 when attention was again focused on subway construction it was found that the city was not in a position to finance the construction.

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1. Rapid Transit Act of New York State, 1891; The Sun, New York 28.5.91.
2. Board of Rapid Transit R.R. Commissioners: Proceedings, vol. II, 1899-1901, p. 769.
3. ibid.

By law, the debt burden of New York City was limited to 10% of the assessed value of real estate in the city but in 1898 this limit had been exceeded. There were three possible courses of action: to wait until the city's borrowing capacity had been enlarged, to obtain legislative authority to issue bonds or to obtain legislative authority to offer the franchise to private enterprise. The latter proposal had strong support as the Commissioners noted that financial conditions were by then much more favourable to construction and operation by private enterprise than they had been at any time previously.(1)

As has already been noted, from 1896 there was a sharp reversal in business activity in the United States, which should have meant that funds were more readily available, as the New York Commissioners noted. This economic recovery coincided with increased activity in the urban railway sector. The contract for the New York subway was finally signed in 1900, and by that time work on electrifying the Manhattan Elevated was well under way, as was expansion of the Chicago elevated system, construction of the Boston Elevated and expansion of the subway there and consolidation and electrification of the Brooklyn elevated lines.

Thus by the end of the century an upturn in investment in the American urban railway industry was apparent, this upturn coinciding roughly with the upturn in British urban railway investment which peaked in 1903. The American upturn is more noteworthy for this period was one of heavy capital exports from the United States, as has been noted. British lines benefitted

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1. ibid. p. 774.

markedly from this flight of capital but it does not appear to have unduly hampered fund raising efforts in America.

The peak in America was considerably less pronounced than that in Britain. In part this was because the previous years of uncertainty in America had seen continued investment in urban railways, albeit on a lesser scale. It was also due to the continuing long term volatility of the American economy, the recovery quickly being followed by another depression. The trough came in the 'Rich Man's Panic' of 1903 but the depression itself had started in 1901 with both the assassination of McKinley and a stock market collapse following attempts to corner Northern Pacific stock and the revelations that more stock had been sold than actually existed. The panic was marked by the suspension of dividends on common stock by many firms, notably U.S. Steel, and the difficulty railways encountered in borrowing on their usual terms.(1) It was a relatively mild depression but on the long side and must have hampered attempts at raising funds for construction of the New York subway.

This depression was followed by a sharp recovery from 1904 to 1907 during which America again became a small-scale importer of capital. This particular period of expansion was the most vigorous since the boom of 1879-82 but it was brought to an end by the financial panic of 1907. This recession in turn was followed by a sharp rebound to 1910. However, the 1907 panic had marked the end of the private building of rapid transit lines, the last such case being a combined subway and elevated line which opened in Philadelphia in 1908.(2)

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1. Friedman & Schwartz: op. cit. pp. 151-2.
2. G. Hilton: 'Transport Technology & the Urban Pattern', Journal of Contemporary History, op. cit., vol. III (1969), pp. 123-35.

The 1910 rebound was followed by another sharp downturn to 1913. In contrast, after the early 1900s, the British economy was generally in a recession although recovery was more noticeable towards 1913 - a high year for British capital exports and American capital imports.(1) British urban railway development reflected this, the only expansion being a certain amount of construction in London, undertaken to take the lines out of the city centre into the suburbs.

Thus urban railway development was highly concentrated, the only major expansion after 1908 being in Boston and to a much greater extent New York, in both of which cities municipal financing of construction was undertaken. In New York in particular, demands for new facilities led to the signing in 1913 of what were referred to as the 'co-operative contracts'. These called for the construction of 360 miles of new line to be constructed at a total cost of $320 m., half to be provided by the city and the remainder by the respective transit companies.(2)

The difficulties of raising money in 1913 and the even greater difficulties after 1914 had a disastrous effect on the companies as by 1919 both the New York transit companies were in receivership.(3) Despite the receivership, the ability of the companies, albeit with municipal support, to raise money in a time of economic recession is noteworthy.

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1. J. G. Williamson: 'The Long Swing ...', op. cit. p. 73.
2. Electric Railway Journal: vol. XLIV (1914), p. 700.
3. Summary of Reports on Interborough Consolidated System, prepared for Judge Julius Mayer, New York, December 1919.

This was a marked difference between the American and British cases. As has just been shown the general ability to raise capital was a variable directly dependent upon overall economic activity, but far more so in Britain than in America. Even in a boom, with a high level of domestic activity and low capital exports British companies found fund raising difficult. On the other hand, at least until 1907, most American companies had access to funds even in a recession.

International capital flows do not appear to have been important for American lines, the Hudson & Manhattan being the sole exception. Again this is in marked contrast to the British experience where the bulk of investment and construction occurred in a short period which was also one of heavy capital inflows into Britain. This goes much of the way to explaining the pronounced peak that was evident in British investment but not in American investment. Thus British companies in general seem to have had difficulties in raising capital due to economic conditions while American companies do not appear to have been so affected. These contrasts in raising capital lead to the question of what funds companies had access to and whether imperfections in the financial markets caused undue difficulties in fund raising.

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In Britain, the apparent lack of interest in urban railway companies demonstrated by investors and financial markets led to a heavy reliance on debenture issues in raising sufficient capital. In this, some companies at least were acting contrary to the spirit, if not the actual letter of Board of Trade regulations on the matter. Strictly speaking, railway companies had the power to borrow on mortgage up to one quarter of total paid up capital but such borrowing powers were not to be exercised until all the shares had been taken and were at least one-half paid up. The strict limitation of loans was deemed necessary to give creditors adequate security but it was only by over-borrowing that many companies continued to pay a reasonable dividend. The requirement of having onehalf of share capital paid up was nominally fulfilled not with payments by bona fide subscribers but through financial contributions or advances made by financial agents.(1) Both these practices were adopted by the Mersey and one or other by several other companies.

There was a major fault in this system - namely that the severe restriction in the proportion of loans to capital meant that most companies were almost always at the limit of their borrowing powers. Consequently the directors were placed under an obligation at a certain time to meet a large amount of debts falling due, whatever might then be the state of the money market. In actual fact, the great majority of railway companies exceeded these quasi-official borrowing restrictions. In this respect the Metropolitan scarcely counted as a culprit - certainly before 1907 its borrowings never rose above a proportion of 29% of total paid up capital, compared to the hapless Mersey, where by 1907 the similar proportion was 44%.(2) The long term implications of this were substantial as interest payments always constituted a heavy burden on annual income and for the Mersey and the Underground Group in London eventually led to short term insolvency. This caused complications, not least because a debenture issue was a

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1. C. C. Wang: Legislation of Railway Finance in England, University of Illinois, 1918, pp. 83-104.
2. ibid. p. 101.

loan, not a subscription. As such, it managed to attract funds which otherwise would not have been forthcoming. Thus debenture issues were exploited to the full in attempts to raise capital from a reluctant public but this in itself created problems. One of these was the requirement that half of the total capital to be subscribed by ordinary shares had to be paid up before any debentures could be issued. This alone was a major problem throughout the 1890s and the difficulties in raising sufficient capital had a considerable bearing on the restricted size of new underground lines in London. Secondly, even where companies were able to float debenture issues, the interest charges added further to the fixed charges already burdening the companies.

As British companies relied heavily on debenture issues so did American companies rely heavily on bond issues. This was by no means confined to urban electric railways as bond issues were important for many American public utilities after 1880. In theory this was largely due to the increased security the investor possessed, in practice such increased security was often hypothetical. Although like debentures, bonds created a burden of regular interest payments, in most other respects the similarities between the two forms of finance were few, largely due to different interepretations arrived at by the respective company legislature.

In Britain, the Court of Chancery would not undertake to manage a railway for debenture holders since a railway was classed as an unending business and the court could not wind it up. In America, on the other hand, an undertaking could be foreclosed on bondholders' rights and sold, or a new company formed to take over and work the enterprise.[1] In the case of the Hudson Tunnels, steps were taken in 1897 to foreclose the mortgage, sell the property and franchises of the company at auction, re-organise, issue new bonds and complete the tunnel.[2] Similarly, the original Greenwich elevated line in New York was sold to a representative of the bondholders by the receiver. Debenture holders were not a corporate body and could not manage the railway in case their interest and principal were in arrears, even if they wanted to do so, and they could not appoint directors to manage for them.[3] Bondholders were far more of a corporate body, insofar as trustees could be appointed to protect their interests.

Debenture holders did not have a preferential claim or mortgage on any outlying surplus land and they certainly could not sell the railway. The right of building the railway was given by Parliament to a certain specific company and neither that company nor any court of law could sell it save by the assent of Parliament. Bondholders could and did sell companies, usually in the context of winding up although they did not have a prior claim on income accruing from such a sale. In Britain, mortgagees could not split their securities, debentures representing lump sums of money being the most common form of securities issued by railway companies. Thus the investors had to take the security as a whole unit.[4]

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1. Railway News: vol. LXV (1896), p. 936.
2. ibid. vol. LXVIII, (1897), p. 306.
3. The Mersey Railway, as always, proved the exception. Following its failure to pay any interest on debentures, debenture holders were allowed to protect their holdings by appointing directors until the line was solvent.
4. The Economist: 2.2.1867; C. C. Wang: op. cit. pp. 67-8.

For companies, income raised from debentures and bonds was basically very similar. It had to be repaid at a fixed date and a regular fixed interest was payable. There was one essential difference. In Britain, no railway company could borrow until half of its share capital had been paid up. American entrepreneurs were not burdened with such a requirement. They could issue bonds more or less freely and at will, although certain institutions were prevented from holding less well secured bonds. Public utility developers were, however, restricted by franchises.(1) These varied from state to state, Massachusetts having some of the tightest controls which effectively deterred the wilder schemes. In theory, in a city like Chicago restrictions were almost minimal but the renowned corruption of the city council meant that substantial sums of money had to be found in advance to line the pockets of aldermen if franchises were to be successfully granted.

Franchises were important simply because a long franchise was looked upon more favourably in the capital market which meant construction could be financed more easily. Mortgage bonds were then sold to the public. Stock was issued but all too often given away to bondholders as an additional inducement to invest, thus increasing fixed charges further. The initial capital structures were inflated by the arbitrary and excessive values assigned to stock, otherwise known as 'capital watering'.(2) Nevertheless, the sometimes peculiar expectations of American investors aided such quasi-fraudulent methods. Witness the engineer who said that:

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1. Under the 1870 Tramways Act in Great Britain, tramway developers there were similarly affected.
2. G. W. Hilton & J. F. Due: Interurban Railways in America, Stanford, 1960.

> Americans are still far too apt to esteem a transportation system great in direct proportion to its bonded indebtedness.(1)

This view notwithstanding, the major problems in raising capital at this time appear to have been faced by British companies. These difficulties in turn led to the undue reliance on debenture and other loan capital which in turn created a heavy burden of interest, which in at least two cases proved too heavy. Why though, at a time when fund raising was supposedly becoming easier, especially with interest rates falling, should such a problem have been so general?(2) For urban electric railways the answer appears to have been that investors were doing nothing more than acting rationally.

This hypothesis is apparent in the raising of capital for the Mersey Railway. It is difficult to assess now the importance and future of this tunnel as envisaged by contemporaries. What is without doubt is that the Victorian press gave the project sustained and complimentary publicity but that this enthusiasm was not matched by any overwhelming eagerness on the part of investors to sink their money into the venture. Indeed, there is irony in the fact that this publicity was greater and more sustained, the more local the press, whereas investment by local interests in the project was little more than minimal. The Southport Guardian informed its readers that

> had the attention of home investors in the past been absorbed by such legitimate speculations (as the Mersey Railway) instead of by foreign loans, there would be less complaining in England today.

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1. Dr. Louis Bell: Cassier's Magazine, Vol. XVI, No. 4(1899), p. 433.
2. From 1894-6 Bank Rate was only 2% - Sigsworth & Blackman: Yorkshire Bulletin, 1965, p. 93.

Legitimate it might have been but Merseyside interests held barely 10% of capital stock in the railway.(1)

Such a statement by a local newspaper was nothing to what national publications were saying. Undoubtedly some journalists had little or no financial knowledge but statements such as

> this enterprise in its vast importance, viewed financially and as a means of communication, will bear comparison with the Suez Canal while the value of the Mersey Railway Company as an investment must be patent to everyone and cannot be overestimated

must have been regarded with considerable scepticism given the limited effect they had.(2) In the event, either the influence or the readership of the Bullionist was minimal, for there was never any rush to buy the company's shares and at an early date a number of financial journals were beginning to outline the highly speculative nature of such an investment.

The difficulties faced by the Mersey Railway led to its chairman Cecil Raikes campaigning hard for a change in regulations so that companies which were under construction but had not yet opened for traffic might nevertheless pay an annual dividend to their shareholders.(3) If a company was not open for traffic,

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1. Southport Guardian, June 1885, Railway News, Vol. XLVII (1887), p. 385.
2. Bullionist, 3.12.83.
3. Henry Cecil Raikes, 1838-91, MP for Chester 1868-82 and then for Cambridge University. In 1886 he became Postmaster General and introduced a telephone link with Paris in 1891 (Dictionary of National Biography, vol. XLVII, p. 167). Although chairman of three other companies, the Mersey was the only railway company of which he was a director.

there was no income and therefore such a dividend could only be paid out of capital. After several notable cases of railway companies indulging in such dubious activities the law had been passed, primarily for the protection of shareholders.

Raikes claimed that

> The ... operation of the standing order was that the only investment denied to the small capitalist was the small English railway.(1)

Despite the opposition of several larger railway companies Raikes was ultimately successful as the relevant standing order was repealed in 1886. The repeal appears to have come too late to have had any significant impact on subsequent railway development although a number of the urban lines made use of it.

There is no evidence that this change in regulations made it any easier for companies to raise capital. The change probably came too late to be of much help to the Mersey Railway but the City and South London had its fair share of difficulties in raising capital. In all subsequent cases where companies chose to pay such a dividend in advance of opening, the Central London being a notable example, capital was in any case tending to remain in the country and to be more readily available for such projects.

Indeed, the case of the Hudson and Manhattan project, forming as it does a comparison with the contemporary Mersey project, suggests that the general flow of capital at any given time may have played a dominant rôle in determining companies'

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1. The Times, 7.6.83.

access to capital. The bulk of British investment in the Hudson and Manhattan came in 1889 at a time when outflows of British capital were at a peak but when the Hudson and Manhattan company was already insolvent.

That British investors should have been prepared to buy bonds in this project but not shares in domestic underground projects is perhaps not as surprising as it at first appears. Not only was the rate of interest on the bonds 5%, compared to the 3½% then more or less standard on English railways but the average price of debenture stock for the Great Western, Midland and North Eastern Railways at this time was 127.(1) However had English investors known as much about the Hudson Tunnel as they appeared to about the Mersey, or indeed as Americans did about the Hudson Tunnel, it is doubtful whether this bond issue would have been so successful. As it was, the 1888 issue provided for $1.5 m. of bonds to be raised in Britain and only $1 m. in America.

The economic problems of this period meant that the Hudson and Manhattan was not alone in America in facing difficulties in raising share-capital; difficulties which led to over-reliance on bond issues, the interest on which became impossible to pay when traffic did not materialise as expected.

In Chicago this was exacerbated by the depression following the World Fair in 1893 and widespread corruption in the city council made the business of obtaining a franchise somewhat more

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1. Railway News, vol. L (1886), p. 144; A. K. Cairncross: op. cit. pp. 138, 140. The Mersey Railway was forced to pay 5% on new debenture issues at this time.

expensive than elsewhere. Here, too, the companies first in the field appeared to suffer the greatest difficulty. In Chicago the pioneer line was the South Side, on which work only started when the street railway company which had initially opposed the project fiercely, acquired half the stock. In desperation to have the line opened to Jackson Park in time for the opening of the World's Fair more and more bonds were issued and problems of debt servicing grew larger. This would have occurred anyway because of the fall-off in traffic once the Fair ended but was heightened when it was discovered that much of the money paid for South Side stock had never gone into the line, whilst the street railway had cleverly placed itself in a legally impeccable position. By 1895 the line was in receivership. It was sold eleven months later for $4 m. but as the nominal capital at this time was $10.5 m. in bonds and $7.5 m. in shares, this left the ordinary shareholders nothing.(1)

The next elevated project in the city, the Lake Street line, originally held an ordinance for the Meig's elevated system which was at that time being tested in Boston but unsurprisingly investors were reluctant to gamble on an untried system. After some two years of trying to sell $3 m. worth of bonds at 6% the Meigs system was abandoned by the backers in favour of a more conventional line. A board re-organisation in 1892 was followed by an increase in the capital stock from $5 m. to $10 m. and the 6% mortgage was replaced by 5% bonds, repayable after forty years.

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1. H. C. Harlan, op. cit. pp. 134-147.

The depressed economic conditions hindered bond sales, the market price of which was 65 in January 1894. It never rose above 70 until July 1897, with a low of 45½ in between.(1)

There was a change of management in 1894 and the new managers estimated that the line should have cost $3.317 m. at the outside ($518,281 per mile) but the previous management had issued $6.24 m. in bonds, owed $0.35 m. to contractors and had a floating debt of $1.067 m. On the existing bonded debt of the main road meeting interest payments alone would have required almost double the existing traffic. The takeover heralded a dramatic improvement with bonds being rescheduled, salaries cut, the line electrified and extensions opened.(2)

The problems of the South Side and Lake St. lines in Chicago highlight the practice of "capital-watering"; that is the construction of a line for a vastly inflated sum, most of the excess capital going straight into the pockets of the original financiers. The company would then be saddled with an enormous capital burden, the servicing of which in most cases proved impossible without restructuring the debt. Certain American financiers had a particular reputation for such sharp practice

1. ibid. pp. 165-8.
2. ibid. pp. 173-6.

although it was by no means confined to Americans.[1]

The early elevated railways in America suffered particularly, if not from "capital-watering" then from other financial sharp practices which usually related to battles between rival financiers for control. Notable among these was the personal battle between Jay Gould and Cyrus Field for control of the Manhattan Elevated Railway.[2] This battle dated from the formation of the Manhattan Elevated in 1875 in a merger of the New York and Metropolitan Elevated lines. The struggle for control was a protracted one and it was 1887 before Gould's control was anything like complete. The price of stock soared as Gould's takeover became more apparent with stock exchange quotations for Manhattan common stock increasing from a high of 53 and low of 38 in 1883 to a high of 175 and low of 120 in 1886 before falling back to a high of $97^5/8$ths in 1889. This was in line with, and no more excessive than, many share price movements during the contemporary railroad boom.[3] The number of stockholders fell from 808 in 1883 to 730 in 1885 but by 1891 had risen to 1002 and by 1897 to 1698.

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1. One of the most notorious cases was that of the Atlantic and Great Western Railroad in which Cecil Raikes of the Mersey Railway and T. B. Forwood of the Liverpool Overhead Railway were involved as trustee and member of the Committee of Bondholders, respectively. This line, conceived and constructed by a Liverpool based capitalist, James McHenry, was basically built upon the contractor's credit and its bankruptcy severely affected several British financial houses and was quickly followed by the crash of Overend, Gurney & Co. - L. H. Jenks: The Migration of British Capital to 1875, New York, 1927, pp. 255-60; Bradshaw's Railway Manual, Shareholders' Guide and Directory, 1886.
2. J. Grodinsky: Jay Gould 1867-92, Philadelphia, 1957, pp. 288-314.
3. Manhattan Railway file, no. 2691.07, Scudder Library.

Although the Manhattan company was authorised to issue bonds up to the value of $67.8 m., by 1894 only some $35.8 m. had been used.(1) By 1896 the total capitalisation of the company per mile was $0.83 m. in stocks and $1.1 m. in bonds. By this time both net earnings and passengers were declining, largely because of the improved competition offered by surface lines. This in turn led to increased irritation with the company's finances. In 1896 one Mortimer Hendricks, a bondholder of New York, charged that in the previous financial year some $277, 951 had been paid in excess of surplus profits and that although income in the first quarter of 1896 was only $147,000, some $450,000 had been paid in dividends. As a result, he claimed the company had a debt of $1 m. contracted from paying unearned dividends.(2) Hendricks was unsuccessful in his attempt to have the directors removed, although by 1899 there had been a marginal reduction in funded debt. By standards of the time the Manhattan's mortgage was not excessive, nor was it obviously overcapitalised, in spite of an increase from $30 m. to $48 m. in the capital stock in 1899 to pay for electrification.

Of the many apparent problems for rapid transit projects in New York, and the views of the Rapid Transit Commissioners notwithstanding, capital was overshadowed by the battle between the differing vested interests. Reference has already been made to the protracted negotiations between the Transit Commissioners and the Manhattan Railroad which lasted until 1898, without any solution. During the 1890s there was steadily growing

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1. ibid.
2. ibid.

dissatisfaction with the inadequacies of the Manhattan company and this dissatisfaction was reflected in a campaign that united the business community and social organisations such as trade unions, immigrant associations and religious groups in demanding an efficient new transit system.(1) This grass roots campaign led to an overwhelming vote in favour of a municipally owned subway system in 1894 but fulfilment of this idea took another nine years.

The continued delay was not due to any problems in finding the necessary capital but to sustained opposition from private interests, rejection of an 1896 Rapid Transit Commission proposal by the Supreme Court and to attempts by the Metropolitan Street Railway and the Manhattan Elevated Railway to block the new scheme. The Manhattan company was considerably helped by opposition from Tammany politicians, who were regarded as the long time ally of the Manhattan company.(2) It was Tammany politicians who first raised the issue of the city debt being insufficient to support the construction of the subway.(3) It was these stalling tactics that led to the Rapid Transit Commission continuing its negotiations with the Manhattan Elevated Company until 1898.

The negotiations at no time appear to have been a realistic attempt by the Manhattan company to provide an alternative to a new subway. The elevated company was heavily criticised for its

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1. C. W. Cheape: Moving the Masses, Urban Public Transit in New York, Boston and Philadelphia, 1880-1912, Harvard, 1980, p. 80.
2. ibid. p. 87.
3. ibid. p. 87.

lack of precision in applications and to its tardiness in commenting on suggestions, in particular its failure to put forward any plan for changing to electric traction. The Commissioners were forced to conclude that

> The public announcement of an intention on the part of the Elevated Railway Company to apply for additional facilities, or for extensions of its existing routes, operates to deter responsible bidders from undertaking the construction and operation of the rapid transit road laid out by this Board.(1)

This failure was followed by the upturn in economic conditions which led the Commissioners to consider private construction of a subway but in the end overwhelming public pressure for a city-owned subway, together with a split between Tammany and the Manhattan company, led to the construction of a city owned line.(2)

A contract for this was drawn up under which the city's cost for the subway was to be the cost of the successful contractor's bid plus an additional $1.5 m. for real estate and terminals. This would be financed by the sale of municipal bonds and the successful bidder was to compensate the city by an annual rental equal to the annual bond interest plus 1% of the construction cost, which was to go into a sinking fund to amortize the bonds. The contract was for fifty years although the bidder had the option of renewing for a further twenty-five years.(3)

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1. Collection of Documents and Reports Submitted to the New York Rapid Transit Railroad Commissioners on the Manhattan Elevated Railway, W. B. Parsons Collection, New York Public Library, p. 16.
2. C. W. Cheape: Moving the Masses, op. cit. p. 89.
3. Rapid Transit Commission: Contract for Construction and Operation of a Rapid Transit Railroad, New York, 1900.

Despite misgivings that there would not be any bidders, these terms attracted two firm bids but the successful contractor, John B. McDonald, faced a temporary crisis when his bankers demanded considerably more onerous terms. He successfully pleaded for more time to obtain backing which was then forthcoming from August Belmont.(1)

August Belmont appears to have been painted as something of a hero for this action and was praised for relying heavily at first on McDonald's integrity, in his apparent anxiety to see the subway built.(2) Belmont generally appears to have been painted as an altruist but his background does not suggest a radical breakaway from America's powerful elite of oligopolists. As an influential member of the Democratic Party, Belmont had considerable political influence and as an experienced banker, being the American representative of Rothschilds, there was no problem in securing access to funds. Indeed, the Belmont banking interests provided major support to the U.S. Treasury in the 1890s.(3) Thus the

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1. Board of Rapid Transit RR Commissioners: op. cit. 1900, pp. 862-3, 873-4.
2. J. B. Walker: 50 Years of Rapid Transit, 1864-1917, New York, p. 169.
3. Amidst political agitation the U.S. Treasury's gold reserve had declined to a low of \$45 m. in January 1895. In an attempt to replenish these reserves, in February 1895 the Treasury signed a contract with a banking syndicate headed by J. P. Morgan and August Belmont which provided for the syndicate to supply \$65 m. of gold to the Treasury, in return for 30 year 4% bonds at 104½, which the syndicate marketed at 112¼. The allegedly onerous contract terms, arranged through agents long identified in Populist literature as "the conspiracy of international bankers" became an issue in the 1896 election campaign. After this was won by the Republicans, domestic accumulation of gold ceased and the pressure on the dollar eased. - Friedman & Schwartz: A Monetary History of the United States, op. cit. p. 111.
   Other indicators of Belmont's affluence were the naming of Belmont Park racecourse in his honour, his patronage of the America's Cup yachting competition and his private railroad car Mineola.

growing concern over the rise of big business monopolies had little real impact, at least as far as urban transport was concerned. Certainly Belmont was opposed to the principle of municipal ownership, at one stage even paying a (London) Times editorial writer to undertake research on municipal ownership and control in Britain.(1) Already financially involved with the New Haven Railroad and more significantly from the New York transport point the Brooklyn elevated lines, Belmont at the time did appear to be the saviour, financially, anyway, of the New York Subway.(2)

The feeling in New York in favour of a municipally owned subway was summed up by the Transit Commissioners when they said

> The striking success of the subway in Boston removed doubts which formerly existed in some quarters, both as to the practicability of such a road and as to the possibility of calculating the cost ... In the City of New York in particular, such franchises as those for the construction of the elevated railways ... have proved the sources of enormous private gains without corresponding returns to the City.(3)

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1. Belmont Papers: copy of letter from Dixon H. Davies of Great Central Railway (England) to Robert Porter, 8.6.06. In 1906 Porter received $10,117 from Belmont and his associates for his research, $8,000 coming from the Interborough Rapid Transit Operating Account and $2,117 from the Equipment Account - note from IRT Treasurer to Belmont, 20.2.07.
2. J. B. Walker: op. cit. p. 167; Belmont Papers, Box 6.
3. Board of Rapid Transit RR Commissioners: op. cit. p. 774.

Like the New York subway the Boston subway which was the first of its kind in the United States was municipally owned. At the time municipal ownership of transport facilities was still rare in America but Massachusetts had a stronger tradition of government investment in public enterprises than did most states.(1) As in New York, public ownership was a result not only of public hostility towards transit monopolies but also a reflection of the risks and costs of innovation. While private capital was readily available for construction of elevated railways, construction of such lines was unacceptable in the crowded city centre. Subway construction meant much greater investment but without the prospect of a higher return on the investment. As in New York, public construction had the support of major business interests.(2)

The major difference with New York was that the Boston subway was built to remove street-cars from the crowded central district streets. It was thus much smaller than the New York line and the capital required was correspondingly less. While the subway was to be financed by City bonds bearing not more than 4% interest, the construction of elevated railways to the suburbs was left to private capital.(3) Although private capital was not forthcoming for the subway project, major investors including prominent local politicians and bankers such as J. P. Morgan & Co. and Kidder Peabody and Co. combined to take over the existing street railway operations and to construct new elevated lines.

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1. C. W. Cheape: Moving the Masses, op. cit. p. 132.
2. ibid. pp. 133, 137.
3. ibid. pp. 138-9.

With a unified transport company, and a Transit Commission as a watchdog, policy in Boston was for the Commission to plan and construct facilities which the Elevated Company then rented. The combination of public ownership and construction with private operation served Boston well, at least until 1918.(1)

The popular demand for municipal ownership of rapid transit systems in New York and Boston was a direct reflection of the unpopularity of existing transport companies in those two cities - the Manhattan Elevated and Metropolitan Street Railway in New York and the West End Street Railway Company in Boston. The same popular mistrust existed in Chicago where Charles Tyson Yerkes, a Philadelphian financier had succeeded by 1890 in gaining control of most of the city's street railway systems.

These systems were highly profitable. The annual dividend of the Chicago City Railway Company never fell below 10% from 1870 to 1900 and between 1884 and 1900, notwithstanding the national depression and an even more severe local depression following the collapse of a real estate boom on the South Side, was a constant 12%. Between 1886 and 1898 the West Side Street Railway paid a minimum of 5% and over the same time the North Side a minimum of 5% and a maximum of 32%. Given the actual capital structure of these companies, these rates are probably largely meaningless, although between one-fifth and one-quarter of all money probably went to investors. In the case of the City company, earnings before payment of bond interest rose from $0.68 m. in 1888 to $1.89 m. in 1900.(2)

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1. ibid. pp. 147-151.
2. L. M. Zingler: Financial History of the Chicago Street Railways - Ph.D. (unpublished), University of Illinois, 1931, pp. 233-4.

The bulk of these paper profits accrued to Yerkes (the City company remained outside his control) and ten years after entering the Chicago traction field in 1886 he was estimated to have made a personal fortune of $29 m. However

> Despite his entrepreneurial workmanship his entire over-capitalized and overcomplicated street railway system would have toppled instantly had it not been for municipal grants of monopoly rights.(1)

Yerkes' downfall was an attempt to secure longer franchises before the existing franchises expired in 1903. There were wild demonstrations in Chicago in 1897 before Yerkes' bid was finally defeated. Blaming his defeat on 'socialists, anarchists and newspapers' in 1901 he sold out his interests in Chicago to two friends from Philadelphia - Peter Widener and William Elkins.(2)

Widener and Elkins were connected with a large number of street railway concerns in America while all three of them, more often in rumour than in fact, were linked with almost every new rapid transit project in America and Europe. To give but two examples, the Franco-Belgian Traction Company, formed in 1896, which played a leading rôle in the creation of the Paris Metro in 1898 was 'apparently linked to the American streetcar magnate Charles Yerkes' and the same interests were expected to finance a subway in Philadelphia in 1910 although Yerkes and Elkins were by then dead.(3)

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1. S. I. Roberts: 'Portrait of a Robber Baron - C. T. Yerkes', Business History Review, vol. XXXV 1961.
2. Ibid.
3. J. P. McKay: Tramways and Trolleys - The Rise of Urban Mass Transport in Europe, op. cit. Ch. IV; Electric Railway Journal: vol. XXXV (1910), p. 422.

The opposition to Yerkes in Chicago had come about primarily through his buccaneering and fraudulent tactics.

> The record of his corporate activity was a palimpsest on which was written reorganisation after reorganisation, with a heavy admixture of stock-watering in each.(1)

His attempts to extend his franchise in the 1890s cost him around $1 m. in bribes and were unsuccessful, with the very real threat of major riots in Chicago had the ordinances been passed.

With further progress in Chicago impossible, Yerkes decided to look elsewhere for opportunities to build up a personal transport empire. With his reputation in Chicago well-known, no city in America was likely to welcome him, so it is perhaps not unnatural that, in line with much of the American capital market, he should look abroad. At this time the underground railways in London were very much in a state of limbo. In contrast to the American situation where large financiers were prepared to back most projects in return for the prospect of obtaining a transport monopoly, such support in England was greatly lacking. By 1901, the year Yerkes sold out in Chicago, the Central London Railway (CLR) and the Waterloo and City Railway had opened, but the Baker St. and Waterloo, Charing Cross, Euston and Hampstead, and the Great Northern Piccadilly and Brompton projects were still hindered by a lack of capital. The City and South London (CSLR) had been operating successfully since 1890.

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1. Dictionary of American Biography, vol. XX, 1936.

Around this time, Yerkes acquired control of the incomplete B.S. & W., Hampstead and Piccadilly tubes and of the District Railway. Whatever the personal motives for this, the move can be seen as another aspect of the outflow of funds from America but it is worth asking the hypothetical question as to whether, given the improvement in the British economy especially with regard to raising capital, these lines could have been completed and the District electrified without Yerkes' intervention. The importance of underground investment in 1903 and 1904 has already been noted and much of this was attributable to Yerkes.

The District was a problem railway and always had been. The problems had been exacerbated by the Inner Circle, the completion of which had absorbed excessive amounts of capital and even though the City of London contributed £800,000 to its completion, it placed the District under an enormous burden.(1) By 1891 it was capitalised at the rate of £383,684 per mile. The only British railway which exceeded this was the Mersey, at £640,250 per mile, while the Metropolitan had only cost £235,780 per mile.(2) Unsurprisingly, in the adverse economic conditions of the early 1890s the District failed to pay an ordinary dividend but it further failed to pay anything before World War I. It fared marginally better on its Preference shares. These bore a nominal rate of 5% and $3^3/8$% was paid in the generally good year of 1897, but from 1901 to 1909 nothing was paid on Preference shares either.(3)

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1. Barker & Robbins: op. cit. vol. I, p. 237.
2. Because the Metropolitan had a long main line out into the country, the capital cost of which was low this should not be regarded as an accurate comparison.
3. Board of Trade: Railway Returns.

It was therefore hardly surprising that between June 1882 and June 1896 the capital value of District Ordinary stock fell by 50% while Metropolitan stock improved 31% over the same period. In spite of the line's poor performance, from 1896 to 1898 ordinary shares were being bought up in large blocks.(1) This appears to have been an action by the Metropolitan District Railway Shareholders' Association, which claimed to have been given £1 m. by the District to construct a deep level line from Earls Court to the Mansion House.(2) Yerkes did not actually acquire the District until 1901, but by this time he had already become chairman of the Hampstead tube, his syndicate having formally taken it over in October 1900. It was 1903 before work actually started on the project.(3) With the acquisition of the Piccadilly line Yerkes' plans were complete for the time being, although there is little doubt that he would also have liked to secure control of the Metropolitan.

Yerkes' syndicate was said to include his friends Widener and Elkins and Marshall Field from Chicago.(4) There is no evidence for the inclusion of Widener and Elkins and it seems highly unlikely. From the outset Yerkes was anxious to avoid conflict in Britain and as far as possible used British contacts. It would hardly have helped his cause had Widener and Elkins been involved, apart from which their heavy involvement in transit enterprises in the United States is likely to have ruled them out

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1. The total Ordinary stock at this time was £2¼m., out of total paid up capital of £12.8 m.
2. Metropolitan District Railway Shareholders' Association: circulars etc., 1897-8, Acc 1297/MDR 4/17.
3. Jackson & Croome: op. cit. p. 63.
4. ibid. p. 63; Daily Express 15.3.01.

as interested partners in London. Furthermore, as Marshall Field was about this time representing a J. P. Morgan syndicate in Chicago, his inclusion too is open to question.[1]

Even before Yerkes had acquired control of the 'tube' lines he had drawn up plans for electrification of the District. In July 1901 the Metropolitan District Electric Traction Co. (MDET) was formed to provide electric traction for the District. Yerkes purchased £433,000 of District ordinary stock for the company which was capitalised at £1 m. in £20 shares. Yerkes took a large number of these and most of the rest went to America. Of the five directors, two were Londoners and the others, including Yerkes, were American although none of them appear to have been involved in any of his previous ventures in Chicago.[2] Once he had acquired control of the 'tubes', Yerkes set up a joint company to control the three of them plus the District and the MDET was wound up in August 1902 when its assets were vested in the new company. To finance the new company Yerkes had approached the banking house of Speyer Bros. who agreed to raise £5 m. for it. Initially all the shares issued were privately subscribed. Of the 400,000 £10 shares eventually placed on open offer about half were subscribed for in Britain and the other half in New York and Boston.[3]

One of the fears widely expressed regarding Yerkes was that he would indulge in stock-watering on an American scale, especially if he could acquire a monopoly of transport in London.

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1. L. M. Zingler: op. cit. p. 68.
2. Metropolitan & District Electric Traction Committee: <u>Minutes</u> - Acc 1297/MDET 1/1; Jackson & Croome: op. cit. p. 71.
3. Jackson & Croome: op. cit. p. 73.

Pierpont Morgan was interested in opening tubes in London and the way Yerkes tricked Parliament into rejecting Morgan's schemes did nothing to allay the fears.(1) Despite this and numerous allegations made in the popular press, stock watering under Yerkes was effectively non-existent. Admittedly following his takeover there were large increases in the authorised capital of the Piccadilly and Hampstead tubes, which probably reflected earlier optimism about construction costs more than anything. The first debenture issue under Yerkes was not made until 1905, for the B. S. & W. From 1906 debenture issues did in fact become substantial but by then Yerkes was dead and the new issues were made under the direction of Edgar Speyer and Sir George Gibb, formerly of the North Eastern Railway, who was one of the most respected railway managers in the country.(2)

Nevertheless, once the London lines were electrified their financial performance lived up to rational expectations. By 1906 the Metropolitan, which had financed electrification itself, was only managing to pay 1% on its ordinary shares and the following year this rate was halved. The District had not been paying anything even on its preference shares since 1900. In spite of this obvious over-capitalisation, in 1905 the securities of both the Metropolitan and the District were in considerable demand because of the anticipated benefits to be gained from electrification. With a dividend of 3%, the Metropolitan ordinary shares rose to par while the District

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1. ibid. p. 79, Barker & Robbins: op. cit. vol. II, p. 84.
2. Jackson & Croome: op. cit. p. 104; Board of Trade: Railway Returns.

ordinarys, which had scarcely seen a dividend, rose to 42¾ although it was suggested that this was merely manipulation by UERL who held most of the shares.

When the results for 1905 were announced, with a drop in the Metropolitan dividend to 2 3/8%, its ordinary stock fell to 66 and that of the District to 22. This was largely attributed to the transition to electric working being incomplete but there was no doubt that electricity was extremely costly in terms of capital. The Metropolitan had issued £1¼ m. of convertible stock to pay for electrification, the annual charge on which was equivalent to ¾% of the ordinary dividend. The District was not so seriously affected as electrification was paid for largely by the issue of ordinary and second preference stock, mostly to Yerkes and his associates.(1)

Given its past financial performance, it was extremely unlikely that investors would have been tempted by the District at all. Similar problems of capital afflicted the other members of the UERL, with the Piccadilly Line capitalised at around £800,000 per mile - more even than the unfortunate Mersey Railway.(2) By 1907 the District was bankrupt. Electrification had brought it to the end of its financial resources and it had been unable to raise any new capital since 1905. A series of temporary loans had been made on the security of surplus lands and Parliamentary approval was now to be sought for the issue of £750,000 of <u>prior lien</u> redeemable debenture stock.(3)

1. The Economist: vol. LXIV (1906).
2. ibid. p. 2047.
3. ibid. vol. LXV (1907), p. 2027.

It would be easy to say that the problems of the District and the rest of the UERL group were the result of 'watering' but it would also be unfair. After all, Yerkes himself had invested a large part of his fortune in the ordinary stock of the enterprises. Admittedly costs had been excessive with electrification of the District costing £2½ m. compared to £1¼ m. for the Metropolitan but this could easily be attributed to Yerkes' grand designs for a first class electric railway.

The question then remains: if the returns were so disastrous why did Yerkes make the investment in the first place? Given the American public's wariness towards him, he would have had extreme difficulty in developing new enterprises there unhindered. London therefore provided an opportunity which was facilitated by the existence on paper of three companies, all with Parliamentary approval. Yerkes made two basic mistakes. Firstly he failed to notice that although capital was being raised in record amounts for domestic investment in Britain, underground railway companies in London were having extreme difficulty in raising capital. The performance of existing urban railways was sufficient to explain this to the average investor but Yerkes' second mistake was to believe that the fault here was the lack of unification of the transport organisations. His grand design had called for the eventual unification of transport in London but he made the seemingly elementary error of basing financial forecasts on the traffic conditions of American cities. By 1908 Speyer admitted:

Our experts were wrong, as experts often are ... The experts were over-sanguine concerning the development of London traffic and did not fully appreciate the difference between London and New York or Chicago.(1)

One of the problems in London was that the Yerkes group were unable to achieve the organisation of a single transport enterprise for the whole of the city as they had hoped. In sharp contrast, after 1906 96% of passengers in New York were carried by just two organisations - the Interborough Metropolitan Group and the Brooklyn Rapid Transit Co., both of which had practical monopolies in their respective boroughs.(2)

One other line in the New York area was the Hudson and Manhattan, a project on which little work took place between 1891 and 1907. In the latter year a newly formed company, the New York and Jersey Railroad Co. bought the organisation from the bond-holders for a nominal sum. The company had the considerable advantage for fund raising purposes of a perpetual franchise but made its first mistake when it was decided to build a second link in 1903, under a separate company, to be known as the Hudson-Manhattan Railroad. In 1906 the two organisations were consolidated into the Hudson and Manhattan Railroad Company and operations started in 1908. The whole enterprise was being underwritten by Harvey Fisk and Sons but over $70 m. had so far invested in it.(3)

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1. Barker & Robbins: op. cit. vol. II, p. 141 (quote from Railway Times 16.5.08).
2. C. M. Latta: The Return on the Investment in the Interborough Rapid Transit Co., op. cit. pp. 90-110.
3. W. G. McAdoo: Crowded Years - Cambridge, Mass (no date), p. 74; J. B. Walker, op. cit.

Following the reorganisation there was little difficulty in attracting sufficient capital although traditional transit financiers were not involved to any great extent.[1] The company did not escape the other disease of urban railways - inability to earn sufficient to meet its obligations. Early in 1913 a scheme was announced for the readjustment of its debt as it had failed even to earn interest on outstanding first mortgage bonds. A syndicate of bankers was formed and a plan drawn up which provided for the surrender of the existing first mortgage 4½% bonds in exchange for half of the principal in new 5% bonds and the other half in 5% adjustment income bonds. Stockholders were to pay $8.50 per share, for which they would receive new 5% first mortgage bonds at a rate of $900 for each $1,000 paid.[2]

The slow growth in traffic and the steadily rising tax burden were blamed for the financial difficulties although the company was undoubtedly guilty of over-optimism in deciding to construct a second, independent, tunnel system given the pitfalls the first one had encountered over the previous 20 years. The early financial history of this company again demonstrates all too clearly the narrow margin between success and failure in raising finance that coincided with fluctuations in business confidence.

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1. W. G. Oakman of the IRT and later Inter-Met did hold some 7,400 shares in 1908 and at one stage was chairman.
2. Electric Railway Journal: vol. XXXIII (1909), p. 889, vol. XLI (1913).

A comparable line with the H. & M. was the Mersey, which had already faced problems in raising capital for initial construction. When completed it had promptly gone into receivership as receipts were insufficient to pay interest on all debentures. Over the next ten years the line struggled on but by 1897 it was apparent that electrification would be only a matter of time.(1) Before this could happen it was clear that some form of capital reorganisation would have to take place. Under the Mersey Railway Act 1900, this was to be provided for by a reduction of interest rates on debentures from 5% to 4% and from 4½% to 3%, by paying arrears of interest on preference shares or ordinary shares and by making debenture interest contingent upon revenue. The £55,000 due to creditors was to be met by the issue of 'B' Debenture Stock.(2) The solution effectively increased the capital issued while reducing the annual burden of the capital charges but it was clear that under the circumstances the company would have extreme difficulty in financing electrification.

It had good reason to be grateful to the British Westinghouse Company (BWEM) with whom the contract was eventually placed. The Mersey Company only had to find some £15,000 to pay for electrification, the remainder of the payment being made through a debenture issue. BWEM were to guarantee the interest on the existing Redeemable 1st Debenture Stock until the line was

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1. The first mention of electric working was in March 1894, noting that replies to inquiries had been received from Mather & Platt and the Electric Construction Company. This was followed by a report submitted by Siemens and Greathead in 1895 on cable and electric working and eventually, in 1898, a recommendation from the Receivers to consider electric working. Mersey Railway: Directors' Meeting Minutes, 475/7, pp. 133, 192, 475/8, p. 141.
2. ibid. 475/8, pp. 201, 220.

electrified. In its place £703,750 of new stock was to be created. £249,000 was to be reserved for issue when the existing Redeemable 1st Debenture stock was paid off. Of the total price paid to BWEM, £620,000 was paid in 4% perpetual 1st debentures and the rest in cash.(1) The Mersey Railway undoubtedly obtained a bargain and BWEM may have had cause to regret their generosity although payments on the new debentures were maintained, but no British electrical manufacturer was in a strong enough position to have been able to do the same. Even if they had been the existing over-capitalisation of the Mersey was an awesome disincentive. Given developments in London, it is not surprising that while the British capital market was raising more money for domestic use at this time than ever before, it was American capital exports that were indirectly responsible for Mersey Railway electrification.

This overall analysis does tend to show that the pattern of raising capital for urban railways fitted into the pattern of general trends in the capital markets, which in turn were affected by economic activity in general. The outflow of capital from the U.S.A. in the late 1890s was apparent in the case of Yerkes' investments in London but also in the expansion of electrical engineering, with both GEC and Westinghouse establishing British subsidiaries in the late 1890s. As shown, the Westinghouse subsidiary played a major rôle in financing electrification of the Mersey Railway. Westinghouse and GEC both made their decision on economic grounds and although Westinghouse later had cause to regret their move, this was primarily because of their optimistic

1. ibid. 475/8, p. 274.

views on the size of the market.(1) GEC's subsidiary on the other hand proved to be profitable.

The movement of American capital into the London railways is a more interesting phenomenon, largely because it was apparently the decision of a single person and personal motives may have been more important than economic judgement. Had private capital under Yerkes not been forthcoming it is unlikely that it would have come from elsewhere for British investors had by this time demonstrated their reluctance to be involved in such enterprises.

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Given this apparent reluctance, a deeper analysis of who did invest in urban railways and why is appropriate, as this may help to explain attitudes to urban railways as an investment. It also provides further information on the sources of capital for the companies.

The first major consideration is that these were completely new railway companies, seeking to raise money against the competition of established companies. Because of this they were

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1. Westinghouse and GEC had cornered the electrical market in the U.S.A. Between 1890 and 1898 Westinghouse sold some 20,000 motors and GEC 30,000 but from 1891 to 1895 the price of GEC's two-motor equipment fell from $2,600 to $750. In spite of this, demand was flagging, largely due to the depression, during which U.S. prices were generally declining, especially in relation to those in Britain. The decision to look overseas for continued growth was a logical one, shared by many American companies at the time. T. C. Barker & R. M. Robbins: History of London Transport, op. cit. vol. II, p. 19.

exceptional; the raising of capital for new companies in Britain was done largely in the provinces, sometimes by private negotiation between business associates and generally by the investment of their own capital by the directors or owners and their friends.(1) In these circumstances the cost of obtaining quotations on the London Stock Exchange was an additional burden, with no guarantee of success. The Mersey Railway for many years maintained a London office while the crucial capital enabling work to start was from the contractor's personal funds.(2)

Meanwhile, the pattern of shareholding in Britain was changing. In 1902, not taking into account shareholdings in different companies, there were some 800,000 holders of railway shares of whom 40% were holders of ordinary shares, the average holding of debenture stock being about £2,000 and of ordinary stock about half that. But by 1912 one-third of the shareholders in the Midland Railway held less than £500 of stock.(3)

In Britain the Central London Railway appears to have been regarded by investors with considerably more favour than the other lines. This may have been due to the growing success of electric traction and the fact that its proposed route underneath London from west to east along the principal thoroughfares seemed

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1. A. K. Cairncross: op. cit. p. 96.
2. In 1881 the contractor, Major Isaac, undertook to place £25,000 of shares on the London Stock Exchange, in order to obtain a London quotation. Subscription to two-thirds of authorised capital had to be achieved for such a quotation. Mersey Rly: Board Minutes, 1881, RAIL 475/4, p. 6.
3. A. K. Cairncross: op. cit. p. 85n.

the most likely to generate a large traffic. More important than this was the apparent seal of approval given to the company by the imposing list of joint stock companies who invested in the enterprise. These were headed by the Exploration Company which formed a subsidiary, The Electric Traction Co. Ltd., to build and equip the line in return for £700,000 of 4% Debenture Stock and £2.54 m. in cash.(1) Whether the Exploration Company's backing provided the security that other companies were looking for or whether the situation was reversed is not clear but either way by 1st December 1895 seven important companies had decided to back the project. Apart from the Exploration Company and its subsidiary these included other mining concerns - Consolidated Deep Levels Ltd and the Transvaal & General Association Ltd. More important perhaps were the banks which backed the project, notably two foreign banks - Banque Internationale de Paris and the Banque de Paris et des Pays-Bas - but also N. M. Rothschild & Sons and the Consolidated Bank. With such names supporting it, once the upturn in economic conditions came the company had no problems in obtaining financial support, a substantial amount of which was foreign.

Although numerically Europeans comprised under 5% of total shareholders theirs were above average holdings - of those shareholders whose investment was substantial enough to qualify them for directorships, over 14% were foreigners. Even more

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1. A. A. Jackson & D. F. Croome: op. cit. p. 44.

revealing is a breakdown of shareholders by occupation. Unsurprisingly, individuals calling themselves either 'gentlemen' or 'managers' formed over 30% of total investors in 1895 but the Company was also a source of attraction for the small investors who were presumably looking for a steady income from a safe enterprise. Thus the second largest social grouping was spinsters, who formed 11.32% of total shareholders. 4.26% of shareholders were widows but there is no record of those unfortunates who might have been orphaned.(1)

The importance of the line as a secure investment can be seen from further study of the occupations of the shareholders. It was a popular investment with clergymen and clerks but some of the less likely investors included artists, students, signalmen and a pig keeper. On the other hand although European interest in the line was substantial there were only two American investors, both from New York.(2) This appears especially strange given the heavy American investment in London lines that was soon to follow.

Conversely, the investment in the company by foreign banks must have helped enormously in giving the CLR a seal of approval. Whatever the reasons, their optimism was certainly justified as from 1901 to 1918 dividends only once fell below 3% and in this respect its performance was better than that of any other London

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1. CLR: Shareholders' Address Book 1895 - Acc 1297/CLR 4/1. There do not appear to be any figures of actual shareholdings.
2. ibid.

line. But if the line with the best route in the capital and the first line constructed adequately enough to cope with the expected traffic could only show a return of 3 to 4% on its capital which was certainly a long way from being excessive, then it demonstrates that the public were justified in their reluctance to invest in urban railways.

This reluctance was apparent in the case of the Mersey Railway where no complete breakdown of shareholders by occupation exists but information on new share issues possibly reveals more as to what the function of the company was expected to be. Given a widely held belief at the time that the line would be taken over by one of the larger railway companies on completion, it is unsurprising that one of the largest groups of purchasers of Mersey Railway shares in 1884 was Great Western Railway shareholders, who were responsible for buying 2,390 shares out of a total of 11,513 subscribed for, or 20.76%, which was identical to the amount subscribed for by London and North Western Railway shareholders.(1) As either of these companies had something to

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1. Mersey Railway Records: RAIL 475/4, p. 165 (21.2.1884). The practice of the major railway companies forming separate companies for constructing new projects, or of supporting independent companies involved in such projects, was a common one. In the urban railway field alone the examples of the Waterloo & City and Great Northern and City railways are obvious ones. Another would be the forming by the Great Western Railway of a separate company to build the Severn Tunnel. The Mersey Railway was designed to join up rival companies and separate dock systems on both sides of the river. There was also originally a plan to build a major terminal station in Liverpool, which added support to the theory that the Great Western Railway, which had access to Birkenhead but not to Liverpool, would take over the company on completion. As the Severn Tunnel was also under construction at the time it was felt that financial problems of constructing two major tunnels prevented the G.W.R. from taking a closer interest in the Mersey although the G.W.R. had two of its board members on the Mersey board. In the event such speculation proved false.

gain from taking over the Mersey Railway it follows that their shareholders were not necessarily interested in Mersey Railway stock per se. Similarly, if investment by shareholders of the Midland, Lancashire & Yorkshire, Great Northern and Manchester, Sheffield & Lincolnshire Railways all of which were intended to have access to the tunnel are added in, a further 2,950 shares or 25.62% were accounted for. In short, 67.14% of the 1884 share issues subscribed for went to parties for whom the investment might have been seen as a way of protecting or boosting an existing investment rather than as a potentially fruitful investment in its own right.

Of the remainder only 982 shares of the issue (8.53%) were allotted to London subscribers but even this was more than the 931 shares (8.15%) that went to residents of Liverpool and Birkenhead. This lack of local interest was a consistent feature of Mersey Railway shareholdings for of its paid-up capital in 1896, some £2½ m. had been raised in London but only £100,000 in Liverpool.(1) This was in marked contrast to the Liverpool Overhead Railway where a substantial amount of the shares were taken by local dignitaries and where almost all the shares were subscribed for locally.(2) There was therefore no inbred reluctance on the part of Merseysiders to invest in local railway facilities, especially in view of the importance of railway issues for the Liverpool stock exchange. One is therefore forced to conclude that the lack of local investment in the Mersey Railway reflected doubts about the project's viability.

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1. Railway News: vol. LXVI (1896), p. 286.
2. C. E. Box: Liverpool Overhead Railway, London, 1959.

The lack of local interest was in contrast to the CLR experience where despite the high foreign interest, interest outside the London area does not appear to have been substantial. 56.71% of the shareholders were from London and the Home Counties and a further 33.73% from the rest of England and Wales. There were only five inhabitants of Merseyside who subscribed which was a smaller number than from Paris.(1) Foreign investment was substantially higher than that from Scotland and Wales and while foreign interest in subscribing to London's underground railways increased over the next ten years that in Britain at best remained static.

Compared to this foreign interest in the CLR and later in other London lines, foreign investment in American lines was minimal. In the case of the Manhattan Railway, of 78,000 odd shares in 1897 for which details are available, only 90 (0.12%) were obviously held abroad. Somewhat curiously, these were held by two British banks, neither of which held any significant securities in British urban railways.(2) The Manhattan Railway at this time had about 1,700 stockholders compared to 751 of the CLR in 1895.(3)

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1. C.L.R.: Shareholders' Address Book 1895, op. cit.
2. Barclays Bank Ltd. held 20 shares and the London, City and Midland Exchange & Trustee Company held 70 shares. Belmont Papers: List of Manhattan Railway shareholders.
3. C.L.R.: Shareholders' Address Book 1895, op. cit.

The Manhattan shareholding patterns reveal very heavy local investment in the company. Outside New York City and its suburbs there were only 4,139 shares, including the 90 already mentioned. Apart from a private holding of 2,230 shares in St. Louis these were predominantly institutional, or privately held in New Jersey. Indeed, the only other shares held outside North Eastern states were 100 held in Savannah, Georgia. Given the plethora of financial institutions with offices in New York this may not accurately reflect overall holdings but even of private holdings only 3,520 shares or 16.6% of the 21,203 privately held were not held within New York City. If suburban holdings are included, the proportion of non-New Yorkers having any interest in the Manhattan Railway was almost insignificant.(1)

In the case of the New York subway details are available for holdings of 7% Interborough Rapid Transit Company bonds in or about 1905. Again minimal foreign interest is apparent as is geographic concentration of most bondholders in the New York area. Some 29.5% of bondholders were New York City residents but these held 54.83% (702,886 bonds) of this stock issue. Foreign investment was confined to 11 people holding a mere 22,000 bonds. (4.26% of bondholders and 1.72% of bonds respectively). The majority of these were American citizens anyway in places such as Japan, China and the Philippine Islands. Only one person was registered from Britain and even then also had an American address and only two foreigners were registered on the American

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1. Belmont Papers: list of Manhattan Railway shareholders.

list. Of the remaining bondholders, the overwhelming majority were from either the North Eastern United States and within 250 miles of New York, or Chicago.(1)

In the rest of the U.S.A. 26.74% of total stockholders held 12.65% (162,200) of the bond issue. Within such a broad area there were substantial variations ranging from just one holder with 500 bonds in Oregon to two with 11,000 in Buffalo and seven with 36,200 (2.71% of holders and 2.82% of shares respectively and the nearest to an 'average' holding) in California. Curiously enough, the state with the largest number of bond-holders, outside New York, New Jersey and Massachusetts was Wisconsin with 13. Conversely, the actual number of bonds held here was low at 9,900 or only 761.5 per bondholder.(2)

At this time there were 1580 bondholders of this 7% issue and with a total of 1,281,000 bonds this gave an average holding of 811 bonds per person. This was high for an average holding. In Boston in 1909 for example the average holding of Elevated Railway stock was just 34 shares and only 9 stockholders owned more than 1,000 shares. Boston stockholdings at the time also reveal a very high concentration of local stockholders, with 88% of shareholders, representing 87% of all shares, living in Massachusetts.(3) By 1914 this had grown to just over 89% of shareholders, or 5,055 out of 5,667. From the rest of the

1. Belmont Papers: undated list of IRT stockholders.
2. ibid.
3. Electric Railway Journal: vol. XXXV (1909), p. 85.

United States there were 376 stockholders, from Britain 21, the rest of Europe 12 and one each from Cuba, Asia and South America, the latter holding one solitary share.(1)

The importance of local capital extended to Chicago where early elevated projects relied for their initial support on 'Eastern capitalists' and faced difficulties in raising sufficient capital as a result.(2) The pattern that eventually emerged in Chicago was of a strong preference for local funds wherever possible with an appeal to Europe as a last resort. With minor modifications this proved to be the pattern for all the American urban lines, the one irony in it being that appeals to Europe for capital were usually made at a time when capital would not be forthcoming, most notably in the example of Belmont attempting to elicit funds for the New York subway from Rothschilds in London in 1913.(3)

The one major exception to this was the Hudson and Manhattan Railway. This was the only American line where British capital ever actually exceeded American capital but it was also the only American line where local interest was minimal, rivalling that of Liverpool's in the Mersey Railway in its apparent apathy. This provoked H. J. Kendall, one of the English bondholders, to remark:

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1. ibid: vol. XLIII (1914), p. 695.
2. H. C. Harlan: Charles Tyson Yerkes & the Chicago Transportation System, op. cit. pp. 157/161.
3. Belmont Papers: October 1913.

> To me it has always been one of the strangest things that New Yorkers have been so apathetic towards a concern which is of such immense importance to their city.(1)

In spite of this, the English bondholders had been advised that no scheme would be acceptable to the Americans which was funded wholly by English money.(2) This attitude typified American thinking which appears to have been remarkably opposed to foreign capital.

After the early 1890s changing international capital flows in any case made the likelihood of further British investment in American urban railways remote, British lending in general to the United States had been most important in the second and third quarters of the nineteenth century and by the end of the century, compared to internal savings generated within the American economic system it was negligible. This is reflected in the absence of any prominent British investment in urban railways. Nevertheless, in total terms it was still considerable enough to be of benefit to America's own capital exports.(3)

Thus while British investments in American urban railways were insignificant, British investments in America in general may have made it easier for Americans to find the capital to invest in British urban railways. This investment was not confined to Yerkes' takeover of most of the London underground projects but included the establishment by the electrical

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1. Railway News: vol. LXV (1896), p. 936.
2. ibid: vol. LXIV (1895), p. 684.
3. S. B. Saul: Studies in British Overseas Trade, 1870-1914, Liverpool, 1960, p. 66.

manufacturers GEC and Westinghouse of British subsidiaries. The Westinghouse subsidiary, British Westinghouse Electric and Manufacturing, was established with £1¾ m., £¾ m. of which was ordinary share capital, held by the parent company and found in America.(1) In spite of the importance of these capital flows there is no evidence that the British public favoured American capital any more than the American public favoured British capital.

Whether it was welcome or not, the inflow of capital from America highlighted the difficulties faced by urban railways in raising funds. Given the dominance of local investors in most cases it seems reasonable to assume that the less local people were prepared to invest in an enterprise, the greater the difficulties in raising capital would be. However this overlooks one important aspect of the raising of capital, namely the degree of support forthcoming through underwriting, or support from financial syndicates.

Such support was prominent in America, where bankers supplied the necessary funds and skills both for reorganising established street railway companies and for financing new lines. August Belmont in New York was the most outstanding example but in Boston the investment bankers Kidder, Peabody and Co. allied

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1. Railway News: vol. LXXII (1899), pp. 116, 287. The remaining £1 m. of capital was raised in Britain. It consisted entirely of 6% preference shares on which the American company would guarantee dividends for the first two years.

with J. P. Morgan & Co. in financing the expansion of the Elevated Co.(1) Even the Hudson and Manhattan was able to obtain such support, from bankers Kuhn, Loeb.

Underwriting apart, institutional backing was much stronger in America. A large number of Boston bonds were held by the Massachusetts Savings Banks and the Manhattan Elevated listed Life Insurance organisations among its stockholders, including one holding of 20,000 shares by the Equitable Life Assurance Society. Under New York regulations such organisations could only hold stock which was rated as 'first class' and adequately covered by earnings. Of 78,000 odd Manhattan shares for which details are readily available, no fewer than 57,018 (72.89%) were held by financial institutions.(2)

Such backing in Britain was much more limited. Of even more significance was the apparent lack of underwriters, with no investment banking in the usual sense. Issuing houses were preoccupied with foreign loans and the commercial banks were unwilling to perform the function of an intermediary.(3)

One exception to this was the Debenture Corporation, whose main function was to assist in underwriting debenture issues by guaranteeing the due payment of capital and interest on the mortgage debentures of sound companies. In 1888 the corporation agreed to guarantee an issue of £200,000 of Mersey Railway

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1. C. W. Cheape: Moving the Masses, op. cit. p. 147.
2. Boston Elevated File (File no. 252), Scudder Library; IRT Papers (File no. 933), 1913-1915, Scudder Library; Belmont Papers, list of Manhattan Railway shareholders.
3. A. K. Cairncross: op. cit., p. 101.

debenture stock, redeemable in five years. A reflection of the conditions in the money market in the mid 1890s is that the Debenture Corporation was left with the bulk of this issue and that the Mersey Railway was completely unable to issue a new loan to repay it. By 1897 the Debenture Corporation still had £179,350, excluding overdue interest, due for repayment.(1)

Where institutional backing did exist in Britain, it appears to have provided the necessary impetus for private investment to follow. This was most notable in the case of the

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1. Railway News: vol. XLV (2.1.86), p. 8. The Debenture Corporation was unwittingly a factor in the problems of the money market which were hampering fund raising for the projected new London lines at this time. One of their directors was one Jabez Spencer Balfour who at their insistence was appointed as a receiver of the Mersey Railway in September 1886. Balfour was also a Member of Parliament but most significantly was the guiding force behind the Liberator Building Society, which suspended payments in September 1892 with debts of over £3.2 m. This had been inspired by the failure of the London and General Bank the previous week with liabilities of over £500,000. This was also part of Balfour's empire and the two failures formed a record bankruptcy in Britain. The crash caused a run on the funds of other building societies but the next largest, the Birkbeck, survived and this helped confidence to recover. Northcote Papers: 51/24/22, The Economist, vol. L (1892), p. 1387, vol. LI, pp. 386, 693, 787; Report of Official Receiver on London and General Bank; Sir E. W. Brabrook: Building Societies, London, 1906, p. 62.

Central London Railway where the interest shown by institutions such as Rothschilds must have increased the attraction the company held for the small investor. This would have been boosted by the rôle of the Exploration Company, which was probably also the stimulus for the substantial foreign interest shown in the CLR.(1)

In spite of the clergymen, widows and occasional pig-keeper who invested in the CLR, the wealthy shareholders owned the bulk of the capital and directed the investment and in the case of some of the other companies, the same names crop up frequently enough to suggest a similar pattern. While the evidence is limited, there is an impression that actual interest in urban railways in Britain was even less than the unfavourable investment patterns reveal, a number of wealthy patrons being involved in more than one line. This is clearest in the case of the Mersey and City and South London Railways. Charles Grey Mott and Alexander Hubbard who were both Mersey Railway directors joined the Board of the CSLR in 1885 and Mott subsequently became chairman. Mott was also later involved in the Brompton and Piccadilly project, while several parties were substantial shareholders in both the Mersey and City & South London lines.(2)

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1. The Exploration Company was also an important shareholder in the General Traction Co. which played a leading rôle in the creation of the Paris Metropolitan Railway. J. P. McKay: Tramways & Trolleys, op. cit. Ch. I., Ch. IV.
2. CSL Shareholders' Minute Book No. 1 (Acc 1297/CSL 1/13).

This concentration of interest in urban railway projects among relatively few people may in part explain why the British pattern for shareholder location does not demonstrate the same basic uniformity that is apparent in America, namely a high level of holdings within the relevant city and its suburbs and most of the remaining stocks held in other major financial or commercial centres.

This basic pattern can be seen most easily in Table 17. The aim of this table is merely to set out in as clear a way as possible the major sources of funds for most lines. From this table the dominance of local capital and shareholdings is immediately apparent, the only notable exceptions being the Mersey, Hudson & Manhattan and possibly the Lake St. lines. Shown in this stylised form the table does overlook certain notable features, such as European investment in the Central London Railway although in absolute terms this was probably not very large in any case - certainly not more than 15% of total capital.

The table obviously makes no allowances for the relative importance of certain cities for certain share issues. The overall importance of London as the major British financial centre would not unnaturally be reflected in the importance of the London capital markets for British issues. The same would be true with New York and the United States.(1) In spite of this,

1. Total bank clearings in New York were always greater than in the rest of the United States put together, in 1901 being more than twice as much in New York as in the rest of the U.S.A. - Bureau of Census: Historical Statistics of the United States, op. cit., vol. II, pp. 1041-2.

Table 17

Sources of Funds for Urban Electric Railways, Britain and the U.S.A.

Financial Centre / Railway Company	Boston	Chicago	New York	London	Liverpool	General U.K.	General U.S.
Boston Elevated	A	-	-	-	-	-	-
Lake St. (Chicago)	-	-	-	-	-	-	*
Other Chicago lines	-	B?	-	-	-	-	-
Manhattan Elevated	-	-	A	-	-	-	-
Interborough R.T.	-	-	B	-	-	-	-
Central London Rly.	-	-	-	B	-	-	-
Metropolitan Rly.	-	-	-	B?	-	-	-
UERL Group	-	-	-	-	-	-	B
Mersey Railway	-	-	-	-	-	A	-
Liverpool Overhead Rly.	-	-	-	-	A	-	-
Hudson & Manhattan R.R.	-	-	-	-	-	B(1)	

Notes

A: over 80% of capital and/or shareholders located within the relevant region.

B: 55%-80% of capital and/or shareholders located within the relevant region.

*: The Lake St. line was financed by Yerkes and while firm evidence is lacking it is probable these funds came from Philadelphia.

(1): Prior to reorganisation of the company.

Sources: In text.

local capital was generally predominant. The importance of local funds was greatest in Boston, where the preponderance of relatively small, local shareholders appears to have been encouraged by the strong regulatory tradtion of the Massachusetts legislative. This tradition helped to sustain the feeling that

> The ... system ranks pre-eminently as the most complete, efficient and best managed street railway property in this country, and it is doubtful if the securities of any similar proposition rank as high in investment merit as those of the Boston Elevated and West End Street Railway.(1)

Although small investors played an important rôle in Boston, financial institutions too played a major rôle. It is here that one important difference between Britain and America was apparent for only in the case of the Central London Railway does there appear to have been a broad mix between financial institutions, wealthy individuals and the small investor. In part this may reflect a lack of information but the much greater importance of financial institutions and influential financiers in America cannot be overlooked. While this was most apparent in New York, where it may have reflected the relative sophistication and importance of the capital market, that it spread throughout the United States is apparent from Yerkes' investments in London, and from the J. P. Morgan syndicate's attempts to finance underground lines in London.(2)

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1. Investors' Agency Report, 8.2.1905, Boston Elevated File (File 252), Scudder Library.
2. Barker & Robbins: op. cit. vol. II, p. 84.

Thus the change in sources of finance demonstrated by comparing sources of capital for the Hudson and Manhattan in the late 1880s and the London underground lines in the early 1900s may have reflected much more than changing international capital flows. The increasing importance of outward capital flows from America has been noted but if the case of the urban railways was any guide the American approach in general towards raising capital showed a much bigger awareness of "big business" needs and methods than was apparent in Britain. Indeed, Cairncross has shown that the small investor actually appeared to be becoming more important in Britain, at least in railway companies, while major issuing houses still showed greater concern over overseas investments.

Nevertheless, the prospects of urban electric railways and general economic conditions must be taken into account. The investment required for an underground line was substantial but the low fares that would of necessity be charged made the prospect of adequate returns much less likely. With elevated railways construction costs were much less and it is no surprise that such companies generally found the raising of capital much easier. Even in Britain adequate capital could be raised, if traffic forecasts were sufficiently promising, as the case of the C.L.R. demonstrated. This suggests that investors were usually acting rationally, another factor which may explain the overall importance of local investors. It is worth noting that locally financed projects generally fared better than other ones. As to the argument that American underground lines found raising capital less of a problem, the two main lines were both backed by the municipal authorities.

Apart from the importance of adequate investor-knowledge of likely returns, the capital intensive nature of most of the lines made them especially susceptible to economic conditions. In rough terms the development of the urban railways coincided with more general economic expansion especially in America where contraction in the mid 1880s was followed by relative stability to 1891 and then by uncertainty in the years to 1897. The sharp recovery from 1897 to 1902 was followed by relatively stable growth from 1903 to 1907. Construction of the underground railways in New York and Boston was realised during these last ten years.

In Britain, although the stock of money was growing quickly after 1887 other indicators did not change so quickly. From 1874 to 1895 unemployment averaged 7.2% while from 1896 to 1914 it was 5.4%. The reduction in employment in the mid 1890s was due in part to a recovery in house building, which may have been stimulated by developments in urban transport.(1) Figures for trade, railway freight and capital issues all revealed a low in 1893 which was followed by recovery. This recovery was accompanied by increases in the paid-up capital of a number of urban railway projects.(2)

In general the pattern of raising capital for urban railways fits into general trends in the capital market, the most notable example being the Baring crisis which hit the

1. S. B. Saul: The Myth of the Great Depression, op. cit., pp. 30-32.
2. E. M. Sigsworth & J. Blackman: op. cit. p. 75; BoT: Railway Returns.

Chicago real estate market, the crash in which badly hit promotion of elevated railways there.(1) The crisis also hit fund raising for the Hudson & Manhattan Railway and did nothing to help raise capital for British lines. This crisis alone demonstrates the difficulties that the urban railways faced in raising capital.

The pattern that develops in both countries is for such organisations to be regarded very much as marginal investments, with some justification, as the next chapter will show. Within this concept actual investor patterns even show some similarity. Of course, there were marked differences, whether it be in the type of investor or his geographical link with the line. However, the most interesting pattern is that of institutional or syndicated interest in specific lines. The most extreme example of this is the case of Yerkes and his friends but in Europe the Exploration Co. provided the initial backing for the CLR, although its interest in the Paris Metro may have been curtailed by the European stock market collapse in 1900.

The problem of finding capital did not end with the opening or electrification of a line - indeed afterwards it may have become more acute. However, the raising of capital in such circumstances became directly related to the financial performance of the individual company, in terms of the returns it offered to investors, and this is the subject of the next chapter.

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1. H. Hoyt: op. cit. pp. 159-196.

CHAPTER 5

THE RETURN ON THE INVESTMENT IN URBAN ELECTRIC RAILWAYS

Having seen that urban railways were frequently regarded as marginal investments, the effect of this on investors and the companies can now be examined. The subject is central to the overall study for the ability to raise adequate capital was important if new cost-reducing technology was to be adopted. Thus potential differences in the returns of individual companies might explain wider overall differences. In examining this, two basic questions arise: firstly, could investors have fared better by placing their money in other enterprises and secondly, how great a burden in attracting fresh capital were earlier financial problems for the companies? A number of other factors should also be considered, such as the effects of the differences between individual and institutional investment, the importance of regional differences in attracting funds and the overlying comparisons between the British and American situations. Were, for instance, American investors as gullible and British investors as rational as was suggested? Were the amounts of capital required, for underground construction at least, so great as to preclude the possibility of a worthwhile return on the capital being achieved? Examination of the varying rates of return may also help to explain the large outflow of American funds just before the turn of the century. It will be shown that, in general, despite evidence to the contrary, the urban railways in the United States offered investors a better return than average opportunities there and that the converse was true in Britain.

This situation, which was primarily due to greater feelings of security in America, in turn made for easier conditions for fund-raising, and therefore continuing investment, but also gave rise to serious financial problems in the long-term. The apparent paradox of higher returns but lower risk in the United States is something that this chapter seeks to explain. In Britain, on the other hand, poor financial performance increased the cost of electrification and other problems further increased the difficulties, giving rise to a poor return on the investment.[1] This supports the hypothesis of the previous chapter that investors were rational, saw urban railways as unremunerative and were therefore unwilling to invest in them although deviations from this pattern will also be noted. Finally, comparison is made with tramway development. This is particularly important, partly because tramways and urban railways were competing for funds at the same time but also because of the corporate structure of many of the American lines, which meant that they were closely involved with street railways.

In England and Wales there was a marked change in railway fund-raising patterns towards the end of the nineteenth century. The percentage of total funds raised in ordinary shares fell from 51% to 36% between 1865 and 1880 and thereafter remained fairly steady.[2] This helps in part to explain the very heavy

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1. The term <u>return on investment</u> is used in a general sense. Throughout the chapter more specific terms are used as necessary and these are defined as they arise.
2. G. R. Hawke & M. C. Reed: 'Railway Capital in the U.K. in the 19th Century', <u>Economic History Review</u>, vol. XXII, 1969, pp. 269-286.

reliance of the new urban lines on debenture capital - railways in general were on the defensive in the capital market and were consequently making greater use of fixed interest payment methods. As urban railways were certainly not on an equal ranking for fund-raising with the larger companies, this must have increased the cost of obtaining capital for the new companies. Whether this attracted or deterred investors in itself is difficult to assess.

Quite apart from the relative attractions of all the companies, it is difficult to determine whether an individual is a risk taker or risk averter and consequently what his reactions would be. There is also the problem of determining investors' knowledge of a particular company. However, it is clear that the period in general was not an easy one in which to raise capital.

Although home railway securities appreciated rapidly in value in the 1890s, after 1901 the terms on which money could be raised deteriorated sharply but this was the time when the older urban lines were seeking funds for electrification, the newer lines funds for completion and electric tramways funds to take away the railway passengers. Fixed interest securities may have eased the problem but in turn created a regular burden of interest payments and the rate of interest frequently had to be higher than average to attract funds which might otherwise have gone elsewhere. Thus the District had a debenture issue paying six per cent and the CSLR had a five per cent preference issue, both high for their classes.(1)

The necessity of paying high interest rates to attract capital was only one side of the main problem in attracting funds, the other being the heavy capital expenditure needed for underground railways or for conversion to electric operation. Table 18 gives the expenditure per mile figures for the early years of this century. The comparisons between the underground lines and the Liverpool Overhead are readily apparent. It is also apparent that, in spite of the improvements in construction techniques, the cost of construction of new underground lines was becoming steadily more expensive, the Mersey Railway, with its larger tunnels and its drainage, ventilation and lift mechanisms being a rather extreme case.

In the case of the early lines, a large increase in capital to pay for electrification is also noticeable. In the case of the Metropolitan, even if the capital per mile in 1908 is calculated at the old mileage, there was an increase of £33,213 per mile from 1901 to 1908. This was certainly not spent on any major developments or improvements outside central London and it represents the cost of conversion of the Inner Circle and Harrow and Uxbridge lines to electric traction, spread over the whole system. Admittedly comparison with the L.O.R. is not entirely fair as this was a special case; its Parliamentary costs were low and for its entire length it ran along the Dock Estate, solving problems of land purchase. Funds were raised locally which avoided the cost of having a quotation on the London Exchange.

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1. Board of Trade: Railway Returns; listings of capital structure of respective railways.

TABLE 18: CAPITAL EXPENDITURE PER MILE OF LINE OPEN

	1901	1905	1908
CSLR	£379,410	£373,653	£371,734
CLR	£591,366	£645,256	£560,857
Mersey	£947,703 (1)	£1,016,626	£1,016,626
Metropolitan	£177,393	£199,548	£361,693 (2)
District	£397,835	£496,299	£518,299
Liverpool Overhead	£87,777	£61,106	£61,106
Bakerloo	Not open		£790,400
Hampstead	Not open		£619,625
Piccadilly	Not open		£654,440
GN & CR	Not open	£693,000	£694,670
Waterloo & City	£303,000	£303,000	

Source: Board of Trade, Railway Returns

1. From 1894 to 1899 the figure was £649,250 - the 1901 figure reflects the raising of capital for electrification.
2. In the annual returns sent to the Board of Trade, the Metropolitan Railway mileage was reduced from 79 in 1905 to 46 in 1906. However, no allowance was made in the capital account for this.

In sharp contrast is the case of the District Railway where the capital increased by over £120,000 per mile from 1901 to 1908. The amount of this that could be directly attributable to electrification is unclear, as the mileage of the system was increased over the same period but if allowance is made for the suburban sections with their much lower construction costs, it nevertheless becomes apparent that the cost of the Inner Circle section, certainly after electrification, was somewhat higher than the cost of building a new 'tube' line. Both the Metropolitan and District were guilty of dubious practice in their capital accounts over the electrification issue. Neither of them wrote off their outdated capital stock from steam days but instead simply credited their capital accounts with the money obtained from the sale of old steam stock. Consequently, from 1897 to 1907 the Metropolitan figures for rolling stock increased from £464,000 to over £1 m. while net revenue fell from £467,000 to £307,000. Over the same period the 'value' of District rolling stock grew from £302,000 also to over £1 m. while net revenue fell from £237,000 to £145,000. In contrast, some of the money received by the Mersey Railway from the sale of old rolling stock was used to pay interest on the New 1st Perpetual Debenture issue.(1) Overlooking the specific issue here, which was tantamount to 'capital-watering', two contrasting factors become clear. Firstly, the railways were increasing their capital to pay for electrification, secondly, revenue was falling.

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1. The Economist, vol. LXVI (1908), p. 323; Mersey Rly.: General Manager's Letter Book, No. XXI (1910), letter from J. Shaw to S. G. Sheppard.

The increase in capital in the case of the Mersey is even more noticeable but misleading. Although the capital per mile increased by £367,000 (56.6%) from 1899 to 1908, this was by no means entirely because of the cost of electrification. The ordinary share capital increased by over £1 m. from 1900 to 1901 while loan stock rose only by some £150,000 over the same period, and by a further £275,000 to 1905. As electrification was paid for entirely out of new loan capital and as no new ordinary share issue was authorised, it would appear that the signing of the electrification contract provoked a degree of semi-speculative share buying. The Mersey was exceptional in two further respects. The terms on which it raised the money to pay for electrification were far from onerous and revenue increased as a result of electrification. Thus, not only was the company able to cover the 4% interest on the electrification capital but in time all the other fixed interest payments (although these had by then been written down in value).

The Mersey was indeed fortunate to find a fairy godmother in the form of the Westinghouse company but the problems remained for the London lines. Funds were being sought in a declining capital market and in competition with potentially more attractive investment opportunities. The period after 1900 was generally one of retardation in the British economy and it has been suggested that a clear order of priorities existed for returns on capital. These were firstly foreign investment, secondly investment in the staple industries and new industries a poor third.[1] Urban railways would probably rank between the second and third of these categories - they were not as yet established and their dependence on the young electrical industry was a further factor inhibiting investment. The situation was complicated still further by the overall pattern of railway investment. The period from 1896 to 1904 was one of the two most active periods of railway investment in Britain. Profits in preceding years had been abnormally high and the stock market was still favourable. Passenger traffic increased rapidly in the 1890s but fairly slowly in the 1900s. Population, especially in urban areas was increasing more quickly in the former period and the growth of population and suburbs brought increased revenue and offered increased scope for investment.[2]

Thus the first problem for electrification or construction of new lines was that by 1904 the railway investment market had passed its peak, but in its peak year of 1901, gross investment in the London Underground lines was only £1.1 m. By 1904 it was £7.2 m. and remained high for the next two years, although declining sharply. The deterioration of the market can only have made fund-raising more difficult and therefore increased the cost of capital. The second problem facing the urban railways was that the rapid growth of urban centres was also stimulating the development of electric tramways. Gross

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1. H. W. Richardson: 'Retardation in Britain's Industrial Growth 1870-1913', Scottish Journal of Political Economy, vol. XII, 1965, p. 148.
2. A. K. Cairncross: Home & Foreign Investment 1870-1913, op. cit. pp. 139-141.

investment in tramways rose from a record £2.5 m. in 1899 to £7 m. in 1900. It then stayed at an annual rate of around £6 m. until 1906.(1) In short, when fund-raising for both ordinary railways and electric tramways was at a peak, work on three London projects had either stopped or not started, due to lack of funds. While it is unlikely that the new tramways attracted funds which might otherwise have gone into the railways, given the predominance of municipally financed tramways, their growth cannot have improved the prospects for the underground lines. In 1898 the London tramways carried 312 m. passengers and although this had only risen to 394 m. in 1903, by 1907 they carried 586 m. and by 1911 822 m. passengers - a growth from 1903 to 1911 of 208.6%. In contrast, passenger traffic on the urban lines was 127 m. in 1898, 186 m. in 1903, 238 m. in 1907 and 312 m. in 1911 - a growth of 168% from 1903 to 1911.(2) This of course takes no account of the opening of new tubes during the period and traffic on industrial lines grew far less spectacularly and stagnated for much of the period. Equally, the figures for passengers by tram take no account of the growth of tramway mileage.

Furthermore, dividends of tramway companies were usually high. A ranking of equity returns between 1870 and 1913 gave an average for railways of only 4.33% but for tramways and omnibuses of 8.95%. (U.S. railway returns were 8.41%.) If these

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1. I. C. R. Byatt: The British Electrical Industry 1875-1914, Oxford University D. Phil. thesis (unpublished) 1962, pp. 164, 204.
2. ibid. p. 217; Board of Trade: Railway Returns.

were 'risk adjusted' the disparity was even wider. Dividends did not increase at all in the early twentieth century but the bulk of extraordinary returns in the tramway sector occurred during this period, probably because takeover by local authorities was at prices well in excess of those reflecting the sector's long term risk characteristics as private enterprise.(1) Such action can have done little to enhance the attraction of urban railways as an investment.

While all the urban railways and some of the tramways were conceived in the 1890s, when overall population grew by twelve per cent, in the following decade the overall growth was only 10.3%. By itself, this was scarcely a profound difference, except that while in the 1890s real wages rose by some eleven per cent, 1900-10 saw them fall by six per cent.(2) This affected all British railways, on which passenger traffic generally stagnated after 1901.

Although it is an over-simplification to say that this was the only factor affecting urban railway performance, it can be seen that any decline in net revenue attributable to growing surface competition, when combined with the difficulty of raising capital initially, would have a detrimental effect on the rates of return on the capital. These rates are given in Table 19. The figures in the table have been defined as the Rate of Return

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1. M. Edelstein: 'Realized Rates of Return on U.K. Home and Overseas Portfolio Investment in the Age of High Imperialism' Explorations in Economic History, vol. XIII (1976), p. 301.
2. H. W. Richardson: op. cit. p. 129.

on Capital Employed which has been calculated by dividing the figure for Operating Profit by the figure for average total long term funds. The Operating Profit in each case has been defined as Total Receipts less Total Working Expenditure and average long term funds as paid-up capital (including loan capital) for the year. It is readily apparent that if the figures are compared with the national average, they are unimpressive. Such a comparison emphasises the much higher capital outlays on underground railways in particular although even the Liverpool Overhead only once managed a return of more than four per cent.

The deterioration in the returns of the Metropolitan and District lines over the period is also apparent. More particularly, this decline coincides with the electrification of the two lines, and the decline in traffic over the same period. The deterioration in the returns of the C.L.R. is indicative of this general decline in traffic also, with the lower figures after 1905 (excluding 1908) coinciding with stagnation in passenger traffic, despite the opening of an extension, and a growth in train mileage. It is noticeable that the stability present in the average national returns was lacking in urban railway returns, even if the average is taken of their performance. It would be reasonable to assume that this fluctuating performance would be at least partially reflected in share price movements but this does not appear to have been the case. For example, from April 1906 to April 1908 earnings of the C.L.R. fell by over ten per cent. This was the heaviest fall in gross receipts of any London railway company

TABLE 19: ANNUAL RETURN ON CAPITAL (per cent)

	CLR	CSLR	L.O.R.	MERSEY	MET.	DISTRICT	UERL Group*	National Average (all UK railways)
1891		1.1		0.55	3.57	3.30		4.31
1892		1.61		0.80	3.55	3.40		4.17
1893		1.82	1.70	0.52	3.38	3.21		3.91
1894		2.10	2.26	0.41	3.48	3.32		4.11
1895		2.16	3.54	0.66	3.31	3.36		4.17
1896		1.97	3.48	0.68	3.66	3.39		4.34
1897		2.23	3.59	0.47	3.74	3.54		4.35
1898		1.80	4.03	0.57	3.71	3.30		4.25
1899		1.40	3.95	0.62	3.74	3.31		4.31
1900	3.78	1.67	3.45	0.56	3.62	2.96		4.06
1901	4.29	2.23	2.83	0.25	3.18	2.31		3.89
1902	5.83	3.90	1.96	0.11	3.11	2.63		4.06
1903	4.43	3.30	2.52	0.14	3.33	1.81		4.07
1904	4.40	3.29	3.54	0.46	3.10	1.58		4.02
1905	4.40	3.01	2.84	0.52	2.75	1.24		4.05
1906	3.98	2.86	1.91	0.66	2.18	0.94	0.36	4.09
1907	3.39	3.20	2.00	0.78	2.14	1.18	0.76	4.10
1908	4.72	3.09	1.78	0.81	2.17	1.57	1.99	3.92
1909	3.14	3.30	1.91	1.10	2.35	1.98	2.26	4.05
1910	3.15	3.24	2.31	1.29	2.64	2.37	2.36	4.24

*Baker Street and Waterloo; Charing Cross, Euston and Hampstead; Great Northern, Piccadilly and Brompton. They were not officially amalgamated until 1910. For earlier years the individual results have been combined. For 1906 only the Baker Street and Waterloo was open. The Piccadilly line opened in December 1906 and the Hampstead line in June 1907.

Source: Board of Trade: Railway Returns

The figures are the Rate of Return on Capital Employed. This has been calculated by dividing the figure for Operating Profit by the figure for average total long term funds. Operating Profit in each case has been defined as Total Receipts less Total Working Expenditure and average long term funds as paid-up capital (including loan capital) for the year.

and was reflected in the 1906 and 1907 figures for the return on capital. However, alone of all the London railway companies from March 1907 to April 1908 the price of C.L.R. stock actually rose.(1) The reason for this lay in the forthcoming Franco-British exhibition at Shepherds Bush which was expected to bring additional traffic to the line. This it did, receipts rising by over £59,000 for the year but by 1909 they had fallen back to below the 1907 level. This explains why there should have been a sudden improvement in the rate of return but why an exhibition of a few months' duration should have had such a marked effect on share prices is not easily explained.

This temporary aberration apart, few lines could demonstrate any improvement in the returns, although in overall performance from 1900 to 1910, the CSLR certainly improved when compared with its first ten years. By 1909 the Mersey was also showing (by its own far from high standards) a marked improvement. Overall, however, the figures cannot be said to be satisfactory. Taking four per cent as a reasonable objective, this being the figure arrived at by urban tramways in providing for adequate depreciation, only two lines ever achieved this - the CLR and LOR. If, on the other hand, the national average is taken as a suitable objective, the only line to achieve it was the CLR, which managed it from 1901 to 1905 and again in 1908. For the older lines, although electrification may have reduced operating costs, the concomitant growth in traffic was not always forthcoming and electrification was therefore a financial burden, at

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1. The Economist, vol. LXVI (1908), p. 829.

least until traffic improved. The Mersey case demonstrates well the decline in traffic and the recovery after electrification but no such clear pattern is discernible in the case of the lines forming the Inner Circle. The problem here was that the extra passengers needed to finance the conversion did not materialise and the conversion probably cost too much in the first place. The figures demonstrate clearly that urban railway operation in Britain was at best marginally profitable and that a firm control of capital expenditure was essential.

In the case of the UERL group and the District line, allegations of 'capital-watering' were frequent but probably unjustified. The truth was nearer to poor supervision of funds than deliberate creation of excessive amounts. The Economist blamed Yerkes for the problems of these lines:

> He took no account of our local government system. He made no preliminary bargain with the local authorities or with the railway companies. He had not even the sense to acquire tracts of land, whose value has been enormously increased by the opening of the tubes ... the ill-success that has hitherto dogged the undertaking is due to the initial blunders, and certainly not to subsequent management.[1]

Mistakes through lack of foresight were compounded by the peculiar problems of London. There were good geological reasons for deep level construction of the tubes but if this made construction cheaper, it was at the expense of operating costs. For instance, the cost of lifts on the CLR was estimated to add 8%, or over £16,000, annually to total operating expenses. The

1. ibid. vol. LXVI, p. 828.

deep-level construction had in itself limited the diameter of the tunnels, which while reducing construction costs may also have increased operating costs. This was the case on the CSLR where the tunnels were so small as to be a hindrance to high-capacity operations. As a result later lines were built with larger tunnels.

There was also the problem, as in America, of rate assessment. While the CLR was paying £32,000 annually in rates and taxes, which was equal to one per cent on its common stock, competing road vehicles paid nothing towards the cost of street widening and in turn the railway fares were kept low by road competition. The deep level of stations, in addition to raising operating costs, increased the travelling time for passengers and therefore acted as a deterrent to short distance travel. However, in 1907 some 83% of traffic in central London came from within a ten-mile radius. Buses and trams could compete with trains over such a short distance. Interestingly enough though, although the narrow, congested streets of London favoured buses, which were also paying no rates, over trams, the three largest bus companies lost money heavily and combined in August 1908. At the time, the LCC trams were showing a six per cent return on capital.(1) Finally, the underground railways in London had not been planned on an overall basis. In the case of the Inner Circle, the theory of a circular railway had in practice failed to provide the kind of communication required for the central urban area and the system was mainly used for east to west (and vice versa) travel on the

1. The Economist, vol. LXV (1907), p. 5; Royal Commission on Transport in London, 1905, para. 147; Electric Railway Journal, vol. XXXIV (1909), p. 1128.

northern and southern halves. In the case of the new lines

> ... the deep level railways as they exist ... have been designed and laid down in accordance with the proposals of different promoters, without special examination beforehand of the whole problem and without continuous control by a single authority ...(1)

These various factors help to explain the high capital cost of the line and the poor passenger figures which combined to result in the disappointing returns on capital. The previous chapter showed that the lines initially suffered difficulty in attracting sufficient funds and it now remains to be seen how investors fared in terms of the returns they achieved. Table 20 gives the ordinary dividends paid out by electric railways in this period. There are of course a number of limitations with such a straightforward comparison but it is immediately obvious that after 1900 the highest dividends were paid out consistently by the CLR. Furthermore, if allowance is made for the dividends paid from real-estate profits in the case of the Metropolitan, the dividends of that company are even less impressive. However, the point about CLR returns is noteworthy, if only because this was the company with the most substantial institutional investment, suggesting (unsurprisingly) greater knowledge of potential returns in such cases. If comparison is made with Table 19 a rough correlation between return on capital and dividends paid is obvious, except in the case of the LOR. This had a deliberate policy of maintaining a far higher Renewal Fund than was necessary, to offset the possibility of a capital loss

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1. Royal Commission on Transport in London, Paras. 128, 55.

TABLE 20: ORDINARY DIVIDENDS - URBAN ELECTRIC RAILWAYS, 1891-1914

	CLR	CSLR	LOR	Metro-politan	UERL Group	U.K. average
1891			Nil	$3\frac{1}{4}$		4.24
1892		$\frac{9}{16}$	Nil	$3\frac{1}{4}$		3.98
1893		$\frac{11}{16}$	$\frac{1}{2}$	$2\frac{7}{8}$		3.51
1894		$1\frac{1}{8}$	$1\frac{1}{2}$	$2\frac{3}{4}$		3.80
1895	3[1]	$1\frac{3}{16}$	$2\frac{7}{8}$	$2\frac{15}{16}$		3.95
1896	3[1]	$1\frac{9}{16}$	$2\frac{7}{8}$	$3\frac{5}{16}$		4.29
1897	3[1]	$1\frac{7}{8}$	$3\frac{1}{4}$	$3\frac{3}{4}$		3.91
1898	3[1]	$2\frac{1}{8}$	$3\frac{1}{2}$	$3\frac{3}{4}$		3.67
1899	3[1]	$1\frac{7}{8}$	$3\frac{3}{4}$	$3\frac{13}{16}$		3.81
1900	$2\frac{1}{2}$[2]	$1\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{8}$		3.34
1901	4	2	$1\frac{1}{2}$	$2\frac{1}{4}$		3.05
1902	4	$3\frac{1}{4}$	$1\frac{1}{8}$	$2\frac{3}{8}$		3.32
1903	4	$2\frac{3}{8}$	$1\frac{3}{8}$	$2\frac{3}{4}$		3.30
1904	4	$2\frac{1}{8}$	$1\frac{1}{4}$	3		3.26
1905	4	$1\frac{7}{8}$	Nil	$2\frac{3}{8}$		3.29
1906	4	$2\frac{1}{8}$	Nil	1	Nil	3.35
1907	3	$2\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	Nil	3.31
1908	$3\frac{1}{4}$	$1\frac{1}{2}$	Nil	$\frac{1}{2}$	$\frac{3}{4}$*	2.99
1909	3	$1\frac{3}{4}$	Nil	1	$1\frac{1}{2}$ (B'loo)**	3.15
1910	3	$1\frac{1}{2}$	$\frac{3}{4}$	$1\frac{3}{8}$	$\frac{3}{4}$	3.48
1911	3	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{7}{8}$	1	3.62
1912	3	$\frac{7}{8}$	$2\frac{1}{4}$	$1\frac{5}{8}$	1	3.45
1913	3	$\frac{1}{8}$	3	$1\frac{5}{8}$	1	
1914	2	Nil				

1. Paid out of capital under 1894 Companies' Act.
2. Paid at this rate for 5 months (opened 1900).

*not on Hampstead line.

**1.1/8 on Piccadilly, $\frac{3}{4}$ on Hampstead line.

No ordinary dividend was paid by the Mersey or MDR in this period.

Source: BoT: Railway Returns; U.K. average figures from C. D. Campbell: 'Cyclical fluctuations in the Railway Industry', Manchester Statistical Society, 1929.

(LOR stocks were not quoted on the London stock exchange) in the event of a takeover.[1]

Nevertheless, the policy was not always popular:

> It seems to me absurd that this Company should be putting £3,000 annually to the Renewals and the Fund now amounting to £50,000. At the same time they must be renewing everything that requires renewing and not charging this Renewal account at all ... The fact of the matter is that they ought to be paying 3% on the Ordinarys instead of 1½% ...[2]

As the table shows, in subsequent years the dividend was increased. In spite of this, a general decline in dividends, as in general rates of return, is noticeable in the later years. The widespread nature of this obviously makes factors other than the cost of electrification of note. In turn, the timing of electrification must be called into question. For if the economy was in a state of retardation, with real incomes falling and low population growth, the additional cost of electrification, with the linked difficulty of raising more money for it in an unfavourable market, would be a severe handicap. This is obviously an <u>ex-post</u> observation but how far the problems were perceived and the share prices discounted in advance, if at all, can be judged from Table 21. This shows the annual average of railway share prices on the London Exchange. Comparison is given with the share prices of the GWR and with an index of industrial share price performance. The GWR figures are not included as a typical example of railway share prices but as an example of one of the 'Big Four' railway companies. Of the 'Big Four', the GWR was probably the most

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1. The original lease with the Dock Board for the land expired in January 1914 and the local authority also had a right to early takeover of the company's tramway. Mersey Rly.: <u>General Manager's letters to Chairman & Directors</u>, Book 9 (March 1911), letter 113.
2. ibid. Book 11, letter from George Waddell (director) to Joshua Shaw (manager).

TABLE 21: ANNUAL AVERAGE OF RAILWAY SHARE PRICES, LONDON STOCK EXCHANGE

	GWR	Mersey	Met.	MDR	CSLR	CLR	W'loo & City	Ind. Index
1886	138.44		*	40.44				88.1
1887	136.31	6.5	*	39.13				85.2
1888	145	3.375	70.13	33.63				87.9
1889	156.56	4.375	83.38	34.25				99.6
1890	164.06	4	78.13	31.25	7			99.7
1891	159.25	3.2	80.13	29.28	4.38			97.9
1892	161.94	2.63	89	30.38	2.5			96.7
1893	159.06	1.75	85.44	28.31	26.5			97.7
1894	160.63	1.0	83.56	28.88	31.75			101.0
1895	160.25	0.63	92	28.19	42			111.5
1896	170.94	0.81	102.44	28.56	43	7.88	7.5	134.9
1897	173.5	0.88	121.13	28	60.25	9.69	10.44	148.9
1898	170.69	0.56	130.5	28.78	68.25	10	97.38	148.1
1899	167.56	0.5	120.5	33.88	66.25	10	106	152.0
1900	155.81	0.5	102	27.38	62	9.88	98.25	150.1
1901	139.25	0.56	76.25	28.75	50.75	32.06	92.75	142.3
1902	137.5	6.94	80.99	31.63	67.75	104	91.25	139.7
1903	138.88	11.5	86.75	36.63	68.88	102.25	95.5	136.4
1904	136.63		91.13	36.63	47.5	90	88.5	128.6
1905	140.25		93.5	37.88	42.38	91.25	90.25	136.4
1906	133.88		72.25	27.25	41.5	88.5	98.75	138.4
1907	125.25		46.13	13.25	43.75	71.5		135.9
1908	121		40	11.75	38.75	70.5		127.7
1909	121.19		37.5	15.19	29.13	62.75		127.2
1910	122.31	3	40.56	21.31	31	66.5		138.1
1911	126.25	3	45.81	27.69	30.25	67.5		144.6
1912	118.25	5	58.31	40.25	38.13	75.5		144.4
1913	115.88		49.38	36.94	36.5	77.5		142.5
1914	115		42.83	28.25		58.33		140.4

Sources: to 1903 Railway News, 1903-14 The Economist

Industrial Index - Index Number of Securities - K. C. Smith & G. F. Horne - London & Cambridge Economic Service - mid 1890 = 100.

*Metropolitan capital structure was altered in 1888.

affected by the general stagnation in passenger traffic after 1901.[1]

Consequently, a comparison with say, NER share price movements might reveal a substantially different comparison. The industrial index is included merely to give a guide to the price of alternative investments. No inference is intended regarding the relative attraction of these shares with the railway shares; the industrial index is included to give some indication of confidence and economic performance in general. The trends revealed in the table can be seen much more clearly in Figure 3. It is readily noticeable that while the trend of industrial securities is upward moving, that of the railway securities, GWR included, is downward sloping. Some of the difference can be accounted for by the base years selected. In the case of the industrial index, 1890 was a year of depression generally and all the figures are affected by the 'Home Boom' of the 1890s. Although it is not shown here, the industrial share price index was higher from 1872 to 1875 than in any year from then to 1896.[2] This does not hide the fact that at almost any time after 1890 industrial securities showed more promise than did those of railways.

The figures for the Mersey Railway and the Waterloo & City have been left off the graph, primarily because of their incompleteness and limited value.[3] Although the Mersey figures

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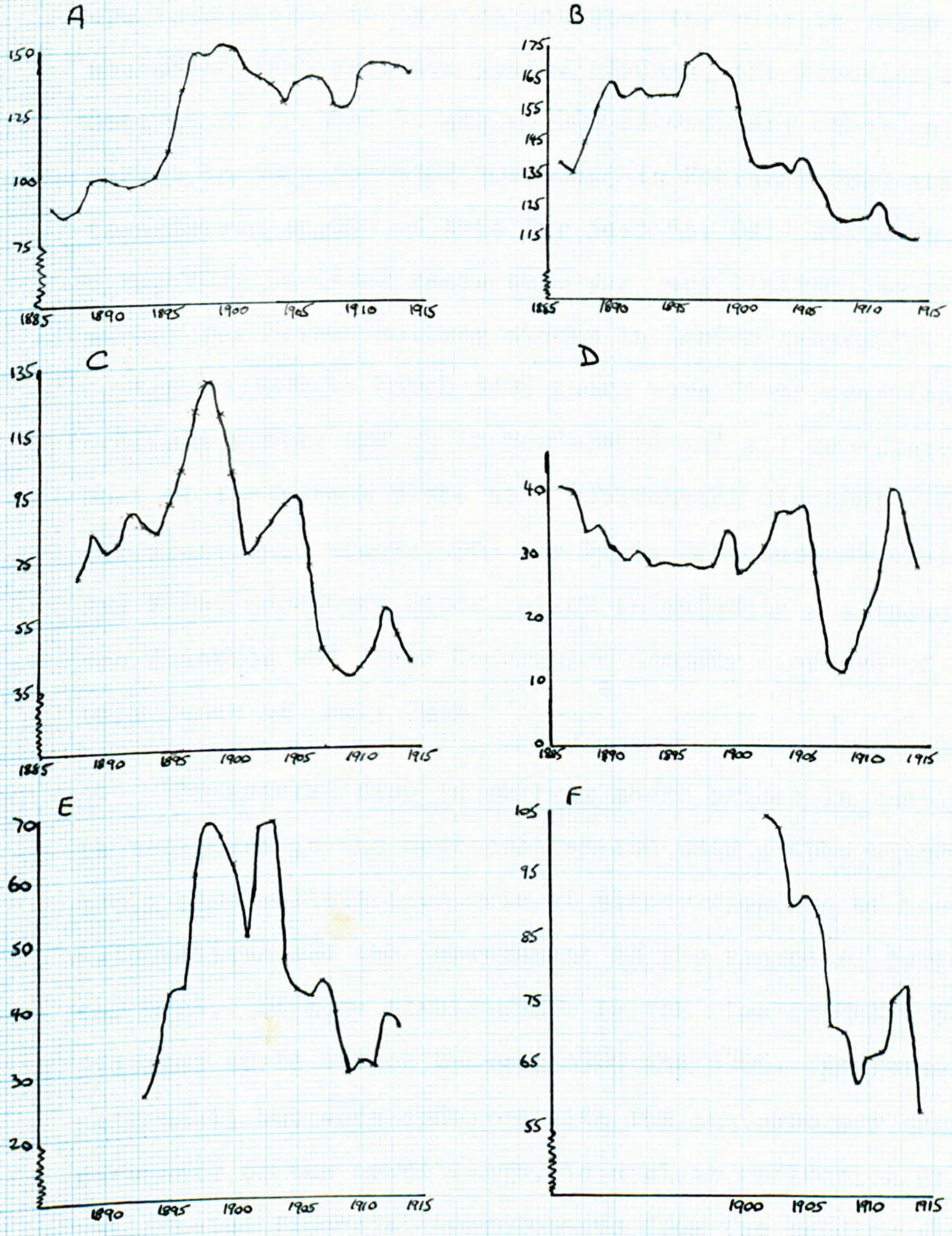
1. The other members of the 'Big Four' were the London & North Western Rly. (LNWR), North Eastern Rly. (NER), and Midland Rly.
2. K. C. Smith & G. F. Horne: <u>Index Number of Securities</u> - London and Cambridge Economic Service Special Memoranda No. 37.
3. The Waterloo & City dividend was in any case effectively guaranteed by the London & South Western Railway.

Figure 3: U.K. SHARE PRICE MOVEMENT 1886 - 1914.



A - industrial all shares
B - G.W.R. ordinary shares
C - Metropolitan Rly. ord.
D - Met. District Rly. ord
E - CSLR ord.
F - CLR ord.

(the share price in the first two years after opening has been omitted from graphs E + F - see Table 21).

are incomplete, it is apparent that the rise in value to 1903 was not maintained in later years. Indeed, the Traction and Power Securities Co. had bought £3,000 of Ordinary Stock on the open market in 1902 for £162 10s. 0d. In February 1907 they transferred £1,000 of this for just 5s. 0d. Although there was a recovery in later years this was very limited, as was the market for Mersey Railway stocks in London generally. From September 1908 to March 1909 there were 21 transactions in ordinary stocks and 25 in preference and all debenture stocks. Most of these took place at a substantial discount - up to 95% for preference stocks, 50% for First Debenture Stocks. Even the New First Debenture Stock failed to maintain its value. In 1913 the Traction and Power Securities Company disposed of £21,600 of this stock at only 79¾%.(1)

The general rise in railway share prices in the late 1890s is reflected in the Metropolitan and CSLR graphs although this could also reflect prospects of electrification of the Metropolitan and the improvement in the financial performance of the CSLR. Of more significance is the rise in Metropolitan and District share values between 1900 and 1905. Admittedly this is only small but when compared with the contemporary share price movements of the newer lines, is a clear reflection of the anticipated financial improvements from the pending electrification. However, the most obvious feature of the graph is the marked decline in the share prices of the London lines. For the

1. Mersey Rly.: General Manager's letters to Chairman and Directors, Book 5, Book 17 (1913), letter 40.

electrified lines this was occurring after 1902. For the older lines the pending electrification stemmed the decline but the electrification was scarcely completed before share prices of those lines also fell. Reference to Table 20 also shows that the movements were fairly consistent with those of the dividends, which is at least consistent.

If comparison is made with the GWR figures, the decline in value between 1900 and 1914 in terms of points on the scale is not significantly different. What is significant is that while the GWR shares at least remained above par value, that was not the case with the London lines. This is understandable for the Metropolitan and the CSLR but the dividends of the CLR, to 1913 at least, were reasonable, if not outstanding. There are two possible explanations for this. Firstly, the poor performance of the other London lines may have had an adverse effect on the CLR. However, it will be recalled that the CLR had attracted extensive institutional investment and the second possible reason is that this was in anticipation of better returns than were actually achieved. The latter seems the more probable explanation, for the Exploration Co. was certainly achieving handsome returns from its other interests when it first became involved in the CLR.(1) Equally, Rothschilds had interests in both the CLR and the IRT in New York and in both cases their expectations may have been higher than their realisations.(2)

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1. Investors' Guardian, vol. LVII p. 274 (February 1896).
2. Central London Rly.: List of Shareholders; Interborough Metropolitan File (File No. 738), Scudder Library.

Certainly the performance of railways in general in this period was none too impressive, for rate of return on paid up capital fell from a peak of 4.41% in 1870 to an annual average of 3.42% between 1905 and 1909. Similarly, as Table 20 shows, average railway dividends in the U.K. fell from 4.24% in 1891 to 3.26% in 1904 and 2.99% in 1908. Yet overall from 1870 to 1913, it has been shown that U.K. manufacturing and commercial equity returns fell roughly in the range from six to nine per cent annually and from 1888 to 1913 debentures averaged four per cent per annum. Somewhat strangely, in fact, the equity returns of U.K. railways do not appear to have exceeded railway preference returns where the risk element was of course somewhat lower.(1) The generally sluggish performance of railways may have affected urban railways adversely but Table 20 also shows that, once the CLR was opened, its dividend was above average until 1909, yet its share prices were below par from 1903 onwards. Additional explanations must exist, therefore, to account for the poor share prices of the London lines, for the decline in urban railway share values was too great to be explained merely by stagnation in passenger traffic. One obvious reason was the series of disappointments with the successive lines but another factor, which may also have accounted for some of the problem of raising capital, was the fear of the lines being taken over by the London County Council

1. D. H. Aldcroft: 'The Efficiency and Enterprise of British Railways 1870-1914', Explorations in Entrepreneurial History, vol. V. (1967-8), pp. 158-74; M. Edelstein: 'Realized Rates of Return on U.K. Home & Overseas Portfolio Investment in the Age of High Imperialism', Explorations in Economic History, vol. XIII (1976), p. 291.

and brought under the wing of the municipal authority. Demands and recommendations of this nature were frequent and cannot have helped to boost confidence in any way.(1)

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The independent nature of London's transport facilities was, however, a serious constraint and in itself must have restricted the attractiveness of the city's railways as investments. Yerkes' aim when he arrived was to create a unified transport system in the same style as his Chicago operations. Although he did obtain control of the London General Omnibus Company, his plans for unification were only partially achieved with the setting up of the 'Common Fund' in February 1915.(2) Although there is no clear evidence that the lack of a unified system acted as a deterrent to investors, it did produce a notable difference to American practice, where only Chicago suffered anything approaching the same diversity of management and enterprise that was evident in London. In Brooklyn and Boston the street railway and elevated systems were unified and the effect of this will be shown in due course. In Manhattan the Interborough-Metropolitan merger created a unified transport service and even Chicago had a more unified system than London.

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1. The Economist, vol. LXV, p. 5; The Royal Commission on Transport in London, 1905, recommended the creation of a single traffic authority and at council level the Progressive Party were frequent advocates of municipal control.
2. The member organisations of this formed a centralized management and the surplus after revenue liabilities, working expenses and interest payments was paid into the Fund and dividends were paid from this on an apportioned basis. T. C. Barker & R. M. Robbins: A History of London Transport, op. cit. vol. II, p. 199.

At the same time, however, investment opportunities in tramways were far more limited in the U.K. In Birkenhead and Liverpool the tramways were municipally financed as was much of the London system. It is not clear therefore whether the absence of opportunities for investment in tramways encouraged investors to turn to railways and buses or whether it created an uncertain atmosphere for investment. The latter seems more likely. The lack of unification seems even stranger given the continuity of interest in underground lines displayed by people such as Charles Mott, and described earlier.

Whatever the reasons for the uncertainty, given its presence, and the changing pattern in fund-raising already outlined, debentures were presumably a more attractive proposition than ordinary shares. The raising of higher proportions of capital through debentures appears to have occurred principally because of the difficulty of raising adequate ordinary share capital. In New York, however, fixed interest capital was raised in preference to ordinary shares as a way of boosting underwriters' profits - this is explained in more detail in due course. If, for railways generally, there was this movement in favour of fixed interest investment, it occurred either because of a marked decline in dividend payments or (less likely) because of a change in attitude by investors who became more willing to forego higher dividend receipts in exchange for greater security. Between 1870 and 1880, for instance, the average investor could have earned 4.3% in dividends and one per cent in principal from a typical portfolio of railway debentures, 4.7% in dividends and 1.8% in principal from railway preference stocks but nearly six per cent in dividends and over 3½% in principal from railway ordinary stocks.[1]

Given the changing pattern of new funds, this situation had obviously changed somewhat by 1900 and the growing attraction of debentures, in their own right, rather than in comparison to ordinary shares, is apparent from Table 22. This gives the figures (unfortunately incomplete) for the yield on selected railway debentures from 1886 to 1914. The national median column is immediately noticeable for the steady rise in yields over this period. The GWR figures, which again are not meant to be 'typical' in any way, display a similar pattern although a steady decline to 1895 is also apparent. The pattern is fairly similar for both the Metropolitan and District lines but little can be said about the other cases. The Mersey was not paying dividends in any regular fashion and the yield figures are therefore meaningless. The movements are shown in Figure 4 of the Flux Median, GWR 4%, Metropolitan 4½%, District 6% and CSLR 4%. The similarities between the stocks in their fluctuations are readily apparent. It should be remembered that these figures and graphs show the yields on the debentures, that is the rate of interest divided by the average market price of the stock over the year and therefore the rise in yield indicates a fall in market price and unfavourable conditions for the companies. Although the trend change between 1900 and 1914 is similar for the District to those of the GWR and Metropolitan,

1. A. K. Cairncross: Home and Foreign Investment, op. cit. p. 230.

TABLE 22: YIELDS OF RAILWAY DEBENTURES 1886-1914

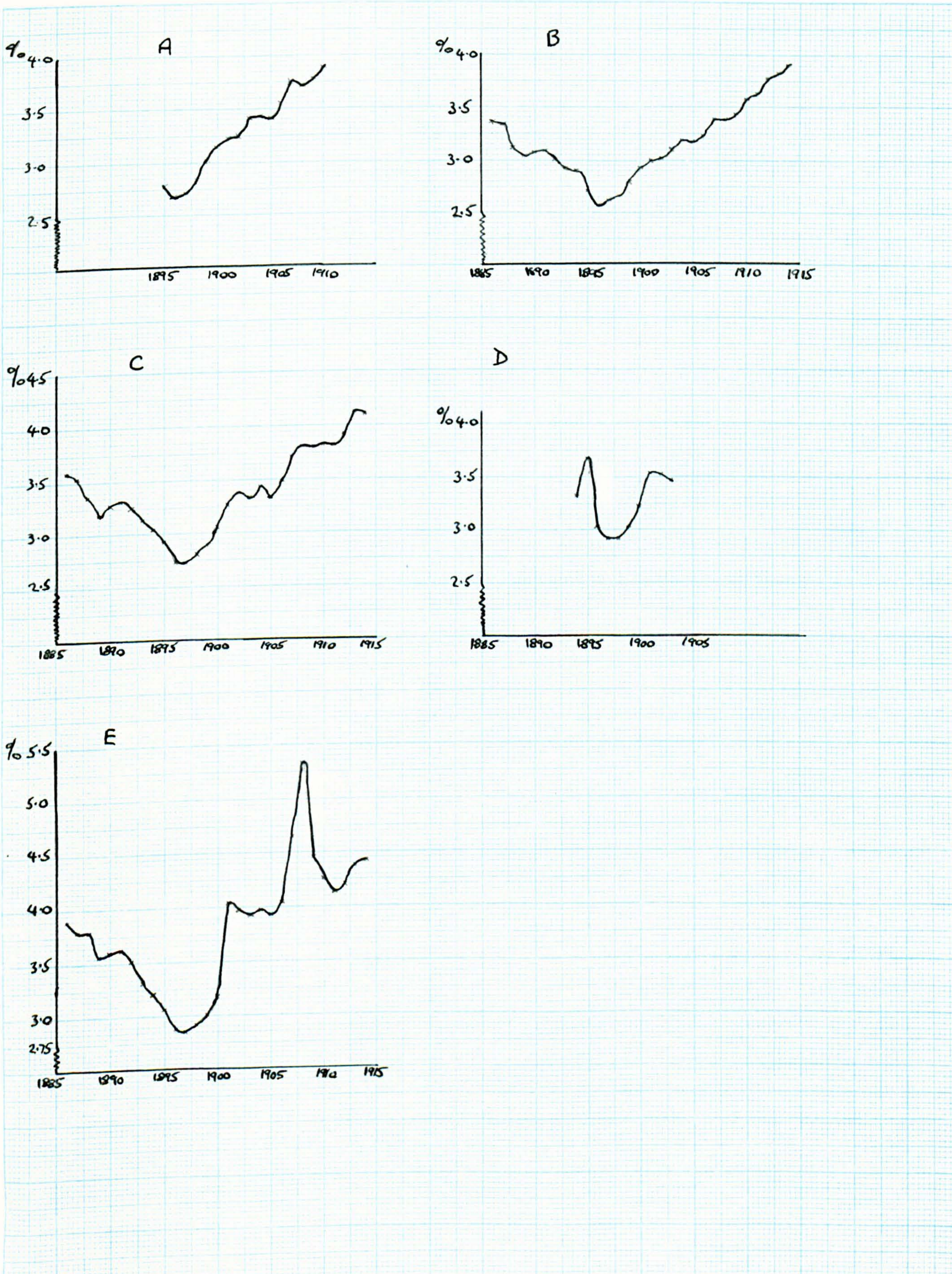
Company	GWR		Mersey	Met	MDR		CSLR	CLR	Flux Median
Nominal Rate	4%	5%	5%	4½%	6%	4%	4%	4%	
1886	3.35	3.49	4.19	3.59	3.89	3.84			
1887	3.33	3.44	4.13(2)*	3.54	3.79	3.76			
1888	3.11	3.26	5.17(2)*	3.36	3.79	3.80			
1889	3.04	3.13	5.80*	3.19(2)	3.56	3.53			
1890	3.07(1)	3.17(1)	5.88*	3.28	3.60	3.56			
1891	3.09	3.19	5.88*	3.31	3.62	3.57			
1892	3.00	3.09	6.35*	3.25	3.51	3.44			
1893	2.92	3.01	7.41*	3.14	3.32	3.33			
1894	2.90	2.93	8.33*	3.04	3.20	3.23	3.33(2)		
1895	2.71	2.77	9.76*	2.92	3.07	3.11	3.67(1)		2.77
1896	2.57	2.61	9.52*	2.73	2.87	2.88	3.01		2.68
1897	2.62	2.64	7.84*	2.73	2.85	2.86	2.91		2.71
1898	2.67	2.70	8.33*	2.80	2.92	2.94	2.92		2.84
1899	2.80	2.82	-	2.89	3.00	3.01	3.02		3.02
1900	2.93	2.95	-	3.05	3.18	3.21	3.23		3.14
1901	3.00	3.04	-	3.27	4.03	4.12	3.54	3.54(2)	3.23
1902	3.01	3.04	8.33(2)	3.37	3.97	4.11	3.52	3.45	3.25
1903	3.10	3.12	8.00	3.34	3.93	4.02	3.46	3.45	3.41
1904	3.19	3.26		3.43(1)(3)	3.97	3.99			3.42
1905	3.17	3.22		3.34(1)(4)	3.93	3.89			3.41
1906	3.24	3.32		3.48	4.04	4.08			3.55
1907	3.38	3.47		3.71	4.65	4.75			3.75
1908	3.38			3.81	5.33				3.72
1909	3.43			3.80	4.45				3.78
1910	3.58			3.82	4.25				3.89
1911	3.64			3.82	4.13				
1912	3.77			3.93	4.20				
1913	3.83			4.12	4.39				
1914	3.91(1)			4.10(1)	4.42(1)				

/Notes overleaf

Notes - 1. Three quotations for year only.
2. Two quotations for year only.
3. Interest rate reduced to 4%.
4. Interest rate reduced to 3½%.
*nominal rate only.

Sources: 'Flux Median' - A. W. Flux: 'The Yield of High Class Investments 1896-1910', _Transactions of Manchester Statistical Society (1910-1911)_, p. 109. Other columns - 1886-1903: London Stock Exchange list, from _Railway News_; 1903-1914: London Stock Exchange list, from _The Economist_ (much less detailed, hence the gaps after 1903).

Figure 4: YIELDS OF U.K. RAILWAY DEBENTURES 1886 - 1914.



A - Flux Median

B - GWR - 4%

C - Met. 4½%

D - CSLR 4%

E - MDR 6%

the sharp jumps reflect uncertainty, initially with the arrival of Yerkes and his takeover and later with the financial problems of the UERL Group. The high interest paid on the District stock is itself a reflection of the problems of that company, representing a substantially higher outlay than a 4% rate would. It would be helpful if more were known of the performance of the CSLR and CLR stocks but it is clear that the other companies, Mersey excepted, reflect the national trend of an increasingly unfavourable situation in which to raise capital. Conversely, the attraction of railway debentures to the investor was growing steadily after 1900. Nevertheless, Flux showed that between 1895 and 1910 the median yield on domestic railway debentures was consistently lower than that on Colonial and Indian Securities and only after 1907 did the margin narrow.(1) However, the difference was never significant, always being less than a full percentage point, the biggest margin being 0.96% in 1896.

Of more importance was the difference between railway issues and municipal securities given that these would include securities issued for tramways. If the hypothesis that investors are less willing to invest in non-unified transport undertakings because of the threat of competition is accepted, tramways would presumably offer a safer long-term investment than independent urban railways. Whether this was actually the case is open to conjecture but between 1898 and 1905, the key period for both tramway and urban railway investment, the balance in terms of yield between the two types of security was very even. As a

1. A. W. Flux: 'The Yield of High Class Investments, 1896-1910' Transactions of Manchester Statistical Society (1910-11), p. 109.

general comparison, the yield on Consols was increasing fairly steadily - from 2.5% before 1898 to 2.9% in 1901, 3.0% by 1907 and 3.4% by 1913.[1] Thus although railway debentures were a fairly attractive investment proposition, they were no better than municipal securities. In spite of this, it is unlikely that urban railways were classified with public utilities such as tramways in the way that they were in America and that in reality the sources of funds may therefore have been more distinct than in the U.S.A. Given the close links in America, however, the point is still worthy of consideration.

What is apparent is that the returns of the British lines were, at best, average. Investors, at least in debentures, were probably modestly happy with their returns. On the other hand, the Mersey Railway defaulted on its debenture payments for a long period and both the District and the UERL Group had to reschedule debt payments. The reaction to this last problem was traditionally somewhat xenophobic.

> Had it occurred in America, the crisis ... would have been speedily solved by the appointment of a receiver ... a new company would have emerged with flying colours; the investing public would have been fleeced; and some great financial magnate would have filled his pockets and won Wall Street's admiration as reorganiser of the concern. Happily in England we have no liking for receiverships, and the cloud which attends an unblushing confession of bankruptcy is not easily dispelled.[2]

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1. Before 1898 municipal securities were more attractive but after 1905 railway securities produced a marginally more favourable yield. ibid. p. 109.
2. The Economist, vol. LXVI (1908), p. 828.

Mersey Railway debenture holders cannot have felt so sanguine about such problems, nor for that matter can District Railway shareholders who, like those of the Mersey, received no dividend payments in this period. The situation for the companies was even less buoyant, as their growing financial problems made the raising of new capital increasingly expensive and the decline in passenger traffic in London reduced net revenue.

It is apparent that the actual raising of capital was difficult and expensive and it is also apparent that the development of the railways took place in conditions far removed from the planned creation of a unified system that was needed. This was in marked contrast to the American situation, where only in Chicago did conditions approach those of London. The differences that this meant are notable. Firstly, while British lines were regarded as railways per se for investment purposes, the American systems were more usually classified as urban transport organisations.(1) Comparisons were therefore made, not with other railway investments but with tramways and other public utilities - hence the wish to know more about the comparability of railway and municipal securities in Britain. This does lead to a slight problem of comparability for while the British lines would come well down any ranking by size of railway companies, the four American enterprises (assuming the Chicago lines to be unified and the Hudson and Manhattan being the exception) were in the top five American urban transport

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1. As, for the most part this is what they were, the classification is not unreasonable.

organisations in terms of gross earnings. For June 1912 to June 1913 their gross earnings were as follows:-

Interborough Rapid Transit	$32,497,870
Chicago (the independent lines were consolidated in 1914)	$30 m. (approx.)
Brooklyn Rapid Transit	$24,152,288
(Philadelphia Rapid Transit	$23,927,179)
Boston Elevated	$16,808,909 (1)

Unlike the British companies, with the exception of the LOR which operated a small tramway at its northern end, three of these concerns also operated the street-car systems in those cities and the Interborough, through its holding company, was connected with the Metropolitan Street Railway.(2)

Therefore the problem of comparability as regards investor preference arises again. Would investors be more likely to demonstrate interest in a tramway than a railway or vice versa? This is as much a problem of comparability within the U.S. as between Britain and the U.S., as the IRT and Chicago systems were wholly railway operations. There is, however, another point, the absence of a single stock market in the U.S. Again, this is not too serious. Admittedly in Britain all the lines, bar the LOR, had London stock market quotations but this only left the Mersey as a non-London line. In comparison, in the United States the problem of geographical mobilisation of capital in this period has been shown to have led to regional differences in the rate

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1. Electric Railway Journal, vol. XLI (30.6.1913).
2. Those in Brooklyn, Boston and Philadelphia also operated street railways.

of return which tended to reflect differentials in the interest rate of short term issues.(1) Thus the average weekly discount rate from 1893 to 1897 ranged from a low of 4.854% for New England cities to a high of 8.99% for Western cities. Between individual cities the ranges were even greater. As the rate of interest, naturally enough, tended to move inversely in relation to the importance of a city as a financial centre, the variations between Boston, New York and Chicago were considerably less than for the country as a whole. Nevertheless, they were still significant, varying for the same period from 3.83% in Boston (the lowest in the country) to 4.41% in New York and 5.74% in Chicago.(2)

From 1870 to 1914 the barriers to short term mobility were overcome, or at least reduced by the seeking-out of inter-regional funds, by commercial bank rediscounting and by the evolution of a national market for commercial paper. In regions with low interest rates, banks and private investors were given a powerful incentive to seek more lucrative alternatives. In the long-term capital market, however, there is evidence that the movement towards a national market did not proceed as far as the movement in short-term capital. Indeed, comparison of mortgage rates suggests that between 1890 and 1914 progress towards a national long-term market may have even been retarded.(3) Such a pattern should have meant that Easterners

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1. L. E. Davis: 'The Investment Market 1870-1914: The Evolution of a National Market', Journal of Economic History, vol. XXV, 1965, pp. 356-8.
2. ibid. p. 359.
3. ibid. pp. 370-393.

would be more willing to move their funds westwards, in search of higher returns. This was the case, even for such organisations as railways and tramways. Money moved from Boston to finance the Brooklyn elevated and from New York and Philadelphia to finance Chicago projects. It would therefore be reasonable to assume that, other things being equal, the Chicago lines would have to pay higher interest rates on their bond capital than say, the Boston Elevated. Whether this was the case can be established without difficulty but the reasons behind possible differences are somewhat more complex. For instance, city financing of subway construction in Boston would in itself provide financial guarantees not forthcoming in Chicago. The same would also be true in the case of the IRT in New York. Given that some investors at least would seek the highest interest rates, it would follow that most investors would be less likely to put their money into distant projects if the rates of return were not better than those available locally. On the other hand, a certain number of investors, for a variety of reasons, would always prefer to invest locally. Therefore, in the cases of Boston, New York and Chicago, the lower the rate of interest in the locality, the higher the proportion of local shareholders to the total. This pattern fits Davis' theory on levels of development.

In other words, the comparative lack of capital in, say, Chicago, would lead to higher interest rates there than in Boston. Logically, even though no examples come readily to mind, some Bostonians were likely to invest in Chicago because of the higher rates but Chicagoans were less likely to invest in Boston, where rates were lower. The major complication in this is of course that some investors may have sought security rather than high interest rates but the general pattern of eastern funds moving westwards but not vice versa appears to hold good. There are of course exceptions to this - notably the Californian investments in the IRT but by this time, according to Davis, the predominant flow of funds was from the North-East and Middle-West southwards and westwards. The Pacific North-West was in any case an exception to this overall pattern but southern investment in all the lines was minimal, bearing out the overall hypothesis. It must now be established how well this model fits the urban railway pattern. Was there any noticeable difference in yields, dividends or market prices between the companies that could reasonably be attributed to the lack of a national market? This is difficult to determine with any great exactness, simply because of the varying financial fortunes of the companies. However, these same vicissitudes, when compared with general stock market performance in the period, should help to determine the relative attractiveness of urban railways to investors.

Attempts to compare the overall performance of urban railway share prices against, say, an index of general railroad or industrial share prices would be unhelpful, primarily because of the intensification of the local importance of urban railways, vis-à-vis other investments. This gave rise to widely differing share price levels at any one time both between cities and within cities. In addition, problems of mergers and capital reorganisation make any comparisons even less meaningful. The major problems here are the Interborough-Metropolitan merger of

1906 and, to a lesser extent, the merger of the Chicago lines for which stock was issued in 1911. To try to minimise the faults and the limitations, two separate comparisons between urban railway and general share prices have been made. Table 23 is a straightforward comparison of Manhattan Railway share prices with an index of common stocks, made until 1898 to try to minimise distortions in share price coming from electrification plans and subway construction. Table 24 uses the same common stock index but shows figures for all the urban railways; for the Boston Elevated from the year of opening, for the New York lines from the year of the Inter-Met merger and for Chicago from 1908, which was the first year that meaningful quotations were available for all the Chicago lines. In all cases, the urban railway figures have been left in their ordinary form rather than made into an index.(1)

As they stand, both tables are somewhat confusing, therefore the information has been represented in chart form, with Figure 5 which shows Manhattan Railway share price movements compared to those of the indices, and Figure 6 which shows similar movements for the other lines up to 1914. Examination of Figure 5 reveals that after 1885 there are noticeable similarities in the fluctuations of overall railroad performance and that of the Manhattan in particular. That this is untypical can be seen from the following graph. Without wishing to claim too much from any comparisons, the two worst sectors over the

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1. As the base for the common stocks is 1941-43, there will be little point in forming an index as the purpose of the tables is merely to give a rough comparison of fluctuations.

TABLE 23: INDEX OF COMMON STOCK PRICES AND MANHATTAN RAILWAY STOCK PRICES 1883-1898

Index of Common Stocks (1941-43 = 100)

	Manhattan Rly.	Total	Railroad	Utilities	Industrial
1883	45.5	56.3	174.4	191.4	22.5
1884	53.5	47.4	146.8	151.6	20.6
1885	94.25	46.0	141.4	148.1	21.9
1886	147.5	53.6	165.7	168.0	24.8
1887	127.19	55.3	171.1	169.3	26.0
1888	87.69	52.0	157.8	169.6	27.0
1889	99.75	53.2	157.0	185.9	32.4
1890	104.5	52.7	158.0	181.4	29.9
1891	102	50.3	152.2	161.6	28.8
1892	130.38	55.5	165.8	191.0	31.9
1893	137.38	47.8	141.5	184.7	26.6
1894	114.82	43.9	129.5	180.9	24.1
1895	107	45.3	132.9	192.5	25.0
1896	93.13	42.3	124.8	188.4	22.2
1897	97.38	44.5	130.6	205.5	23.2
1898	105	50.5	147.1	234.4	27.4

Sources: Manhattan Rly.: Scudder Library, Columbia University.
Rest: Cowles Commission stock price indices, Historical Statistics of the U.S. - Abstract, vol. II, p. 657.

TABLE 24: INDEX OF COMMON STOCK PRICES AND URBAN RLY. STOCK PRICES, 1901 TO 1914

	Boston	Brooklyn	I.M.C.	Chicago (All lines average)	Common Stock Index (1941-43 = 100)			
					Total	Industrial	Railroad	Utilities
1901	190 (high)				78.4	40.0	250.1	278.2
1902	161.50				84.2	39.2	283.7	282.5
1903	144				72.1	32.0	247.1	244.8
1904	146.25				70.5	29.2	246.1	241.9
1905	155.25	74.26			89.9	41.1	318.5	255.9
1906	153.5	82.57	44.5		96.4	48.2	340.6	232.5
1907	134.88	55.19	21.94		78.4	38.4	280.9	173.6
1908	130.75	53.5	13.38	37.88	77.8	37.4	281.8	161.1
1909	129.63	74.94	18.76	37	97.1	49.9	347.9	193.9
1910	129.38	75.44	19.88	32.38	93.5	50.2	329.0	190.8
1911	127.5	78.19	16.75	43.75	92.4	48.2	324.3	200.0
1912	123.38	85.63	19.13	32.83*	95.3	51.8	328.3	209.2
1913	98.13	88.25	16.51	26.25	85.1	45.6	294.8	189.2
1914	81.75	86.63	14.5	20	80.8	45.0	273.9	181.4

*Chicago common stock issued late 1911

I.M.C. - Interborough Metropolitan

Sources: as for Table 6.6.

period were utilities, followed by railroads. Sound conclusions are hampered by the lack of statistics for New York and Chicago in the earlier years but only the Brooklyn company's shares were not following a similar downward trend. The untypical nature of the Manhattan shares is apparent in that in the following period it was the movement of utility share prices which appears to have provided the overall model. There is, on the other hand, little in common between utility share price movements and those of the Manhattan elevated in the earlier period. While one must be cautious about deriving too much from this, there is a fairly plausible explanation. The Manhattan Railway was controlled by the Gould interests, which were heavily involved in railways in general. To the extent that the Manhattan company was a part of Gould's empire, its share price at any one time was unlikely to openly be affected by general share price movements. On the other hand, the lines in Boston and Brooklyn, some of the Chicago lines and the Interborough in Manhattan were either integral parts of, or already linked with, street railway companies. Therefore it is no surprise that they should have more closely reflected the fluctuations in utility share prices.

What is notable, if comparison is made with Figure 3 is that there is very little similarity between the movements of share prices of the different companies. This is far more marked, however,in the U.S.A. than in Britain. In the latter case there is some correlation between three of the London lines (the District being the exception) and the downward trend after 1900 is also evident in the case of the GWR. In America, however,

Figure 6 reveals no similarities at all between the different companies. This reinforces the idea that local influence and capital was more important in these cases and also the fact that each company was effectively a transport monopoly in its own area. It is no surprise that the performance of some London lines should affect others. Equally, in line with Davis' thesis, inter-regional differences would lessen similarities which would be reinforced in Britain by the existence of a national capital market. The only surprise here is the tremendous contrast between the Brooklyn situation and that of the IRT. This is largely explained by the merger with the Metropolitan street railway. Overall, the variations are important for they suggest that the American lines were affected by fluctuations in the national economy far less than those in Britain. Accepting all this, however, it is also apparent that while the British lines appear to have been affected by overall movements in railway share prices, the same was true, with the exception of the Brooklyn system, after 1901 in relation to the general trend in public utility share prices.

At the same time, the sheer size of these companies, with combined gross earnings of $103.5 m. in 1913, is likely to have been sufficient to affect the national index of public utility share prices, in which case it would be more a case of the overall situation reflecting the particular performance of the companies, rather than vice versa. Accepting this, the figures are still of interest. It is no surprise to see, for example, that until 1913 share prices of the Boston Elevated were higher

Figure 5: SHARE PRICE MOVEMENTS 1883-1898

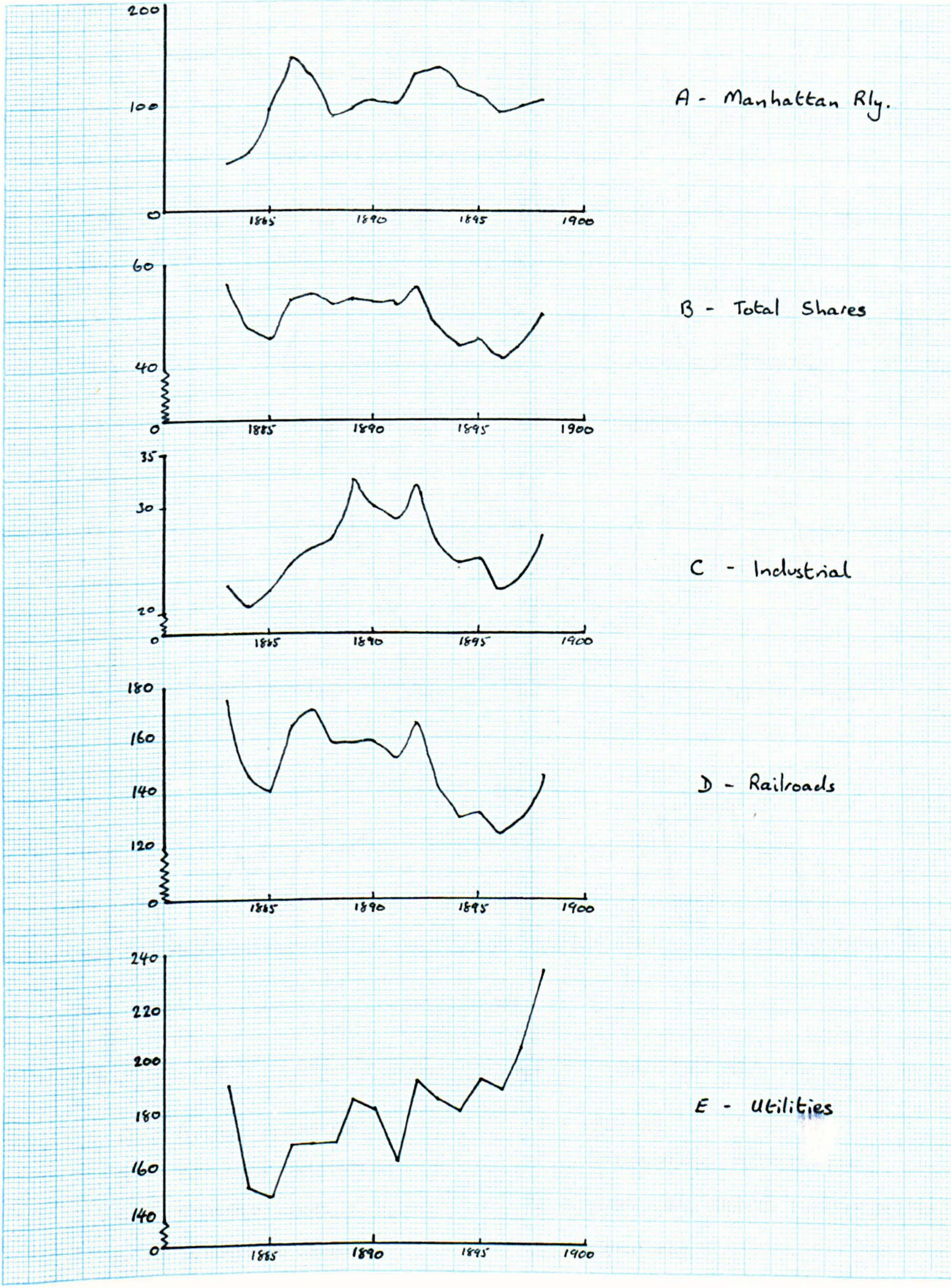
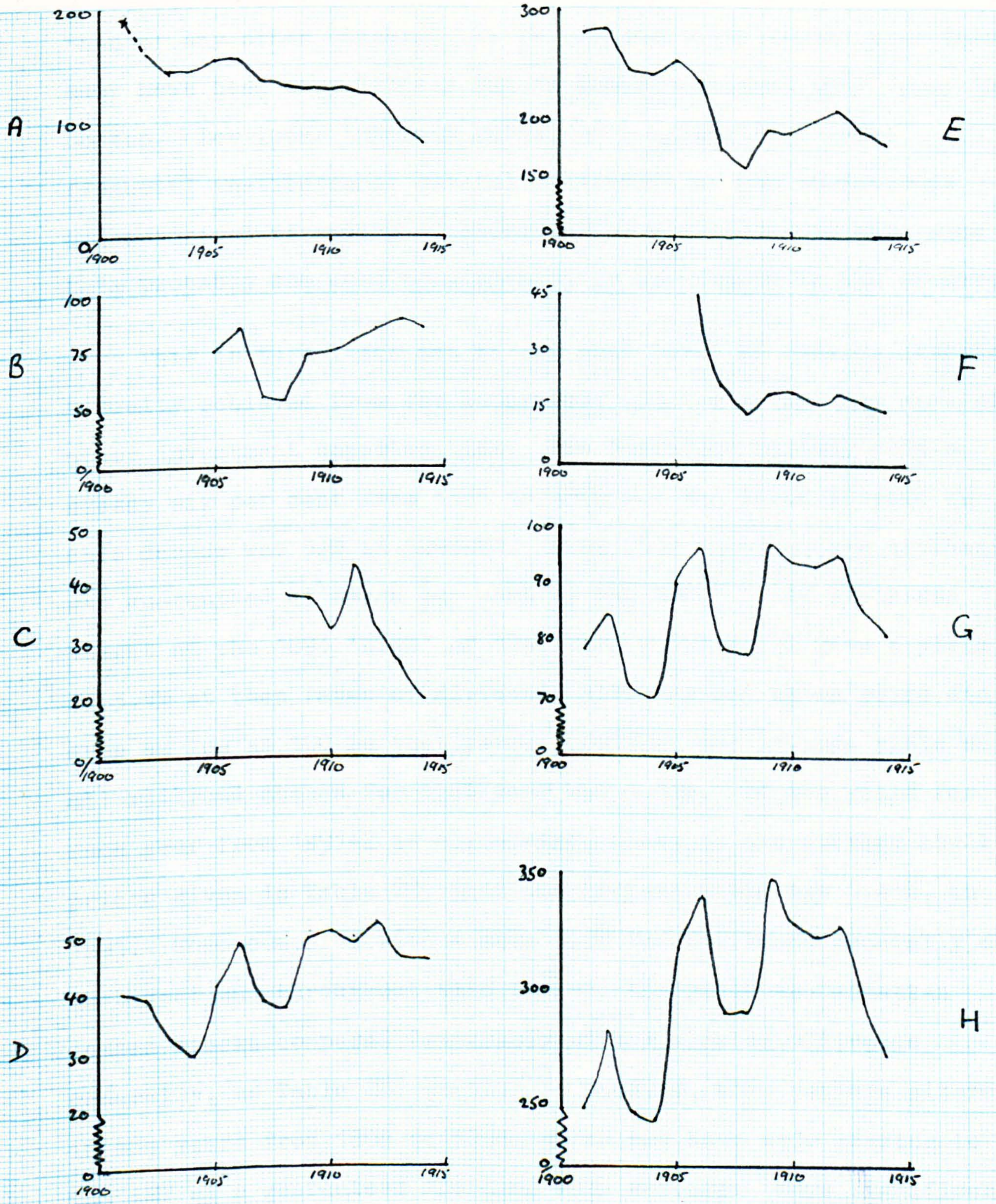


Figure 6: SHARE PRICE MOVEMENTS, 1901 - 1914



A - BOSTON ELEVATED

B - BROOKLYN RAPID TRANSIT

C - CHICAGO LINES

D - INDUSTRIAL SHARES

E - UTILITIES

F - INTERBOROUGH - METROPOLITAN

G - TOTAL - ALL SHARES (COMMON INDEX)

H - RAILROADS

than of any other concern. It is reasonable to assume that this must have been very largely due to the exceptional conditions in Boston. Low local interest rates, well established local financial institutions, careful regulation by the legislature and municipal financing of construction all appear to have made this probably the most popular utility investment in the country.

This in turn leads one to ask what level of returns investors actually achieved from the companies, and how aware they were of other investment opportunities. The Manhattan Railway paid a steady six per cent from 1891 to 1896 and the least it paid in this decade was 3¼% in 1898-99. From 1904 onwards, the dividend was guaranteed at seven per cent by the IRT.(1) If stock was bought at the 1893 'high' of 174¾ this would still give a yield of 3.4% at then rates of dividend, although the share price did drop as low as 100 in that year. However, the average yield on all railroad shares for that year was 4.35%. If the yield for each year from 1891-2 is calculated, based on the average stock prices given in Table 23 then the highest yield was 5.61%, in 1895. This compares with a mere 3.5% for railroads generally on that year and throughout this period, the yield on Manhattan common stocks compared favourably with yields of railroads generally, as Table 25 shows.(2) However, this pattern altered in the years from 1898 to 1903, which may have made leasing to the IRT at a guaranteed dividend very welcome. More significantly,

1. Scudder Library, Manhattan Railway file (file no. 2691.07).
2. Yields for railroad stocks are those of the Cowles Commission Historical Statistics of the U.S., op. cit. vol. II, p. 656.

however, was that it was only in 1895 that the yield on Manhattan stock was better than the average industrial yield and similarly the yield on utility stocks was often more favourable. Too much should not be made of this as lack of investor knowledge and individual preferences will always mean that behaviour does not necessarily appear rational. Certainly, if comparison is confined to railroads and utilities, the Manhattan figures appear satisfactory. However, the Manhattan could not be classed as typical. The payment of seven per cent on its stock by the IRT after takeover is sufficient proof of that. Add to that the Goulds' interest in it, the geography of Manhattan and the continuous growth of the island and the difference between the Manhattan line and the Chicago elevateds becomes substantial.

Comparisons can be made in the later period for Brooklyn and Boston but not meaningfully for Chicago, where dividends were largely unknown. There is also a comparability problem with the IRT. Following the merger with the Metropolitan group, the Inter-Met company held almost 97% of the IRT stock and the dividends on the latter helped the Inter-Met to pay the interest on its bonds.(1) The dividend payments were impressive but how far this was due to the needs of the Inter-Met is not clear. In the opening year (1904) two per cent was paid, in 1905 8¾% and 8½% in 1906. This would suggest that the annual payments of nine per cent from 1907-10 (which happened to be just sufficient

1. The exact holding was $33.9 m. out of $35 m.

to cover Inter-Met bond interest) was not excessive. In 1911 10¼% was paid and in 1912 fifteen per cent.[1]

The peculiar conditions of the IRT, with an almost moribund market in its common stock, make calculating yields meaningless but Table 26 gives a comparison of the yields on common stocks of the Brooklyn and Boston systems with the Cowles Commission figures for the years 1902-14. The differing nature of the public utility investment market is apparent in looking at the movement of the various columns. The years 1907 and 1913 stand out as being periods of uncertainty, and therefore high yields, in the all shares, railroad and industrial columns. In contrast, the yield on utilities reveals a steady upward movement through the period. This trend is far more marked in the Boston case than in that of Brooklyn, however. If Tables 25 and 26 are taken together, the pattern of utilities yields is seen as declining to the turn of the century and increasing thereafter, reflecting the increasing disillusionment with utilities as attractive investments and also greater municipal control, restricting franchises and profits. The yield on railroad shares also increased after 1902 in a somewhat uneven but noticeable way. Although growing economic uncertainty from 1910 onwards noticeably affected the all-share and industrial columns, there is no readily noticeable upward trend in a similar fashion. It is highly unlikely that this pattern did not have at least some effect at company level. In the case of the Boston line, for instance, the steady increase in the yield fails to reveal that

1. Interborough-Metropolitan File: (File no. 738), Scudder Library.

while the dividend was a steady six per cent from 1902 to 1913, the share price was falling. The dividends did not exceed six per cent primarily because under the 1897 Act establishing the Company, if the dividend did exceed this level all excess earnings would have to be paid to the Commonwealth of Massachusetts. The fall in share prices therefore becomes interesting. Prior to 1902 dividends paid were 2¼% in 1898, 5¼% in 1899, 4½% in 1900 and 5¾% in 1901. They did not fall until 1914, when growing problems led to a reduction to four per cent.(1) In spite of the high prices prevailing for shares, it can be seen that the high dividends resulted in generally satisfactory yields on the shares. Although the yield was usually higher than the average railroad yield, it was considerably lower than the utilities average and usually lower than both the industrial average and the all shares average, reflecting the limited scope of the company for new investors.

On the other hand, the regularity of dividend payments, the obvious local pride in the operation and the opportunities for small investors to hold stock, coupled with a high proportion of bonds being held by Massachusetts Saving Banks were all factors giving stockholders in the company a high measure of security which was presumably more esteemed than a slightly higher yield.(2)

1. Electric Railway Journal, vol. XXXI (1908), p. 95; Boston Elevated Rly. File: (File no. 252), Scudder Libary.
2. Savings Banks were restricted in where they could invest money to only what were regarded as the most secure companies.

TABLE 25: YIELDS ON COMMON STOCKS. MANHATTAN RAILWAY COMPARED WITH COWLES COMMISSION FIGURES 1892-8

	Manhattan Rly.	Total all shares	Industrial	Railroad	Utilities
1892	4.6%	4.16%	5.51%	3.77%	5.05%
1893	4.37	5.03	8.12	4.35	5.45
1894	5.23	4.62	6.03	4.17	5.94
1895	5.61	3.97	5.46	3.50	4.99
1896	4.83	4.15	5.56	3.77	4.76
1897	4.11	3.90	5.32	3.47	4.73
1898	3.1	3.72	5.04	3.38	3.91

Sources: Manhattan Rly. - dividend figures given in Railway News compared with share price figures, Scudder Library file 2691.07.
Others - Cowles Commission - Yields on Common Stocks; Historical Statistics of the U.S., Colonial Times to 1957, Statistical Abstract Supplement, U.S. Bureau of Census, Washington DC, 1960, p. 656.

TABLE 26: YIELDS ON COMMON STOCKS, BROOKLYN & BOSTON LINES COMPARED WITH COWLES COMMISSION FIGURES, 1902-1914

	Boston El.	Brooklyn RT	Total all shares	Industrial	Rail-road	Utilities
1902	3.72%		3.71%	4.83%	3.21%	4.03%
1903	4.17		4.65	6.77	3.90	4.60
1904	4.10		4.18	4.83	3.85	4.64
1905	3.86	4.79	3.53	3.76	3.20	4.77
1906	3.91	7.39	3.96	4.17	3.58	4.67
1907	4.45	9.84	5.38	6.16	5.21	4.78
1908	4.59	8.61	4.93	4.81	4.97	4.93
1909	4.63	5.74	4.31	3.64	4.47	4.57
1910	4.64	6.63	4.84	5.33	4.63	5.04
1911	4.71	8.95	4.92	5.36	4.68	5.28
1912	4.86	9.49	4.85	4.98	4.73	5.11
1913	6.11	10.22	5.37	5.71	5.16	5.66
1914	4.89	*	5.01	5.32	4.64	6.06

Sources: As for Table 25. (Scudder Library file 252 (Boston) and 293 (Brooklyn)).

*in this year a large quantity of mortgage bonds were converted into stock, affecting the figures unduly.

Certainly, few other organisations sold stock at such consistently high levels.(1)

The yields on Brooklyn Rapid Transit stock form a sharp contrast with those of the Boston stock. Admittedly the significance that can be attributed to such a short run of figures is limited but the yields were considerably higher than in Boston and also considerably higher than any of the group averages. The yields were so consistently high because of the peculiar combination of good dividends and comparatively low share prices. Significantly, as Figure 4 shows, alone of the urban railways, Brooklyn share prices improved over the period, albeit marginally. However, Table 24 also shows that in spite of this, the average market price was usually considerably below par value, the highest it reached throughout this period being 94½ in July 1912. Dividends did vary somewhat, from as low as three per cent in 1904 to nine per cent in 1913, although after 1905 they were always over four per cent. Exactly why Brooklyn shares sold at such a discount is difficult to explain. It may have been due to the organisation of the company, for its assets consisted entirely of stocks and bonds of the eight companies it controlled and dividends on its own stock were payable only from the receipts from the securities of these companies, after all its own bond interest had been paid. Of its total mileage of 238.5, only 63.61 was elevated railway. It could be argued, therefore, that the high street railway element in its structure

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1. Boston Elevated Rly. File: (File no. 252), Scudder Library.

accounted for the low market price of shares but this was a situation similar to that in Boston, where the West End Street Railway was leased by the Elevated Company. It is conceivable that the Brooklyn organisation suffered simply because the large number of subsidiary companies heightened potential feelings of reduced security but with an average annual dividend of 5.9% from 1905 to 1913 this seems unlikely. The mystery of the low market price of Brooklyn shares was only partially solved by a 1909 report which revealed from an examination of financial operations over the years that the company consistently failed to obtain satisfactory credit. This meant it was unable to market bonds at anything like a satisfactory price, as has been mentioned elsewhere. One can only assume that the problems the company encountered in selling bonds also made the sale of ordinary stock more difficult, although this is unlikely to be a complete explanation.(1)

Why the Brooklyn Rapid Transit Company should have had credit problems is unclear, especially if compared with the favourable reports emanating from the Boston Elevated. Indeed, the two systems invite comparison because of the apparent similarities. Each operated in a district of great congestion but with outlying communities where traffic was light. However, while Boston traffic primarily originated and was received there, the Brooklyn system was important as a tributary for traffic into Manhattan

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1. Between 1903-9 the discount on bond sales amounted to $6,401,704 and it was alleged by some parties to be due to the low rate of interest (4%) paid on them. Investigation & Report on B.R.T.Co. Capital Stock, 1909, Scudder Library.

and traffic was to some extent restricted by the capacity of the Brooklyn bridge. By 1911 only 5.3% of the Boston system was elevated railway compared with 11.6% in Brooklyn and the latter was also the largest street railway system in terms of track mileage, in the world.(1) In Boston the elevated system was largely supplementary to the trams and much of its traffic was simply direct transfers, and therefore not strictly fare paying, from the trams. In Brooklyn, however, one-third of passenger earnings came from the elevated railway. The irony is that whatever financial comparisons are made seem to favour the Brooklyn system. Its gross earnings in 1911 were 40% greater than in Boston, yet its mileage was only 25% greater. Boston carried 625,202 revenue passengers per track mile compared to 932,922 in Brooklyn. The ratio of operating costs to income was 64.7 in Boston but only 55.3 in Brooklyn. Maintenance costs per track mile were marginally higher in Boston, where net earnings were 10.1 cents per car-mile compared to 12.3 cents in Brooklyn. Nor was this an isolated case. In any year from 1902 to 1914 the Operating Ratio was consistently lower for the Brooklyn system than for the Boston one, almost always by substantial amounts.(2)

Why then should the market price of Brooklyn stock have been so poor? A partial answer may lie in the problems with bond issue. The heavy discounts on bond sales would have raised the

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1. Scudder Libary, op. cit. File 293; Electric Railway Journal vol. XXXIX, p. 904.
2. Electric Railway Journal, vol. XXXIX (1912), p. 904; vol. XXXI (1908), p. 95; Scudder Libary, op. cit. File 293.

yields of bonds considerably. If it was felt that the rate of interest, at only four per cent, was unattractive, such discounting would obviously have boosted their appeal. However, average bond yields were not very high in this period anyway. Up to and including 1913, the highest average yield for municipal high grade bonds was 4.22%, in 1913, and the highest average for railroad bonds was 4.44%, also in 1913.(1) Even with a four per cent rate of interest therefore, the discount would not have had to be substantial to give an average yield or better. Furthermore, in 1909 $5.4 m. of discount on bonds offered since 1903 was written off, which could hardly be construed as financial weakness.(2) Therefore, the most convincing explanation for the difference in share prices between Boston and Brooklyn must lie in the particularly favourable conditions for credit that existed in Boston. This would not merely be the lower interest rates prevailing there but also the tight government control which helped the general feeling of security. The only irony in this would be that if interest rates were higher in Brooklyn than in Boston, Boston investors would rationally invest there rather than in their own city.(3) That this was not the case can be explained by already cited factors - the importance of small investors in Boston and the high sense of security there - plus local feelings in Brooklyn

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1. Historical Statistics of the U.S., op. cit. vol. II, p. 656.
2. Electric Railway Journal, vol. XXXV (1909), p. 156.
3. In fact, a Boston company - Farmers Loan & Trust Co. - were instrumental in the financing of the first Brooklyn elevated line.

about outside financing. Whatever the precise reasons behind investment, it is clear that investors in both the Brooklyn and Boston systems, like those who invested in the Manhattan company, could be reasonably satisfied with their decisions. The returns achieved, when compared with those of the London lines, are strong evidence of the benefits to be derived from investment in lines built under close municipal scrutiny with limited, if any, competition. These factors were probably paramount in Yerkes' decision to invest in London, where despite the widely held beliefs about American investment opportunities, such conditions of stability were lacking.

Although the Brooklyn and Boston systems were the two most successful urban transport organisations in America, the Interborough theoretically provided reasonable returns. Someone who bought IRT stock at par in 1902 and sold the Inter-Met securities issued in exchange in 1905 could realise an average annual return of 31.16%.(1) However, quite apart from the limitations of short term trends of more appeal to speculators, as already pointed out, the actual market in IRT stock was very limited.

This reflected the fact that the financial structure of the IRT was not geared to the interests of small investors but to the profits of large financial institutions, Rothschilds for instance

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1. C. M. Latta: The Return on the Investment in the Interborough Rapid Transit Co., Ph.D. (unpublished), Columbia University 1975, p. 288.

holding 35,000 shares of common stock. Therefore, since the market would discount monopoly profits in determining the value of the stock, the dividends might as well be kept down and the growing profits paid out on a return on new securities. That way the underwriters, frequently synonymous with common stock-holders, could also make more money.(1) Although the typical investor was very different from the typical Boston stock-holder, the IRT itself certainly reflected the faith that the institutions placed in it. As already pointed out, the dividends of the IRT were usually sufficient to pay the Inter-Met bond interest and the seven per cent guarantee on the Manhattan stock was being paid out before any dividend was declared. In addition to helping the Inter-Met with its financial problems, such a steady dividend also gave the underwriters the possibility of making a profit on bond issues. For instance, when eventual agreement was reached with the city over new subway extensions, $170 m. of new bonds were issued. These were expected to be underwritten at 96 but any amount in excess of the par value (100) and any accrued interest would be shared with the IRT. Thus the underwriters, in this case a syndicate headed by J. P. Morgan, were given the potential to make a considerable profit, at little risk if the dividend earnings are taken into account. As the stock was actually underwritten at only 93 by Morgans, the net loss to the IRT was substantial.

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1. ibid.pp. 299, 285; Scudder Library, File 738.

The returns on capital provide further evidence of the strong position of the IRT. Surplus earnings in 1913 were equivalent to a return of 18.68% on the capital stock and 16.07% in 1912.(1) The return to the IRT on its own investment had risen from 7.91% in 1906 to 15.91% in 1909, although if the total return is taken, including investment by the city, the figures were slightly less impressive - from 5.64% in 1906 to 9.23% in 1909. This still compared favourably with the return on total capital of 5.4% for the Boston Elevated in 1914.(2) The problem with these figures is that they have all been computed differently, which makes comparisons somewhat limited. The figures in Table 27 ,however, have been calculated in the same way as the earlier figures for British lines. This

TABLE 27: RETURN ON CAPITAL EMPLOYED, IRT & BROOKLYN R.T. COMPARED, 1908-1912 (figures given are percentages)

	IRT	Brooklyn R.T.
1908	10.57	4.11
1909	13.11	4.17
1910	17.37	5.58
1911	14.68	6.82
1912	18.71	8.28

Source: Scudder Library, File 933.

demonstrates quite clearly not only that the IRT was a highly profitable concern, burdened with financing interest payments

1. Electric Railway Journal, vol. XXXIX (1912), p. 1140, vol. XL (1913); Scudder Library, File 933.
2. C. M. Latta: op. cit. p. 110; Electric Railway Journal, vol. XLIII (1914), p.675.

on the bankrupt and over-capitalised street railways but also the enormous gulf that existed between these two organisations and the London lines. The table also calls into question the supposed pre-eminence of the Boston company, for its returns on capital were declining steadily over this period.

By 1913 it was experiencing a problem which would also become more acute in New York over time. This was the rigid provision of a fixed, flat-rate fare in the company's charter, which was leading to a deterioration in the company's capital returns. In 1888 capital invested for every dollar of gross earnings was $2.38, by 1913 it was $6.22; in 1888 for each dollar of investment, 8.37 revenue passengers were carried, compared to 3.09 passengers for the same amount in 1913.(1) In the medium term this led to an increasing difficulty in raising capital. The company was restricted in the amount of bonds it was allowed to sell but was also forbidden by law from selling stock below its par value. By 1917 the stock price in the open market was only 77 and the only way in which the company could raise money was through expensive short-term loans.(2) As a result the Boston Elevated was taken into public operation in 1918. The Brooklyn R.T. was also in receivership by 1920 and by the same year the return on IRT investments was at best minimal (below one per cent) if not actually negative. These problems stemmed largely from the low, fixed rate fares that were effectively a

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1. Electric Railway Journal, vol. XLIII (1914), p. 675.
2. Report on Financial Condition of Boston Elevated Railway to Commonwealth of Massachusetts, February 1917, Scudder Library, File 252.

political way of controlling the companies. This was ironic for it was the initial local government intervention through franchise control, and general overseeing that had done so much to make the companies attractive investment propositions. The same political control was now a constraint but it had at least helped to achieve a short era of prosperity.

These were the successful American companies, however, and many American investors lost money through urban railways. This was most notable in Chicago, where the sharp contrasts between the returns achieved by the street railways and the problems of the early elevateds have already been discussed. It was here particularly that the criticisms of American receiverships made by The Economist and already referred to, were most justified. The problems in Chicago were exemplified by the South Side elevated when it went into receivership in 1895. Although the south side street railway company owned 51.8% of the elevated stock, it had paid nothing for this, whereas many of the remaining stockholders had paid between $75 and $115 per share in 1892-3. When the company defaulted on the bond interest in April and July 1895, prior to foreclosure in October, many people were faced with heavy losses. The reasons cited for failure bore a close similarity to those cited in London ten years later: the company was blamed for not using electric traction from the outset, for being too slow in buying up land, and therefore paying too much for it, and for having spent too much on construction in general.(1)

1. H. C. Harlan: Charles Tyson Yerkes and the Chicago Transportation System, op. cit. pp. 138, 147, 150.

The foreclosure and re-organisation left many stockholders with absolutely nothing but similar problems soon became apparent with the Lake St. line. This had effectively been allowed to dictate its own capital requirements through the use of a 'creeping mortgage', which allowed the capital stock to be increased as needed up to the level of $850,000 per mile. By January 1895 the Lake St. line was unable to meet its interest obligations. As a solution to the problem the bonded debt was to be written down to only 60% of its face value. Slightly surprisingly, an overwhelming number of bondholders agreed to this course, mostly in the knowledge that the existing mortgage was a poor one. In addition, however, some of those deeply involved in the South Side foreclosure had been professionally embarrassed by it and sought to recoup by being heavy buyers in Lake St. bonds and were now faced with a second debacle which they could scarcely afford. As the bond interest <u>had</u> to be met to avoid bankruptcy, re-organisation and heavy losses, they were left with little option but to agree to the re-scheduling.(1) The need for debt re-organisation was hardly surprising given that the total capital issued was some $2.79 m. per mile, when the Yerkes group estimated that its entire 6.4 mile length should have only cost some $3.317 m.

Such failures were by no means unusual, even though it was felt that

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1. ibid. pp. 169, 178-184.

> To allow investors to infer that they will be permitted to enjoy considerable profit if the enterprise prove successful, and then to cut them off from future enjoyment thereof if the enterprise should prove temporarily unsuccessful, by keeping the amount of securities to be issued in re-organisation down to cost of replacement would seem to be of more than doubtful morality.(1)

Even after re-organisation, however, none of the Chicago lines were very successful. The Metropolitan elevated, despite being electrified from the start, went into receivership in 1897. After re-organisation in 1897, the South Side paid a dividend of one per cent in 1899 and then a steady four per cent from 1901 to 1907. In 1908, whilst advocating the abolition of the five cent fare, the company president was moved to remark that

> spectacular dividends and eras of splendid prosperity have slowly vanished and the traction shareholder who today is receiving five per cent on his money considers himself fortunate indeed.(2)

In the same year, the company paid only ¾% on its common stock and then suspended payments. The 1909 surplus was equal to a return on capital of only 2.52%. Between 1907 and 1910 the Metropolitan elevated suspended payments on its preference shares. What is remarkable is that despite failure after failure, optimism in Chicago remained high. In the early battles for elevated franchises, many companies were formed and spent large

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1. F. W. Strauss in Electric Railway Journal, vol. XXXIX (1912), p. 159.
2. Electric Railway Journal, vol. XXXI (1908), vol. XXXIII (1909) p. 1176.

sums in unsuccessful attempts to secure their bids, the lines when built were grossly over-capitalised, necessitating re-organisation, even after which returns were precarious. After the many failures, agreement was reached in 1911 over merger plans. Not only did this lead to an improvement in the price of most stocks but a new note issue, bearing interest at 5% and made at 98½, was oversubscribed.(1)

The problems of the Chicago lines again demonstrated the value of tight control over capital spending, without which capital accounts appeared to mushroom out of control.(2) The Chicago system was not the only one, however, to disappoint its backers. The prize for the biggest failure, in this period at any rate, must go to the Hudson and Manhattan. The project had been started before any of the Chicago lines but was finished later. There were never any allegations of corrupt or sharp practices, which proliferated in Chicago, yet several million dollars were lost in it. Even the corporation which finally succeeded in opening the Hudson tunnels and which was one of the few urban transit organisations to receive popular press support, having bought the first tunnel substantially completed, was forced to re-schedule its debts. Yet again this was due to the inability of the company to pay interest on its first mortgage bonds. The capacity of the line was 200 million passengers annually but only 60 million passengers were using the tunnels by 1913.

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1. ibid. vol. XXXV (1910), p. 52, vol. XXXVII (1911), p. 1085.
2. These problems were also largely a reflection of initial over-building. By 1914, for example, the Manhattan Elevated had about the same mileage as the combined Chicago system but served only one-third the area and carried twice the passengers.

Unlike most of the other companies, the Hudson & Manhattan was freed from the fixed fare burden as it was classified as an inter-state railway. Fares were raised at an early date but it was felt that they could not be raised further.

> Aside from the load that this would put upon our patrons, it might tend to arrest the development of New Jersey and to check the growth of business.(1)

By July 1913 the re-adjustment plan had received the assent of 98½% of the 4½% mortgage bondholders and 95½% of the preferred and common stock owners. Like the Mersey shareholders ten years earlier, the feeling was largely that it would merely be a matter of time before traffic built up, and that this would solve the problem.

In making conclusions about the rate of return on capital there is no fixed model of performance in either Britain or America, although certain transatlantic similarities are apparent. Firstly, it is apparent that, in this period of study at least, by no means all the companies were unsuccessful. If the yardstick for success is taken as the ability of a company to earn a sufficient rate of return to finance its own subsequent development and for investors to earn a 'reasonable' return - that is, comparable with what they would achieve elsewhere - then the distinctions are fairly clear, even though the problems of generating capital were becoming acute for most companies by 1914. Lines which would fit this category are the

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1. W. G. McAdoo (President, H&MRR): Electric Railway Journal, vol. XLI (14.1.13).

IRT (ignoring its support of the Metropolitan system), the Manhattan Elevated, the Brooklyn and Boston systems, the Liverpool Overhead, the Metropolitan, the CLR and the CSLR. If dividend payments alone are taken, three of the last four would probably not qualify but the LOR had a substantial depreciation account, the Metropolitan financed its own electrification and the CSLR financed its continued expansion. If failure is defined narrowly as the inability at some stage to meet the burden of interest payments, or the need to re-schedule them, or write off capital, then all the Chicago lines, the Mersey, the Hudson & Manhattan and the UERL group qualify. If it is taken as inability to pay returns on common stock on a regular basis, the District must be added.

With regard to investment patterns and the returns achieved by British investors, it has been noted that British railways offered investors low returns in general - to such an extent that Indian railway debentures were probably the only overseas railway debenture grouping whose realised return fell short of British railway debenture returns (mainly because the Indian government guarantees acted to reduce the level of risk).(1) In general, American railway debenture returns surpassed those of the U.K., yet British investors were not significant in American urban railway investment, except in one of the early Hudson & Manhattan projects. Despite this, as was mentioned in the previous chapter, the pattern of British overseas investment was

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1. M. Edelstein: op. cit. p. 301.

changing substantially. In 1870 overseas assets formed about 33% of U.K. portfolios, by 1913 they were about 45%. More particularly, the longest and most marked stretch of overseas dominance in terms of higher returns, rather than destination of capital, was from 1897 to 1907 - the peak period for raising capital for urban railways. Over the whole period (1870-1913), however, both domestic and overseas returns were subject to secular decline, and this must be borne in mind in judging the specific company performances.(1)

The comparisons between tramways and urban railways in Britain are significant, especially when compared with the American situation, for it would appear that in both cases tramways were a high risk (which may explain the high Brooklyn yields) but also a high return investment. Railways in Britain, on the other hand, were low risk, although the poor return on equity stock helps to explain why they were forced more into the fixed-interest securities market. Urban railways appear to have been a combination of the worst features of the two - high risk but low return. Muncipality and public willing, Yerkes might have been more successful if he had taken control of the London tramways.

Although the growth of passenger traffic has not been discussed here it is significant that in the case of all the 'failures' except Chicago, traffic did not meet expectations.

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1. ibid. pp. 285, 309.

In comparing the American systems it is interesting that neither the Chicago lines nor the Hudson & Manhattan were controlled by the municipality as closely as the other lines. In the case of the IRT, municipal guidance meant the financing of construction of the subway as in Boston, although there the elevated was privately financed. In both cases clauses ensured that over a reasonable rate of return (six per cent in Boston), profits would be shared with the city. This alone was probably sufficient to deter speculators of the Chicago variety. The further restrictions on raising capital in Boston, while causing long-term problems, doubtless boosted confidence initially. Significantly, the British lines were neither municipally backed nor controlled in anything like the same degree.(1) Whether a municipal watchdog in the form of the Public Service Commissions in America would have helped to reduce the costs of construction is unclear, although municipal financing would undoubtedly have helped, if only to the extent of buying ordinary share capital and reducing the burden on debenture stock by doing so.

Alternatively, it may be argued that the problem lay not in control of the companies themselves but in control of the competition. Significantly again, Chicago was the only American case where the elevateds were not connected with the street railways on a formal basis. This caused severe problems, notably

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1. Apart, that is, from the City of London helping with finance for the completion of the 'Inner Circle'.

with the South Side line. Conversely in Brooklyn and Boston the systems were public transport conglomerates. Even in Manhattan, before the Inter-Met merger, the IRT had control of all the elevated and subway lines and traffic volumes were suchthat street railway competition was not a problem although another subway company might have been, which was the alleged reason for the merger.

From the investment aspect, two points are apparent. Firstly, institutional investors were probably more successful than individuals, the major companies in each country for this being the IRT and the CLR. Secondly, local investors although with some notable exceptions in Chicago, were generally, in terms of the lines where the local investment was most significant, more successful. This is less applicable in Britain although the Mersey and the LOR are two good examples. This therefore tends to support the idea that it was imperfect investor knowledge, rather than irrational behaviour that explains certain decisions. The most notable case is that of Yerkes' investment in London. While at the time the decision may have appeared a sound commercial judgment, time proved otherwise. Thus although there is no set pattern of performance, with the possible exception of the Manhattan companies, none of the lines could be claimed to have provided a consistently reasonable, let along high, rate of return to the investors.

CHAPTER 6

THE IMPACT OF ELECTRIFICATION ON RAILWAY OPERATING COSTS AFTER 1900

Given that the profits of the urban railway companies were not high enough to enable adequate returns on capital to be made, a measure of the costs of operation may help to quantify the importance of much of the innovation, particularly the impact of electrification. This evaluation of working costs must cover a broad field - not simply the overall figures but trends in labour costs, the costs of power, additional costs such as lifts, pumping and ventilation, the burden of taxation and comparative operating costs of competing organisations.

The first significant comparison between urban operations on both sides of the Atlantic claimed that in the mid-1880s London underground trains cost 3s. 4d. per train-mile to run compared to 1s. 9d. for the New York elevated lines although the respective costs per passenger were 0.9d. in London and 1.92d. in New York. If the cost of the motive power and train service on the New York lines had been as great as in London, then receipts would not have covered running expenses.(1) However, this chapter is concerned less with such comparisons than with overall conclusions that could be derived from broad movements in costs. After all, if it can be shown that the introduction of electric traction had no significant effect on operating costs, then the implications for the subsequent adoption of electric traction by other railway companies are substantial. Similarly, if it can be shown that the burden of taxes was unduly heavy, this may help to

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1. T. C. Clarke in E. B. Dorsey: English and American Railroads Compared, New York, 1887, p. 96.

explain rates of innovation. Also worthy of note is the importance of fares charged. These were fixed by governmental restrictions in America and, to a lesser extent, in Britain, where competing forms of transport often made permitted fare levels purely nominal. Therefore, in both countries, ceteris paribus, the effect of fixed fare levels, especially if costs were rising, should have been to accentuate the search for cost-reducing innovations. In some respects, therefore, any examination of costs is bound to be a review and re-consideration of arguments which may have already been postulated. However, the broad theme remains unchanged. The companies were in the forefront of railway innovation yet frequently were unable to cover capital charges. Closer examination of their overall costs should help to explain why this might have been the case. In a less specific context, Dorsey's general conclusions that English railways were considerably less efficient than their American counterparts will be qualified, at least in the urban sector.(1)

The first task in examining overall cost movements has been to compare Operating Ratio figures from 1890 to 1913 and these are given in Tables 28 and 29. 'Operating Ratio' simply expresses working expenditure as a percentage of gross revenue at any given time, so that over time a clear indication of changes in cost is given. There are a number of limitations in its use, most notably that working expenditure is simply a generic term covering all items of expenditure, irrespective of how they were incurred. Consequently it is difficult to isolate

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1. E. B. Dorsey: op. cit.

exogenous factors, such as an increase in taxation, from total working expenditure. This means that the statistics cannot be used as an accurate measure of efficiency, firstly because the price of inputs cannot be influenced by the company and secondly because the regional and national variations in input prices make its use for comparative purposes limited. Fortunately, the relative homogeneity of the input in this case - namely short distance passengers - means that the traffic in all cases was similar, although no allowance can be made for fluctuations in traffic patterns.

However, in spite of these limitations, and the added one that expenditure is not 'quality adjusted' for its impact on output or efficiency, the Operating Ratio is useful because its use was widespread as a simple tool of analysis and comparison and as a convenient means of measuring the effect of changes in expenditure.(1) Therefore for both investment and innovation, it does at least provide a guide to the relative attractions of the different companies, although particularly in the case of the American companies it should be borne in mind that methods of calculation varied considerably. Taxes were frequently substantial and some companies included them while others excluded them from calculations. However, as far as possible, the figures for any one company have been calculated on a consistent basis. The British figures are from a standard source, so this problem does not arise to the same extent.

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1. For a detailed discussion of the merits and drawbacks of the use of Operating Ratios see R. J. Irving: The North Eastern Rly. Co. 1870-1914, Leicester, 1975, p. 286.

TABLE 28: OPERATING RATIOS, ENGLISH URBAN RAILWAYS, 1885-1913

	CLR	CSLR	LOR	Mersey	Metro-politan	MDR	UERL	Waterloo & City	GN&CR
1885					44	48			
1886				68	42	47			
1887				78	43	49			
1888				89	42	47			
1889				84	43	48			
1890				80	43	47			
1891		78		78	43	45			
1892		69		74	43	45			
1893		65	67	82	44	46			
1894		61	70	85	44	46			
1895		61	63	76	47	46			
1896		58	63	76	44	46			
1897		56	64	83	44	46			
1898		56	62	80	45	48		(2)	
1899		57	63	79	46	48		(2)	
1900	59	58	67	81	48	50		63	
1901	54	56	73	89	51	57		53	
1902	52	44	80	94	52	53		47	
1903	53	49	76	93	50	56		48	
1904	53	48	76	80	49	58		48	75
1905	53	48	80	79	52	63		48	52
1906	56	47	79	75	58	74	(85)*	48	50
1907	58	45	78	72	58	68	66+	51	51
1908	50	48	80	72	58	61	55+	57	53
1909	60	45	77	63	56	54	49+	52	53
1910	57	47	73	58	52	49	47	50	51
1911	58	47	70	54	53	47	46	49	50
1912	56	50	67	52	54	42	42	46	51
1913	58	62	62	55	57	48	43	(2)	58(1)

Source: Board of Trade Railway Returns

*Baker St. & Waterloo Rly. only.
+Average of constituent companies.
(1)Six months working only.
(2)Figures for these years not calculated separately from overall London & South Western Railway figures.

TABLE 29: OPERATING RATIOS, AMERICAN URBAN RAILWAYS, 1892-1914

	Manhattan Elevated	I.R.T. Subway	Brooklyn R.T.	Boston El.	Chicago S. Side	Chicago N.W.	Chicago Met.	Hudson & Manhattan
1892	55							
1893	56							
1894	60							
1895	63							
1896	65							
1897	65				85			
1898	66			72*	56			
1899	66			70*				
1900	61		55	67*				
1901	59			68				
1902	58		66	69				
1903	45		60	69				
1904	41		59	70				
1905		43(1)	60	68				
1906		42(1)	56	69	67		49	
1907	47	51	59	69	69	46	50	
1908	52	49	60	67	70	50	51	79
1909	54	37	58	65	68	50	50	71
1910	52	36	57	64	67	51	51	53
1911	52	41	55	65		51		44
1912	53	41	54	69		48		44
1913	53	42	53	66		49		46
1914	53	37	55	64		48		46

NOTE: The actual financial years of the different companies started on different dates. The figures given are for the financial year ending in the particular year, unlike the English figures which are all based on calendar years.

*the first elevated lines opened June 10th 1901. These figures are for street railway operations only. (The Boston Elevated was incorporated in 1897.)

(1) figures for all I.R.T. operations (subway and elevated combined).

Sources: Railway News, Electric Railway Journal, Scudder Library.

If comparison is made with the tables in the previous chapter showing Rates of Return on Capital, it will be seen that the relationship between this and the Operating Ratio is not usually a particularly strong one. This should not be surprising as, theoretically at least, the link between capital and operational costs should be minimal. Of far greater interest in the tables is the variation in long-term trends. Admittedly these will be influenced by changes in the tax burden or business cycle fluctuations but they are nevertheless useful for giving at least a rough guide to the impact of electrification upon operating costs. In this respect the Mersey Railway was clearly the most successful innovator. After the opening year, the ratio never dropped below 74% under steam operation but by 1912 it was down to 52%. However, the initially slow decline in the ratio after electrification in 1903 suggests that the medium term growth in traffic was of possibly greater significance than electric power although there is no doubt that the latter begat the former. Allowing for the limitations of comparison this is significant for not only was the long term reduction in the ratio the largest but the proportionate growth in passengers following electrification was also the greatest. Compare the other three examples - the Metropolitan, District and Manhattan Railways. On the Mersey, passenger traffic after electrification rose 80.02% to 1913, on the Metropolitan 7.38%, the District 24.22% and the Manhattan Elevated 8.66% (to 1914).

Leaving aside the reasons for such growth the varying positions are largely borne out by movements in the Operating Ratio.(1) The Metropolitan's was extremely stable up to 1900 but then increased noticeably, if not significantly. The District followed a similar pattern although its overall position showed greater improvement than that of the Metropolitan. The Manhattan position cannot be explained so concisely. The variations in business confidence are apparent in the movement through the 1890s. Equally apparent is the marked drop following electrification in 1903.(2) Once electrified, however, the trend on the Manhattan appears to have been upward once again.

Two qualifications must be made to this hypothesis. Firstly, there are no figures for the Brooklyn system prior to electrification, secondly, limited though they are, the figures for the Chicago South Side suggest a dramatic impact on operating costs after electric traction was introduced in 1899. Further analysis of passenger growth and costs obviously has to be undertaken but if the overall evidence shows that it was the growth of traffic that led to any reductions in costs then clearly this has significant implications for the value of innovations. Equally if traffic is actually growing but operating ratios remain high, this would have implications for operating practice, unless increases in revenue are absorbed by higher taxation. One important problem with this is the relationship between

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1. Although it may be noted that an 80% increase could not possibly be put down merely to cyclical fluctuations.
2. This can be compared with the British lines where the initial impact of electrification led to a deterioration in the ratio, usually because train frequencies were increased to attract more passengers.

revenue and increase in expenditure on an annual basis. This is particularly important in the U.S.A. where the cost-of-living index rose from 78 in 1890 to 80 in 1900 and to 100 in 1913, while transit fares were in all cases maintained at the uniform rate of five cents.(1) This was a particular grievance of the companies, the wholesale price of steel rails rising from $17.63 in 1898 to $30 in 1914 and the average price of a ton of coal from $3.55 to $5.32 over the same years.(2) Although the British lines did not face such a restrictive policy, in practice road or ferry competition made the situation worse. Thus as late as 1919 the Metropolitan was still charging fares set in 1883 and in some cases even lower than the then approved levels.(3) Such restrictions obviously affected the Operating Ratio, particularly in the U.S.A. where the flat-fare and widespread use of free transfers from tram to train in Brooklyn and Boston meant that new extensions, while increasing operating costs, might generate little in the way of extra revenue. Such problems obviously merit more detailed analysis of the relationship between local politics and urban transport. Nevertheless, the figures would suggest that there was a 'trade-off' situation. The Boston Elevated had consistently one of the worst ratios of any line in Britain or America, yet the attraction of its shares for investors has already been noted.

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1. U.S. Bureau of the Census: Historical Statistics of the U.S., Colonial Times to 1970, Bicentennial Edition, Part 1, Washington DC, 1975, p. 212.
2. ibid. p. 208. The impact of wage increases is examined later in the chapter.
3. London Traffic Conference 1919 - Acc 1297/MET 10/382.

This apparent paradox is also clear in at least some other cases, the relationship between falling costs and passenger growth being much more difficult to prove in the case of the 'new' lines - that is, those electrically worked from the outset. A good example of this is the Liverpool Overhead. Traffic grew by 72.8% from 1894 to 1904, while the Operating Ratio deteriorated. Admittedly there are some year to year similarities in the fluctuations but passenger traffic alone could not account for this as the longer term trends show. Two other possibilities are worthy of discussion, both of them linked. Firstly, the peak year for receipts prior to 1913 was 1903, although the actual train mileage run was higher in 1901 and then in every succeeding year. This could be accounted for either by the workings of the business cycle alone, 1903 also being the peak year for passengers prior to 1912, or more likely, by the additional effects of competition from electric tramways, forcing the company to reduce its fares and introduce faster trains, which were conceivably more expensive to operate. The proportionate variations in receipts suggest that what tended to occur was the permanent loss of short distance passengers to the tram services. Such results, approximate though they are, clearly challenge the hypothesis that an increase in passengers led to a reduction in costs. In principle it is successful but in practice only while the railway companies have some degree of control over fares.(1)

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1. One aspect worthy of further research would be analysis to determine whether there was any relationship between the Operating Ratio and the building cycle. The Merseyside case suggests that there was not, for while operating improvements may have boosted housing development indirectly, evidence of a direct relationship is lacking.

However, the results of the CSLR bear a much closer relation between passenger variations and the operating ratio, as do those of the CLR, the UERL, the New York Subway and the Chicago elevated lines. This certainly supports the argument that the railways were more successful at increasing the overall number of passengers than they were at reducing the proportionate cost of carrying passengers and the LOR experience lends further weight to this. In other words, without exception the companies were sales maximisers rather than profit maximisers but more than this, over time they were unsuccessful at reducing the cost per head of passenger carrying. To establish such a hypothesis, more information than mere operating ratios is needed, not least to establish that innovations were capacity increasing, rather than cost reducing. If this can be shown to be the case it may be possible to establish that costs, while rising with inflation or through increased taxation, were rising more because of declining efficiency.

This can be examined initially through train size and service frequency. Yerkes once remarked that it was the 'straphangers who pay the dividends' and this was later reiterated by Speyer of the UERL.(1) In marked contrast, the Mersey, which has been shown to have been one of the more successful lines in reducing costs, had in 1913 a rush-hour <u>seating</u> capacity of 10,000 passengers per hour yet carried only some 6,600 passengers per hour at peak density. Although this does not rule out the

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1. <u>Dictionary of American Biography</u>, vol. XX, 1936, pp. 609-611. 'Straphangers' were standing passengers.

possibility of standing passengers on one or two trains during the period, the average loading of trains throughout the day was only 21% of capacity.[1] Such a situation arose largely through the desire to provide as frequent a service as possible to attract passengers. The question is, how typical was it? The Waterloo & City Railway had made an early attempt to keep costs to the minimum in 1899 when five single cars were introduced for off-peak working and all the other companies operated longer trains during peak hours than at other times.[2]

To try to gain a better overall comparison, an attempt has been made to compare the actual peak hour operations of various lines in 1908 with ideal conditions by seeking to establish the optimum train length in numbers of cars, using an existing formula.[3] Firstly it is assumed that the total cost of operation on an annual basis will be equal to the total costs of operation plus the annual costs of permanent way, buildings and other structures (capital) such that

$$TRC = TROC + SR \qquad (1)$$

where TRC is total annual costs, TROC is total annual operating costs and SR is total annual structural costs. For optimum train length

$$\frac{\delta TROC}{\delta n} = \frac{\delta SR}{\delta n} + \beta \qquad (2)$$

1. Joshua Shaw: Notes on the Mersey Railway, paper read to Liverpool Engineering Society, 1.12.1915.
2. A. A. Jackson & D.F. Croome: Rails Through the Clay, London 1962, p. 52.
3. This is a simplified version taken from J. R. Meyer, J. F. Kain, M. Wohl: The Urban Transportation Problem, Cambridge (Mass.), 1965, p. 173, Appendix A.

where

n = number of cars in a train

and β = constant for additional costs, such as rental of joint stations, additional terminal facilities, etc. (which may not be constant but the model is simplified).

Next it is taken that

$$\frac{\delta TROC}{\delta n} = \frac{W.V}{rcn^2} \qquad (3)$$

where

W = annual wage costs of a train crew

V = maximum peak hour passenger volume

r = number of round trips one train can make in one hour

c = seating capacity of one car

and

$$\frac{\delta SR}{\delta n} = CRF_{n,i}\ \emptyset\ k.g. \qquad (4)$$

where

$CRF_{n,i}$ = Capital Recovery Factor, such that the capital cost is spread over n years, at interest rate i where

$$CRF_{n,i} = \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

$\emptyset$ = annual construction cost of stations per foot (which varies depending on station size)

k = car length in feet

g = number of intermediate stations

such that

$$\frac{W.V}{rcn^2} = CRF_{n,i} \text{ Ø k.g.} + \beta \qquad (5)$$

The equation is not entirely satisfactory. Because of the employment of gatemen to open and close carriage doors wage costs are a variable unit depending upon the length of the train, so these have been calculated on the annual costs of a train crew based on maximum peak hour operation, plus an extra allowance of 25% for additional costs such as lift operators and porters, the cost of which cannot be accurately assessed for individual trains. With the Capital Recovery Factor, the cost has been spread over fifty years. This should perhaps have been shorter for the New York Subway and would have been for the Boston calculations. However, in Boston all the subway tunnels were owned by the city and annual rental paid by the elevated company. In most cases this was 4½% of the total construction cost for a varied number of years depending on the particular line but in the case of the East Boston tunnel, for which the calculations have been made here it was ⅜% of the revenue from traffic through the tunnel plus one cent for every passenger.(1) In this case, the equation has been modified to

$$\frac{W.V}{rcn^2} = 0.00375R + \frac{V}{100} \qquad (6)$$

where

R = total annual receipts

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1. Boston Elevated Rly: <u>50 Years of Unified Transportation in Metropolitan Boston</u>, Boston 1938, p. 61.

In all cases the rate of interest used has been the prevailing rate of interest payable by the company on bonds or loan stock at the time of construction. Figures for wage rates were based upon the Board of Trade Earnings & Hours Enquiry - VII - Railway Service of 1907, giving information for Electric Railways as a group, with weightings based upon the actual rates paid by the Metropolitan and District Railways in the same year. The remaining figures were taken from a wide variety of sources.(1) Some difficulty was caused by the construction costs, which varied significantly. However, as the final cost was the actual burden, rather than estimates, this has always been used, based as far as possible on the average construction costs of a station for the particular company, although in one or two cases estimates have been made, based upon comparable figures elsewhere and overall costs. A problem also arose with the figures for rush-hour traffic. These should be based on the equivalent hourly flow of passengers at the busiest time of day, which was usually the period 5.30 p.m. to 5.40 p.m., rather than the actual passenger volume in the rush-hour, as the former figure should determine the capacity of the busiest trains. In most cases the difference between the two

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1. Apart from figures in the Board of Trade Railway Returns and the Electric Railway Journal, these include: Joshua Shaw: Notes on the Mersey Railway, op. cit; Charles M. Jacobs: The Hudson River Tunnels of the Hudson and Manhattan Railroad Company, Minutes of the Proceedings of the Institute of Civil Engineers, vol. CLIV, 1909-10; W. B. Parsons: Diaries; Parshall & Hobart: Electric Railway Engineering, London 1907; Scudder Library: files on IRT and Boston Elevated Companies.

figures is marginal and the latter figure has generally been used, most notably for the London figures. The effect of this will be to marginally reduce the given optimum value for n. A greater problem arose with the Inner Circle in London and the New York Subway, where branch lines affected the figures considerably. Of all the lines, the figures for the Inner Circle are probably the least reliable.

In New York the problem was to some extent overcome by weighting the value of traffic on the various branches, which produced reasonable results, with the notable exception of the figure for the 180th St.-Atlantic Avenue express service. The major problem here is that due to a lack of information about services between Brooklyn and Manhattan, this has been assumed to be the only service between the two boroughs although other services did exist. This undue influence is further widened by it being the only service over the full length of the Lenox Avenue branch. The overall result is therefore inaccurate. This is a general problem in varying degree for figures A to E inclusive for the New York line. To try to obtain more accurate figures calculations were made for the 96th St.-Brooklyn Bridge section only, which carried some 50.22% of all subway traffic at the time.[1] Although this appears to have been successful for the local trains, the figures were arrived at by weighting the overall figures on the basis of the ratio of the total number of

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1. Arnold Report on New York Subway Traffic, Electric Railway Journal, vol. XXXIII, pp. 188-195.

passengers boarding the train to the number of seats provided. As the express trains were used by longer distance passengers going beyond 96th St. or Brooklyn Bridge, the length of express trains has been underestimated although it would be more accurate for an express service operating only between these two points.(1) No account has been taken either of passengers transferring from local to express services at transfer points although to some extent this should be incorporated in the figures as the express service figures have only been calculated on the basis of actual express stations.

The only other note concerns $\underline{\beta}$. This varies enormously from line to line. In the case of the Mersey Railway it comprises the rental of space at Rock Ferry station, which was not owned by the company, amounting to £4,260 annually. In contrast, for the Hudson & Manhattan it comprises the CRF annual cost basis of the Hoboken and Church St. terminals, the total cost of these being £532,000.(2) For the New York subway it includes, where applicable, an estimated cost for the run-round facilities at Brooklyn Bridge station. It was also used rather arbitrarily, where for instance figures for station construction costs seemed excessively low, to try to give as true an estimate as possible of the annual capital costs on a comparable basis.

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1. ibid. The average length of trip in 1908 was 2.08 miles by local train and 5.52 miles by express train.
2. Mersey Rly: Board Minutes, 1908, RAIL 475/10 p. 280; C. M. Jacobs, op. cit. p. 45.

The results of the calculations are given in Table 30. Accepting the problems of running incomplete cars, if all the figures are rounded up, the Mersey Railway clearly becomes exceptional, even though this is partly due to the incompleteness of the figures. The running of single cars on the Waterloo & City Railway in off-peak periods has already been noted. The most unfavourable conditions of all are not given in the table as they were those of the Metropolitan Elevated in Chicago, where the off-peak flow of around 4,000 passengers per hour jumped to 36,000 per hour, necessitating a change from two-car trains to five-car trains, at double the normal frequency.(1) Although the figures in Table 30 may slightly over-estimate optimum train size as the maximum flow usually lasted for perhaps a five minute period only, two basic patterns can be discerned; of railways with over-capacity in their peak hour operations and those where capacity was a problem.

With the exception of the City and South London and the Central London lines, all the London lines clearly had space available in peak hour trains.(2) Admittedly spare capacity was not of Mersey Railway proportions but in most cases opportunities did exist for reducing the length of trains and a similar situation existed on the Hudson & Manhattan. In marked contrast are the New York Subway figures where, if the short-distance

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1. Electric Railway Journal, vol. XLIII (1914), p. 532.
2. Complaints on the UERL about overcrowding were not uncommon but these were both a reflection of the reluctance of Londoners to stand and of the higher occupation of the centre cars in trains, these being nearest to platform entrances. A. A. Jackson & D. F. Croome: op. cit. p. 138.

TABLE 30: COMPOSITION OF PEAK HOUR TRAINS, 1908

Line	Optimum Number of Cars per Train	Actual Number of Cars per Train
Mersey Railway	1.372	5
Baker St. & Waterloo	4.299	6
Charing Cross, Euston & Hampstead	3.911	5
GN, Brompton & Piccadilly	4.763	6
Inner Circle	4.86	6/7
Central London Railway	6.57	7
City & South London	6.32	5
New York Subway:		
A. 137th St.-Brooklyn Bridge local	6.799	
B. 145th St.-Brooklyn Bridge local	9.606	
C. 242nd St.-South Ferry local/express	9.244	
D. Dyckman St.-South Ferry local/express	7.982	local 8*
E. 180th St.-Atlantic Ave local/express	17.542	express 9*
local average	8.202	
express average	11.589	
F. 96th St.-Brooklyn Bridge local	9.56	
G. 96th St.-Brooklyn Bridge express	8.42	
East Boston Tunnel	2	1
Hudson & Manhattan (1909 figures)	4.804	6

*express trains were shortly afterwards increased to ten cars at peak periods.

Sources: see text.

Broadway branch figures (137th St. to Brooklyn Bridge and Dyckman St. to South Ferry) are ignored, the low figures here being partly due to the difficulty of assigning accurate weightings in any case, peak hour capacity was clearly insufficient. The figures for the CSLR and East Boston tunnel suggest a similar situation but in the case of the latter it is largely a reflection of the low fixed but high variable capital cost for the elevated company. The CSLR figures reflect that company's long-standing problem of reduced tube (tunnel) size and capacity compared to other London lines, a five car CSLR train not having the same capacity as a similar size UERL one.

If the CSLR is ignored, for the reasons just outlined, then it becomes apparent that the most profitable companies in terms of Operating Ratios were those operating nearest to the optimum level, although it must be emphasised that this is only a guide. Many factors affected overall profitability but clearly the more nearly a company could match the needs of the public to its own capabilities, the more effectively it was being operated.

This serves to re-emphasise the differences between over-capacity and spare capacity for these conditions would have an important bearing on future investment and innovation. Depending on the company, further investment should have taken one of two forms - either to increase capacity or to reduce costs. Bearing in mind however, that the companies were sales maximisers rather than profit maximisers, it is quite conceivable that further investment may not necessarily have been cost effective. In fact it is suggested that close control of costs in most cases came second to capacity improvements, even where these were not always needed. A number of railway managers at least were probably quite content, provided that the Operating Ratio stayed fairly constant from one year to the next, and as long as most interest payments were made or at least as long as progress in that direction could be seen to be made. Obviously this is a considerable generalisation and an attempt will therefore be made to support it. If reference is made again to Tables 28 and 29 in the crudest sense it will be seen that excluding Chicago, in nine out of fourteen cases the lowest Operating Ratio occurred in later years, and in a further two instances - the Metropolitan and CLR - it stayed relatively constant over long periods, except for occasional aberrations. Notwithstanding the crudeness of the calculations therefore, at first sight there would appear to be an overall improvement but much of this was accounted for by traffic growth, as already stated. In theory, for any line operating at less than optimum capacity, any increase in passengers should have improved the overall ratio and up to a point this would be the same for capacity increasing innovation, where the costs would come from the capital account. In effect provided funds were available, investment would frequently take place without detailed calculations of the financial benefits. More particularly, even investment to improve capacity or extend subways or elevated lines may not have had any significant effect on costs per se. The Boston Elevated for instance found that while passenger revenues for the entire system including the street railways rose by 81.42% from 1897-8 to 1912-13, not only was this typical of experiences elsewhere but none of the additions to facilities had had any effect on the normal growth of business.[1] While without such additions the congestion of the system would have hampered any traffic growth, from the point of view of net financial results the change was for the worse. However, while this was applicable elsewhere, it was most noticeable in Boston where the heavy burden of fixed charges, reflected in the comparatively high Operating Ratios, was combined with longer rides made possible by the new facilities and the extensive free transfer system between trams and trains. In Boston there was also a need to invest to maintain the capacity of the system in line with traffic growth.

This was not necessarily the case elsewhere and indeed it can be asked what electrification achieved in terms of overall operating costs. If the Operating Ratio is taken as a guide, in some cases at least its effect appeared to be marginal. Therefore a more rigid comparison is necessary and at the same time an attempt will be made to provide accurate comparisons of the costs of operation between different electric railways. Table 30 is of only limited use in this respect as the figures in Table 31 clearly reveal. Each mile of track on the New York Subway was used about three times as effectively for moving both cars and passengers as was the case with the London tubes and there were also three times as many passengers moved each year on the subway as were handled on average on each single track-mile of all the Chicago elevateds. However, while London had the lowest number of passengers per single track-mile and the highest

1. Financial Aspects of the Relief of Congestion by the Construction of Subways and Viaducts, Electric Railway Journal, vol. XLII (1913), p. 813.

TABLE 31: COMPARATIVE TRAFFIC FIGURES OF SELECTED LINES, 1908*

Line	Single Track miles operated	Car-Miles, Total	Total Passengers	Passengers per single track-mile	Passengers per car-mile
IRT Subway	69.9	44,005,211	200,415,050	2,870,172	4.56
Manhattan Elevated	90.66	64,584,611	282,870,540	3,120,125	4.38
London Underground (all tube lines)	167.3	32,728,130	160,000,998	958,762	4.90
Chicago Elevated	150.53	39,264,008	147,267,113	981,780	3.75

*Figures are based on IRT results for year ending 30.6.08, London figures for first six months of 1908 doubled and four Chicago elevated lines for 1907.

Source: Arnold Report on New York Subway Traffic, Electric Railway Journal, vol. XXXIII (1909), p. 189.

mileage, its passenger per car-mile figure was the highest. Such results clearly indicate that whatever the overall problems of these lines due to over-optimism at the planning stage, in day to day operation their performance was respectable, although it has to be accepted that rush-hour conditions were more favourable in London than elsewhere, as far as this target is concerned. It also must be remembered that a high passenger per car-mile figure could be the result of the lack of an adequate service although there is no evidence that this was the case in London.

Usual comparisons of costs of operations are expressed in terms of car-miles or train-miles run annually but in this case, owing to the difference in capacity of the rolling stock of various companies, such figures are of only limited value. Similarly, a seat-mile comparison could be objected to because of wide variations in seating capacity between different lines. To overcome these difficulties, costs have been expressed in terms of foot-miles run, these being the annual car-mileage multiplied by the length of a car available for passenger use.(1) Costs of power generation and distribution can also be reduced to a unit cost per train, so that a functional relationship is obtained for the cost of operation, such that

$$C = \frac{(c + r + m + x) K + R + O}{d} \qquad (7)$$

1. J. B. Sparks: Electric Railway Costs, Times Engineering Supplement, London, 6.3.1912; Electric Railway Journal, vol. XLI (1913), p. 1061. While an interesting calculation it was never widely adopted, subsequent calculations reverting to ton-miles and seat-miles.

where

C	=	total cost of running trains per effective foot-mile
c	=	average cost of electricity per kilowatt-hour
r	=	interest per kilowatt-hour
		$\left[= \frac{\text{interest on investment in electric traction}}{\text{annual kilowatt-hour delivered to trains}}\right]$
m	=	maintenance costs per kilowatt-hour
x	=	increase in cost per kilowatt-hour due to distribution loss
K	=	kw.hr. delivered to trains annually
R	=	interest on capital
O	=	operating and repair costs, including driver's pay
d	=	effective foot-miles run per annum

This calculation takes into account only the actual costs of operation; the figures refer only to the plant and energy used for the trains and do not include any allowance for station lighting, ventilation or lift working. These costs were significant, 10% of the power generated on the CLR being used for lift operation and a further 12% for station lighting.(1) Precisely because these additional costs are ignored, however, the calculations give a closer comparison between actual train operating costs for the different companies. Nevertheless, the idea of effective foot-miles travelled is not perfect as no account is taken of varying car capacities, the narrow width of CSLR cars severely restricting the effective space available for

1. C.L.R.: <u>Miscellaneous Reports, 1902</u>, Acc 1297/CLR 4/1.

passengers for instance, without this being fully shown. A number of other difficulties exist, mainly in the statistics. Both the Brooklyn and Boston systems made no clear distinction between power used by trains and power used by street-cars. The Brooklyn system, like the North Eastern Railway in Britain, bought almost all of its power from outside suppliers, whereas the other systems met most of their needs themselves.(1) The only other system to buy substantial amounts of power was the Chicago group, some 28% of its requirements being purchased from Commonwealth Edison. The other lines sold varying amounts of power that they produced to other users.(2)

Consequently the figures are of limited value as they do not give a full comparison between the different companies, although they do give a reasonable idea of varying operating costs. Full details of the figures used in the calculations and the results obtained are given in Table 32. A comparison over time would be of considerably more use as this would give an indication of improvements or otherwise in performance. However, even as they stand the figures give a reasonable guide to differing performances. The figures probably somewhat underestimate the actual operating costs as the effective foot-miles run in all cases has been calculated on a generous basis. More problematical is that, of necessity, the figures for operating costs for the London lines, with the exception of the Metropolitan, are from different returns to those for foot-miles and the operating costs

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1. New York City: Public Service Commission, First District, Returns.
2. Electric Railway Journal, vol. XXXVII (1911), p. 1085.

TABLE 32: ELECTRIC RAILWAY OPERATING COSTS IN EFFECTIVE FOOT MILES RUN

(a) Figures used for calculations.

		CLR(1)	CLR(2)	MDR	UERL	CSLR	IRT	Met.
c	=	1.542c.	0.76d.	0.648d.	0.648d.	1.054d.	0.885c.	0.69d.
r	=	0.034	0.017	0.005[+]	0.005[+]	0.02	0.05	0.002
m	=	0.04	0.02	0.015	0.015	0.023	0.06	0.02
x	=	0.048	0.023	0.02	0.02	0.074	0.03	0.021
K	=	10450000	11209029	73223466	50855779	5854451	44000000	36316800*
R	=	$72250	£14866	£23637	£29750	£14100	$460350	£6875[1]
O	=	$148500	£34500	£76626	£66571	£18321	$1714630	£104582
d	=	206380000	297798912	871904480	504777921	195168660	1804213733	841033256

(b) Results obtained for C (Operating costs per effective foot-mile)

CLR(1)	CLR(2)	MDR	UERL	CSLR	IRT	Met
0.192c.	0.031d.	0.058d.	0.069d.	0.035d.	0.268c.	0.032d.

Notes:

Years. London lines - 1913-1914, IRT 1908-1909, except that CLR(1) is expressed in dollars and cents (as is IRT figure) and is for 1910-1911. Figures for K are based on an estimate of 97% efficiency in power generation, except for the CSLR (93%).

/overleaf

+Figures for c for MDR and UERL are based on Lots Rd. power station cost, interest charges for both are based on electrification costs.

*97% of power generated (hence K may be overstated).

[1]Assuming existing carriages were converted for use as trailer cars.

in these cases have been rather understated.[1] With the exception of the figures in column (1) however, all figures have been calculated on the same basis and so are roughly comparable. The most surprising thing about them is the relatively low figure for the CSLR, which was the oldest line after all. This is probably explained by the year - 1914 - by when the CSLR had been absorbed into the London Electric Railways Group and its own power station closed.[2] It does not explain why the MDR and UERL operating figures should have been so much higher, however. Even though the figures are only a rough guide, the IRT figure is sufficiently lower to suggest a clear operating advantage, relative to the other lines.

While it is unlikely that this problem applied to American lines to the same extent, problems with statistics prevent a clear answer. The difficulties with the Boston and Brooklyn systems have already been outlined but Chicago possessed a system which should have been readily comparable. However, in 1911 the unified system was recorded as consuming 168 m. kilowatt-hours of electricity. Admittedly Chicago had a record of a higher per capita electricity consumption than any other city in the world, but this figure appears to be on the high side.[3] Although annual car-mileage in Chicago was higher than for the London

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1. For instance, if an attempt is made to compare the CLR figures for consistency, the first figure expressed in pence is three times the second figure, yet overall operating expenses were only 23% higher in the first period.
2. UERL: Miscellaneous Records. Acc 1297/LER 4/1.
3. Electric Railway Journal, vol. XXXVII, p. 1085; UERL: American Tour 1929, report, Acc 1297/UER 4/81.

lines (excluding the Metropolitan), in 1914 total consumption by the London lines was only 153.9 m. kw. hours. If the 8.15 m. units for lift operation are deducted, the difference is too great to be accounted for merely by differences in car-mileage.(1) The Chicago system used on average 3.6 kw. hours to propel, light and heat one elevated car for one mile, the approximate cost of energy being some five cents per mile. The District Railway in 1906 estimated the comparable cost as 1.810d. but more relevantly consumed only an estimated 2.793 kw. hours of electricity per car-mile. Over a two year period (1911-1912) directly comparable with the Chicago figures, the Metropolitan figures for current consumption per car-mile varied between a minimum of 2.69 kw. hours and a maximum of 3.09, still way below the Chicago average.(2) Admittedly Chicago winters were much more severe than those in London but this could hardly account for such a great difference.

While of interest for comparative performances, the figures from Table 32 give little weight to the underlying hypothesis that companies were only concerned about costs as a proportion of receipts, rather than in their own right. This was the case with British railways generally, the Operating Ratios of which were deteriorating fairly steadily down to 1914. Admittedly this was not necessarily a true reflection of a decline in efficiency for it was partly the result of a rapid rise in working expenses in relation to gross earnings. Overall they rose 116.6% and 79% respectively. However, while the majority of British trains were

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1. UERL: Operating figures for 1914, Acc 1297/LER 4/1.
2. Traffic Statistics, Acc 1297/MET 4/1, Acc 1297/MDR 4/3.

loaded no more heavily in 1900 than in 1880, the situation after 1900 was even more difficult for the urban railways. How far this position was eased by the adoption of electric traction is not easy to assess although in cost terms the difference between steam and electricity was probably overstated. That the Mersey Railway gained most from electric traction is apparent but it is equally apparent that the bulk of such gain arose from indirect rather than direct benefits. On the Mersey Railway the comparative operating costs per ton-mile were 0.344d. for steam traction and 0.254d. for electric traction.(1) Such a difference is respectable but if the wages element is removed the figures are 0.267d. and 0.2243d. respectively.(2) In aggregate terms, around 47% of the savings in costs realised from the introduction of electric traction was attributable to reductions in staffing levels. This of course does not invalidate the argument for savings in costs through electric traction but it does suggest that, even taking into account the higher productivity of electric trains, about which there was no dispute, in cost terms alone the difference was not so great. A number of objections spring readily to mind. Firstly, ton-mile costs are not necessarily the best way of measuring productivity, as already explained and if in the case of the Mersey train-mile costs were taken instead, the difference would be considerably more marked. Secondly, no account is taken of associated cost reductions in ventilation,

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1. Joshua Shaw: Notes on the Mersey Railway, op. cit. The figures are the averages of the last three years and first three years of the respective modes.
2. Joshua Shaw: The Equipment & Working Results of the Mersey Rly. under Steam and under Electric Traction, Proceedings of the Institute of Civil Engineers, 1909.

or the growth in traffic directly attributable to the improved conditions. Total cross river traffic grew from 14.35 m. in 1892 to 17.6 m. in 1902 and 25.2 m. in 1912. The railway share in each year was 59.19%, 31.65% and 59.63% respectively, electric traction commencing in 1903.(1) Clearly electric traction enabled the railway to recover its earlier market share, if not increase it. However, flimsy though the evidence may be, this helps to support the theory that management was more concerned with traffic rather than costs. Electric traction was seen as a way of stimulating passenger growth and financial analysis of it was rudimentary at best.

While the Mersey, with its steep gradients, was seen as an ideal case for the early introduction of electric traction, if the special charges for pumping, ventilation and lifts are excluded from overall figures, its operating costs even in steam days were not significantly greater than those of the Metropolitan or District lines. For 1893, these were 37.6d. per train mile, 35.4d. and 34.4d. respectively. However, the locomotive expenses showed a more noticeable contrast, being 13.99d. per train-mile, 9.61d. and 8.4d.(2) Clearly this formed a substantial proportion of overall running costs - 37.21%, 27.15% and 24.42% - which would be significantly reduced under electric power. Equally clearly, there was scope for improvement in other areas. The possibility of substantial reductions in costs attributable to higher labour productivity through electrification has been hinted at but how near was this to reality?

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1. Joshua Shaw: Notes on the Mersey Rly., op. cit.
2. Northcote Papers: Comparative Statement of Working Expenses ... 1893.

Ideally, some form of production function is needed to measure the growth (if any) of labour productivity but of equal concern here is an assessment of the total proportion of operating costs going in wages. There can be no doubt that the remuneration of staff was becoming a growing problem in the years down to 1914. This was particularly marked in America, where the fixed fare levels, coupled with the increased capital for line extensions, was leading to conflict, which in the case of the Boston Elevated was marked by a bitter strike in 1912.(1) A rough indication of the problem is given by the percentage of value of net output going in wages. In Massachusetts, this was 47.7% in 1899, falling to 46.7% in 1904 and 45.6% in 1909 but rising to 50.4% in 1913. Although the short-term variations differed, the overall pattern for the United States as a whole was the same - from 44.9% in 1889 to 48.4% in 1899, 50.3% in 1909 and 52.1% in 1919.(2) Irrespective of whether a similar pattern actually occurred in urban transit systems or not, such movements generally would obviously create pressure on the systems, in the form of higher staff turnover or increased labour unrest. Given that fare levels were fixed, an increase in revenue could only come about through a growth in traffic, which in turn would necessitate higher labour productivity, an increase in staff or labour-saving innovation.

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1. Electric Railway Journal, vol. XXXIX (1912). The strike lasted for 3 weeks from early June.
2. W. G. Hoffmann: The Growth of Industrial Economies, Manchester, 1958, p. 7.

Of all the companies, the general problem of labour remuneration was most severe for the Boston Elevated, where the further burden of high taxation levels reduced still further the surplus available for paying returns on capital. There was no doubt that the payment of adequate returns was considered more important than increasing wage rates. It was felt that

> It is not the duty of the company to meet demands of employees for increased pay by foregoing the payment of an interest return on the reasonable capital value of the property. It is the capital outlay which creates the property that furnishes work for the employees and, in connection with that work, provides service for the public.(1)

However, the 1912 strike was not ostensibly over wage levels but over union recognition and the reaction was generally hostile. It was claimed that most of the strikers had been employed for only one or two years although, as will be shown in the case of New York, this could still have meant the majority of employees, and a large number of strike breakers were brought in. The strike in fact failed and some two hundred jail sentences, varying in severity from three months to one year were passed.(2) That wage rates may have been a catalyst of the strike action is suggested by the fact that minimum wages were increased only one week before the outbreak of the strike, which meant that the highest wage rates had risen 30% over the previous ten years.(3)

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1. Electric Railway Journal, vol. XLI (1913), p. 878.
2. Electric Railway Journal, vol. XXXIX (1912).
3. ibid.

That the strike, the wage increase and a reduction in the working day from ten hours to nine hours in 1913 all failed to solve the problem is apparent from the setting up of an arbitration board and the granting of union recognition in 1913. That this was necessary is apparent from the fact that of some 9,700 employees in 1913, over 7,000 were union members.(1) The arbitration board rejected suggestions that the work in 1913 was more arduous than it had been in 1897, claiming that improvements in conditions such as enclosed platforms, seats for motormen, improved methods of fare collection and more efficient equipment very nearly offset factors such as the introduction of larger cars, operation of faster schedules, increased traffic and more general orders.(2) These findings in themselves suggest that the company was in fact trying to operate more efficiently, largely trying to meet increased demands and that these attempts were meeting with opposition from the operating staff. Although comparisons with wage rates in other industries in the Boston region were rejected, it was noted that several other street railways in the district paid higher rates and the board felt this situation should have been reversed.(3)

Of greater significance were comparisons between changes in cost of living and in wage rates. Between 1897 and 1913 the cost of living had increased by about 24%, between 1903 and 1913 14% and between 1908 and 1913 8%. Although it was accepted that wage levels had kept pace with this, there was no evidence as to the

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1. Report of Arbitration Board on Boston Elevated Railway, Electric Railway Journal, vol. XLIII (1914), p. 170.
2. ibid.
3. ibid.

adequacy of wages in 1897 and the cost of living only determined the wages of the lowest paid and skilled workers should have been paid in proportion.(1) The dissatisfaction felt at failure to achieve this was clearly reflected in the high labour turnover as some forty per cent of car-operating staff left the company every year and this high total was reflected in a steady increase in the number of street car accidents.(2)

The problems the company faced with capital and taxation burdens were noted but the board considered that

> if the Elevated company is to furnish all the improvements demanded by the community they ought not to come out of the pockets of the men, that the men are entitled to fair and adequate wages ... and that it is for others to decide whether the company is to be gradually bankrupted, whether the passengers are to pay more, or whether the community as a whole is to come to the rescue of the situation.(3)

Although the hours of work had been reduced in December 1913, there was still a very large body of men who might be on duty for up to sixteen hours, which the arbitration board considered 'an almost intolerable hardship'. The overall recommendations of the Board therefore were for a substantial wage increase - over fifteen per cent in most cases - but spread over two years, with reductions in hours and improved overtime payments.(4) This ruling had an immediate adverse effect on the company's finances, the dividends being reduced from six per cent to four per cent per annum in 1914. Even this failed to solve the problem and in 1918 the Boston Elevated system was taken into public ownership.

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1. ibid.
2. ibid.
3. ibid.
4. ibid. p. 174.

This was prompted as much by the problems of raising new capital and meeting existing capital charges and the taxation burden as by increases in wage rates. Indeed, it is not unreasonable to suppose that the problems of raising new capital limited the introduction of labour saving technology and the fight against increasing wage rates was a result of this. However, the Boston system was by no means the only one to face staff problems. In the first nine months of 1912 4,904 new employees were enrolled by the Interborough organisation in New York and 5,276 left the company. This was equivalent to a complete change of rank and file personnel every seventeen months and, as in Boston, was leading to a high accident rate. Of equal concern was that a very high percentage of the staff withdrawals were compulsory, due to dishonesty.(1)

The IRT's approach to the problem differed from that of the Boston Elevated. While the latter after initial strong opposition accepted unionisation of its workforce, the former adopted a paternalistic approach. Theodore Shonts' reaction to the high labour turnover was that

> The more one studies the general labor situation, the more firmly convinced one becomes that we are verging on a moral and economic awakening to the great need of improving social conditions as a means of heightening the degree of labor efficiency now obtaining.(2)

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1. Belmont Papers, Box 4.
2. ibid.: letter to Frank Hedley from Theodore Shonts, Interborough Metropolitan Co. 10/10/1912.

Belmont had been aware of the general trend for some time as from 1908 onwards, through the offices of the National Civic Federation he campaigned vigorously for proper provisions for workmen's compensation. In this he was assisted by Shonts and although between them they received praise for their enlightened attitude, they were both strongly anti-union and their campaign for employees' relief and insurance was undertaken primarily for reasons of self-interest.(1) Belmont was well aware that the cost of training new employees was becoming an increasingly great burden, as was that of accident compensation, the growth of which largely reflected the employment of inexperienced staff. The theory behind employee insurance was that this would help to tie staff to the company, thereby reducing the labour turnover and increasing overall efficiency. That the IRT was not a particularly beneficent employer, however, is revealed by Belmont's complaints about the possible construction of a competing subway by the city. He complained that it was well known that

> City operated companies work their men the shortest hours, pay them the highest wages, (and) employ an unnecessary number.(2)

The publicity Belmont and Shonts gained nationally for the concept of employee insurance could therefore be interpreted as an attempt to reduce the unacceptable labour turnover by improving conditions but doing so at minimum cost to the IRT company. Nevertheless, the company were unable to avoid the burden of increasing labour

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1. ibid.
2. ibid. letter from Belmont to Hedley, 29.5.13.

charges and, like the Boston Elevated, increased wage rates substantially in 1912. These increases were to cost $230,000 in the first year.[1] As with the Boston system, they were graded to provide higher wages for longer service and greater experience. Whereas the Boston system was consolidating these grading structures, however, the IRT was expanding them, in an obvious but not particularly successful attempt at reducing staff turnover. Significantly, the rates for motormen were scarcely increased, the major sectors to benefit being guards and conductors.[2]

The significance of these patterns lies in the clearly defined trend of overall operating costs movements in relation to income. It was argued earlier in the chapter that management was not over-concerned with costs, provided they did not rise above certain levels. Unfortunately, the rigorous provisions of five cent fares and free transfers meant that costs as a proportion of income would inexorably rise unless steps were taken to control them. It was also argued that most of the American lines saw innovation as capacity increasing, rather than cost reducing. Therefore crews were expected to work harder in reflection of this but a result of the improved working conditions campaigned for by Shonts and Belmont was legislation for shorter working hours. In Boston the maximum working day was set at nine instead of ten hours from January 1913, with wage rates to be unaffected.[3] That working conditions and rates were determined to some extent exogenously is clear from the high labour turnover. However, it is also clear

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1. Electric Railway Journal, vol. XXXIX (1912), p. 946.
2. ibid.
3. ibid.

that wage rates were not regarded as a problem until 1911 or 1912, largely due to the changing social conditions, and it was only when this became apparent that management became truly conscious of the finer details of wage costs.

This applied to workshop staff as much as to operating staff, although in the workshops there was more obvious scope for increasing capacity through attempting to reduce the time equipment was out of commission for overhaul or repair. Alterations in wage levels reflected both this and the shortage of suitably skilled workmen. This was particularly so in New York, where the IRT introduced new forms of wage payment to increase wages and attract the services of skilled men.(1) This was attempted by the adoption of piece work and bonus payment systems in the workshops, which was a practice adopted by other American lines. Its adoption was usually considered beneficial. On the Hudson & Manhattan for instance, following the adoption of piece rates, the average output of car cleaners rose from $8\frac{2}{7}$ to $12\frac{1}{3}$ cars per day and average painting costs fell from $25.29 per car to $19.70 per car.(2) This was as much a reflection of the company's need to have as much stock available at any one time as possible as of its desire to reduce costs. Indeed, certain of the practices adopted on the Hudson & Manhattan, while possibly reducing the time a car spent out of service, increased maintenance costs unnecessarily. Most notably, because of the practice of

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1. ibid. p. 576, <u>Piece Work & Bonus Systems in the I.R.T. Co. Shops</u>.
2. <u>ibid.</u> vol. XXXVII, p. 1097.

doing as much repair work as possible while cars were being inspected, labour costs for inspection, at over 0.5 cents per car-mile were comparatively high.(1) However, workshop staff on the Hudson & Manhattan were comparatively well paid, averaging $2.29 per day in 1914.(2) This compared favourably with IRT rates and the low overall maintenance costs justified such expenditure.

An attempt must be made, however, to ascertain how well the wage rates on the elevated railways compared with those in similar occupations. The prevailing rates in Boston in 1912 were $612 per annum for motormen, $510 for brakemen and $561 for guards. As the national average annual earnings for all grades of street railway workers were $674 in the same year, these rates were clearly not excessive.(3) If comparison is made with steam railroads, the difference is even greater, for average annual earnings here were $721.(4) These comparisons would tend to suggest that wage rates in Boston were held down to maintain dividend payments. Of greater interest, however, is that while the highest wage rates on the Boston system increased by 30% from 1902 to 1912 the national average increased only by 17%, yet was still higher than the top Boston rates.(5)

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1. As a rough comparison, power costs for the subway in New York were about 2.3 cents per car-mile and train crew costs about 0.8 cents per car-mile.
   ibid. Maintenance Costs on the Hudson & Manhattan R.R., vol. XLIV (1914), p. 159; vol. XXXIII (1909), p. 374.
2. This average included car cleaners and labourers.
3. U.S. Bureau of Census: Historical Statistics of the U.S., op. cit. part 1, p. 168.
4. ibid.
5. ibid.; Electric Railway Journal, vol. XXXIX, p. 946.

For the most part, elevated railway workers were not paid as highly as ordinary railway workers. While in 1910 average earnings for the latter were $14.07 per week, only motormen on elevated lines regularly received higher earnings, although senior categories of conductors on the IRT did receive more. Even if comparisons are made with street railways, elevated workers were not noticeably better paid. National average earnings for street railway workers were $681 in 1910, while for transit workers in New York on the IRT and Brooklyn systems they were $684.33.(1) In Boston, of uniformed staff (i.e. train workers) only brakemen did not receive this figure, suggesting that rates in New York were actually lower, even though Boston rates were lower than many in the region. Whether, therefore, rates in New York reflected the greater availability of labour in the city, or merely the high labour turnover, is difficult to determine. Although the average rates were not significantly above those in street railways it is worth pointing out that the average rates for street railway workers compared very favourably with those in other industries. Again in 1910, the annual average for all industries excluding farm labour was $630 and for manufacturing only $558. Even for steam railroads, the average was only $677.(2) These comparisons do not say much, however, for the overall proportion of skilled workers to total workers was higher

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1. Historical Statistics of the U.S., op. cit. part 1, p. 168, Electric Railway Journal, vol. XXXV, p. 127; Averages for the Brooklyn and IRT systems are based on weighted averages of earnings, based on 60 hrs./week, 51 weeks/yr.
2. U.S. Bureau of Census: Historical Statistics of the U.S., op. cit., part 1, p. 168.

for street and elevated railways than for other organisations. As a simple example, the vast armies of porters, shed cleaners and other unskilled grades present on steam railroads were almost totally lacking on street railways. In the above comparisons, this is not a factor as calculations have been based on the rates paid to skilled urban railway workers only. Thus the rates paid by the urban railways appear less favourable although if the earnings of motormen only are compared, the differences are substantially in favour of the railways. Nevertheless, staff turnover was very high and given Shonts' and Belmont's anxiety about this, it cannot have been confined to unskilled grades.

Ideally, in calculating the cost of wage payments to the companies, an attempt should be made to calculate the cost of training new staff and an allowance should also be made for the cost of accident compensation. However, given the relative wage rates in the street railway industry, where the quoted figures are national averages, not New York or east coast averages, it is reasonable to assume that upward movements in urban railway wage rates occurred very largely in response to external pressures. In Boston at least there was a severe constraint - the difficulty of earning enough to pay capital charges - but it is suggested that these difficulties arose, in part at least, because of management's failures to keep a close enough control of costs. Keeping down wages was an easy option, at least until 1910.

This suggestion contradicts the generally held view that labour was scarce, and therefore expensive, in the United States although the findings must be qualified by the close involvement between the large street railway concerns and the rapid transit systems which may have significantly affected the average wages given in census reports, from where some of the figures have been taken. In Britain, given the lack of any close link between street railways and the rapid transit systems, one would expect sharper distinctions to emerge between the three broad sectors of steam railways, urban electric railways and tramways.

Preliminary comparisons confirm this. In 1907 the average actual earnings of engine drivers for all non-electric railways in Great Britain were 45s. 11d. per week while the average actual earnings of electric railway motormen were, depending upon method of payment, either 41s. 9d. or 38s. 10d. per week.(1) Similar differences existed for other comparable occupations, such as guards although these were classified differently on most urban lines. Only in two occupational groups were rates of pay higher for urban electric lines - signalmen and platelayers.(2) In both cases the differences can be explained by the considerably more arduous traffic conditions, particularly for platelayers, as most of the work was done in restricted conditions and unsocial hours.

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1. Board of Trade: Earnings & Hours Enquiry, VII - Railway Service 1907, p. xxvii. The difference in rates is due to the varying classifications - the lower figure is the average for '6 day workers', the higher that for 'other workers'.
2. ibid.

Contrasts in earnings were highlighted by the different methods of calculating wage payments. On non-electric lines the great majority of the labour force were classified as 'six day workers' so that they were paid overtime for Sunday working. On electric railways it was common practice to pay by the hour or by the day, rather than weekly rates, with no allowance being made for Sunday working. This practice was similar to that followed in the U.S. In other respects, such as provision of free uniforms, paid holidays and limited provident schemes, practice in Britain and America was generally similar.(1) The actual wage rates were substantially less in Britain than in America but that of course was common practice and if comparison is made with other industries, the relative standing was about the same.

For example, rates of pay on tramways, as in the U.S.A., were close to levels paid on the electric railways. The most noticeable difference was in rates paid to motormen. Although the highest paid were in London, only exceptionally were their earnings higher than 36s. per week. In 1904 weekly rates paid in East Ham were from 33s. to 35s.(2) In other grades, however, differences were less noticeable and it is incidentally worth pointing out that the difference between the wages of a motorman and a tram driver was much less than between a motorman and a

1. ibid. Holidays were generally three to seven days annually, for about 60% of the workforce.
2. Board of Trade (Labour Department): Abstracts of Labour Statistics in the U.K., various years.

railway engine driver. Even in a provincial city like Sheffield, tramcar conductors could earn from 25s. 1½d. to 27s. 11d. per week, which compared favourably with similar grades on electric railways.(1) Although there is strong support for the claim that the municipalisation of tramways in Britain led to higher wages being paid than would otherwise have been the case, in much the same way that August Belmont objected to the city building a new subway in New York, this does not explain why the difference between wages paid on urban railways and on tramways should have been so similar in both Britain and the U.S.A. Given the similarity, it is reasonable to assume that wage rates on urban railways were largely set by tramway wage rates, without (at least before 1910) any conscious attempt to attract the most skilled men by significantly higher rates. This would help to explain the high labour turnover in New York although the rapid population movement and generally fluid nature of the American labour market are other factors to be taken into account and the lack of concern for close overall cost control. Only when the annual cost of training and accident compensation became significant were steps taken to alleviate the situation.

The importance of tramway wage rates is given credence by the position of railway wages relative to national average wage levels. The American figures quoted are proportionately similar to the 1907 U.K. figures of an annual national average of £71 and urban railway average of £74. By 1913-14 the national average was £77

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1. ibid.

and the railway level had risen in line.(1) In some respects, however, the British companies were ahead of the American lines in attitudes to employees. The District was second only to the North Eastern Railway in Britain in deciding to recognise and negotiate with the trade unions. Notwithstanding apparent hostility in America to unionisation, Yerkes negotiated with the footplate unions over the issue of electrification and manning. The unions were anxious to retain two men in the cab, while the company wanted one man, at reduced wages. At this time - 1904 - District men worked a seven day week for 8s. per day. A compromise was reached, with existing men being paid around the same level, and new men receiving a lower wage.(2) In the same way that this was ahead of negotiations in Boston with the unions, the Metropolitan's paternalist approach preceded that of the IRT. When the company moved its sheds and workshops to Neasden in the 1880s, houses were built for employees at low rents. As in the later case of the IRT, the company had its own interests at heart, its chairman (Edward Watkin) finding that

> 'experience is that we gain indirectly a great benefit by practically improving the comfort of the people whom we employ'.(3)

In another important respect there was a difference between the two countries. Whereas piece-work and bonus systems of payment were being steadily adopted by the American lines, in

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1. E. S. Hobsbawm: <u>Industry & Empire</u>, London, p. 167.
2. Barker & Robbins: <u>History of London Transport</u>, op. cit. vol. II, p. 315.
3. ibid: vol. I, p. 290.

1907 out of 6,951 electric railway workers in the U.K., only eleven were piece-workers.[1] This contrast supports the hypothesis made earlier in the chapter that while American lines should, on the whole, have been concerned with increasing capacity, for the British lines reducing costs was a more important objective. Different rates of growth of traffic meant that while the American lines needed as much as possible of their equipment in use during rush hours, such a need was less pressing in Britain. Much of the new innovation adopted more extensively in America than in Britain reflected this. For instance, in 1913 the Hudson & Manhattan introduced 'baking enamel' in painting work which reduced by 75% the time occupied in carriage painting. This enabled the company to have a coach varnished between the morning and evening rush hours, and it was prepared to pay higher wages, through piece-work, to ensure that this could be achieved.[2] It would also appear from this that the British companies did not experience the same difficulties that the American ones did in obtaining satisfactory labour. If this was the case, it would tend to reinforce traditional arguments about American and British labour in general, especially in the context of the performance of the two economies prior to 1914.

While it is being argued that passenger growth had greater significance for cost reductions than did innovation, there was one important cost which was usually rising steadily but about which the companies could do little, if anything. This was

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1. Board of Trade: Earnings & Hours Enquiry, VII, op. cit. p. xxvi.
2. Electric Railway Journal: vol. XLI (1913), p. 241.

taxation, the burden of which varied enormously from line to line. At one extreme was the Boston Elevated, which under its 1897 Act of Incorporation was to pay 7/8% of gross earnings to the Commonwealth and in addition had to pay heavy rentals on the city built subways that it used. In 1910 the combined outgoings on rentals and taxes, excluding rental of the street railway lines, was 77% more than the amount paid in dividends.(1) At the other extreme, the IRT was exempt from paying taxes on the subway.

Although the British companies sometimes felt that the burden of taxation upon them was excessive, for the most part the American lines were taxed considerably more severely. This was in many respects a reflection of public disquiet over early franchises and company organisation, as a result of which excessive taxation assessments were made, supposedly in partial recompense. This was particularly so for the Manhattan Elevated, whose 1880 losses excluded taxes of $650,000. Unsurprisingly, the company asked for a re-assessment but the requested level of five per cent on net earnings or two per cent on gross earnings would be considered almost unbearable in future years.(2) This changing attitude reflected the impact of taxation with regard to other costs and the ability of a company to pay an adequate return on its capital. In prosperous times, taxation could be tolerated and endured, as a way of demonstrating the responsible nature of a company but when the dividends were in danger, complaints about excessive

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1. Report for 4 years of Public Operation of the Boston Elevated Rly., 1922, Scudder Library, File 252.
2. New York State Courts 1881: The People of the State of New York vs. the Manhattan Railway Co.

taxation soared. Strictly speaking, taxation ought not to be regarded as a working cost, as it gives no direct indication of the efficiency or otherwise of a line but if it can be shown that there was insufficient concern with the long-term burden of taxation, it will surely lend support to the overall argument about cost control.

The main issue therefore is whether or not the tax-assessment of a company could be regarded as reasonable, and what advantages and benefits the company might obtain in return for payment of taxes. In making this assessment, the precise form which the taxation took must be considered, for the Boston method, whereby a fixed proportion of gross receipts was taken, was exceptional. Although the Manhattan company had pleaded to be levied in the same way, like most other companies it was assessed upon the physical value of its property and any notional franchise value was excluded. Unsurprisingly, the tax authorities would attempt to levy taxes in line with the inflated value the property had acquired through 'capital-watering'. Equally unsurprisingly, the company objected.(1) Nevertheless, grievances could be legitimate, if excessive. Whereas, for example, the subway in New York was exempt from taxes, the Hudson & Manhattan in return for being granted a perpetual franchise, paid taxes to both New Jersey and New York, which in 1912 amounted to some $500,000.(2) Given that in the city streets it took a form identical to the subway and that unlike the subway it received no financial aid from the city, this was somewhat harsh.

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1. New York: <u>Department of Taxes & Assessments in the matter of re-assessment of the Capital Stock & Surplus of the Manhattan Rly. Co.</u>, 1895.
2. <u>Electric Railway Journal</u>: vol. XLI, 14 January 1913.

All too often, however, complaints about the tax burden were a way of hiding unsatisfactory operating results, or explaining poor dividends. The Brooklyn system for example claimed that between 1893 and 1913 its tax burden rose 330%.(1) While such a figure may be accurate, it is largely meaningless given that the entire structure of rapid transit companies in Brooklyn altered enormously in those twenty years. More significantly, it complained that in 1899 it was paying $2,900 in taxes daily, or one dollar for every $3.62 that went to the stock and bondholders.(2) Possibly its most justifiable grouse was that from 1902, when the system became more or less fully consolidated, to 1913, there was a 135.6% increase in its tax charge, while total passenger earnings grew only 90.35%, from $12.3 m. to $23.4 m.(3) Similar complaints were made by other companies but in the case of Brooklyn, despite the actual increase in taxes, as a proportion of total operating earnings they rose only from 5.94% in 1902 to 7.27% in 1913. The impact on total earnings therefore was no worse than the rise in maintenance costs, from 13.8% to 16.1% of earnings, over the same period.(4) Certainly taxes totalling six to seven per cent of total earnings were far from insignificant being in money terms $0.74 m. in 1902 and $1.75 m. in 1913 but equally they were not so great as to provide a disincentive to reductions in overall operating costs.

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1. Brooklyn Rapid Transit Co. File, File no. 293, Scudder Library.
2. ibid.
3. ibid. Comparative Statistics for the Fiscal Years ending 30 June 1902-13 inclusive.
4. ibid.

The position in Boston was somewhat different, taxes there almost certainly proving more burdensome but again the position must be placed in context. Firstly, the very security provided by the regulations imposed by the city almost certainly led to over-investment in rapid transit there. The Cambridge subway link, which opened in 1912, represented an investment equal to $1,400 for every house in Cambridge. The interest charges alone were equal to twelve million single fares annually and the entire taxable value of all the property in Cambridge was only 4½ times the railway investment.(1) Unlike the other subways in Boston, which were built by the city and rented to the company, the Cambridge subway was built by the elevated company itself. Had it been built as an isolated venture, there can be little doubt that it would have joined the Mersey and Hudson & Manhattan lines in its unsuccessfulness. As it was, the interest burden brought problems for the company, which were blamed on the increase in labour costs and unacceptably high taxation. In 1914, the Arbitration Board in its report blamed the company for having signed a wasteful and extravagent contract for construction of the Cambridge Link, which contributed unnecessarily to its final costs.(2) Construction of the subway meant that by 1917 the company was unable to obtain the additional capital necessary for new lines and other improvements but significantly, no good case was made for the necessity of such extensions. The permanent investment of the elevated company rose from $25.3 m. in 1897 to $116 m. in 1916. This was an increase of 359% but

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1. <u>Electric Railway Journal</u>: vol. XXXIX, 1912, pp. 782-789.
2. <u>Electric Railway Journal</u>: vol. XLIII, 1914, p. 171.

the population of the area served grew only 50% and revenue passengers only 111% in the same period.(1) The system was subsequently taken into public control, largely because, apart from an inability to pay capital charges, adequate current maintenance and depreciation allowances could not be earned.(2) This situation could be blamed on the tax burden only insofar as this was part of the overall city regulatory system, which induced the company to indulge in expensive and unjustifiable new lines. The relative consistency of the Operating Ratio figures in Table 7.2 (which include taxes) support this, although the comparatively high figures (by American standards) do reflect a higher than average tax burden.

Up to a point, conditions in Boston exemplified the pitfalls that might occur through over-optimistic expansion without sufficient regard to cost. In 1897-8 the passenger revenue of the street railway lines was $8.96 m. and this had increased by 1912 to $16.27 m. Such an increase of 81.42% could certainly not be regarded as excessive and would tend to suggest that none of the several additions to the unified rapid transit system in Boston had accelerated the normal growth of traffic.(3) Against this it could be argued that without many of the additions, physical constraints would have restricted the 'normal' growth but as far as net financial results were concerned, the position

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1. Report on Financial Condition of Boston Elevated to Commonwealth of Massachusetts, 1917, File 252, Scudder Library.
2. Boston Elevated Rly.: Report for 4 years under Public Operation, Boston, 1922.
3. C. S. Sergeant: 'Financial Aspects of the Relief of Congestion by the Construction of Subways & Viaducts', Electric Railway Journal, vol. XLII (1913), p. 814.

in Boston was aggravated by expansions, due to both the heavy burden of fixed charges and the extension of lines under a universal fare constraint.

At first glance, the very low operating ratio of the subway in New York tends to support those who argued that the burden of taxes was frequently excessive. Undoubtedly this was a bonus for the IRT but before making any conclusions, the very different operating circumstances of the subway must be borne in mind and even if the company had had to pay taxes, the Operating Ratio would still almost certainly have been lower than it was for any other company. Probably the most convincing argument against taxation in America, however, was that the railway lines contributed directly to land values, and therefore tax income, to a substantial degree and that to the extent that taxes hindered further expansion the long term tax receipts were restricted. Unfortunately, in no case does the existence of high taxes appear to have been the sole factor inhibiting expansion.

In Britain, as in America, taxes tended to arouse strong emotions but for a slightly different reason. Admittedly,it was not infrequently felt that the actual burden of the taxes was excessive and caused problems although again this was usually expressed as the inequity of denying shareholders their rightful returns. The Central London for instance was paying £32,000 per annum in taxes in 1906 and this was equivalent to an extra one per cent on ordinary stock.(1) In 1892 the Metropolitan and

1. The Economist: vol. LXV (1907).

District lines between them were paying some £80,000 on rates, taxes and government duty, amounting to between 4.7d. and 4.9d. per train-mile for each company. To give a comparison with American figures, the rates as a proportion of receipts were seven per cent for the Metropolitan and 6.72 per cent for the District. For the Mersey Railway in the same year the proportion was 3.64%, although this may have reflected an inability to pay any more.(1) Deciding whether these rates were 'fair' or not is difficult. Although the cost of under-utilised lifts on the Mersey Railway was only 2.73% of receipts, the rental it paid for using Rock Ferry station and the toll for using other companies' lines to enter the station amounted to 8.97% of receipts.(2) For the most part, expenses are not directly comparable with American figures, being compiled differently but it is noticeable that compensation for damages was a negligible sum - not more than 0.02% of operating costs. Assessing the relative tax-burden in the two countries is therefore difficult, although the limited evidence suggests that if measured as a proportion of receipts, British taxes were not lower than American ones, as was claimed although accident costs were certainly a lot lower.(3) Given that in 1893, both the Metropolitan and the District (but not the Mersey) gave more in taxes than they spent on either track maintenance or carriage and wagon maintenance and repair, the taxes were not insignificant.(4)

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1. W. M. Acworth: 'Railway Economics', Economic Journal, vol. II, 1892; Northcote Papers: Comparative Statement of Working Expenses. Half-Year ended 31.12.93.
2. Northcote Papers: ibid.
3. Electric Railway Journal: vol. XLI (1913), p. 193.
4. Northcote Papers: op. cit.

However, the major complaint about taxes in Britain was not over the amount paid but over what was considered to be the unfair advantage given to competitors. Muncipal facilities such as tramways and river boats were aided from the rates by the London County Council. The 1905 Royal Commission had suggested that a similar policy could be adopted with respect to the construction of new railways, as it was felt that re-housing in the central area involved a heavy loss to the rates, and the construction of new houses in the suburbs would be cheaper and in other ways preferable.(1) Little came of this suggestion and it was in any case of only marginal concern to the urban railway companies for whom even the tramways were not a major threat, given their limited extent.(2) The real threat in London was felt to come from buses, which encountered few regulations and paid minimal rates and taxes. Although it is not directly relevant to the operating costs of railways, the growth of motor bus operations in London is of interest, given the criticisms made of British entrepreneurs. For while automobile usage in the U.S.A. soared, to the extent that by 1919 the number of cars in New York City alone was about equal to the total for England and Wales, in the same year there were very few motor buses in the U.S.A. Where motor buses did exist, they were usually confined to routes along the main thoroughfares such as 5th Avenue in New York, where street railways were restricted and

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1. Royal Commission on Transport in London, 1905, p. 104, Para 216.
2. In London in 1908 there was one mile of tramway to 20,000 inhabitants, compared to ratios of 1:5,000 in Glasgow, 1:3,000 in Manchester and 1:2,500 in New York. - Electric Railway Journal: vol. XXXII (1908), p. 771.

fares were often twice those charged by the street railways. As a result, bus travel raised passengers into a different social category.(1) Had the same restrictions existed in London, bus travel may well have followed similar lines. However, the liberal nature of regulations and the lack of tramways meant that bus travel boomed. As early as 1908 the Underground was facing noticeable competition, most of it from small companies which were confidently expected to go out of business because of the high rate of depreciation on buses, for which insufficient allowance was made in the accounts. Most bus companies were also losing money, despite the liberal nature of regulations.(2)

The comparative nature of bus development in the two countries would suggest that where conditions were favourable, British entrepreneurs were capable of exploiting new markets and new technology. Of more direct relevance, it also provides a further insight into the comparative operating conditions of the railways in London and New York. In New York, the subway fare was five cents, buses charged double that. In London, the narrow congested streets were so favourable for the growth of bus companies that the railway companies found the fares they could charge limited by the competition. Bus competition obviously affected short distance traffic more severely, where the additional time involved in descending to deep level stations was a further disincentive to taking the trains, and British railway managers were not very interested in short-haul business

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1. F. Pick: 'Traffic & Politics in America, 1919, with some impressions of New York', UERL staff visit to USA 1919, report, Acc 1297/UER 4/79.
2. Electric Railway Journal: vol. XXXII (1908), p. 65.

in any case.(1) In New York, the fixed-fare structure naturally meant that short-haul traffic was more popular with railway management.

Objections to short-haul traffic in Britain stemmed originally from the main-line railway companies, who regarded even suburban traffic as only marginally profitable. This attitude was largely shared by the American main-line companies but the urban railway companies reacted very differently. In the U.S.A., the Manhattan Elevated was always reluctant to indulge in 'pioneering work' into the undeveloped suburbs and many of the problems of the Boston Elevated in future years stemmed from the adoption of such a policy. In London, such a policy was pursued actively, the underground system extending far out into the suburbs, in an attempt to acquire long-distance traffic. To a certain extent such a policy was also the case with the Liverpool lines, the Mersey Railway electrification having a marked effect on traffic going beyond that company's termini. Although the company was permitted by the Railway Clearing House to levy a considerable supplement on the normal short-distance fare through the tunnel, in practice this was never done, due to the competition from the ferries. Therefore longer distance traffic was actively sought as a means of alleviating this.(2) Even the LOR sought to benefit from long distance traffic, with through services on to the Lancashire and Yorkshire Railway.(3)

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1. ibid. p. 1484.
2. When the Bill for electrification of the Mersey Railway was passed in 1900, a Bill approving electrification of the adjoining Wirral Rly. was also passed. Had the Wirral Rly. been electrified the Mersey Rly. would have been able to operate through trains to the holiday resort of New Brighton and to West Kirby, which was slowly developing as an upper-class residential area.
3. [illegible] The Liverpool Overhead Railway, op. cit.

These substantially different approaches to the object of seeking new traffic, and thereby maximising sales, should have been reflected in the overall cost structures of the different companies. There is, however, no very satisfactory way of measuring any differences. The limitations of Operating Ratio statistics have been referred to more than once but even allowing for such limitations there are no readily obvious patterns. Two areas worthy of further analysis therefore are the actual growth, if any, in passenger traffic, which has already been mentioned, and specific economic conditions which may have adversely affected costs.

Of relevance to any growth in passenger traffic is a change in the size of the population served by a line or group of lines. In this basic relationship lay the expansion towards the suburbs of almost all the lines, in most cases in advance of the population, which followed when the transport facilities were available. American research suggested that the increase in traffic was approximately equal to the square of the population increase. Although figures varied considerably, for practical purposes in no cases was the growth as slow as a direct ratio between earnings and population.(1) The same report sought to quantify the cost-effectiveness of investment in new transport facilities, with reference to the cost-reducing effect that such new investment might have and highlighted the cost-reducing impact

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1. 'Arnold report on Pittsburgh rapid transit', Electric Railway Journal, vol. XXXVII (1911), pp. 257-61.

of subways compared to other facilities. As a rule of thumb guide, it was felt that, due to the expected cost reductions, if subways increased the annual earnings of rapid transit operations by $10 m., this would justify capital expenditure of $70 m. On the other hand, new surface lines increasing annual earnings by the same amount would justify only half that level of expenditure - $35 m. The same report emphasised that to be viable propositions subways should earn each year at least ten per cent of their initial costs.(1) Although a somewhat rule of thumb approach, this figure is useful as a guide to relative performance.

Of greater relevance to operating cost figures, however, is the claim for the proportional relationship between population growth and traffic earnings. In the report this relationship (with minor variations) was found to hold for all the relevant cities. Given past growth of these cities and assuming that management was aware of population trends, it is reasonable to deduce that in all but the most extreme cases the natural population increase would boost earnings. Therefore, other things being equal, cost fluctuations would be of less importance, provided that is that any increases in operating costs were less than projected increases in earnings. As long as traffic could be expected to grow in such a proportion, concerted attempts to reduce costs would be of less importance. Obviously a threshold level would apply where the cost of new facilities would have to

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1. ibid, Electric Railway Journal, vol. XXXVI (1910), p. 82.

be taken into account but for the most part these would affect capital, rather than operating, charges. Only in exceptional circumstances could an increase in traffic be possibly expected to increase operating costs, especially when unit costs could be made more easily divisible through multiple-unit operation, as has been shown. Equally, as the report on Pittsburgh pointed out, innovations designed to cope with growing traffic tended to have the effect of reducing unit operating costs - otherwise they would not have been introduced.

The hypothesis of the ratio between earnings and population growth appears at first sight a reasonable one. Figures for population and traffic on 3rd Avenue, New York in the late 19th century showed a population increase of 0.36 m. between 1878 and 1890 and traffic growth of 75 m. This is rather less than the square of population growth but relates to Third Avenue only. From 1891 to 1914, however, the traffic on the Manhattan Elevated grew from 215 m. passengers to 311 m., which was far in excess of the square of population growth, however measured.(1) This is a very crude analysis, given that neither 1891 nor 1914 are particularly representative years. Traffic declined substantially in following years, picked up at the turn of century, then increased rapidly after electrification, but this is enough to suggest that population growth alone was not a sufficient guide to future earnings, except in the long run,

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1. Traffic figures are those listed in Railway News and Electric Railway Journal while population figures are from Bureau of the Census, Historical Statistics, op. cit., part 1.

whereas operating costs were of short term importance. This is supported by evidence from elsewhere, although it does not invalidate the claim that population growth was relevant as an indicator of expected earnings. After all, in theory, even with a flat-fare revenue system, as long as prices were stable long-term passenger growth should have led to some reductions in cost as a proportion of total earnings.

In most cases, at least in America, Operating Ratio figures tend to support this, although no conclusions can necessarily be derived from this. However, a comparison of the larger transit companies in America outside Manhattan showed that while there was no definite trend in earnings in a car-mile period there was an evident relationship between earnings and expenses.(1) Although this study was primarily concerned with street railways, the Boston and Brooklyn results included the elevated railway figures. A contrast between the two systems is readily apparent. Whereas car-mileage increased steadily each year up to 1910 (the last for which figures are given) on the Brooklyn system, there was a significant cut-back in Boston after 1907. The most noticeable effect of this was a jump in gross-earnings from 26 cents per car-mile in 1906 to 28 cents in 1908. Although this caused a noticeable fall in the expenses attributable to power and transportation, the effect on overall operating expenses was less noticeable, a fall of 0.4 cents per car-mile in 1908 being negated by a similar increase in 1909. Up to a point, the

1. Electric Railway Journal: vol. XXXVII (1911), p. 259.

increase in earnings is precisely what would have been expected, as a reduction in car-miles operated would lead, initially at least, to increased car-loadings. The evidence on costs, however, would suggest that except for power costs, which did show a noticeable decline, reducing these was more difficult.(1)

Bearing in mind the complaints voiced by the Boston organisation about high taxes, the low rate of growth of traffic and fixed fares, it is noticeable that both power costs and general operating expenses, on a car-mile basis, were higher in Boston than in any comparable city. If comparison is made with Brooklyn alone, gross earnings were higher there and expenses lower, yet there was no major difference in the amount spent by either company on maintenance and repair work.(2) A large amount of the differences must be accounted for by the higher passenger density of the Brooklyn system, enabling fixed costs to be spread over a higher car-mileage. Nevertheless, some of the cost differences were too substantial to be accounted for by this alone. The Brooklyn system which it may be recalled bought its power from outside suppliers, had fairly consistent repair and power costs, which apart from a slight increase in 1907 were declining slightly from 1905 onwards, and quite sharply after 1908. Although the Boston system also managed to reduce these costs after 1908, they still averaged nearly 12 cents per car-mile in 1909, by when they were under nine cents in Brooklyn.(3)

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1. ibid.
2. Electric Railway Journal, vol. XXXIX (1912), p. 904.
3. Electric Railway Journal, vol. XXXVII (1911), p. 259.

Indeed, the Brooklyn company managed to reduce its overall operating expenses significantly after 1905, in sharp contrast to the Boston system.

Both systems, however, reveal a similar pattern between costs and earnings, the only noticeable difference being that the decline in earnings in Brooklyn started in 1906, one year after costs began to fall. This serves to support the idea that management was not over-concerned about costs. As gross earnings rose, so operating expenses tended to rise in proportion but where there was a dramatic change in one, the other also changed. This was far more noticeable in Brooklyn than in Boston, where, at least in the short term, a reduction in costs accompanied a rise in revenue. Even this serves to emphasise the point, however, in the overall context. Operating expenses were consistently higher in Boston than in Brooklyn and to this had to be added higher taxes and the subway and street railway rentals. At the end of 1908 the capital stock was increased from \$13.3 m. to \$19.95 m. and the desirability of a successful issue could well be seen as the stimulus behind the perceptible efforts at improving operating costs.(1) Although the necessity of securing adequate return on capital was undoubtedly important, this cannot be used to mask the financial position. After all, even after this increase in capital, the total capitalisation of the Boston system was only \$120,000 per mile, compared to \$213,800 in Brooklyn, where gross earnings per mile in 1905 were

1. Boston Elevated Railway file, File no. 252, Scudder Library.

$27,808 but $28,137 in Boston.(1)

The comparative car-mile figures would suggest, given this evidence, that the much higher density of traffic in Brooklyn was an important factor, or in other words, the level of service in Boston was not justified by the traffic. In defence of the management in Boston, it has to be admitted that the strong regulatory conditions were a factor. Minimum levels of service were laid down for off-peak services in the franchise conditions, as were staffing levels for trains, many of whom were supernumerary as a result of improvements in carriage design.(2)

In Brooklyn, on the other hand, earnings rose rapidly after 1902. As with the Manhattan Elevated, the Chicago lines and the Mersey Railway, electrification appears to have been important here. Significantly, the opening of the elevated railway in Boston had a much less noticeable effect, the annual average growth in passenger traffic in the three years after opening being only 4.23 per cent.(3) In Brooklyn, the rise in earnings was immediately significant, being accompanied by a slight reduction in car mileage and fall in costs. From then on, however, earnings rose steadily, as did car-mileage and, to a lesser extent, costs. Taken over the full period (1902-1910) the overall trend in costs was marginally downwards but not by more than would be expected as a result of the steady introduction of new equipment and operating techniques. In short, as long as costs were kept within a reasonable proportion, there was no

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1. ibid.
2. ibid.
3. ibid.

great concern about their levels. Although the evidence may be somewhat limited, therefore, the experiences in Brooklyn and Boston tend to support the idea that as long as certain profits constraints could be met - namely the payment of dividends and interest, with a small surplus, sales maximisation was the major objective of the respective managements.

Both companies, however, along with others, display similar characteristics at identical times - rising earnings, falling costs - that the performance of the economy as a whole in the period must be analysed for any likely effects.

From 1902 to 1907 - a period of traffic growth for all the U.S. elevated lines, not just those in Brooklyn and Boston - the economy in general was in a period of industrial growth. Immigration was high, as was manufacturing output and the volume of railroad traffic and net national product was growing vigorously - five per cent from 1902 to 1903, then by 23 per cent (at constant prices) over the next three years, rising from $273 per capita in 1902 to $349 per capita in 1907. Prices also rose, however, by 6.3 points from 58.9 to 65.2.(1) These conditions are reflected in the performance of all the companies at this time. The cost of materials was rising but not as quickly as the volume of traffic, while electrification in all cases had had a beneficial effect on operating costs and even the Chicago lines were able to pay something to their stockholders. Just as important was the fact that in almost all cases capacity

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1. M. Friedman & A. Schwartz: A Monetary History of the United States, op. cit. p. 153; Bureau of the Census: Historical Statistics of the United States, op. cit. part 1, pp. 200, 224.

limitations were proving a burden. Although sales-maximising organisations would seek to increase their capacity in any event, in most cases the companies were encouraged, persuaded or even ordered to do so by the respective Rapid Transit Commissions. Any anxiety about increasing costs and a slowing down in the growth of revenue had not yet therefore manifested itself.

Conditions altered somewhat with a sharp drop in output and employment following the banking panic of October 1907. From 1908 the economy experienced a sharp rebound, with a cyclical peak reached in January 1910. This was followed by a protracted but mild recession, lasting until January 1912 after when a sharp rise in wholesale prices preceded a brief expansion which terminated in 1913.(1) The price index rose sharply from 1908 to 1909 but this was cushioned by price falls in two of the most important product groups for the railways: fuel and lighting, which covered power costs, and metals and metal products. The comparisons are given below in Table 33.

The differences in the three columns help to explain why costs for most systems could fall in the period from 1907 to 1909. This price fall helped to hide the fact that the high annual growth rate of traffic had now eased considerably and that income had, as a result, reached a plateau. This was in large measure hidden in the Operating Ratio figures which showed a slight decline over the years. It is significant, however, that concern over costs was only becoming significant in the last few

1. Friedman & Schwartz: op. cit. pp. 173-4.

years before the outbreak of war, as the implications of operating expanding transit empires, when earlier revenue growth rates could no longer be taken for granted, began to be fully realised.

In Britain, the Operating Ratio figures would suggest that, the Mersey Railway excepted, electrification did not have as beneficial an effect on costs as might have been expected. Overall, there is certainly no discernible difference between the ratios in either country taken collectively. Furthermore, excluding the Boston elevated in its worse years, the Hudson & Manhattan in its early years and the Chicago South Side, the individual Operating Ratios were consistently below the average for railroads in the U.S.A., although not always better than street railway performance.(1) If one excludes the two Liverpool companies (although after 1908 the Mersey could be included) the same could generally be said of the British companies. What is more, for all the qualifications which have been rightly made about the value of Operating Ratios as a measure of comparison, in both cases the difference between the average performance of urban railways as a group and the national average of 64 in the U.S.A. and 62 in the U.K. for the period 1900-1912 is remarkably similar.(2) In the broadest view, this might suggest that operating conditions in the two countries were similar, especially if differences could be accounted for by economic

1. General Managers' Association of Chicago: 'Railway Statistics of the U.S.A.', Electric Railway Journal, vol. XXXV (1910),
2. ibid; Board of Trade: Railway Returns.

TABLE 33: WHOLESALE PRICE INDICES (1926 = 100), U.S.A.

Year	All commodities	Fuel & lighting	Metals & metal products
1902	58.9	51.8	91.0
1908	62.9	53.7	86.3
1909	67.6	51.6	84.5
1910	70.4	47.6	85.2
1911	64.9	46.7	80.8
1912	69.1	51.4	89.5
1913	69.8	61.3	90.8
1914	68.1	56.6	80.2

Source: Bureau of the Census: Historical Statistics of U.S. Colonial Times to 1970, op. cit. part 1, p. 200.

TABLE 34: WHOLESALE PRICE INDICES 1900-1914 (1900 = 100)

Year	A. Coal & Metal Prices	B. Total Prices
1900	100	100
1902	76.1	96.4
1903	74.1	96.9
1904	70.9	98.2
1905	71.3	97.6
1906	78.3	100.8
1907	86.9	106.0
1908	78.5	103.0
1909	73.6	104.1
1910	76.6	108.8
1911	74.7	109.4
1912	84.9	114.9
1913	92.5	116.5
1914	86.7	117.2

Source: B. R. Mitchell & P. Deane: Abstract of British Historical Statistics, p. 476.

conditions. However, as shown, the evidence does not really support such a view and any similarity in operating performance is more likely attributable to the traffic conditions of urban railways, which were similar.

Given that the average operating ratios were not significantly different, greater analysis of British economic conditions might help to explain firstly the limited success of electrification and secondly why different operating conditions did not yield widely dissimilar results. For strict accuracy, some calculation must be made for the higher cost of operating deep-level undergrounds where lighting, ventilation and lifts increased operating and maintenance costs. For the sake of simplicity, however, this will be ignored as it will be assumed for average figures that maintenance costs of elevated railways offset this. The very high (for America) figures for Boston are, in part, a reflection of the much higher costs of operating in its narrow streets and subways than elsewhere. If economic circumstances were adverse in the U.K. at specific times, this might explain why urban railways were running at spare capacity and why electrification did bring problems, initially anyway. For British railways in general, it is interesting to note that after increasing sharply in 1900 and 1901, working expenses thereafter ceased to rise and displayed much greater stability up to 1912.(1) In particular, despite coal prices allegedly

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1. R. J. Irving: 'The Profitability & Performance of British Railways 1870-1914', Economic History Review, vol. XXXI (1978), p. 60.

remaining high, significant economies were achieved in the costs of locomotion and traffic costs. Evidence has also been produced to show that train-miles per employee increased over this period.(1) However, most of the improvements were made in goods traffic, with passenger train mileage increasing more quickly than passenger journeys and receipts per passenger train mile reaching a low between 1906 and 1909.(2)

This must be borne in mind in considering urban railway operations, although conditions were rather different. Of possibly greatest interest is the movement of prices around the turn of the century, given that this was claimed to have affected the District Railway's decision to electrify, and given the supposedly high coal prices. Although after 1902, the Board of Trade wholesale price index was generally rising, the coal and metal price index (in which coal had by far the largest weighting) remained way below its 1900 level until 1914.(3) Table 34 gives the performance of the two indices in the period. The 1900 price of coal was in no way representative of earlier coal prices, or of prices in following years. Such an increase may therefore have acted as a stimulus for electrification, although this was far from being the only cause. The significant years, however, are in the period from 1905-1909. There was an enormous expansion in the transport facilities in London, at a time when prices were

1. H. Pollins: Britain's Railways: An Industrial History Newton Abbot, 1971, pp. 100-1.
2. R. J. Irving: op. cit. p. 61.
3. B. R. Mitchell & P. Deane: Abstract of British Historical Statistics, op. cit. p. 476.

rising again. In 1906 and 1907 national output peaked and real wages were rising but these were two of the worst years for the British urban lines, although actual passenger figures increased in line with economic conditions.(1) Passenger figures for the District were a record high in 1906 and for the Metropolitan were at their highest level since 1899.(2) Despite having risen, real wages were still below the level of 1902-1903 - even money wages were no higher - and although fares were unchanged, for the most part electrification should have reduced working costs. In fact, for the Inner Circle lines expenditure continued to rise at about the same level as the general price level, (considerably more for the District) while receipts fell for the Metropolitan, despite increased traffic, and in other cases failed to match the growth in traffic. For other lines in London there is no clear trend but it is interesting that the pattern displayed on the older lines should have followed that displayed by railways nationally, where managers were still 'struggling with the concept of the railways as a public service'.(3)

Perhaps this should not be too surprising given the evidence about lack of proper financial control by British railway managers during this period, except that the District, even after Yerkes'

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1. C. H. Feinstein: Economic Journal 1961, p. 384 gives Net National Income (current prices) as £1,704 m. (1904), £1,776 m. (1905), £1,874 m. (1906), £1,966 m. (1907), £1,875 m. (1908). For wage figures see Mitchell & Deane, op. cit. p. 344.
2. Board of Trade: Railway Returns.
3. R. J. Irving: op. cit. p. 63.

takeover, does not appear to have made many radical changes. Admittedly much closer controls were adopted before 1914, the UERL pioneering in this as far as the urban railways were concerned. However, the available evidence highlights the fact that American management was similarly not over-concerned with costs, until the constraints became considerably more telling. There was, however, a basic difference. In all cases, the American lines were charged, by the respective Rapid Transit Commissions, with maintaining certain levels of service as a public obligation and in addition were usually operating at or near full capacity in peak hours. Traffic was growing fairly steadily and in such conditions continuing investment was necessary. Although this investment had a marginally beneficial effect on costs it did, in the long-term, increase the burden of capital charges and only then did anxiety about costs manifest itself. In Britain, conditions were very different. Firstly both Liverpool and London had a far more developed urban transport network for their population sizes than any of the American cities, with the possible exception of Boston. As the transport system was not unified, the benefits of short term traffic were lost to other operators and this encouraged the building of lines out to the suburbs. Such lines were far less of a drain on capital than the tunnels in the city centre and showed more potential for long-term traffic prospects. They were also rational long-term developments, given the spare capacity that existed in most cases. However, partly because of public opposition and partly to encourage the increase in traffic that was needed, extravagant levels of service were provided although probably the best example of this was the Mersey Railway, rather than any London line. Over time, as in America, closer attention was paid to financial accounting but the failure to achieve this sooner undoubtedly had a detrimental effect on the returns paid on capital.

APPENDIX 1. COMPANIES EXAMINED IN THE TEXT

A. LONDON

1. The Metropolitan Railway

Opened on 10th January 1863 with an initial capital of £1.4 m. this was an 'underground' railway, immediately below street level, constructed by digging up the street, making a tunnel and then replacing the street. The congestion this caused was one reason why later London lines were constructed at a much deeper level. Initially the line ran from Paddington in the west to Farringdon St. in the east but was subsequently extended from Paddington to South Kensington where it connected with the Metropolitan District and from Baker St. to Aylesbury, which was reached in 1892, and beyond. Ultimately it stretched for some 60 miles from Baker St. in a north-westerly direction but the major proportion of traffic was carried over the 'Inner Circle' section in the heart of London this being the only underground section. The first electric service, from Baker St. to Harrow and Uxbridge started from 1st January 1905, followed by the Inner Circle in July 1905. By 1905 paid up capital was £15.7 m.

2. The Metropolitan District Railway (MDR)

In 1864 a Joint Parliamentary Committee evolved proposals for a circular transport link in Central London. Three Acts of July 1864 resulted in the MDR. Initially this was a line from South Kensington to Westminster Bridge. Close links were established with the Metropolitan Railway, the intention being for the latter to operate the MDR, hence the construction of the line from Paddington to South Kensington. However, after J. S. Forbes became Managing Director of the MDR in 1871 and Edward Watkin Chairman of the Metropolitan in 1872, relations between the two companies were characterised by mutual animosity largely because of the personal antipathy these two individuals held for one another. The MDR was further affected by the 1866 financial crisis following the crash of Overend, Gurney & Co. This hit railway promotion in general very badly but especially the MDR whose leading bankers also failed. As a result, a high proportion of MDR capital was raised through fixed interest stock and this proved to be a severe burden in future years. The original section of line was opened in 1868, but like the Metropolitan extensions were put in hand - southwards to Wimbledon and westwards to Hammersmith. The animosity between the two companies reached such a level that over a short length between High St. Kensington and South Kensington duplicate lines were built.

The original intention was for the MDR to build a line eastwards from Westminster to join up with the Metropolitan again, forming a continuous line to be known as the 'Inner Circle'. Completion of the Inner Circle was not forthcoming until 1884 and then only after the City of London contributed £0.8 m. Despite this, the companies each had to subscribe £2.5 m. to the construction cost of £1 m. per mile. The project was a failure in that the additional passengers needed to pay the capital costs failed to materialise and the completion of the Inner Circle signalled the end of conventional urban railway construction in London.

The MDR section of the Inner Circle was electrified at the same time as the Metropolitan section, in July 1905, although teething troubles delayed the complete electrification by several months. By this time the paid up capital of the MDR was £12.4 m., and it operated over twenty-five route miles of track.

3. The City and South London Railway (CSLR)

This was the first of the 'tube' lines, making full use of recent developments in tunnelling practice to construct a railway several feet below ground level. By doing so it was hoped to keep the cost of construction down. Although the line was originally planned for cable haulage, the decision to adopt electric traction was made prior to opening and it thus became the first underground electric railway in the world. In a further attempt to keep costs down the diameter of the tunnels was kept considerably below standard railway size and this posed a severe constraint in limiting train capacity and therefore overall passenger capacity. Opened on 4th November 1890, with an initial capital of £0.81 m. at the date of opening, the line was initially three miles long running from London Bridge to Stockwell, with extensions opening to Clapham at the southern end in 1900 and Angel (Islington) at the northern end the following year. A further extension was opened to Euston in 1907 bringing the length of the route up to eight miles.

4. The Waterloo and City, the Central London and the Great Northern and City Railway

The next 'tube' to open after the CSLR was the Waterloo and City which ran from Waterloo main line station to Bank station in the financial area of the City. It opened in 1898, its main function being to provide a link for commuters into the City from Waterloo station which was south of the river. Because of this, the capital was guaranteed by the London and South Western Railway which brought the commuters into Waterloo. Traffic was always light by other urban railway standards and the line was wholly absorbed by the LSWR in January 1907. In sharp contrast, the Central London Railway (CLR) occupied a major traffic route through the City and in financial terms was the most successful 'tube' line in London, opening on 30th June 1900 and with an initial capital at the opening date of £2.85 m.

Originally six miles long but extended to seven in 1908, the line ran west to east under Oxford St. and other main thoroughfares from Marble Arch to the Bank. It was subsequently extended at the western end to serve the exhibition site at White City, and from the Bank to Liverpool St. at the eastern end in 1912. The line's success lay chiefly in the areas it served (the main shopping and financial districts as well as fashionable residential areas) although technical improvements compared to the early CSLR design helped to reduce operating costs.

The Great Northern and City, like the Waterloo and City was intended to provide a direct link from a main line railway company (the Great Northern) to the heart of the City. The GNR went further than the LSWR in that it encouraged the promoters of the line to construct a railway with full size tunnels so that its trains could run through to the City but its enthusiasm for the scheme then faded and died. The line opened in February 1904 but was never profitable.

5. The Underground Electric Railways of London Group

All the 'tube' lines so far mentioned were considered by a Parliamentary Joint Select Committee in 1892 which was set up primarily to consider whether such lines could successfully be operated by electricity, whether or not they ought to be linked with existing railways (it was eventually agreed that the choice was between small-bore tubes and no lines at all) and over ownership eventually passing to the London County Council.

The Committee also considered two other schemes - the Baker St. and Waterloo and the Charing Cross, Euston and Hampstead Railways, of which the latter was to be cable worked. Capital was not forthcoming for either of these two schemes although work did start on the BS&W but stopped at the end of 1900 when its major backer failed. The same problem afflicted a third scheme - the Great Northern, Piccadilly and Brompton Railway. These three schemes remained dormant until 1902 when control of them was acquired by the Chicago tramway tycoon Charles Tyson Yerkes, who obtained control of the District Railway (MDR) at the same time. Yerkes did not live to see the opening of any of the lines, none of which were financially very successful. At first the lines were operated individually, full integration not coming until 1910 (as London Electric Railways). By 1914 the CLR and CSLR had also been taken over by the group.

Dates of opening:

Baker St. and Waterloo (BS&W)	30 March 1906
GN, Piccadilly and Brompton	15 December 1906
Charing Cross, Euston & Hampstead	22 June 1907

Length:

BS&W - 4 miles, Piccadilly - 8 miles, Hampstead - 9 miles
For the most part, the lines served central London although the Hampstead line served the northern suburbs and what were then the green fields immediately north of Hampstead Heath. Very roughly, this line ran in a northerly direction through the city from Charing Cross, the Piccadilly crossed the city from north-east to west at Hammersmith and the BS&W ran from Waterloo to Charing Cross, then to the west of the Hampstead line to Baker St. Initial capital at date of opening was £3.2 m. for the BS&W, £5.9 m. for the Piccadilly and £4.95 m. for the Hampstead line.

London's Population Pattern - a general note

In 1907 the population of the London County area was 4.8 m. and that of the 19.2 square miles of this comprising the central area was 1.5 m. Even at this date Greater London spread over a much larger area, including almost all of Middlesex and parts of four other counties. This total area covered 688 square miles and had a population of 7.2 m. The only urban lines serving any parts of this large suburban area were the Metropolitan and MDR, although future extensions were all in these regions rather than in the central area. The greater proportion of urban railway mileage was still confined to the 19.2 square miles of the central region which relative to the rest of the city was heavily criss-crossed with underground lines. Thus they served not only the resident population of that region but commuters arriving at main line stations such as Paddington, Euston, Kings Cross and Waterloo, many of which were inconveniently situated at some distance from the city proper. As a rough comparison the central area of London was the same size (in square miles) as Manhattan Island in New York but the population of the latter at 2.2 m. was very nearly 50% greater. The spread of urban lines in London was also very uneven. The central area north of the river was heavily developed in this respect while almost all development to the south was left to the main line railway companies. This development did not follow any set pattern - instead one fairly confined area of the city was over-developed in this respect while huge areas elsewhere were ignored.

B. LIVERPOOL

1. The Mersey Railway

Opened in 1886 with paid-up capital at the time of opening of £2.56 m. this was a tunnel under the River Mersey from Liverpool to Birkenhead. The line was the world's first deep-level underground railway, and the only such one ever operated by steam locomotives. The steep gradients necessitated the use of what were then the most powerful passenger traffic locomotives in Britain. The cost of necessary ventilation, pumping and lifts at stations combined to help the line become the first in Britain to switch from steam to electric operation which started in May 1903. The line developed as an urban railway almost by accident. The original intention of the promoters had been to link up all the various main-line companies on either side of the river, large freight traffic between the docks being anticipated. The line would also enable the Great Western Railway to run through main-line expresses from Liverpool to London. In the event, the costs of construction meant that the planned links were never completed and less than a year after opening the company was placed in receivership, this being hastened by the death of the contractor, who had provided much of the capital.

The foul conditions in the tunnel meant that passenger traffic dropped alarmingly, although the presence of the tunnel contributed to the growth of cross-river traffic and the development of commuting suburbs. After electrification, this pattern was accelerated and the subsequent growth in traffic eventually led to dividends being paid on ordinary shares. Although two distinct urban centres were initially linked, this was not unique as it also occurred in some cases in America. When completed the line was just under four miles long making it the shortest of the lines in the study.

2. The Liverpool Overhead Railway

Opened in March 1893 with initial capital of £570,000, this was the first electric elevated railway in the world and the only elevated railway in Britain. Initially it was intended to use steam power, but the decision to change was taken in 1891, reducing estimated construction costs from £585,000 to £466,000 and the consequent very low initial capital cost of £570,000 permitted regular dividends to be paid. Like the Mersey Railway this was not an urban railway in the strictest definition. It ran for some seven miles alongside Liverpool docks, its function being to improve passenger movement and thus reduce congestion in the area. The resident population of the region was small, although a large suburban population was served by both termini.

C. NEW YORK

1. The Manhattan Elevated

A number of underground schemes for New York City had all been rejected by the legislature before approval was given for an experimental elevated project which commenced working in December 1867. Initially cable worked this proved a failure and from April 1871 steam working was introduced and the company was reorganised as the New York Elevated with a capital stock of $10 million and plans to build 160 miles of elevated railway. The company was joined in the 1870s by the Metropolitan Elevated; the two were then reorganised and leased to the Manhattan Elevated Railway Company, control of which was obtained, after a struggle, by the financier Jay Gould.

The company operated elevated railway lines along several of the main Manhattan avenues, extending northwards into the Bronx as the city expanded in that direction. Thus, the company served practically the entire population of what was at that time the City of New York (Brooklyn, Queens and Staten Island did not become boroughs of the city until 1898) ans was the only urban railway in the city.

The system was electrified in stages between 1902 and 1903, by when its capital stock was $48 million. From January 1903 the entire Manhattan Railway Company was leased by the Interborough Rapid Transit Company.

2. The Interborough Rapid Transit Company (IRT)

Incorporated 6th May 1902, with an original capital of $25 million, all in common stock, this was the operating company for the New York subway, the first section of which opened on

27th October 1904. Electrically operated from the outset, the Rapid Transit Subway, as it was known, ran immediately below street level through rock for the most part, from Brooklyn to southern Manhattan (this section was not the first to be opened), then northwards through Manhattan, the line dividing at 96th Street, one section continuing to the northern tip of Manhattan Island, the other serving the Bronx. The intention was to provide as comprehensive a service as possible to the city. A major expansion was agreed upon but none of this was opened by 1914.

The subway differed from the British lines in that the capital for construction was provided by the city. As the operating company, the IRT provided the trains and leased the subway from the city, the lease being arranged to run for a set period of years and to include an element for a sinking fund to pay the construction cost. The line was constructed on a more substantial scale than the British lines, not only in taking almost standard size trains, but also in being equipped with four tracks, for both 'express' and 'local' services.

In January 1906 the IRT merged with the Metropolitan Street Railway Company creating a transit monopoly holding company in Manhattan known as the Interborough Metropolitan Company.

3. <u>The Brooklyn Rapid Transit Company (BRT)</u>

This was not primarily a railway company but a street-railway (tramway) system. By the turn of the century Brooklyn had the greatest tramway mileage of any city in the world. Indeed, Brooklyn was synonymous with street-cars to the extent that its baseball team were known as the 'Trolley Dodgers'.

As late as 1893 the street railways had largely been in the hands of fairly small, independent companies. By 1914 almost all rapid transit operations in the region were controlled by the BRT; for practical purposes consolidation had been achieved by 1902, the BRT having been formed as a separate entity in 1898. Although most of this was in street railway form, some fairly short sections of elevated railway were opened in Brooklyn from 1885 onwards. By 1890 there were about eighteen miles of elevated track and shortly afterwards all the elevated companies were acquired by the BRT. The system was electrified in 1902-3 and expanded steadily, so that by 1910 there were about seventy-one miles of elevated track. Most of the mileage radiated from central Brooklyn, there being a link across the Brooklyn Bridge into Manhattan.

4. The Hudson and Manhattan Railroad (H & MRR)

There were strong similarities between the H & MRR and the Mersey Railway. Both were under-river tunnels, the intention of the promoters of the Hudson lines being to provide a link between Manhattan and New Jersey. When work started in 1874, as in the case of the Mersey, all cross-river traffic was carried by ferries. The legal and financial problems were such that work proceeded only very intermittently and by the mid-1890s was completely abandoned. In 1901 a new company was formed which finally succeeded in completing the tunnel, and in constructing a second one, providing links from Hoboken and Newark in New Jersey to mid-town and down-town Manhattan. This company had an initial capital of $6 million although by the time operations started in 1908, some $70 million had been spent. Although the difficulties of completion are of interest these are not related to this work, and the H & MRR is of only secondary interest.

D. BOSTON

1. The Boston Elevated Railway

The Boston Elevated Railway was incorporated in 1894 and three years later leased the West End Street Railway Company which operated all the streetcar lines in Boston. Thus, as in both Brooklyn and Manhattan, a transport monopoly was created. It worked in close co-operation with the city authorities. To ease congestion the latter constructed a number of subways in the city for both trams and trains which were leased by the elevated company. The elevated company built all new street railway and elevated extensions at its own expense, the first elevated section opening in June 1901. Paid up capital at this time was $13.4 million.

The outcome of this relationship was that Boston (with a population of 1.3 million in 1910, the smallest American city to have a fully fledged rapid transit system) had, for its size, undoubtedly the best and most extensive system. This was reflected in annual journeys - by 1907 Bostonians made 500 trips by public transport annually per head, the next highest figure being 406 in New York. The basic philosophy was to build elevated railways with stations fairly widely spaced, out into the suburbs. From the relatively few stations tramway routes radiated, offering an integrated service.

The geographical nature of the city, scattered as it was around Boston Bay, further encouraged the building of subways to connect what were otherwise isolated suburbs.

E. CHICAGO

In contrast to other American cities, the elevated systems in Chicago were not amalgamated until fairly late - 1911 in fact. For the size of the city (both in area and population), they were also rather late in being opened, this being largely attributable to political factors. A further remarkable feature was that some of them initially used steam locomotives at a time when the success of electric power had been proven, although they were also among the first lines to change to electric power.

1. The Chicago South Side Railway

Opened in late 1892, in time for the 1893 Columbia Exposition, this line had an initial capital stock of $17.5 million, $7.5 million of which was in bonds.

It was an elevated railway running from the southern edge of the city centre to Jackson Park, where the World Fair was held. The line was less than ten miles long - the disproportionate capital was a feature of other lines in Chicago but also reflected the anxiety of the promoters to have the line completed in time for the Fair traffic. Shortly after the Fair ended the company's problems became apparent; a receiver was appointed in October 1895 and the line was sold in September 1896, for $4 million. Electrified in July 1898 the line was the first to adopt the multiple-unit system of control. In 1900 the total population of Chicago was just under 1.7 million, only a small fraction of whom had easy access to the South Side Elevated.

2. Lake Street Elevated and Northwestern Elevated

As with the South Side line, the only capital readily available was highly speculative in nature, and development took place in an atmosphere of instability. Although the initial capital was only $1 million, by the time of opening in November 1893, this had swollen to over $10 million in stock and $6 million in bonds. Serving West Chicago, the line was electrified in 1896.

The initial problems of the Lake Street line were greater even than those of the South Side. By 1894, however, a group thought to be connected with C. T. Yerkes had acquired control of it and electrified it. This group also controlled the Northwestern Elevated. This, too, suffered problems. Serving one of the least populated parts of the city, it remained in a half completed state for two years after August 1896 before being eventually completed and opened in 1900.

3. Metropolitan West Side Elevated Railroad

Opened in May 1895, this was the first electric elevated railway in the U.S.A., running for some twelve miles into the west side of the city. Although this area was well developed residentially, over-capitalisation and competition from the Lake Street line combined to help to send the line into receivership in January 1897.

4. Other Chicago Lines

Prospects for all the Chicago elevateds improved in 1897 when the Union Loop was opened. This enabled the trains of all the individual lines to run into the heart of the city and its opening had a dramatic effect on property values in the area.

Although major backing came from the Lake Street/Northwestern interests, the other companies also had access to the line.

Chicago had one more elevated - the Chicago and Oak Park line. Like the others, this spent much of its time in receivership and subsequently merged into the Northwestern Group (although the lines in this group continued to operate as independent concerns until all the Chicago lines amalgamated).

APPENDIX 2

TABLE 1: PASSENGERS CARRIED BY BRITISH URBAN RAILWAYS 1891-1913 (in millions)

	CLR	CSLR	LOR	Mersey	Metro-politan	MDR	UERL
1891		5.2		8.3	75.1	39.2	
1892		6.0		8.5	74.2	39.5	
1893		6.2	3.8	7.5	72.2	38.6	
1894		6.7	6.5	6.5	74.5	40.8	
1895		6.3	7.2	6.9	73.7	40.9	
1896		6.7	7.7	7.3	76.2	41.1	
1897		6.8	8.7	7.2	79.7	42.6	
1898		6.9	9.4	7.2	78.8	41.1	
1899		6.9	9.7	7.5	80.0	41.5	
1900	14.9	9.2	10.3	7.6	77.1	40.4	
1901	41.1	12.9	10.8	7.1	70.9	39.0	
1902	45.3	19.1	10.5	5.9	72.0	44.0	
1903	44.9	18.2	11.4	7.3*	74.3	49.0	
1904	44.9	17.6	11.2	9.2	74.4	50.7	
1905	44.7	17.3	11.2	9.8	75.9*	53.2*	
1906	43.1	18.1	11.0	10.6	78.7	60.1	9.8
1907	36.9	20.8	11.2	11.2	76.9	48.4	55.2
1908	41.9	21.5	10.5	11.4	81.0	56.2	84.0
1909	38.4	22.5	10.1	11.6	80.0	60.3	94.4
1910	40.7	23.5	10.5	11.9	82.7	64.6	95.6
1911	37.6	24.4	11.2	11.9	80.6	70.1	99.3
1912	34.1	22.7	12.2	12.6	78.9	74.5	97.2
1913	34.4	21.1	13.2	13.2	81.5	74.7	95.7

*electric working introduced

All figures exclude journeys by season ticket holders. The impact of these varied. Season ticket journeys would add about 7.5-8.75 million annually to Metropolitan figures, about 3 million to MDR figures, 1 million to Mersey figures (after electrification) and about 0.5 million to CSLR figures.

Source: Board of Trade, Railway Returns

APPENDIX 2.

TABLE 2: PASSENGERS CARRIED BY URBAN RAILWAYS IN NEW YORK 1891-1913 (in millions)

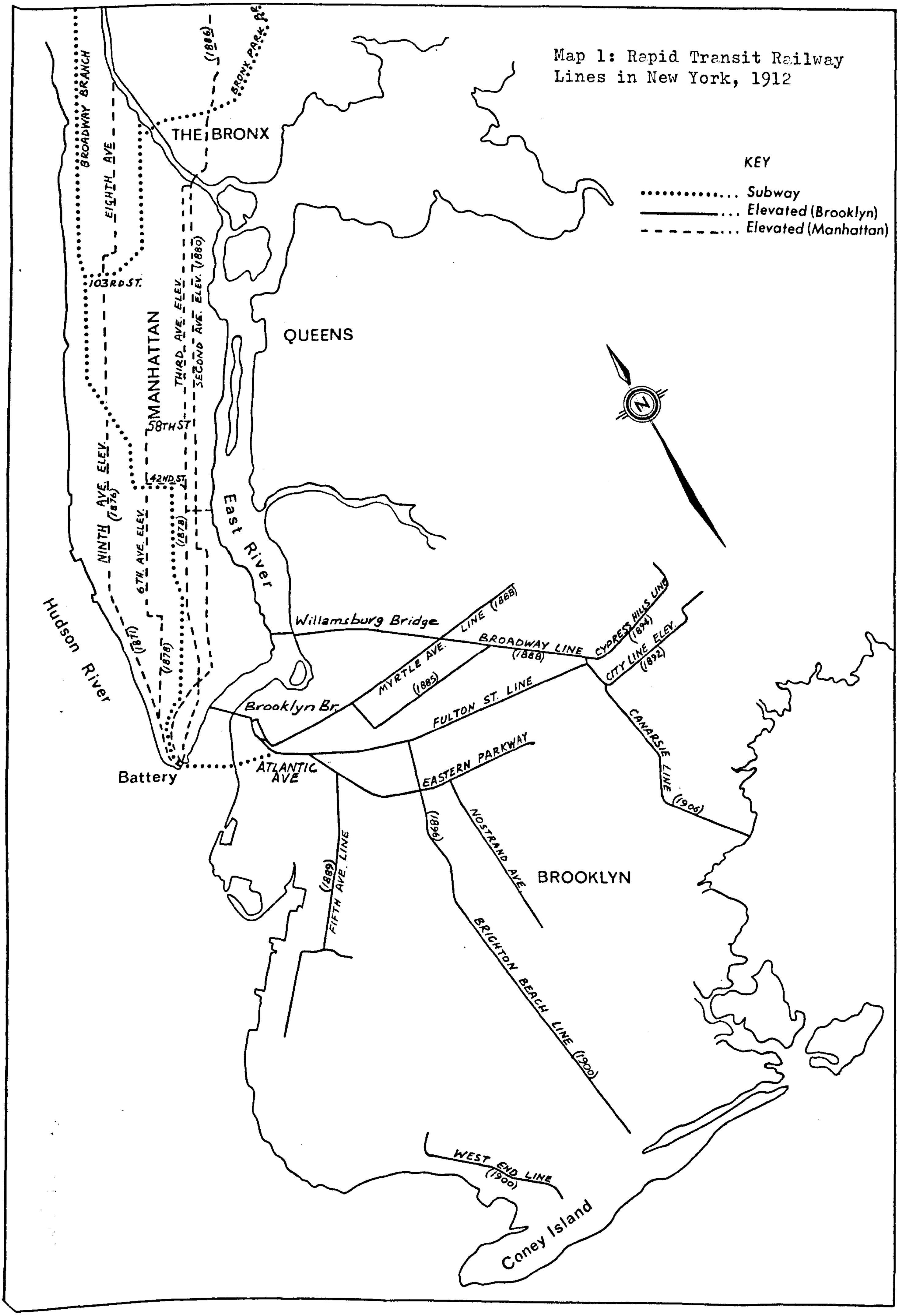
	Manhattan El.	IRT Subway	Broolyn RT §	Hudson & Manhattan	
1891	215.1				
1892	219.6				
1893	196.2				
1894	188.1				
1895	182.4				
1896	183.1				
1897					
1898					
1899	183.8				
1900	194.1				
1901	215.3				
1902	248.6		85.3		
1903			98.1		
1904	286.6	16.2	117.2		
1905	266.4	116.2	132.0		
1906	257.8	149.8	155.7		
1907	282.9	182.6	197.6		
1908	273.8	221.0	200.9	4.4*	
1909	276.2	238.4	206.2	14.2+	
1910	293.8	296.0	226.1	42.8+	
1911	301.4	276.7	224.2	50.9+	56.7
1912	306.3	303.0	228.6	58.1	
1913	306.8	327.5	234.3	60.6	

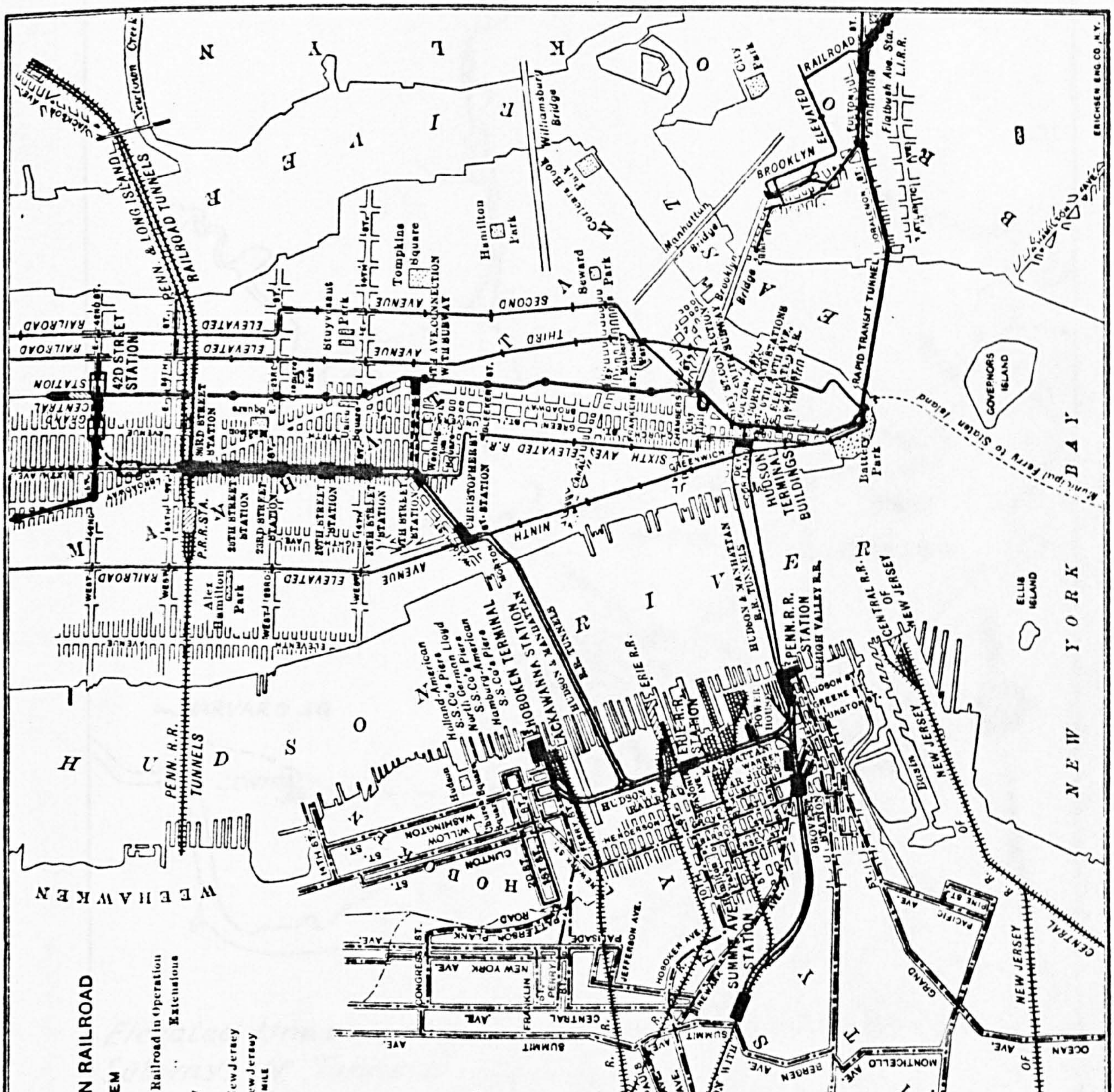
§ Figures obtained are calculated on basis of proportion of total earnings attributable to elevated lines.

* First four months of operation only (25.2.08 to 30.6.08).

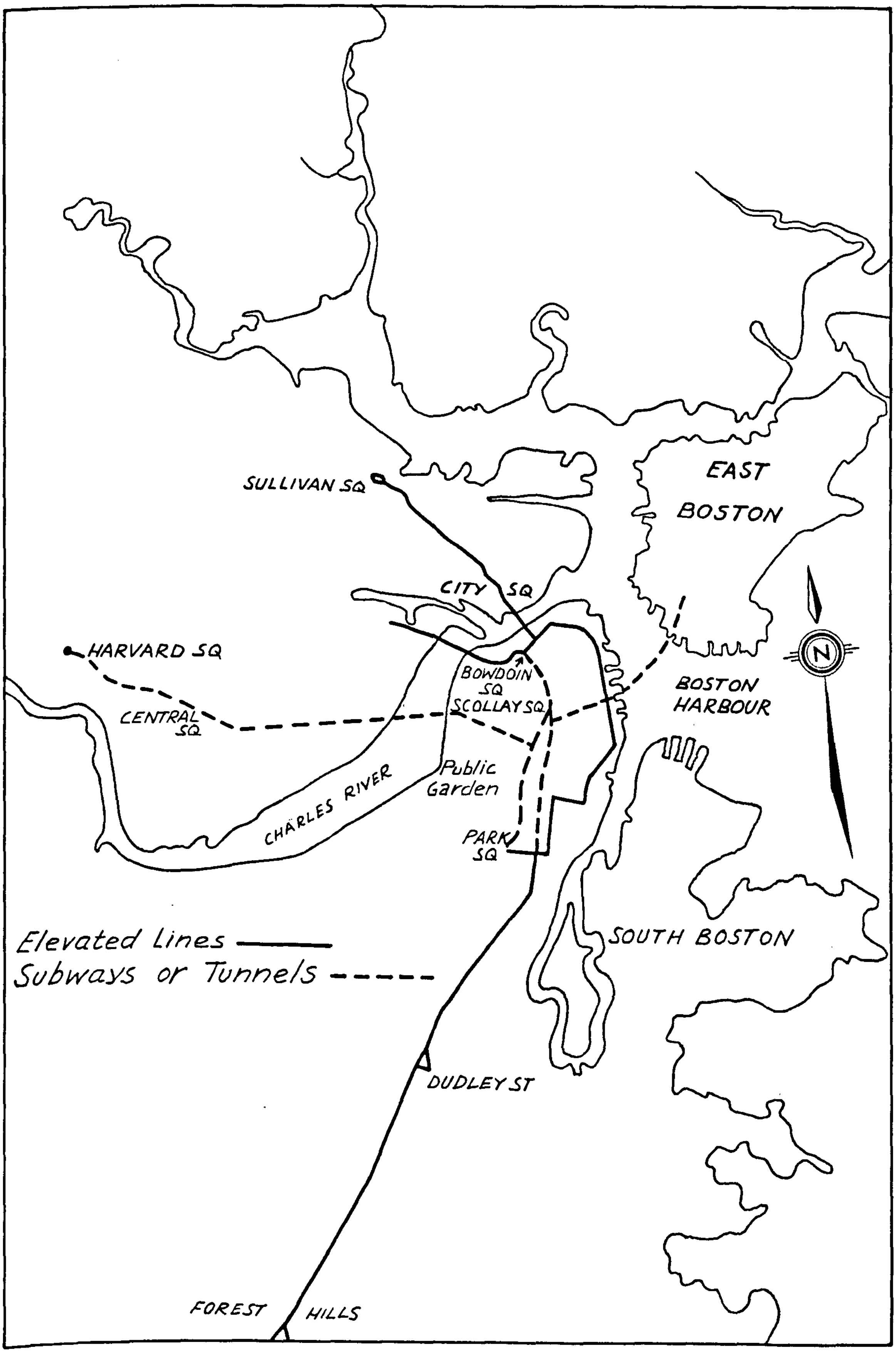
\+ Year ended 30th June.

Map 1: Rapid Transit Railway Lines in New York, 1912

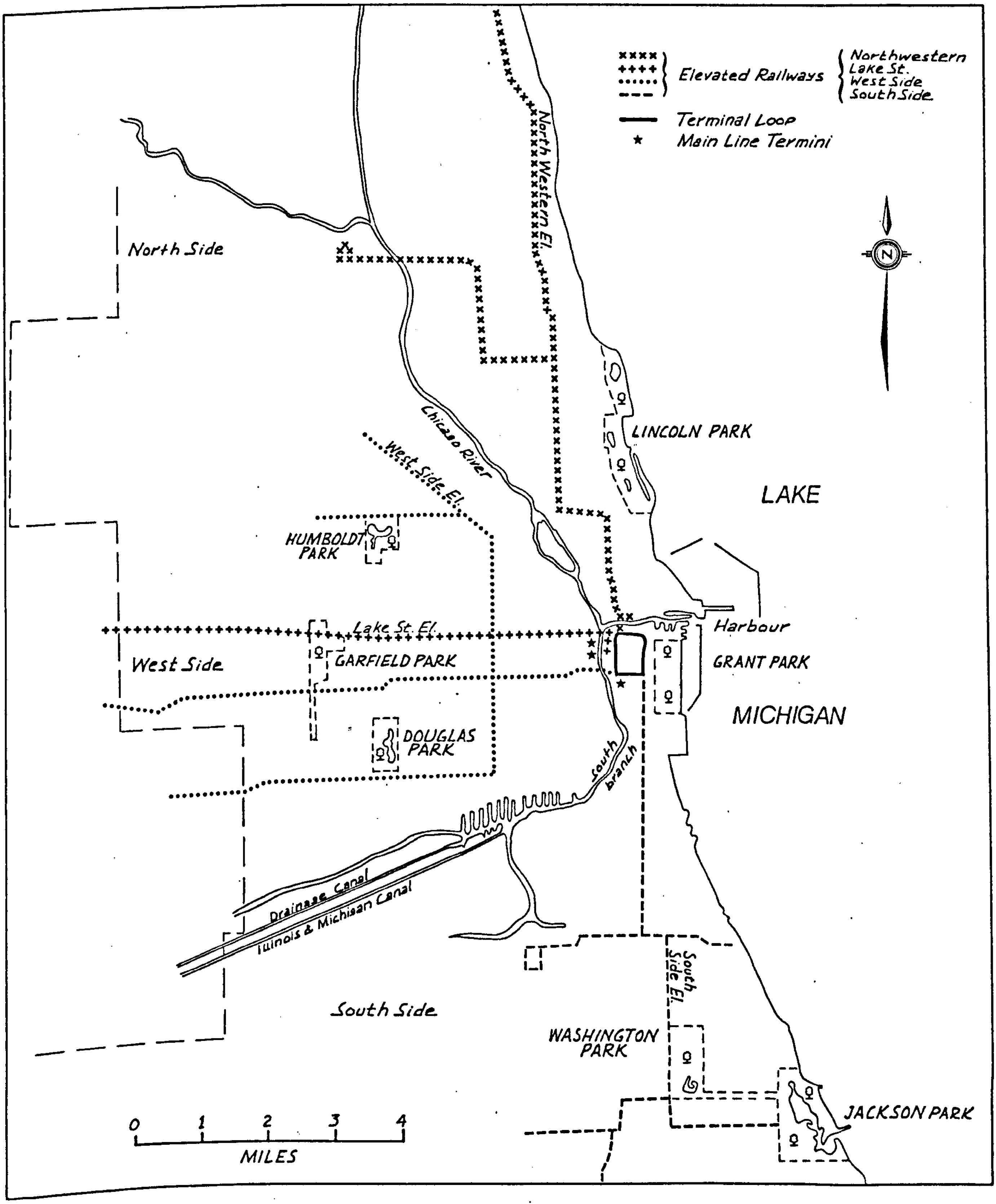




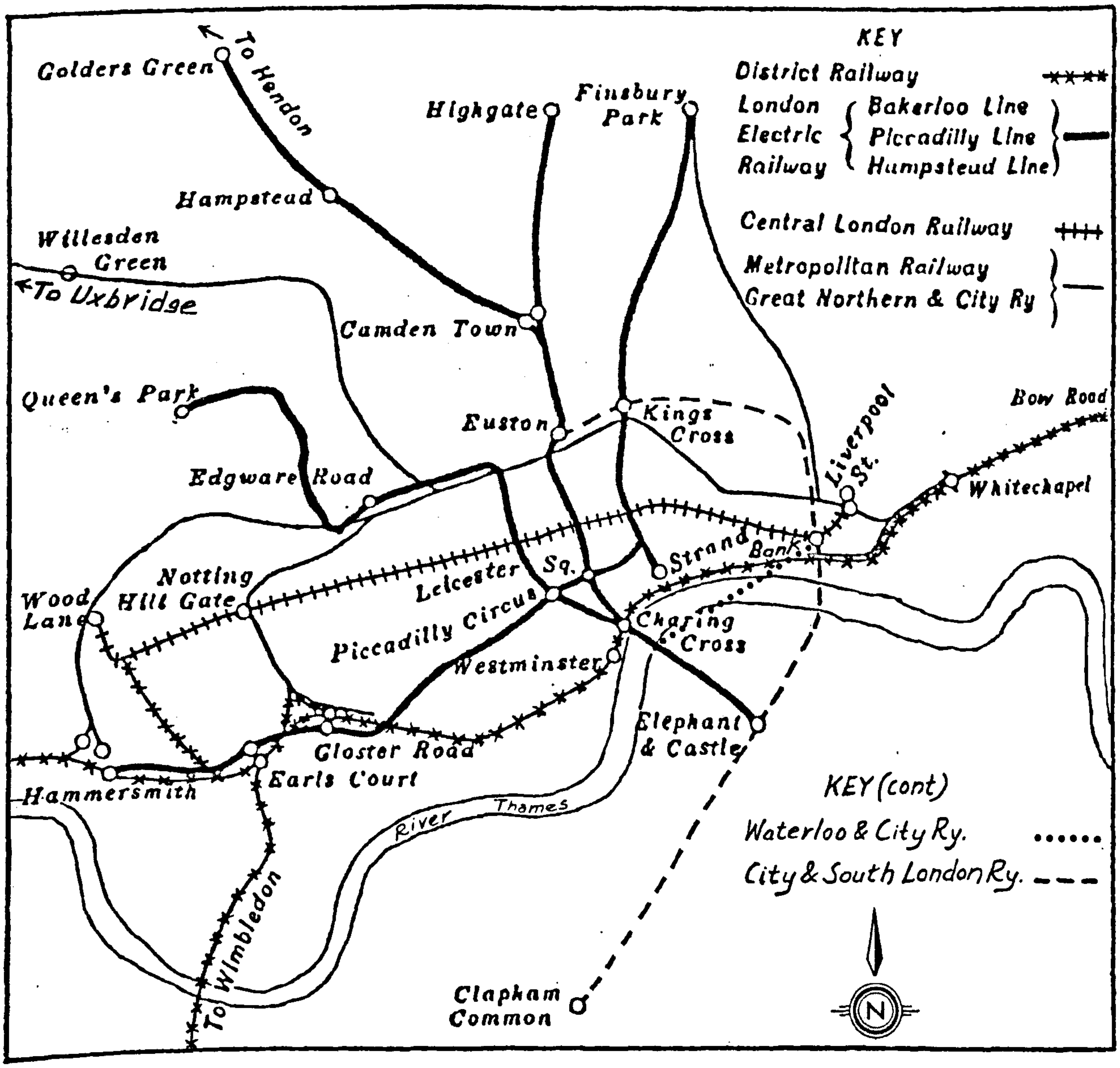
Map 2: The Hudson & Manhattan Railroad System. The Map also shows the layout of rapid transit lines in Lower Manhattan. source: Transactions of the American Society of Civil Engineers, vol.LXXVI, Paper 1239, 1912.



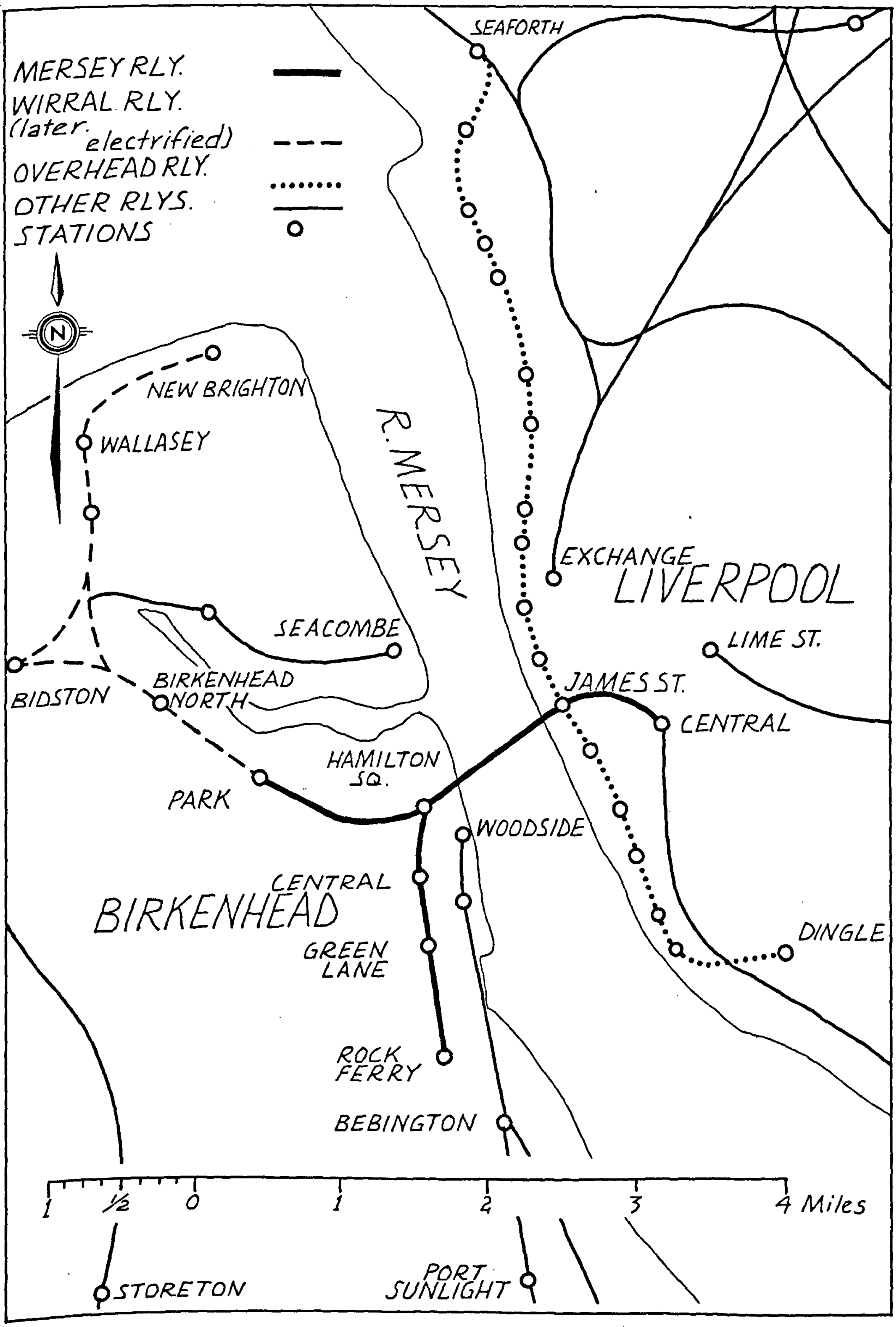
Map 3: The Boston Elevated System, 1912



Map 4: Elevated Railways in Chicago



Map 5: Underground Railways in London, 1910
The very limited level of development south of the river is immediately apparent. This was the territory of suburban lines of the main line railway companies.



Map 6: Urban Electric Railways in Liverpool, 1910

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A NOTE ON SOURCE MATERIAL

There is a considerable amount of archival information covering the early development of urban electric railways. In Britain the Public Record Office is the repository for major records of the Mersey Railway but the Merseyside County Museum in Liverpool hold a considerable additional amount of material, including the regular correspondence of the General Manager and detailed information on the electrification of the line. The East Devon Records Office in Exeter also holds considerable pertinent material in the form of correspondence and reports of the Company Receivers amodst the Northcote Papers.

Material on electrification in London is more concentrated, the Middlesex Records Office of the Greater London Council holding all the records relating to London's railways. However, the amount of specific detail for the different companies various considerably, with information on Metropolitan Railway electrification being the most comprehensive. In comparison, information on the City & South London and the American owned lines in London is limited.

Much of the detailed financial information on the lines in New York and Boston came from comprehensive reports and correspondence in the files of the Scudder Library in Columbia University. Columbia University also holds the correspondence of William Barclay Parsons, which provided information on the construction of the New York Subway, as did the Belmont Papers in New York Public Library.

Considerable additional material is available in Parliamentary Papers and Municipal Documents. The latter are particularly useful for examining the development of rapid transit in New York, both the New York Public Library and the New York Muncipal Records Office having considerable relevant information. The former, as well as including Royal Commission Reports includes the detailed information provided in the Railway Returns published by the Board of Trade.

Contemporary journals also provided a fruitful source of information. Of these, by far the most comprehensive was the American publication, Street Railway Journal (Electric Railway Journal after 1908) which, while primarily a trade journal for tramway operators, devoted considerable coverage to electric urban railway development.

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