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Time is Money: A Re-assessment of the Passenger Social Savings From Victorian British Railways

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Time is money: a re-assessment of the passenger social savings from Victorian British Railways[1]

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Abstract

This paper reassesses and extends Hawke's passenger railway social savings for England and Wales. Better estimates of coach costs and evidence that third class passengers would otherwise have walked reduce Hawke's social savings by two-thirds. We calculate railway speeds, and the amount and value of time saved by railways. Initially small, time savings was three times fare savings by 1912, when total railway passenger social savings exceeded 13% of GDP. The transition from railways saving money to saving time came when railway technology stopped simply fulfilling existing demand more cheaply (travel for the affluent) and became a new good (travel for the masses).

Introduction

Improvements in passenger transport technology can have many effects. The new technology may raise or lower the cost of travel, it may speed it up, or slow it down, it may be more or less comfortable, and

[1] In his Economic History Association Presidential Address, Fogel wrote that 'Scientific creations, however, are usually protracted over long periods, approach perfection quite gradually, and involve the efforts of a large number of investigators. The social savings controversy has demonstrated the great complexity of the analysis of the developmental impact of railroads, the wide range of issues that need to be pursued, the large amounts of data that must be retrieved and the many pitfalls that may be encountered in the analysis of these data. Such problems are resolved through collective effort, one aspect of which is the intense debate over the significance and validity of successive contributions.' This paper is written with that in mind. Where it alters the existing literature it does so in the spirit of collective effort, and, to quote Newton, 'If I have seen further it is by standing on the shoulders of Giants'. Although it is right to acknowledge the valid criticisms that have been made of some aspects of the work of Fogel, Fishlow, Hawke, and other social saving pioneers, theirs are works of the highest calibre, that are still exciting to read more than a generation after they were written. I thank Nick Crafts, Peter Mackie and Abay Mulato and seminar audiences at LSE and in Oxford for helpful comments, and my first rate research assistant, Judith Allen, for the unenviable task of entering all of the railway timetable data. I could not

involve more or fewer deaths and injuries for those who travel. Each transport technology will offer a differ combination of attributes. We can say two things with certainty. First, all of these factors are potentially valuable to consumers and to society. Second, if the new technology is adopted, then users must value the net change in attributes positively.

The correct way to analyse transport improvements, ex ante and ex post, is via cost-benefit analysis. Governments and others have undertaken considerable work to refine and improve the quality of such analyses.[2] Cost-benefit analysis starts from the premise that the benefit of passenger transport is getting from one place to another, or, to be more general, transporting one person one mile. Costs consist of monetary and non-monetary costs, which, once monetary values have been attached to the non-monetary costs, are added together to make what is termed 'generalised cost'. Of the non-monetary costs, the most important is almost invariably the value of the time saved. In more sophisticated analyses this value varies according to the type of person travelling, the reason for travel, and the comfort of the mode of transport used. Where possible it should include the time waiting for public transport, or the time taken to find a parking space for private travel.[3]

Economic theory states that individuals' valuations of time are related to the alternative uses that they have for that time. If a person can use their time profitably, they will value it highly so that the value of time is related to the wage rate. For those travelling on work time, the usual assumption is that an hour saved can be valued at the total hourly cost to the employer, since if travel were instantaneous, every hour of travel

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have done it without her. Funding from the ESRC, under grant R000239536, is gratefully acknowledged. All remaining errors remain my own.

[2] See, for example, the websites of the Department for Transport's Transport Analysis Guidance, available at www.webtag.org.uk, and Leeds University's Institute for Transport Studies, www.its.leeds.ac.uk.

[3] Standing Advisory Committee on Trunk Road Assessment. Great Britain, *Transport and the Economy* (London: The Stationery Office, 1999)., pp. 196-7.

could be replaced by an hour's productive work.[4] Total cost includes gross wages, payroll taxes and employer pension contributions, as well as a share of overhead costs (office space, back office functions, and so on) which are today estimated at 21.2% of the gross wage.[5] Current studies assume that the amenity or disamenity of travel compared with work is too small to warrant inclusion.[6]

Neo-classical economics holds that workers value leisure time at the wage rate. If they value it less, they should work longer, if they value it more, they should reduce their working hours. Both revealed-preference and willingness-to-pay studies are unambiguous that people value their own non-working time, including commuting, but do so at rates far lower than the cost of employing them. The British Department for Transport attributes to commuting and leisure time in vehicles a value equal to one quarter of the cost of working time, including overhead costs, while the value of walking time taken as half the wage rate, reflecting the greater disamenity that people get from walking than travelling using other modes.[7] The difference between the neoclassical prediction and the empirical value of time studies – a ratio of four to one – appears large. In fact the neoclassical prediction is that workers value leisure time at their shadow price of time, which is their take-home wage, not their gross wage. Income and payroll taxes, and overheads mean that 25% of the total cost of employment to an employer today equates to around 46% of the employee's take home wage. This is plausible: it implies that workers are prepared to pay 92% of their hourly take home pay to eliminate an

[4] It is rare that the wages of travellers on any particular journey are known, so the usual proxy is the average wage for that mode of transport. Thus, for example, one hour of a taxi passenger's working time saved is currently valued at £36.97, more than double that of bus passenger's time. Department for Transport, *Values of Time and Operating Costs* (London: Department for Transport, 2004). p. 4 table 1.
[5] Department for Transport, *Values*., p. 2, para 1.2.4.
[6] Were, for example, people to strongly dislike travel, jobs involving much travel would require higher wages in compensation. That wage premium should be included in the cost of travel.

hour's walking, that is to say, walking and working offer similar disutility, while travelling to work is less unpleasant than the job itself.[8] In modern studies leisure time is valued equally, irrespective of the person's income, an assumption difficult to square with economic theory, but with obvious political attractions.[9]

That such benefits are not included in measures of GDP is of no concern. Our interest is in consumers' welfare gains from the new technology, whatever form those gains take. If they are valued by consumers then they are part of consumer surplus, if they are part of consumer surplus then they should be included in any cost-benefit analysis.[10]

In addition to the costs and benefits that accrue to users, which represent the transport benefits, there may be externalities to those who do not travel at all, and which need inclusion to estimate the total economic benefits to society. For example, better transport can destroy local monopolies and increase productivity through agglomeration effects, but can also change the rates at which non-users are killed or injured, and affect levels of local and global pollution. These additional factors are potentially important, but lie outside the scope of conventional transport cost benefit analyses, and of this paper.

The form of cost-benefit analysis used by historians to study nineteenth century railways is known as social-savings. This approach was first used in the 1960s in the pioneering works of Fogel and

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[7]Great Britain, *Transport and the Economy*., p. 197, para 9.35.
[8] The proportion would be higher for affluent higher rate tax payers, and for those on means tested in-work benefits.
[9] This assumption was introduced when Castle was transport minister. P.J. Mackie, M. Wardman, A.S. Fowkes, G. Whelan, J Nellthorp and J. Bates, "Values of Travel Time Savings in the Uk," *Institute for Transport Studies, University of Leeds in association with John Bates Services Report to Department for Transport* (2003)., p. 2.
[10] Great Britain, *Transport and the Economy*., 3.10-3.12, pp. 57-8.

Fishlow.[11] Their studies aimed to quantify the value of railways to the United States in 1890 and 1859, respectively. Put simply, the social saving from railways is defined as the minimum additional amount that society would have to pay to do what the railways did, without them. In the case of freight, it is the additional cost of using canal or wagon rather than rail, and in the case of passengers, it is the additional cost of coaching, or whatever means of travel would have been used.

Hawke applied this approach to English and Welsh railways, calculating the social savings from goods and passenger travel from 1840 to 1870, with particular emphasis on 1865. He finds that in 1865 the social savings on freight were 3.0-3.4% of UK national income, with these figures representing lower and upperbounds respectively.[12] For passengers, he argues that the nature of rail journeys meant that the only alternative was coaching, with sea transport essentially irrelevant.[13] On that basis, he finds that the social saving was either 2.1% or 5.8%, depending on whether first class rail is held to be as comfortable as the inside of a stage coach, or travelling by private post-chaise.[14] Hawke argues that the latter is more representative of the facilities and comfort offered by first class travel in 1865. Overall, then, using his preferred measures, Hawke finds that railways had a value to society of around 9%, of which almost two-thirds came from passenger travel.

These findings have not gone unchallenged. In his Journal of Economic History review Baker notes that Hawke's social saving estimate

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[11] Robert William Fogel, *Railroads and American Economic Growth: Essays in Econometric History* (Baltimore and London: The Johns Hopkins Press, 1964)., Albert Fishlow, *American Railroads and the Transformation of the Ante-Bellum Economy*, Harvard Economic Studies ; Vol.127 (Cambridge, Mass.: Harvard University Press, 1965).

[12] G. R. Hawke, Railways and Economic Growth in England and Wales, 1840-1870 (Oxford: Oxford University Press, 1970). pp. 145-6, 188-191.

[13] In any case, steam ships depended on essentially the same technology as railways, so a counterfactual of steam ships but not railways has little intuitive appeal.

[14] Hawke, *Railways and Economic Growth*., pp. 48-9, table II.02. The figure of 2.1% is incorrect, it should be 1.6% as given on p. 44.

is roughly double those of Fogel and Fishlow, with much of the difference coming from ‘Hawke’s attempt to quantify the greater convenience and comfort of rail over non-rail passenger service.’[15] He adds ‘Here this reviewer is not convinced’.[16] Similarly, in his Journal of Economic Literature review, Fishlow notes that ‘the largest part of the cost savings emanate from reduced fares for personal travel (in particular first class accommodations)’.[17] Noting that posting costs, at 6 times coaching costs, seem exceptionally high, Fishlow recalibrates Hawke’s social savings figures with a lower cost of posting, and finds that social savings fall by one half. This leads him to comment that ‘it is disquieting to discover how sensitive the calculations of social savings are to modest, and apparently reasonable, changes in Hawke’s underlying assumptions’. Gourvish is more critical, arguing that all we can safely conclude is that the actual value for passenger social savings lies between 0.6% and 14.2% of GDP, bounds so wide as to tell us nothing about the value of railways to passengers.[18]

Hawke does not formally use a generalised cost model of transport, but he splices together the costs of two different non-railway modes of travel to measure the rise in comfort. He does not include any benefit for time savings, arguing that inflexibility of working hours meant that few workers were able to use the additional time saved to work, so it is likely that it was primarily leisure, not production that increased. That said, he acknowledges that excluding time savings imparts a downward bias, in that some travel was for business purposes, and clearly faster journey times did allow greater production. He argues that this bias is likely to

[15] William J. Baker, "Railways and Economic Growth in England and Wales, 1840-1870," *Journal of Economic History* 31.3 (1971)., pp 718-9.
[16] Baker, "Railways.", p 719.
[17] Albert Fishlow, "Railways and Economic Growth in England and Wales, 1840-1870," *Journal of Economic Literature* 10.1 (1972)., pp. 75-6.

have been small, given that the majority of miles travelled were third class. He also argues that because workers did not have a choice as to working hours, the theoretical construct that workers value leisure at the wage rate is invalid, and therefore he regards such time saved as valueless. Finally, he notes that if we are to compare leisure time savings with GNP, we would need to include the valuation of all leisure time in our estimate of GNP.

Boyd and Walton argue that it is legitimate to compare the value of time saved with money GNP providing that we interpret the social saving result carefully. They note that because much of the social saving from faster passenger travel comes from increased leisure time, the social saving 'measure *does not* show how much GNP would have been reduced if the railroad had not been available to travellers. It *does* show in the aggregate the percentage of GNP travellers in 1890 would have been willing to exchange for the opportunity of travelling by rail rather than by the next best alternative.'[19] It is worth noting that modern transport economics always includes the value of leisure time saved, on the simple and clearly correct grounds that people value leisure time.[20]

Boyd and Walton estimate the social saving from faster passenger rail travel in the United States in 1890. They note that, contrary to Fishlow's assumption, it was cheaper to travel by canal and steam boat than by railway, and yet people overwhelmingly chose to travel by train. As such, if only fares are included in the analysis, then the result generated is clearly incorrect: passenger rail travel would then generate a negative social saving. That people chose to use the more expensive

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[18] Terry Gourvish, *Railways and the British Economy 1830-1914*, Economic History Society Studies in Economic and Social History (London: Macmillan, 1980)., pp. 58-9, expressed here as a percentage of UK GDP for ease of comparison.
[19] J. Hayden Boyd and Gary M. Walton, "The Social Savings from Nineteenth-Century Rail Passenger Services," *Explorations in Economic History* 9.3 (1972)., p. 240.

railway rather than the cheaper boat must mean that people were prepared to pay to save time, and therefore that economic historians should include that valuation in their estimate of social savings.

This paper revises and extends Hawke's social savings for passenger rail travel in England and Wales. It seeks to achieve four things. First, to improve the quality of Hawke's analysis of the monetary savings available from railways. Second, to use modern transport economics to expand the analysis to include time savings. Third, to extend the monetary and non-monetary social savings estimates to cover the period 1843 to 1912. Finally, to divide social savings into money and time components, and between premium and third class passengers. This will allow a better understanding of the new technology's nature, the sources of its welfare gains, and the distribution of those gains.

Analysis

Part A: monetary costs

In this section we first set out Hawke's calculation for 1865, before revising it. Hawke's methodology is simple and correct. He finds the number of people who travelled in each class and assesses the means by which they would otherwise have travelled. The social saving is then the difference in cost per passenger mile, multiplied by the number of passenger miles travelled, summed over the three classes.

For 1865 Hawke takes the total receipts and average fares by class in England and Wales from the Railway Returns. These data are as authoritative as any nineteenth century data. Dividing receipts by the fare per mile should give the number of miles travelled. There are, as Hawke

[20] A good discussion can be found in A.J. Harrison and D.A. Quarmby, "The Value of Time," *Cost-Benefit Analysis : Selected Readings*, ed. Richard Layard (Harmondsworth: Penguin, 1972).

notes, 'some complications.'[21] These include return tickets, which had lower prices per mile, and express tickets, which had higher prices. Hawke's assumptions to overcome these problems are plausible. The Railway Returns also give revenues for season ticket holders, which represent 3% of total revenues in 1865. Inevitably, we have no data on these ticket's price per mile, and thus no accurate way of assessing how many miles were travelled by season ticket holders. Hawke assumes that season ticket holders paid a fare per mile approximately equal to third class passengers, while travelling in the first or second classes.[22] On this basis, it is possible to construct the following table, which sets out Hawke's mileage calculations.

Table 1: Miles travelled: Hawke's 1865 calculations

		1st class	2nd class	3rd class	Season
1	Rail costs (£)	3,228,351	4,254,804	4,581,630	396,027
2	fares (d/mile)	2.11	1.55	1.01	0.9
3	miles (million)	367	659	1089	106

Note: rounding errors make these numbers trivially different to those given in Hawke page 43.
Sources: Row 1: Railway Returns; Row 2: Hawke, p. 43; Row 3: Row 1/row 2

A social savings calculation requires an alternative, counterfactual, mode of transport. Hawke uses two different counterfactuals, one based on Lardner's book – first class rail equivalent to inside a stage coach, other classes to seats outside the coach – and another based on the 1867 Royal Commission report – equating first class rail with travelling post chaise, second class with inside the stage coach, and third class with outside it.[23] Season ticket holders are assumed to travel as other

[21] Hawke, *Railways and Economic Growth*. p. 40.
[22] Hawke, *Railways and Economic Growth*. p. 41.
[23] Dionysius Lardner, *Railway Economy; a Treatise on the New Art of Transport, Its Management, Prospects, and Relations, Commercial, Financial and Social, with an Exposition of the Practical Results of the Railways in Operation in the United Kingdom,*

third class passengers. Hawke uses Lardner's comparison for years up to 1850, and that of the Royal Commission for years from 1865, with a linear transition from one 'comfort comparison' to the other, reflecting the steady improvement in railway comfort.[24] Bagwell shows that posting passenger miles were almost as high as coaching miles prior to the railway age, and that the number of post horses went down rapidly after the introduction of railway services.[25] It seems most plausible, therefore, that first class rail travel replaced posting as soon as the railway began, and for that reason we prefer the Royal Commission approach to that of Lardner. Throughout this paper, therefore, we report figures on the Royal Commission basis. We now construct table 2, which sets out Hawke's costs of pre-rail and rail travel, and the savings that came about from the invention of the railway.

Table 2: Social savings: Hawke's 1865 estimates

		1st class	2nd class	3rd class	season	total
1	miles (m)	367	659	1089	106	2220
2	rail fares (d/mile)	2.11	1.55	1.01	0.9	
3	rail costs (£m)	3.2	4.3	4.6	0.4	12.5
4	pre-rail fares (d/mile)	24	4	2.5	2.5	
5	pre-rail costs (£m)	36.7	11.0	11.3	1.1	60.1
6	rail saving (£m)	33.5	6.7	6.8	0.7	47.7

Note: rounding errors make these numbers trivially different to those given in Hawke page 44.
Sources: Row 1: table 1, row 3; Row 2: Hawke p. 43; Row 3: Railway Returns; Row 4: Hawke p. 44; Row 5: Row 1 x Row 4; Row 6: Row 5 – Row 3

on the Continent, and in America. (New York: Harter and Brothers, 1855)., p. 164, Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXXVIII, part 1p. liii, para 118.

[24] Hawke, *Railways and Economic Growth*., p. 53.

[25] Philip S. Bagwell, *The Transport Revolution from 1770* (London: Batsford, 1974)., pp. 54-55, 138-9.

Thus Hawke assesses the alternative cost of travel in 1865 at £60m, giving social saving of £48m, or 5.8% of GDP.

A: i

We make three revisions to the calculation of monetary social savings for 1865, and note each of their effects separately. First, we noted earlier that, in the absence of any data, Hawke assumes that all season ticket holders paid a third class fare, travelled in the first and second classes, but would have travelled as third class passengers in the absence of railways. The division of season tickets revenues by class is not generally available, but is given in the Railway Returns for 1875.[26] This shows that 58% of season ticket revenues came from first class, 35% from second class, and the remaining 7% from third class. We assume that this ratio holds for all years, and that the price paid per mile was equal to one half the regular fare. This second assumption is arbitrary but plausible. It gives an overall average season ticket fair of 0.92d, very close to Hawke's equally arbitrary figure of 0.9d. As such it does not determine any of the results that follow. We assume, unlike Hawke, that those who travelled using first class season tickets would have travelled like other first class ticket holders in the absence of railways. This seems more plausible: even at half the price per mile, a first class season ticket was not cheap, and such a person must have been from the more affluent part of society. We can now revise table 2 accordingly.

Table 3: Revised estimates of 1865 social savings: allocating season tickets

		1st class		2nd class		3rd class		Total
		standard	season	standard	season	standard	season	
1	rail costs £m	3.2	0.2	4.3	0.1	4.6	0.03	12.5
2	rail fares (d/mile)	2.11	1.055	1.55	0.775	1.01	0.505	
3	miles (million)	367	52	659	43	1089	12	2223
4	pre-rail fares (d/mile)	24	24	4	4	2.5	2.5	
5	pre-rail costs £m	36.7	5.2	11.0	0.7	11.3	0.1	65.1
6	rail saving £m	33.5	5.0	6.7	0.6	6.8	0.1	52.7

Sources: Row 1 allocates season ticket revenue by class in the ratio 58:35:7; Row 2: standard from Hawke p. 43, season equal to half standard; Row 3: Row 1/row 2; Row 4: Hawke p. 44; Row 5: row 3 x row 4; Row 6: row 5 – row 1

Compared with Hawke's original estimates, as set out in table 2, table 3 shows a £5m rise in the estimate of social savings, which raises the estimate to 6.4% of GDP. This comes about primarily by assuming that 52 million season ticket miles would, in the absence of railways, have been travelled by post-chaise rather than on the outside of a stage coach.

A: ii

Our second change relates to the cost of non-rail travel. Hawke assumes that the cost of travelling by coach and chaise did not change over time. It is possible to claim that such costs would have risen (greater demand for horses, congestion) or that it would have fallen (economies of scale in coach building, better roads), so the assumption of constant prices is reasonable. Hawke reports coaching costs as 4d inside, and 2.5d outside, similar to figures given elsewhere.[27] Hawke gives the cost of

[26] Parliamentary Papers 1876 LXV p. 98 (p. 226).

[27] John Copeland, *Roads and Their Traffic 1750-1850*, [Reprints of Economic Classics] (Newton Abbot: David & Charles, 1968)., p. 93. As Gourvish has noted, Hawke mistakenly used the cost of inside, rather than outside, the coach for second class rail travel in his table II.02 Lardner counterfactual, which overstates the social saving by a

posting as 2s per person per mile, which cannot be correct. Fishlow drew attention to the very high – 6:1 – ratio between the cost of posting and the cost of travelling inside a carriage.[28] No other author suggests such a ratio, with Bagwell, for example, arguing that the cost of posting was 'at least twice as expensive' as travelling inside a coach. The 2s cost, mentioned in the Royal Commission and elsewhere, is in fact for a post-chaise per mile, not per person per mile.[29] Since a chaise could carry 3 or 4 people, the cost per mile was between 6d (four people in the chaise) and 2s (one person).[30] There are two further reasons to believe that posting was on average cheaper than 2s per mile. First, the cost of posting varied in time and space, with many references to costs lower than 2s. Early nineteenth century editions of *The Times* include four references to the cost of hiring a chaise being 1s, eight to 1s 3d, and two to 1s 6d. There are no references to costs above this, although one reference notes that the cost had fallen to 1s 6d, implying that they had once been higher.[31] In their evidence to the 1837 Committee on taxation,

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quarter. The number given in the text on page 44 is correct. Gourvish, *Railways and the British Economy 1830-1914*., p. 34, Hawke, *Railways and Economic Growth*., p. 44, table II.02.

[28] Fishlow, "Railways.", p. 76.

[29] Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXXVIII, part 1p. liii, para 118. Charging per coach rather than per person is to be expected since the costs were essentially invariant in the number of passengers. This is generally clear from the context, but is made explicit in a 1761 advert in *The Ipswich Journal,* the 1802 accounts of a Suffolk postmaster, a 1793 article in *The Leicester Journal,* the 1823 Best family account books, all quoted in Copeland, p. 155-9. In addition, articles in The Times always refer to the cost of hiring a chaise and pair per mile, with no suggestion that this is per person per mile. See references in footnote 28

[30] Mr Henry Gray, Chairman of the Association of the Postmasters, when interviewed on post horse duty, stated in answer to the question 'How have you calculated how many passengers on an average you carry post, for each horse hired? – Two I should say, four is considered the average with a pair horse carriage', Parliamentary Papers 1837 Vol XX p. 9 (305), para 145.

[31] References to 1s: Issue 5400, 26 April 1802, p. 3 col C; issue 11570, 29 May, 1822, p. 3, col A, issue 11598, 01 July 1822, p. 3, col F and issue 11822, 18 March 1823, p. 3, col D, References to 1s 3d: Issue 5198, 29 August 1801, p. 3, col A; issue 5202, 3 September 1801, p 2 col C; issue 8343, 17 October 1814, p. 2, col D; issue 9450, 21 February 1815, p. 3, col G; issue 11152, 24 January 1821, p. 4, col A; issue 11217, 11 April 1821, p. 3, col A; issue 11822, 18 March 1823, p. 3, col D and issue 11873, 16

both Henry Gray and Thomas Cass argued that they would be able to provide posting at 1s per mile were the tax to be abolished.[32] Similarly, Copeland reports various early nineteenth century advertisements for a post chaise and pair of horses at 1s – 1s 6d per mile.[33] Although tolls may have been in addition, it is clear that some journeys could be done 'post haste' for less than 2s per mile. Finally, it seems likely that the 2s included the cost of hiring a postillion to return the horses at the end of the stage, and the tolls on the horses on their return. Since the average first class rail journey was under 15 miles long in 1865, some journeys would have been short round trips to relatively local places, for which it would have been cheaper, when travelling by chaise, to have retained the horses at the destination until return, rather than paying the postillion and tolls for the return legs.[34]

We have no reliable information as to how many people travelled in the typical chaise, but given that they could carry 3 and perhaps 4 people, and given that 2s appears to be towards the upper end of the likely cost per chaise mile, an average cost of 10d per passenger mile seems reasonable.[35] This estimate – 2.5 times the inside coach cost – is in keeping with Bagwell's statement that posting was 'at least twice as expensive' as coaching. We can now revise table 3 accordingly.

May 1823, p. 4, col D, References to 1s 6d: Issue 7246, 1 January 1808, p. 3, col B and issue 9008, 6 September 1813, p. 3 col E.

[32] Parliamentary Papers 1837 Vol. XX, p. 9 (305), para 145, p. 11 (307), para 178

[33] Copeland, *Roads and Their Traffic 1750-1850*., p. 155, see also similar figures on pp. 156-160.

[34] 369 million miles divided between 25,053,443 passengers, both from Railway Returns, Parliamentary Papers, 1866, lxiii, p. 36.

[35] Mr Henry Gray, Chairman of the Association of the Postmasters, stated that four would be average, but since this is the maximum, it is hard to believe that this was also the average. Parliamentary Papers 1837, Vol. XX, p. 9 (305), para 145.

Table 4: Revised estimates of 1865 social savings: new post-chaise costs

		1st class		2nd class		3rd class		Total
		standard	season	standard	season	standard	season	
1	rail costs £m	3.2	0.2	4.3	0.1	4.6	0.03	12.5
2	rail fares (d/mile)	2.11	1.055	1.55	0.775	1.01	0.505	
3	miles (million)	367	52	659	43	1089	12	2223
4	pre-rail fares (d/mile)	10	10	4	4	2.5	2.5	
5	pre-rail costs £m	15.3	2.2	11.0	0.7	11.3	0.1	40.7
6	rail saving £m	12.1	2.0	6.7	0.6	6.8	0.1	28.2

Sources: Rows 1-3 as table 3; Row 4: Hawke p. 44, with 1st class revised to 10d; Row 5: row 3 x row 4; Row 6: row 5 – row 1

Including a more realistic estimate of the cost of posting reduces the overall social saving to £28m, or 3.4% of GDP, a reduction of 46% from Hawke's estimate.[36]

A: iii

The third change that we make is to argue that those people who travelled third class, would not, in the absence of the railways, have travelled by coach, but would instead have walked. Although both Lardner and the Royal Commission base their third class comparisons on outside coach fares, there is ample evidence that the sort of people who travelled third class would never have been coach travellers. The Royal Commission itself noted this, arguing that 'The poorer classes have benefited most in regard to speed, because formerly they had no means

[36] If we apply the 10d figure to table 2, the social saving falls to £26.3m. Gourvish also uses the 2s per mile figure in his 'Revised high' estimate of social savings. He estimates a cost of £128.2m for the non-rail cost, assuming that first and second class passengers both would have travelled by post. Using 10d per passenger mile gives a figure of £62.1m, and Gourvish's 'high' social savings estimate would then be 12.6%, not 22.9% of England and Wales GDP. Gourvish, *Railways and the British Economy 1830-1914.*, p. 59.

of travelling except by wagon or on foot.'[37] This is in keeping with evidence given to various parliamentary enquires. For example, Sir Rowland Hill, when describing the improvements brought about by railways, notes that 'even those whose best attainable means of travelling were wagons proceeding at the rate of two or three miles an hour, are now conveyed by third-class carriages in tolerable comfort and with great speed.'[38] G. Duncan, the Director of the Dundee and Arbroath Railway, when asked how his third class passengers would have travelled without the railways, stated 'They had no means but going by the carriers' carts or walking'.[39] Captain Lawes, of the Manchester and Leeds Railroad, stated that third class on that railway was made up primarily of hand loom weavers who would otherwise had to walk into Manchester once a week, saving at least half a day per weaver per week,[40] while W.F.L. Cargenie, Chairman of the Forfar and Arbroath Railway, commented simply that the sort of people who travelled in third class were 'labourers, artizans, fish-women, and the lower classes of society, the poorest'.[41] Table 5 incorporates this revision.

[37] Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXXVIII, part 1p. liii, para 118.
[38] Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXXVIII, part 1p. cvii, para 2.
[39] Parliamentary Papers 1840 XIII p. 285 (479), para 4862.
[40] Parliamentary Papers 1840 XIII p. 242-3 (436-7), para 4249-4265.
[41] Parliamentary Papers 1840 XIII p. 282 (476), para 4812.

Table 5: Revised estimates of 1865 social savings: third class walking

		1st class		2nd class		3rd class		Total
		standard	season	standard	season	standard	season	
1	rail costs £m	3.2	0.2	4.3	0.1	4.6	0.03	12.5
2	rail fares (d/mile)	2.11	1.055	1.55	0.775	1.01	0.505	
3	miles (million)	367	52	659	43	1089	12	2223
4	pre-rail fares (d/mile)	10	10	4	4	0	0	
5	pre-rail costs £m	15.3	2.2	11.0	0.7	0	0	29.2
6	rail saving £m	12.1	2.0	6.7	0.6	-4.6	-0.03	16.7

Sources: Rows 1-3, as table 3, Row 4: Hawke p. 44, with 1st class revised to 10d, and 3rd class revised to zero; Row 5: row 3 x row 4; Row 6: row 5 – row 1

The social saving has now fallen to £17m, a little under 2% of GDP.[42] It is made up of a £14m gain to first class passengers and a £7.3m gain to second class passengers, partly counterbalanced by a loss of £4.6m to third class passengers. £17m is barely more than one-third of Hawke's estimate, and it is clear that his results cannot stand, even on their own terms. The scepticism of Baker and Fishlow proves to be well-founded.

Part B: Time savings

We noted earlier that the modern transport literature is unanimous in viewing the cost of transport as a generalised cost, that is, made up of money and non-money components. Once converted into monetary values, the non-money components can be added to the money costs to give the 'generalised cost'. Although this formal method of expression is

[42] When using Hawke's original mileage numbers (rather than including some season ticket holders in the premium classes), the social saving estimate is £13.8m, 1.7% of GDP. Note too that with first class passengers posting, second class inside the coach, and third class walking, no-one is travelling outside the coach. If we assume that second class would have travelled inside and outside the coach (as Hill suggested would have happened, Parliamentary Papers: Report from Commissioners: Railways,

relatively new, the concept is not. Lardner, for example, included the time saving in his analysis of the importance of railways.[43] Furthermore, the economic literature is clear that all time, including non-working time, has a positive value.

In the nineteenth century trains were much faster and often much more frequent than coaches, and became both faster and more frequent over time. Furthermore, train companies believed that customers valued speed: it played an important part of their advertising strategy, and they were keen to set new records. In addition, faster trains were generally more costly to operate, so given increasing speeds, we know that railway companies believed that passengers were prepared to pay more for faster travel. This would also fit with the finding that Britain had faster trains than elsewhere in Europe: as the richest country, British people were rationally prepared to pay more to save a given amount of time, and train companies catered for their needs accordingly.[44] In addition, the fastest trains within Britain often required the purchase of an express ticket, demonstrating a willingness on the part of travellers to pay to save time.

There were two contemporaneous estimates of the value of faster travel in Victorian Britain. Lardner argued that in 1848 coaches travelled at 7.5mph and trains at 25mph. With 170m passenger miles the time saved amounted to just under 16m hours, which at Lardner's 6d per hour value of time implies a saving of £0.4m.[45] Chambers Journal, discussing the railways in 1854, was more optimistic, arguing that 111m passenger hours were saved, which, even at a lower value of time of 4.5d per hour,

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1867, vol XXXVIII, part 1p. cvii, para 2), then, with an average coach fare of 3d per mile for the second class, the social saving falls to £13.8m, which is again 1.7% of GDP.

[43] Lardner, *Railway Economy*., p. 164.

[44] Ernest Foxwell and Thomas Cecil Farrer, *Express Trains : English and Foreign : Being a Statistical Account of All the Express Trains of the World* (London: s.n., 1889)., pp. 66, 163-179.

[45] Lardner, *Railway Economy*., p. 164.

gave a saving of £2m.[46] In addition, in his 'high estimate' of social savings for 1865, Gourvish includes £1m for the value of time saved in 1865.[47]

In order to value the time saved, we first calculate average travel speeds by rail and pre-rail methods, from which we calculate the number of hours saved. We do this using both the actual journey time itself, and including an allowance for the lag when the train (or coach) does not depart at the traveller's preferred time. We then assess the value of one hour of time saved, and use that to calculate the value of total time saved.

B: i

Although we know that trains were faster than coaches, and that train speeds increased over time, there is no systematic study of average train speeds. That is not to say that we know nothing – Foxwell and Farrer, for example, give good data on the number and speed of express trains between 1871 and 1888 – but nevertheless our knowledge is surprisingly weak given the extent of the railway literature.[48] Thankfully, the surviving railway timetables mean that we are in a good position to calculate the speed of any given train journey. Bradshaw's Railway Timetables, published monthly, give the scheduled time of departure and arrival for every train in the United Kingdom, and Bates' Directory of

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[46] Quoted in Jack Simmons, *The Victorian Railway* (Thames and Hudson, 1991)., p. 373.

[47] He assumes coach and rail speeds of 10 and 30 mph respectively, but only attributes value to the time of 20% of passengers, that is, 445.69m passenger miles, with time valued at 8d per hour. Gourvish, *Railways and the British Economy 1830-1914*., p. 59.

[48] Foxwell and Farrer, *Express Trains : English and Foreign : Being a Statistical Account of All the Express Trains of the World*., pp. 66-69. Thus, for example, Bagwell's generally authoritative book makes no mention of railway speeds prior to 1914 (Bagwell, *The Transport Revolution from 1770*.), Ville simply writes of 'substantial improvements in speeds'. Simon Ville, "Transport," *The Cambridge Economic History of Modern Britain : Industrialisation, 1700-1860*, eds. Roderick Floud and Paul Johnson, vol. I (Cambridge: Cambridge University Press, 2004)., p. 307, while Thomas notes only that 'Locomotives roared through the countryside at speeds of up to 40 miles per hour' Mark Thomas, "The Service Sector," *The Cambridge Economic History of Modern Britain : Economic Maturity, 1860-1939*, eds. Roderick Floud and Paul

Coach services does the same for coaches in 1836.[49] Of course, neither trains nor coaches would always have operated precisely to their timetables, but it seems more likely that punctuality was better on the railways than on coaches, and that punctuality improved over time. Thus although timetables will overstate the true speeds, the effect is likely to be small and declining over time. It is obviously not practical to computerise every journey, and nor, having done so, would we be able to allocate passengers to each journey with any degree of accuracy. Instead we construct two samples, consisting of 50 'important' and 222 'minor' journeys respectively.

The important routes are defined by the likely traffic on them.[50] These include the obvious intercity pairs, such as London to Birmingham, but also many shorter but high density routes, such as London to Reading and Manchester to Oldham.[51] For these 50 routes we computerised every journey on each route in 1836, 1850, 1870, 1887 and 1910. The timetables give the time of every journey during the day,[52] but simply averaging these would overstate the average time taken, since people will not take an earlier train if it will be overtaken en route by a later-leaving, but faster-travelling, service. We eliminate trains and coaches that were overtaken, which leaves 342 'useful' coach journeys for 1836, and an average of 884 'useful' train journeys for each of the four railway benchmark years. Following modern transport analysis best practice, we

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Johnson, vol. II, The Cambridge Economic History of Modern Britain (Cambridge: Cambridge University Press, 2004)., p. 102.

[49] Bradshaw, "Bradshaw's Railway Guides for Great Britain and Ireland.", Alan Bates, *Directory of Stage Coach Services 1836* (Newton Abbot: David and Charles, 1969).

[50] We ranked journeys by the product of the population of the two places, divided by the distance. This captures two intuitions: that more journeys will be made when there are more people in the two places (the benefit of travel increases), but that there are likely to be fewer journeys if the distance is long (the cost of travel increases). In effect this model assumes that people travel to meet other people, rather than to visit a scenic place, such as the seaside.

[51] A full list is given in the appendix.

[52] For tractability we limit ourselves to weekday trains.

average the 'useful' journeys on each route using a 'twin-peak' weighted average, that is to say, we assume more people wish to travel at peak times than at off-peak times, and give higher weight to trains at those times in calculating the average speeds on each route in each benchmark year.[53] The averages for individual routes are then averaged in proportion to each journey's importance, as defined by the likely traffic on the route. For tractability we assume that any passenger could have travelled on any train. In reality this was not the case in the early years, when not all trains had third class carriages. That said, the effect of this bias is small, since only a relatively low proportion of passengers travelled in third class in the early years.

We calculate miles per hour by dividing the 'crow-flies' mileage between the two towns by the time taken. We use 'crow flies' rather than 'track' miles because this is what matters to travellers. This also has the useful property that the construction of a shorter line, on which trains travel at the same speed, counts as an increase in speed.[54] As a rule of thumb, track mile speeds exceed crow flies speeds by around fifteen percent.

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[53] We assume that people wish to travel in the following ratios: each hour between 1am and 6am, 1 passenger unit per hour, between 6am and 7am, 11am and 5pm, 9pm and 1am, 100 units per hour, between 7am and 8am, 10am and 11am, and 8pm and 9pm, 400 units per hour, and between 8 am and 10am, and 5pm and 8pm, 1000 units per hour. We then assume that these passenger units wish to depart evenly within the hour bands, and that they catch the first useful train after their preferred departure time. This allows us to calculate the number of people on each train, and that is the number used to produce the weighted average. Many different weightings were used, including uniform inherent demand over the 24 hour period. Contrary to our initial expectations, the pattern of demand does not alter the results by more than a few minutes, and does not alter the final social savings results. Both coaches and trains were sufficiently frequent, and fairly uniform in speed, that the precise allocation of passengers to individual trains is of no great importance.

[54] Thus, for example, the Great Western Railway shortened its routes from London to South Wales and the West in the later Victorian years by building straighter lines through new cuttings through hills it had previous detoured around. As such, it lost its nickname of the 'Great Way Round'. P. J. Cain, "Railways 1870-1914: The Maturity of the Private System," *Transport in Victorian Britain,* eds. Michael J. Freeman and Derek H. Aldcroft (Manchester: Manchester University Press, 1988)., p. 93.

Speeds on important routes may not have been representative of speeds on more minor routes. To find the speeds on minor routes we took a simple average of the speed of the first train after 7am into each of the 222 towns with a population over 12500 in 1901, in each of our four railway benchmark years.[55] We do not know the times of coaches on these routes, so we simply assume that they travelled at the same speed as coaches on primary routes. This is generous towards coaches, since both the quality of roads and reduced competition on minor routes would have reduced coaching speeds. We average the speeds on important and minor journeys to find the overall average speed for each of our benchmark years.[56] The results are given in table 6. The equivalent speeds for coaches are 7.8mph,[57] and for walking we use a value of 2.5mph, the highest figure recommended by the Ramblers' Association for estimating journey speeds.[58] This is a relatively generous figure, since it only applies to level or downhill routes, and is a route-miles speed, not a crow-flies speed. It would certainly be possible to make a good case for, say, a crow-flies speed of 2mph.

[55] Journeys over two hours were excluded, and the remainder varied dramatically in length, from the very short (Glossop to Dinting, 1km) to the rather long (Peterborough to Doncaster 120km), the average was 28km. The full list of towns is given in the appendix.

[56] We give important journeys a weighting of 52%. This is based on working out the implicit demand for travel between each of the 185 towns and each of the other 36,000 settlements in Britain listed in the Ordnance Survey Gazetteer, according to the earlier formula that implicit demand equals the product of populations divided by the distance, with a minimum distance of 5km. Of total implicit demand, we assume that the average speed for important journeys holds only for those journeys themselves, with other journeys over 120km being proxied by the simple average of important and minor journeys speeds, and all other journeys under 120km by the minor journey speed. It is possible to argue for different weights, but given the numbers it is hard to see the overall average presented here being wrong by more than 2 or 3 miles per hour at most.

[57] Bates, *Directory*., important routes.

[58] http://www.ramblers.org.uk/info/practical/navigation.html#Planning. The recommendation is 3-4km per hour, we use 4km. Summerhill uses 3km per hour, but it seems likely that walking speeds were higher in England and Wales owing to better quality roads and higher nutritional standards. William R. Summerhill, "Big Social

Table 6: 'In-train' train speeds at different dates, crow-flies miles per hour

	Important journeys	Minor journeys	All journeys
1850	22.7	17.8	20.1
1870	28.4	18.4	23.2
1887	32.8	18.9	25.6
1910	36.9	20.4	28.3

Source: Bradshaw's Railway Directories.

As table six makes clear, train speeds on important routes were considerably higher than on minor ones, and grew more quickly over time. Overall, a rise in speeds from 7.8 or 2.5mph in the pre-railway era to 20 and then later to 28 mph in the railway era represents a major improvement in quality for consumers. Tables 5 and 6 are used to calculate the number of hours saved by railways in 1865.

Table 7: Time savings in 1865

		1st class	2nd class	3rd class	Total
1	miles (million)	420	702	1101	2223
2	pre-rail speed (mph)	7.8	7.8	2.5	
3	pre-rail time (m hours)	53.8	90.0	440.4	584.2
4	rail speed (mph)	22.4	22.4	22.4	
5	rail time (m hours)	18.7	31.3	49.2	99.2
6	time saved (m hours)	35.1	58.7	391.3	485.0

Notes: Row 1: table 5; Rows 2 and 4: table 6 and notes; Row 3: row 1 / row 2; Row 5: row 1 / row 4; Row 6: row 3 – row 5

Railways were much faster than the alternatives. The total travel time fell by over eighty percent, to 99m hours. Of this fall, the vast majority – over three-quarters – was saved by third class travellers, both

Savings in a Small Laggard Economy: Railroad-Led Growth in Brazil," *Journal of Economic History* 65.1 (2005)., p. 85.

because they represented the largest single category of traveller, and because their alternative methods of transport – walking, or wagons moving at walking pace – were very slow. As with all social savings numbers, we need to be careful in how these figures are used. Just as Hawke's social saving figure of £48m did not mean that society spent £48m less on transport in 1865 than at some previous date, nor does table 7 mean that 485m hours were actually saved. Rather, it tells us that to make the journeys made by rail, without the railways, would have taken an additional 485m hours.

B: ii

We also know that trains were more frequent than coaches, and that people value frequency, because it reduces the overall journey time. This was appreciated by contemporaries. Thus Mr Edward Bury, superintendent of locomotive power on the London and Birmingham Railway, told the 1840 Committee on Railways that 'The great advantage to the public will be, in not having a single train per day carrying all the passengers that go, but in having a multiplicity of trains throughout the day', adding later in his evidence that 'I think the public would not have the convenience the railway ought to give them, unless there were frequent trains'.[59] Competing coaches, in contrast, often departed at similar times to each other, so that passengers wanting to leave at other times would have had to wait many hours. Thus, for example, all London to Leeds and London to Liverpool services departed in the afternoon, while the six coaches to Manchester all went either first thing in the morning, or in the early evening, with no departures between 8.30am and

[59] Parliamentary Papers 1840 XIII p. 112 (306), para 2327, p. 115, (309), para 2392.

5.30pm, or after 7.45pm.[60] That said, two modes of travel have no waiting times – walking, and travelling in a private chaise.[61]

In keeping with current transport economics best practice, we model the effects of changing frequencies. For very frequent services (say, six per hour or more), people turn up randomly, and catch the next available service. In this case average waiting time can simply be added to the journey time. When frequencies decrease, people cease to arrive at the station randomly. Although this means that average waiting times at the station do not increase much as frequencies decline, passengers do incur disutility because the train does not go at the time that they would like it to, forcing them to remain in one place when they would by definition rather be in another. They can use the time in the original place, but it is worth less to them than that time would be at their destination. The transport economics literature converts the nominal waiting time (the time between preferred and the actual departure time), into what is termed 'in-vehicle time' (IVT) equivalent minutes. This is the additional in-vehicle time assessed as having equal disutility to the delay in leaving. Waits of up to ten minutes are simply added onto the journey time, but (nominal) waits of over ten minutes are valued less highly, since the person can do something in their place of departure.

Wardman reports that current UK practice is to convert nominal waiting times into in-vehicle equivalent times by multiplying the former by 1 for times up to 10 minutes, and by 0.8, 0.55 and 0.43 for half-hourly, hourly and two-hourly services.[62] There is no best practice for the value of very long gaps between services, so we use an arbitrary but plausible value of 0.1 for twelve-hourly gaps. We then convert these observations

[60] Bates, *Directory*., pp. 30, 32, 34-36.
[61] It was not possible to travel by chaise at a moments notice, given that horses and the like had to be ordered. But it was possible to travel at a time of one's choosing, and therefore we model this as a zero wait.

into a smooth series.[63] This tells us that a departure 30 minutes after the passenger would like to leave has the same disutility as one that departs at exactly the preferred time, but takes 23 minutes longer. Similarly a one hour gap is equivalent to a 35 minute longer journey, a two hour gap to 51 minutes, and a 12 hour gap to 82 minutes. The falling marginal cost reflects the fact that the longer you have, the better you are able to deploy your time usefully, and so the marginal disutility is lower.

There were almost four times as many useful services on important routes in 1910 as in 1836 or 1850. That said, there were still sufficient coach and train services in the earlier years that increasing frequencies did not radically alter the pattern of overall improvement given by the in-vehicle speeds themselves. The same is true for trains on minor journeys. As we noted earlier, we recorded details of the first train to arrive after 7am in each town, and so the wait after 7am can reasonably be taken as a measure of the nominal waiting time. This falls from 74 to 53 minutes between 1850 and 1910, or 34 to 30 IVT equivalent minutes – a trivial difference. The hardest calculation to make is the fall in waiting times from coaches to the initial trains, since we have virtually no information about coaches on minor journeys. That said, the issue is second order, as only second class passengers are assumed to travel by coach. If we assume one coach per day on minor routes the average nominal wait would be 12 hours, equivalent to 82 IVT minutes, which reduces the average speed from 7.8mph to 5.6mph. The full results are given in table 8, and comparing tables 6 and 8 shows that including frequency does not alter the pattern of change over time in any meaningful way.

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[62] M. Wardman, "Public Transport Values of Time," *University of Leeds Institute for Transport Studies Working Paper*.564 (2001)., para 2.5.

[63] We regress these conversion factor onto time and log time, to get the result that the conversion factor equals 1.58 + 0.0002time – 0.57logtime. This predicts values of 0.99,

Table 8: Train speeds at different dates, crow-flies miles per hour, including allowance for waiting

	Important journeys	Minor journeys	All journeys
1850	19.4	11.1	15.1
1870	24.2	11.2	17.4
1887	28.2	11.7	19.6
1910	32.0	13.0	22.1

Source: Bradshaws Railway directories.
Notes. The equivalent speeds on all journeys for chaises are 7.8mph, for coaches 5.6mph, and for walking 2.5mph.

Again, combining our data for miles travelled with the speed data in table 8 allows us to calculate the number of hours saved, including an allowance for changing frequencies.

Table 9: Time savings in 1865, including the effects of frequency

		1st class	2nd class	3rd class	Total
1	miles (million)	420	702	1101	2223
2	pre-rail speed (mph)	7.8	5.6	2.5	
3	pre-rail time (m hours)	53.8	126.1	440.4	620.3
4	rail speed (mph)	16.9	16.9	16.9	
5	rail time (m hours)	24.9	41.6	65.3	131.8
6	time saved (m hours)	28.9	84.5	375.1	488.5

Notes: Row 1, table 3, row 1; Rows 2 and 4: table 8 and notes; Row 3: row 1 / row 2; Row 5: row 1 / row 4; Row 6: row 3 – row 5

Including frequency in the analysis proves to have little effect, with an overall time saving different by only 1%. At first sight this may seem surprising, but is caused by two factors. First, the delay to second class passengers in waiting for the relatively infrequent stage coach was sufficient to offset the delays for first and third class passengers waiting

0.75, 0.58, 0.43 and 0.1 for gaps of 11, 30, 60, 120 and 1440 minutes, very close to the values given by Wardman.

for the train. Second, Britain was already a remarkably developed economy prior to the railway. Stage coach services were particularly extensive on core routes, but were also well established on relatively minor cross country journeys as well. Bates records regular, usually daily, services on 786 different routes excluding those that started or ended in London.[64] The finding that the British transport system was well-developed in the pre-railway era fits with recent work by Bogart, which looks at the significance of turnpike trusts in speeding up coach journeys.[65] It is also in keeping with the recent article by Crafts and Mulatu, which finds that British railways did not lead to a geographical relocation of production: previous transport had been sufficiently good to allow industry to be located in economically efficient locations.[66] Since the figures for time saved are so similar, we limit ourselves to considering only in-vehicle time saved.

B: iii

We now turn to valuing time saved. As we noted earlier, the value of time saved during working hours is taken as the gross wage rate, plus overhead costs. In the nineteenth century overhead costs would have been small, and we disregard them. This introduces a downward bias, but it is hard to believe that the bias is large in an era without payroll taxes on employers, and with few employer funded pensions or other such benefits.

We also noted earlier that it is common to value wages by the type of transport used, with higher values attributable to those travelling by modes used more extensively by the affluent. One initially plausible

[64] Bates, *Directory*., pp. 85-138.
[65] Dan Bogart, "Turnpike Trusts and the Transportation Revolution in 18th Century England," *Explorations in Economic History* (2005).
[66] N. F. R. Crafts and A Mulatu, "What Explains the Location of Industry in Britain, 1871-1931?," *Journal of Economic Geography* 5 (2005).

assumption is that the typical third class passenger was a typical member of the working class, and can thus be proxied by the standard working class wage data. Feinstein finds that in 1911 average earnings for both sexes were £58 10s which, taken backwards using his wage growth series, gives an hourly wage estimate of 3.3d in 1865.[67] This is only half the 6-7d per hour put forward by Chadwick as the typical wage for third class passengers in 1867.[68] Relative to earnings, the cost of travelling by third class rail was significant in 1865. With earnings of 3.3d per hour, an average member of the working class could afford to travel a little over 3 miles for one hour's wages, approximately one-tenth of the distance that a modern typical British worker could travel for the same effort. It is therefore more plausible to believe, as Chadwick must have done, that the third class passengers, although clearly working class, were made up disproportionately of the skilled and semi-skilled, rather than of labourers and domestic servants. Chadwick's estimate seems a sensible basis on which to proceed, although for completeness we include estimates using both the Chadwick and Feinstein wages.

In keeping with the modern literature, we assume people who travelled in premium classes (in this case first and second class travel) were affluent, and value their time in 1911 at £250 per 2300 hour year, a

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[67] Average earnings for both sexes. Charles H. Feinstein, "New Estimates of Average Earnings in the United Kingdom, 1880-1913," *Economic History Review* XLIII.4 (1990)., p. 604. In that this figure is for the UK it understates wages in England and Wales, although the margin of error will be small. 18821912 using Charles H. Feinstein, "Changes in Nominal Wages, the Cost of Living and Real Wages in the United Kingdom over Two Centuries, 1780-1990," *Labour's Reward : Real Wages and Economic Change in 19th- and 20th-Century Europe*, eds. Peter Scholliers and Vera Negri Zamagni (Aldershot, Hants., England ; Brookfield, Vt: E. Elgar, 1995)., Appendix 24 p. 264, and 1843 to 1882 using Charles H. Feinstein, "Pessimism Perpetuated: Real Wages and the Standard of Living in Britain During and after the Industrial Revolution," *Journal of Economic History* 58.3 (1998)., p. 653.

[68] Edwin Chadwick, Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXXVIII, part 1p. 838, para 17181.

decent but not spectacular wage.[69] Again, we index this series using the Feinstein series, to give a value per hour of 16.8d for 1865.

As noted above, the current literature assumes that travel today is no more or less pleasant than being at work. Although conditions at work would have been poor for many workers, it is easy to imagine that hours spent on a stage coach – or walking – could have been far less pleasant than the equivalent time at work. Under those circumstances, the cost of labour will understate the value of time saved. It is not possible to make any correction for this, but instead we simply note that the discomfort means that it would be plausible to argue that the time saved should be valued more highly than the figures used here.

B: iv

The next issue is the proportion of people travelling during work time, and the proportion of commuting and leisure travel. As we noted earlier, those travelling on business should have their time proxied by wage costs, whereas those who were travelling in their own time should have their time valued at 46% of their take home wages if the time saved would otherwise have been spent in a train or carriage, and at 92% of wages if the time saved would otherwise have been spent walking.[70]

It is clear that many premium class passengers would have been travelling on business. Some authors, including Hawke, assume that no third class travel was on business.[71] Against that, Captain Lawes noted

[69] This is the average salary of those in Census class V, Merchants etc, using information from Routh, and assuming that commercial travellers earned £99 a year, Guy Routh, *Occupation and Pay in Great Britain 1906-79*, 2nd ed. (London: Macmillan, 1980). p. 63.

[70] The current ratio of leisure to work time values includes pensioners in the leisure value. Pensioners' average value of leisure time is 25% lower than non-pensioners. Since there was a lower ratio of pensioners to non-pensioners in the nineteenth century than today, it would be legitimate to increase the ratio of leisure to working time value to take account of composition effects. Since it is hard to assess the magnitude, we use the standard value of 46%. Department for Transport, *Values*., para 1.2.17.

[71] Hawke, *Railways and Economic Growth*., p. 52.

that handloom weavers travelling on business made up most of the third class custom on the Manchester and Leeds.[72] The truth is that we simply do not know what proportion of travellers in any class were travelling on business in 1865. The sensible way to proceed is to assume first that all travel was on business, and second that no travel was on business, and then to consider the plausible bounds within these extreme cases.

Table 10: Valuing time saved in 1865

		1st class	2nd class	3rd class Feinstein	3rd class Chadwick	Total
1	time saved (m hours)	35.1	58.7	391.3	391.3	485.0
2	value of one working hour (d)	16.8	16.8	3.3	6.5	
3a	value of time saved (£m)	2.5	4.1	5.4		11.9
3b					10.6	17.2
4	value of one non-working hour (d)	7.7	7.7	3.0	6.0	
5a	value of time saved (£m)	1.1	1.9	4.9		7.9
5b					9.7	12.7

Notes: Row 1: table 7, row 6; Rows 2 and 4: see text; Row 3: row 1 x row 2; Row 5: row 1 x row 4; 'a' indicates using the Feinstein 3rd class value of time; 'b' indicates using the Chadwick 3rd class value of time.

Table 10 gives a range of figures, from £8m to £17m. It is clear that both extremes are unrealistic: it is not credible to claim that all passengers were on business, or that none were on business. In addition, the lower values for third class passengers are barely above the £4.6m that they paid in fares. Given that the benefit must exceed the cost for the marginal passenger, it is unlikely that the benefit to cost ratio for the average passenger was only 1.06:1. If, as seems more realistic, we take

[72] Interestingly, he notes that whereas a handloom weaver could carry only his own cloth into town if he walked all the way, he could carry the loads of three weavers if he only had to walk the short distance to and from the station. As such, it would be legitimate to value the time saved in this case at the wage of three workers, rather than one. Parliamentary Papers 1840 XIII p. 242-3 (436-7), para 4249-4265.

the Chadwick value of time, and assume that two-thirds of premium class and one third of third class travel was on business, the social saving is £15.4m. This estimate seems realistic, and represents 1.9% of UK GDP.

B: v

Since we now have a revised figure for the monetary saving, and a figure for the value of time saved, we can calculate the total social saving. Hawke divides the social saving for railways in England and Wales by GDP for the UK. As Gourvish noted, this is inappropriate.[73] Crafts has recently broken down British GDP figures into regions.[74] He finds that in 1871 England and Wales accounted for 79% of UK GDP, a ratio that we assume holds for 1865, implying 1865 England and Wales GDP of £649m.

Table 11: Money and time social savings for 1865, £m

		1st class	2nd class	3rd class	Total	% UK GDP	% E&W GDP
1	Hawke's social saving	33.5	6.7	7.5	47.7	5.8%	7.3%
2	Revised monetary social saving	14.0	7.3	-4.6	16.7	2.0%	2.6%
3	Value of time saved	2.0	3.4	9.9	15.3	1.9%	2.4%
4	Total revised social saving	16.0	10.7	5.3	32.1	3.9%	4.9%

Row 1, table 2, row 6; Row 2, table 5, row 6; Row 3, table 8, assuming two-thirds of premium traffic and one-third of 3rd class traffic was on business; Row 4: row 2 + row 3

73 Gourvish, *Railways and the British Economy 1830-1914*., p. 36.
74 N. F. R. Crafts, "Regional Gdp in Britain, 1871-1911," *Scottish Journal of Political Economy* 52 (2005).

Table 11 tells us that both the monetary and time savings were significant, with the money savings slightly larger than the time savings. Together they amount to 3.9% of UK GDP, or 4.9% of England and Wales GDP, one-third lower than Hawke's estimate. For premium passengers the gains were primarily monetary: lower fares represent almost 90% and 70% of the total gains to first and second class passengers respectively. For third class passengers the picture is very different: their fares increased by £4.6m, but they saved £9.9m worth of time.

The social saving methodology, as used by Fogel, Fishlow and Hawke in their original studies measures the cost to society of doing exactly what it did with the railways, without them. Elementary economics tells us that demand falls as price rises, and so, were the generalised cost of travel to have been as high in 1865 as in the pre-railway era, fewer people would have travelled, with the fall in travel depending on the (generalised) price elasticity of demand. Fogel sets out the formula to convert the social saving into the increase in consumer surplus, according to the elasticity of demand.[75] The estimates of consumer surplus under different elasticity assumptions are given in table 12.

[75] Robert William Fogel, "Notes on the Social Saving Controversy," *Journal of Economic History* XXXIX.1 (1979)., pp. 10-11, equations 11 and 12:

$$\frac{S_t}{S_0} = \frac{\phi^{1-\varepsilon} - 1}{(1-\varepsilon)(\phi - 1)} (when\ \varepsilon \neq 1) \qquad (11)$$

$$\frac{S_t}{S_0} = \frac{\ln \phi}{\phi - 1} (when\ \varepsilon = 1) \qquad (12)$$

Where S_t is the true social saving, and S_0 the zero elasticity social saving already calculated, ε the elasticity, and ϕ the ratio of prices without railways to with railways. The intuition is that the higher the price ratio, the more journeys will not now take place.

Table 12: The effect of different elasticity assumptions on total social savings in 1865

1	Elasticity of demand	0	0.4	0.75	1	1.5	2
2	CS/SS (%)	100%	79%	64%	56%	44%	35%
3	Consumer surplus (£m)	32.3	25.4	20.8	18.2	14.1	11.2
4	'Consumer surplus as % E&W GDP	5.0%	3.9%	3.2%	2.8%	2.2%	1.7%

Notes: Row 1 are Fogel's elasticity levels.[76]; Row 2: the ratio of consumer surplus to social savings generated by Fogel's formulae; Row 3: Row 2 x total social saving from table 11; Row 4: Row 3 / England and Wales GDP (£649m)

The different elasticity assumptions give significantly different results, from 1.7% of GDP to 5% of GDP. In their analysis of US passenger railways Boyd and Walton assume unitary price elasticity, an assumption endorsed by Fogel, and used by others, including most recently Summerhill.[77] In addition, modern transport economics uses a similar rule.[78] For that reason, we concentrate on the unitary elasticity case. As can be seen, this reduces the welfare gain by almost a half, to 2.8% of GDP. It should be noted that this factor – 56% – applies equally to the money and time savings, and if we are interested in the gain to consumers then the same adjustment should be made to Hawke's numbers. As such, the ratio of these revised numbers to those of Hawke are unaffected.

[76] Fogel, "Notes.", p. 12.
[77] Boyd and Walton and Fogel also give figures for other elasticities, from zero to two, Summerhill also notes other studies that have used unitary elasticity. Boyd and Walton, "Social Savings.", p. 249, table 3, Fogel, "Notes.", p. 11, Summerhill, "Big Social Savings.", p. 82.
[78] The 'famous rule of a half' is a linear approximation to this. Great Britain, *Transport and the Economy*., p. 65, figure 3.3.

Part C: Extending the social savings numbers to 1843-1912

We now go on to extend the series to cover the years 1843 to 1912. We do this in four parts. First, we assess the fares and miles travelled prior to 1865, for which good data are available. Next we assess the same for the period after 1865, for which the data are poorer. Third we calculate the value of monetary savings, and finally we calculate and value the time saved.

Hawke uses Lardner's passenger mile estimates for 1843-8, and the Railway Returns until 1870, when his analysis stops.[79] Gourvish is sceptical about Hawke's reliance on Lardner, but that scepticism is not well-founded.[80] Both Lardner and the Railway Returns give figures for 1845-8, and the two series are identical. For that reason is seems reasonable to trust Lardner's figures for 1843-4.[81]

We make a few small changes to the procedure followed by Hawke. First, he uses passenger mileage figures given in the Railway Returns from July 1851 to December 1859. However, a few companies did not submit passenger mileage returns between 1851 and 1855. We add a proportionate allowance to passenger miles, based on their train miles, raising total passenger miles by 1 to 5%, depending on the year. Since rail receipts remain unaltered, and non-rail costs rise 1-5% with the additional miles, the social savings rise. The effect is, however, small, never exceeding 0.3 percentage points.

Second, between 1852 and 1859 a few companies, never accounting for more than three percent of the total passenger miles, did not divide their passenger miles by class. Hawke allocates them to the third class, we distribute them pro-rata, in line with the average of other companies. Again, this raises the social saving, since it increases the

[79] Hawke, *Railways and Economic Growth*., pp. 45-7.
[80] Gourvish, *Railways and the British Economy 1830-1914*., p. 38.
[81] Lardner, *Railway Economy*., p. 163.

alternative non-rail cost, without altering the rail cost. The estimate of social savings rises by a maximum of 0.2 percentage points.[82]

We know both receipts and fares per mile by class for the periods 1843-8, July 1851-December 1859, and for 1865. It is therefore fairly straightforward to divide the former by the latter to find the number of passenger miles. We interpolate fares per mile for 1849-Jun 1851 and 1860-1864 from observations immediately on either side, and use these prices to calculate miles travelled from the receipts given in Railway Returns. The price per mile was very stable in this period, so this cannot involve any significant error.

C: i

Our numbers, like those used by Hawke, for the post-1865 period are less precise, because no information on average fares are available, and season tickets, workman's and excursion fares become more important. Like Hawke, we note Acworth's statement that the average fare fell to 0.55d per mile by the outbreak of war.[83] The issue is assessing the pattern of fare reductions between 1865 and 1912. In the absence of other evidence, we assume that fares fell linearly over time and evenly by class. We assume, therefore, that average fares, including all discounts, season tickets, and so on, fell from 2.11d in 1865 to 1.02d by 1912, from 1.55 to 0.75d and 1 to 0.5d, in each class respectively. This gives an average fare of 0.56d in 1912, which is very close to the number proposed by Acworth. There are two other estimates of fares, by Cain and by Paish. Cain suggests 0.75d and 0.6d per mile in 1900 and 1912,

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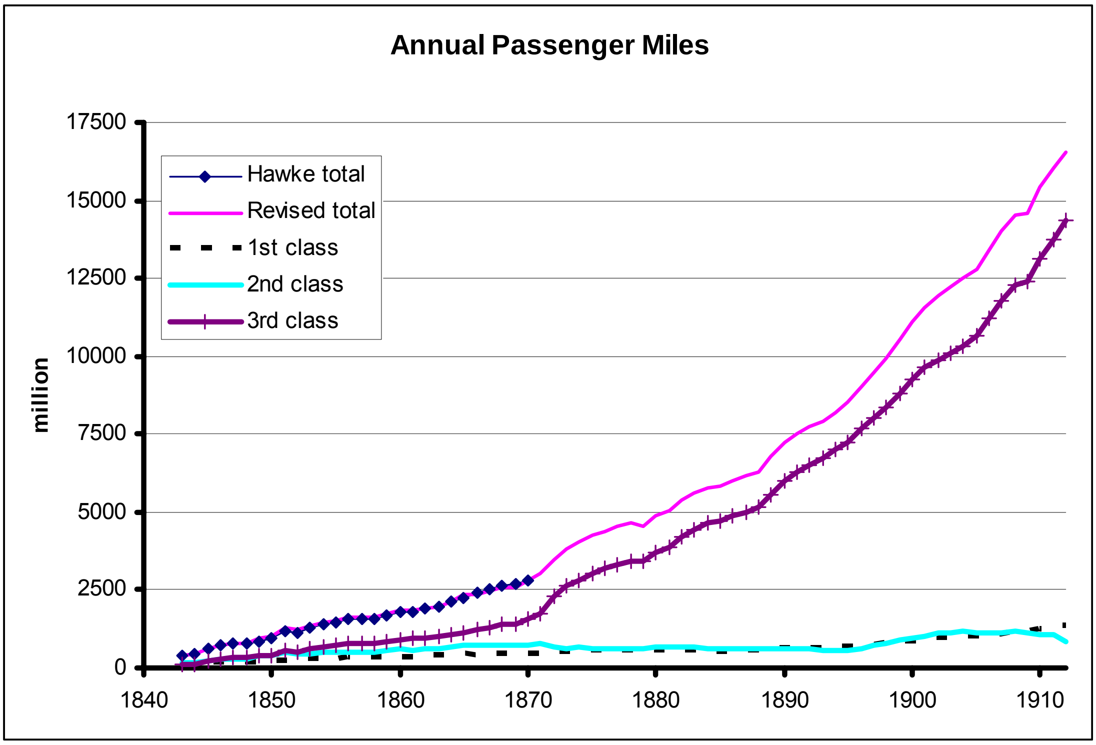
[82] In general there were more companies with undivided passenger mile figures in years in which there were fewer companies submitting no passenger mile data. As such those two increments are to some extent alternatives.

[83] W. M. Acworth and W. T. Stephenson, *The Elements of Railway Economics*, New ed. (Oxford: Clarendon Press, 1924)., p. 207.

which are close enough to our figures of 0.71d and 0.56d.[84] Paish gives fares for the five main railway companies for 1900, which when averaged give 0.775d per mile.[85] This is higher than both our estimate and that of Cain, probably reflecting higher prices on the faster, mainline routes that make up Paish's sample. In short, our figures are plausible, even though they lack the authority of the earlier data. We then divide receipts – given in Railway Returns for all years – by the estimated fares per mile, to give the number of miles travelled in each class.

Figure 1.



Sources: Lardner & Railway Returns.

Second class mileage peaked in 1871, after which time the number of second class passenger miles fell in absolute terms for some years, as railway companies began to move to a two class system (known as first

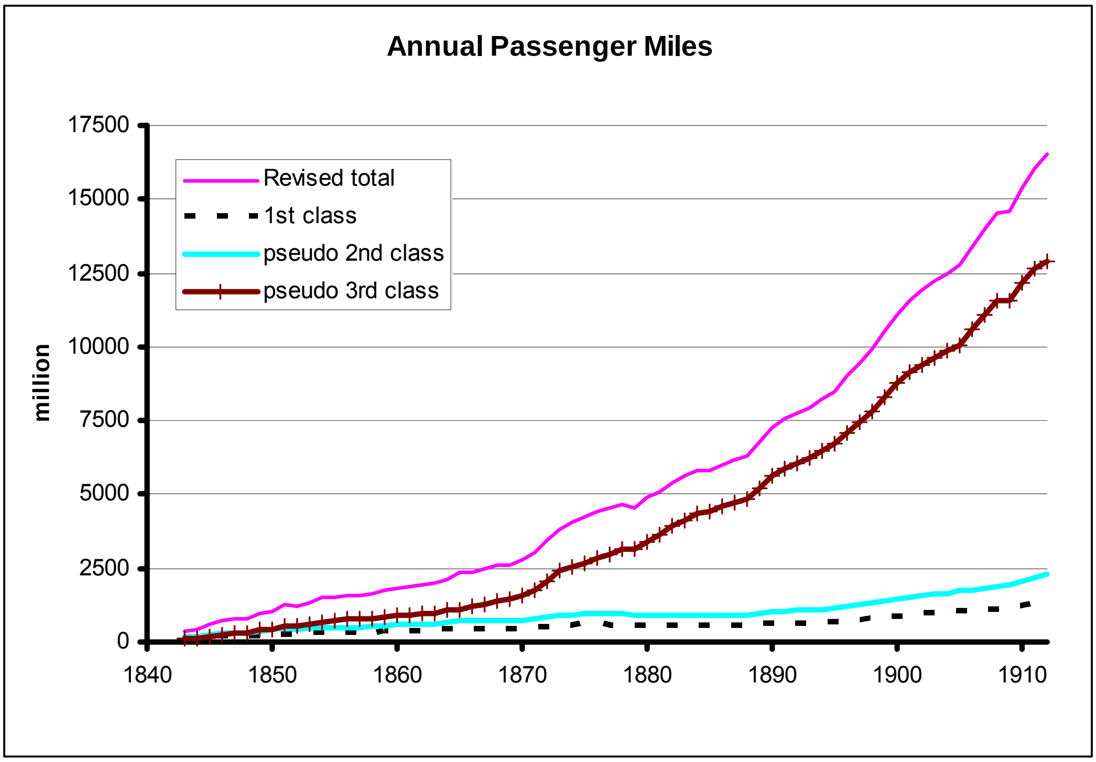
[84] Cain, "Railways.", p. 124.

and third classes). It was the third class, rather than the first, that gained. It would be wrong, however, to assume that people who now travelled third class, but would have travelled second class in earlier years, would have walked in the absence of the railway. To avoid that implication, we construct a pseudo-second class from 1872 onwards, which simply follows first class traffic, at the 1871 1st to 2nd class ratio. The pseudo-third class is then the actual number of third class passengers, less those who are transferred into the pseudo-second class.[86] This procedure raises the monetary social savings estimate, but lowers the value of time saved. For simplicity we refer to the pseudo-second and pseudo-third classes simply as second and third classes from here on. The revised mileages are given in figure 2.

[85] George Paish, *The British Railway Position* (London: The Statist, 1902)., pp. 40, 180, 202, 222 and 285.

[86] The pseudo second class is 50% larger than the actual second class by 1900, while the pseudo third class is 5% smaller than the actual third class. By the end of the period the effect has roughly doubled.

Figure 2.



Sources: Lardner and Railway Returns.

We now know the miles travelled in each year, the railway fares, and the cost of alternative modes of transport. That is sufficient to generate the monetary social savings estimate, which is given in figure three.

Figure 3

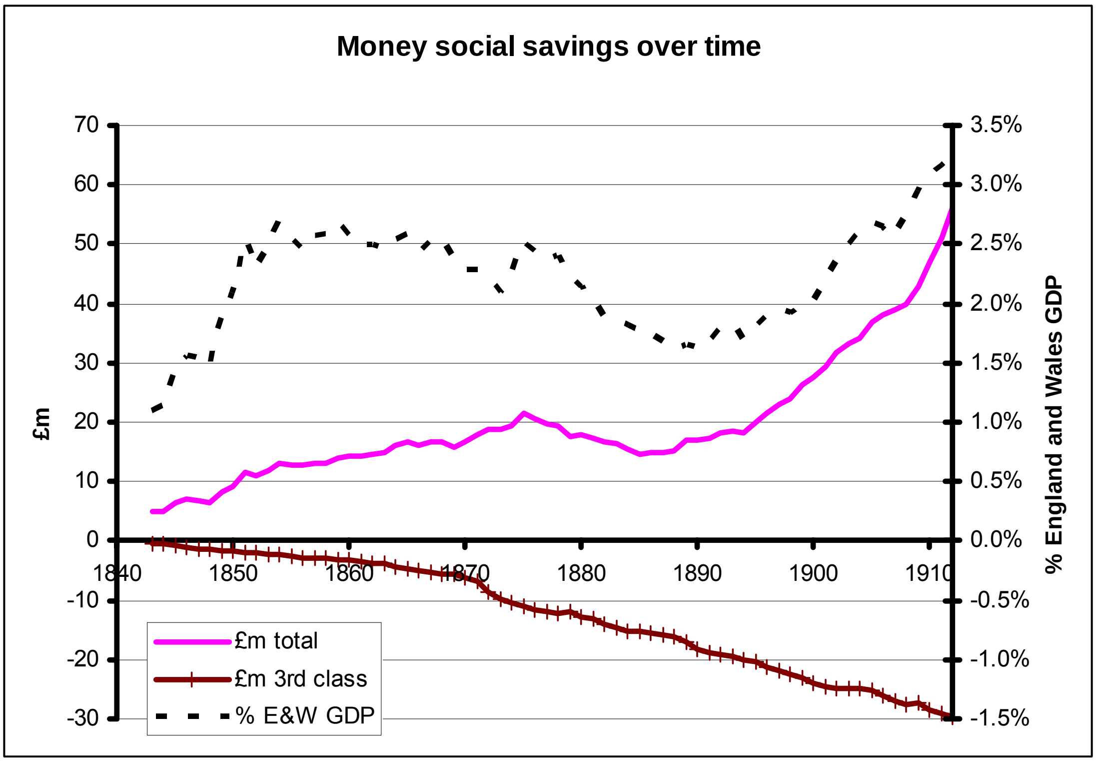


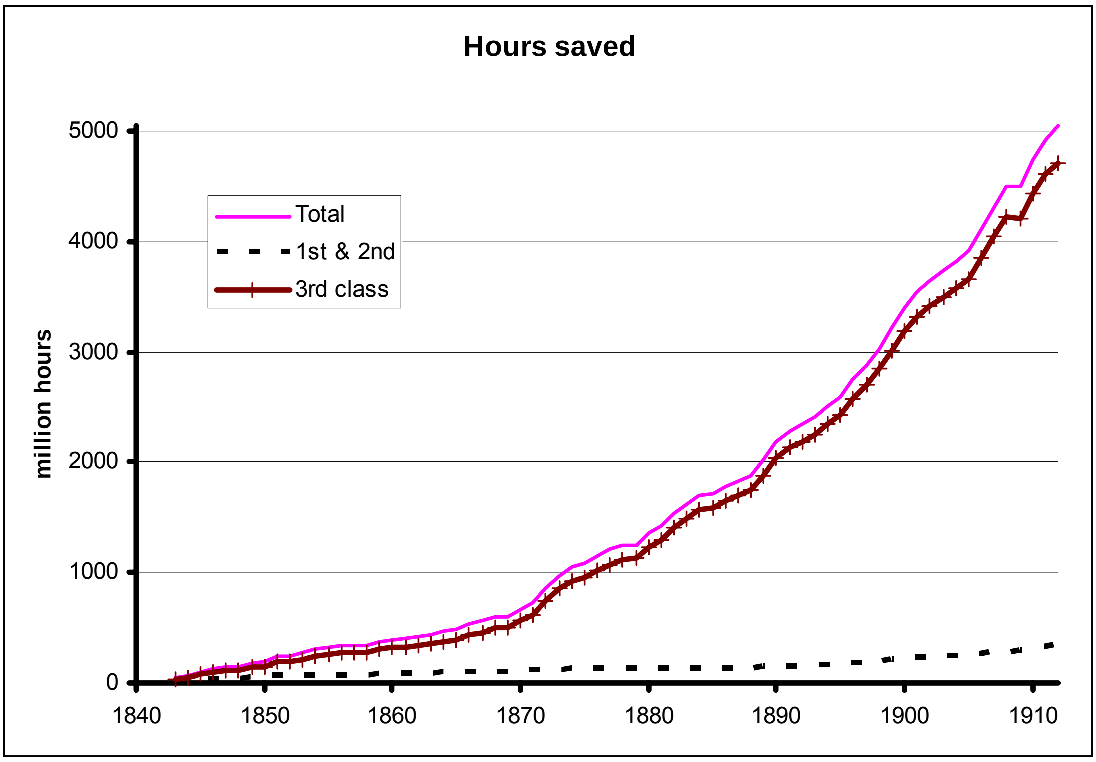
Figure 2 showed that passenger miles rose sixteen fold between 1850 and 1912. Despite this, figure 3 shows that the money social savings rose only six fold. As figure 2 shows, most of the rise in passenger miles was in third class travel. Even when we exclude the proportion of third class passengers who would have travelled second class were it to have been offered, we still have a large rise in the number of people who would otherwise have walked. For this group, the money social saving falls will every extra mile travelled. The increase in fares paid by third class passengers partly counteracted the additional savings made by first and second class passengers, for whom the money cost of travel fell sharply.

Given that we have imposed a linear fall in the price of tickets between 1865 and 1912, we should not place too much confidence in the pattern of savings between those dates. Our initial starting point in 1865 is sound, and our final observation in 1912 is in line with both Acworth and Cain, but the results in between these two dates must be viewed as an educated guess. It is probably most sensible to see social savings rising to 2.5% in the early 1850s, and remaining in that region for the next fifty years.

C: ii

As well as calculating the monetary savings, we are also able to assess the value of time saved. We do this first by combining the data on speeds given in table 8 (with linear interpolations between benchmark years), and the passenger miles given in figure 2. This gives the total number of additional hours needed to make the railway journeys without them.

Figure 4: not including waiting.



Sources: table 8 and figure 2

The number of hours saved rose dramatically over the railway era, from 54 million hours in 1843, to 527 million hours in 1866, and finally to 5 billion hours by 1912, roughly the time worked by 1.8 million workers that year. Here, of course, the number of hours saved rises more sharply over time than passenger miles, since over time an increasing proportion of those travelling by train would otherwise have walked. Even at the very beginning the third class accounted for over half the hours saved, rising to 80% by 1860, and 90% by 1880. As such, the Royal Commission was correct: the poorer classes did benefit most in terms of speed.[87]

We now go on to value these hours. We retain our earlier use of an annual wage of £250 in 1911 for first and second class travellers, projected backwards as appropriate. For third class passengers we noted that Feinstein's standard all-employees working class wage series were too low in 1865. Over the nineteenth century the cost of third class travel fell relative to workers' wages. Whereas in 1865 workers could travel only 3.3 miles on an hour's earnings, in 1912 they could travel 10.4 miles on an hour's wages. That fall in price would have brought train travel into the reach of more people, but rail travel was still around three times as expensive relative to earnings as it is today. Given that today rail travel – and all forms of transport except those such as buses that are dominated by other means of transport – are used disproportionately by the affluent, it is again unrealistic to assume that third class rail travellers would have been a representative cross section of the working class. This fits with the qualitative literature, which notes that railway travel was not used regularly by the working class.[88] That said, the relatively greater affordability in 1912 than in 1865 must mean that the difference between

[87] Parliamentary Papers: Report from Commissioners: Railways, 1867, vol XXVIII, part 1p, liii, para 118.

[88] John Reginald Kellett, *Railways and Victorian Cities*, Studies in Social History (London: Routledge and Kegan Paul., 1979)., ch. XI has a good discussion of the means of transport – walking, horse drawn omnibus, tram – used by the working class.

the average traveller and the average working class person was smaller in 1912 than in 1865. We assume, arbitrarily, that the 1912 premium of travellers to average wages was half that of 1865, with a linear transformation between the two dates.[89] For years before 1865 we use the Chadwick premium, applied proportionately to Feinstein's series. Table 13 gives the value of the 5bn hours of time saved assuming first that all travel is in work time and second that it is all in non-work time. The estimates range from £111m and £190m. As for 1865, neither extreme makes sense, and using the earlier plausible hypothesis that two-thirds of premium and one-third of third class traffic was for business gives a saving of £175m, just over 10% of England and Wales GDP. It is worth noting that even without any work time travel, the value of time saved still represented 9% of GDP on the Chadwick wages.

Table 13: Valuing time saved in 1912

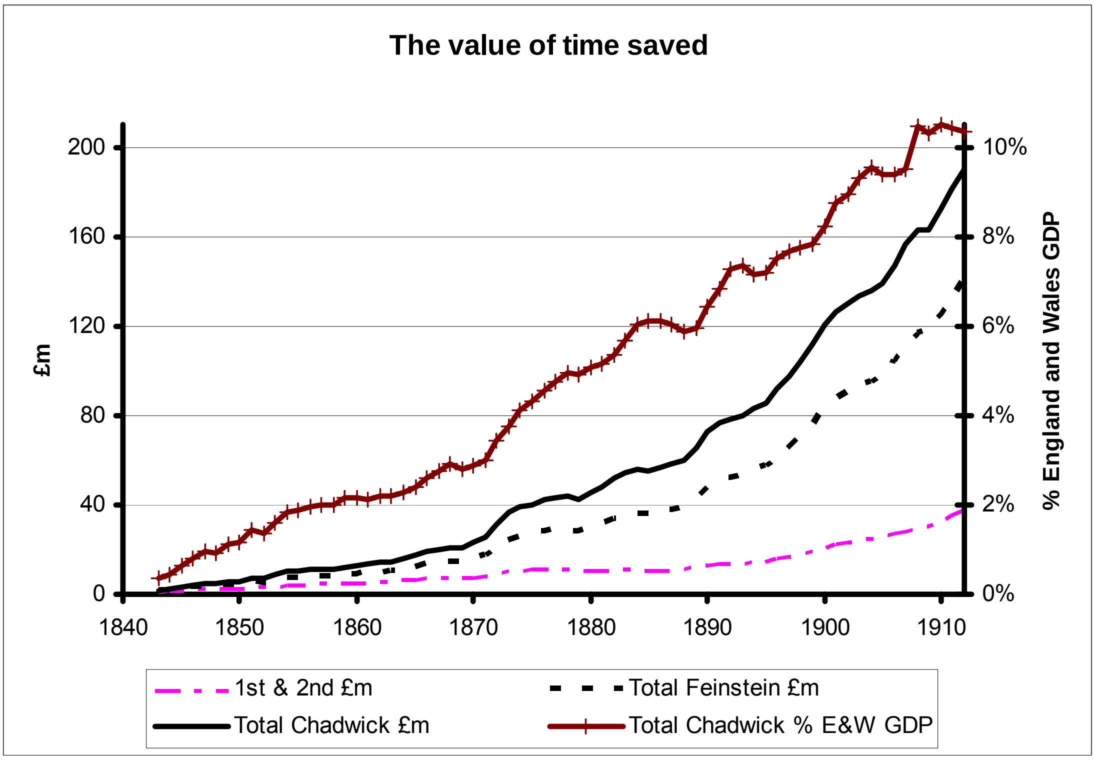
		1st class	2nd class	3rd class Feinstein	3rd class Chadwick	Total
1	time saved (m hours)	126.7	214.3	4707.1		5048.1
2	value of one working hour (d)	26.7		5.2	7.8	
3a	value of time saved (£m)			102.3		140.2
3b		14.1	23.8		152.2	190.1
4	value of one non-working hour (d)	12.3		4.8	7.1	
5a	value of time saved (£m)			94.1		111.6
5b		6.5	11.0		140.0	157.4

Rows 1, 2 and 4: see text; Row 3: row 1 x row 2; Row 5: row 1 x row 4; 'a' indicates using the Feinstein 3rd class value of time; 'b' indicates using the Chadwick 3rd class value of time.

89 The average English person was taking 26 trips per year by the end of the century: such volumes of travel indicate that travellers were people of at least moderate means. Walter E. Weyl, *The Passenger Traffic of Railways*, Publications of the University of Pennsylvania. Series in Political Economy and Public Law ; No. 19 (Philadelphia: Pub. for the University, 1901)., p. 110.

The results for all years are given in figure 5, which for clarity shows the absolute value of time only on the assumption that all travel is during work time. The non-work time estimates can be found by multiplying the work-time estimates by 46% for premium class travel, and 92% for 3rd class travel.[90] The saving relative to national income is given on the more plausible basis outlined in the previous paragraph.

Figure 5



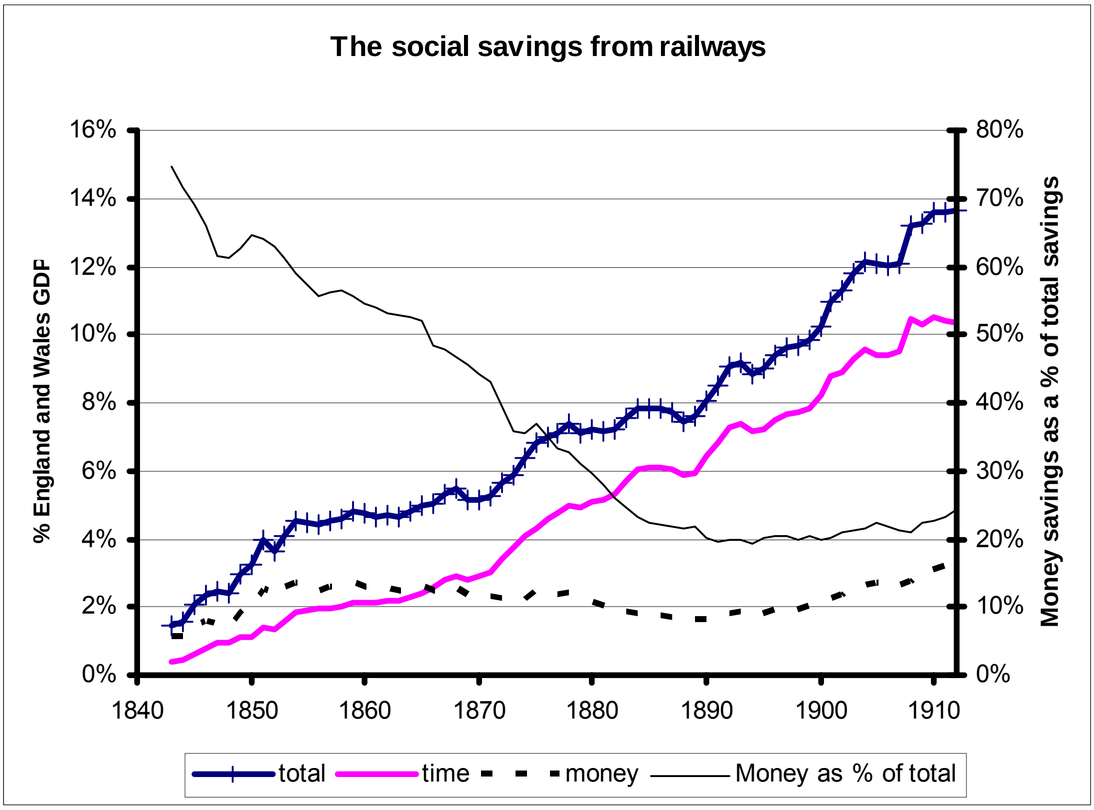
Note: the absolute £m values assume that all travel is during work time. The % GDP values are on the more realistic basis that two-thirds of premium class and one-third of third class travel was during work time.

[90] Crafts, "Regional Gdp.". We interpolate linearly between Crafts' benchmark (Census) years, and use the 1871 ratio of England and Wales to UK GDP for all years prior to 1871.

Part D: Analysing the changing nature and composition of social savings

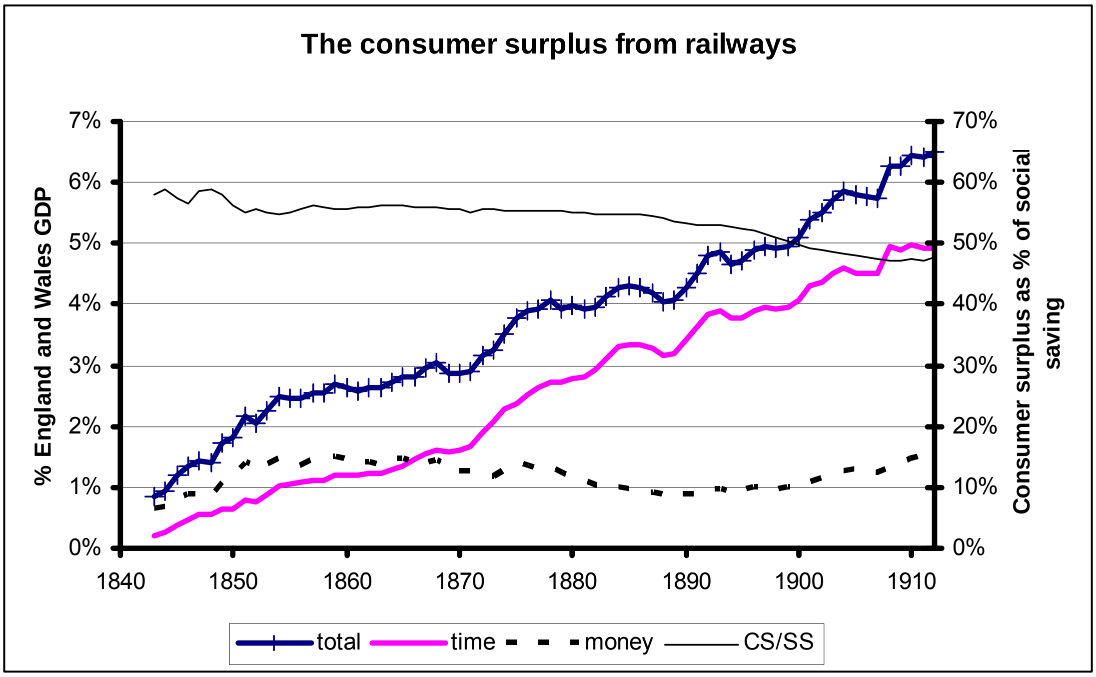
Since we now know both the monetary savings and the value of time savings for each year between 1843 and 1912 we can easily calculate the total social saving generated by railways in England and Wales. The three series – money, time, and total – are given in figure 6. The value of time is based on the earlier plausible assumption that two-thirds of premium and one-third of third class travel was on business. From 1.5% in the early 1840s, the total social saving grew rapidly to reach 4.5% by the mid-1850s, before growing reasonably steadily to reach 13.6% by 1912.

Figure 6



We noted earlier that the social saving overstates the rise in consumer surplus. If travel costs had been as high in 1912 as they were before railways then far fewer people would have travelled. We set out the formula to convert social savings into consumer surplus above, along with our reasons for preferring unitary elasticity. On that basis we calculate the consumer surplus for each year in our period. As figure 7 shows, consumer surplus, primarily from time savings, rose steadily. The rise is not, however, as rapid as the rise in social savings, since the relative price of rail to non-rail travel fell over time. This means that a higher proportion of rail journeys towards the end of the period would not have been undertaken without railways: these are included in social savings, but excluded from consumer surplus. Nevertheless, consumer surplus rises fairly steadily from 1% in 1843 to 6.5% in 1912.

Figure 7



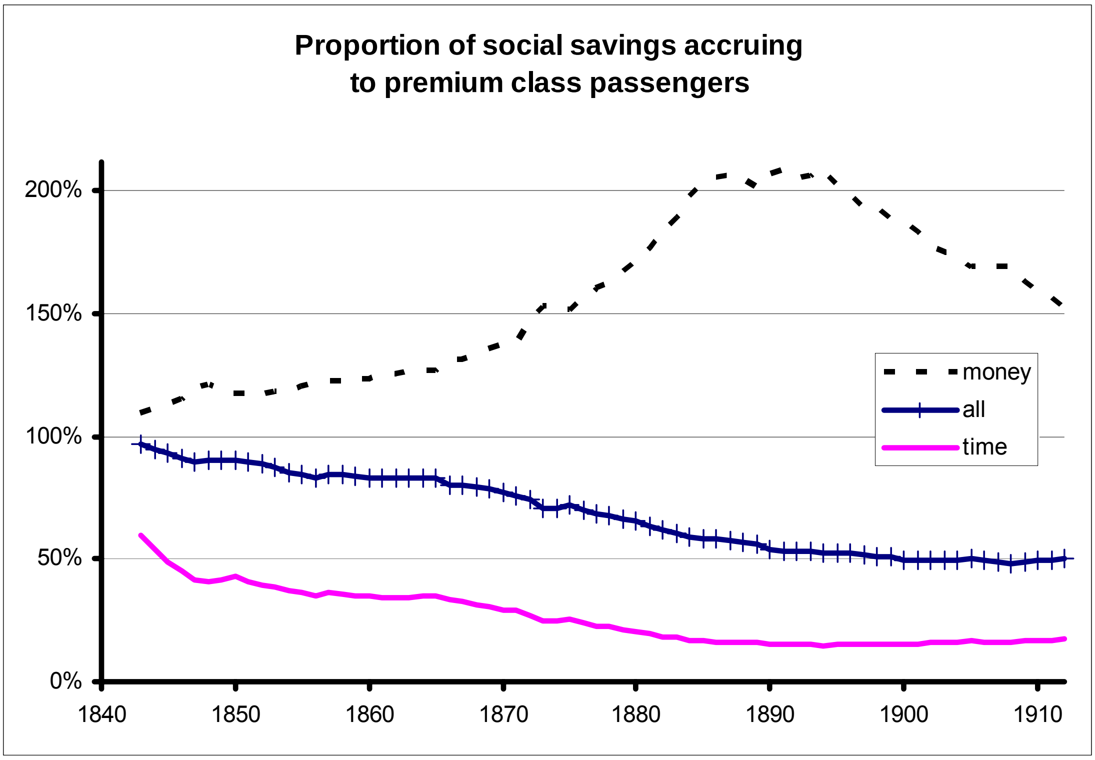
Note 'CS/SS' is the ratio of the consumer surplus gain to the social saving gain, using unitary elasticity and the Fogel formula set out earlier.

D: i

As figure 6 shows, the ratio of money to total savings fell over time, from three-quarters at the beginning, to one half in 1866, to 25% in 1883, after which it stabilised between 20-25% until 1912. The rise in the importance of time relative to money savings reflects the changing nature of the railway in this period. Initially railway companies saw the railway as an alternative to coaching, and offered services that were priced and structured accordingly. But from 1870 onwards, railways became an ever more mass market commodity, whereby train companies often aimed to make a profit by conveying many people, relatively cheaply, at high load factors. We can see this transition in figure 8, which gives the percentage of total social savings that went to premium class travellers. This pattern may have been a peculiarly British phenomenon, since we know that railway penetration was much less extensive in other countries.[91]

[91] For example, while England had 26.5 journeys per capita in the mid 1890s, the figure for France was 9.1, lower than the level reached in England in 1864. France was low even by continental standards, but nonetheless, Belgium, Denmark, Prussia, Netherlands, Saxony, Sweden and Switzerland all lagged significantly behind England in the number of journeys per head, and thus, almost certainly, in the proportion of people who travelled by train at some point. Weyl, *The Passenger Traffic of Railways*., chapters VIII & IX.

Figure 8



Initially premium passengers gained almost all of the benefit – they represented the majority of the traffic, and, at the initial price and speed combinations, third class passengers did not gain a large amount of surplus per mile travelled. Over time, however, the third class became a larger share of total travel, and the rise in speed and fall in prices increased the gain per mile for third class passengers. As such, the premium passengers' share of gains fell steadily to around a one-half from the mid-1890s onwards. When, however, we look at the two different types of saving, very different pictures emerge. The premium class passengers always gain more than 100% of the monetary social saving, since for third class passengers the railways are more expensive than the alternative. But for time savings the position is very different. Not withstanding that the time of premium passengers is valued much more highly per hour, the share of the value of time saved by premium passengers fell sharply from three-fifths in 1843 to around two-fifths by

1850, followed by a steadier decline to one-sixth by 1885, after which it stabilised.

This pattern fits with what we know about technological adoption. In the initial period, new technology is used in the same way as the previous technology. In this case, railways were used to carry the well-to-do in comfort, while conditions for those in the third class were very poor, both in terms of comfort and convenience.[92] Only from 1870 did the railways, in part under pressure from legislation, and in part under the threat of nationalisation, appreciate the potential of third class travel, and offer better conditions, greater frequency, and lower fares. Economies of scale, in terms of adding extra carriages to services, and extra services to routes were the economically sensible strategy in a high fixed cost environment. At that point trains became a 'new good' for many. Whereas before many people could not have realistically expected to travel at all, given prohibitive coaching costs, and the high cost of walking in terms of time out of the labour market, they could now travel, and they did. As such, social savings and consumer surplus increased as a share of GDP, as did the share that came from time saved, and the share that went to those new travellers in third class.

This continued increase in the value of railways to society long after their invention and adoption fits with what we know about other so-called 'general purpose technologies'. David has shown how initially electricity had only limited effects on business: it was only when factories reorganised production to take account of the possibility of unit drives that the productivity revolution occurred.[93] The same intuition underlies the earlier Solow productivity paradox, that we could see computers everywhere except in the productivity numbers. In the railway case it was

[92] Bagwell, *The Transport Revolution from 1770.*, p. 107-110.
[93] Paul A. David, "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," *Technology and Productivity: The Challenge for Economic Policy,* ed. OECD (Paris: OECD, 1991).

only when train companies realised that the best use of railways was for mass transport, including high load factor commuting and excursion traffic, that society was able to reap the full benefits. It is an open question as to whether the time lag between the railway's invention and its use as a mass transit system was caused by technological bottlenecks, such as inadequate engine power limiting train lengths, or by a significant entrepreneurial failure on the part of railway managers, who failed to see a new market until surprisingly late.

There is another way in which these findings fit well with the more general literature on technology. Nordhaus has shown that, on average, postwar American entrepreneurs in the non-farm sector captured only 2.2% of the total benefit to society from new inventions. The remaining 97.8% went to consumers as additional consumer surplus.[94] Arnold and McCartney have recently compiled data on the return on capital employed for UK railways. They conclude that although returns were initially reasonable, 'From that date [1872], however, through to the outbreak of war in 1914, the industry's results, and the returns it was able to provide to its investors, were consistently disappointing.'[95] Although it is not possible to directly compare the percentage rate of return on capital employed with the estimates of social savings or consumer surplus presented here, it is clear that ex-post average returns of under 4% on capital employed imply little if any monopoly power, and were far smaller in absolute terms than the average consumer surplus of 3.7% of GDP over the same period.

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[94] William D Nordhaus, "Schumpeterian Profits in the American Economy: Theory and Measurement," *NBER Working Paper* 10433 (2004).
[95] A.J. Arnold and S. McCartney, "Rates of Return, Concentration Levels and Strategic Change in the British Railway Industry, 1830-1912," *Journal of Transport History* 26.1 (2005). pp. 54-5.

Conclusions

This paper makes a number of contributions. First it shows that the passenger savings numbers put forward by Hawke cannot be sustained. The use of an erroneous figure for posting means that Hawke's figures need to be reduced by almost one-half. Furthermore, we have produced evidence that those travelling third class would have walked in the absence of the railway. Taking this into account reduces the monetary gain further, to 2% of UK GDP, or 2.6% of England and Wales GDP, a little over one-third of the value given by Hawke. We also extended the social savings series to 1912. Although the price data – which is used to convert total receipts into passenger miles – is not as reliable as for the earlier period, we show that the overall monetary cost savings to railway passengers remained roughly constant as a share of GDP from the 1850s onwards.

We assessed railway speeds more accurately than has been done before. Train speeds rose from 19 mph in 1843 to 29 mph in 1912, on a 'crow-flies' basis. Within that, speeds on important journeys rose much more rapidly, from 21 mph to 37mph, while speeds on minor routes rose much less, from 18 to 21 mph. Including the 'in vehicle time equivalent' of the wait for the train, we find that the average speed increased from 14mph to 22mph, with core route speeds rising significantly from 18 to 32 mph, and minor route speeds only rising from 11 to 13mph. It would have taken an extra 50m hours in the early 1840s, 500m hours in the mid-1860s, and 5bn hours by 1912 to undertaken the journeys made by railways without them.

This paper then went on to value that increase in speed, using modern transport economics. We find that the social saving of time saved rose steadily from under 0.5% of GDP initially, to 10% by 1912. Although the quality of the post-1870 data is weaker than in the earlier period, the size of the results found here means that there can be no doubt that the value of time saved rose dramatically as the period progressed.

Whilst initially money savings outweighed the value of time savings by a factor of almost three to one, the two became of equal magnitude in the mid-1860s. The importance of time savings continued to rise until the mid-1880s, when they outweighed the monetary savings by a factor of three. Time savings then fluctuated between three and four times the value of monetary savings until 1912. We find a similar, and related change, in the distribution of gains across classes. Until the mid 1860s those who would otherwise have walked did not gain dramatically: the value of their time saved was little more than the cost of their fares. From that point on, their share of the total social saving rose steadily to become one-half of the total by the mid-1890s.

Railways represented a dramatic change in transport technology. The cost of travel fell significantly, and its speed and comfort rose dramatically. People who could never have expected to travel at all in their lives were able to do so for the first time. And those who did travel were able to do so more often. This paper does not claim to measure all of the benefits of railways to travellers, let alone to the economy or society as a whole. But it does claim to have calculated the social savings and consumer surplus of railways from fare and time savings. Those figures show that the contribution of railways relative to national income continued to rise over in the Victorian and Edwardian eras, as rail companies discovered new and better ways to make this technology valuable to society. As the period progressed railways offered poor returns to investors, but they delivered tremendous welfare gains to travellers and to society.

Appendix 1: 50 core routes

Birmingham-Dudley, Leeds-Bradford, Liverpool-Birmingham, Liverpool-Leeds, Liverpool-Preston, Liverpool-Sheffield, London-Bath, London-Birmingham, London-Bradford, London-Brighton, London-Bristol, London-Cambridge, London-Canterbury, London-Cardiff, London-Chatham, London-Colchester, London-Coventry, London-Derby, London-Dover, London-Hull, London-Ipswich, London-Leeds, London-Leicester, London-Liverpool, London-Maidstone, London-Manchester, London-Newcastle, London-Northampton, London-Norwich, London-Nottingham, London-Oldham, London-Oxford, London-Plymouth, London-Portsmouth, London-Preston, London-Reading, London-Sheffield, London-Southampton, London-Wolverhampton, Manchester-Birmingham, Manchester-Blackburn, Manchester-Bolton, Manchester-Bradford, Manchester-Leeds, Manchester-Liverpool, Manchester-Macclesfield, Manchester-Oldham, Manchester-Preston, Manchester-Sheffield, Manchester-Stockport

Appendix 2: 222 towns.

Abergavenny, Alderley Edge, Alfreton, Altrincham, Andover, Ashford, Ashton-Under-Lyne, Barnsley, Barnstaple, Barrow, Barry, Basingstoke, Bath, Bedford, Berwick, Beverley, Birkenhead, Birmingham, Blackburn, Blackpool, Blyth, Bolton, Bournemouth, Bradford, Bridgnorth, Bridgwater, Bridlington, Brighton, Bristol, Bromsgrove, Burnley, Burslem, Burton on Trent, Bury, Buxton, Cambridge, Cardiff, Carlisle, Carnarvon, Castleford, Caterham, Chatham, Chelmsford, Cheltenham, Chertsey, Chester, Chesterfield, Chichester, Chorley, Cirencester, Clevedon, Coalville, Colchester, Colne, Colwyn Bay, Conway, Coventry, Cowes, Crewe, Darlington, Dartford, Dartmouth, Darwen, Denton, Derby, Dewsbury, Doncaster, Dorchester, Dover, Driffield, Dudley, East Grinstead, Eastbourne, Eccles, Exeter, Felixstowe, Fleetwood, Folkestone, Garston, Gateshead, Glossop, Gloucester, Grantham, Gravesend, Grimsby, Halifax, Hanley, Harrogate, Hartlepool, Hastings, Hereford, Heywood, Hinckley, Huddersfield, Hyde, Ilkeston, Ipswich, Jarrow, Keighley, Keswick, Kettering, Kidderminster, Kings Lynn, Kingston upon Hull, Kingswood, Kirkby Lonsdale, Lancaster, Leamington, Leeds, Leek, Leicester, Leigh, Leighton Buzzard, Lewes, Leyland, Lichfield, Lincoln, Liverpool, Llandudno, Llanelly, London, Long Eaton, Longton, Loughborough, Lowestoft, Luton, Lyme Regis, Macclesfield, Maidstone, Malvern, Manchester, Mansfield, Margate, Merthyr Tydfil, Middlesbrough, Middleton, Mirfield, Nantwich, Newark, Newcastle, Newcastle under Lyme, Newmarket, Newport, North Shields, Northampton, Northwich, Norwich, Nottingham, Nuneaton, Oldham, Oxford, Padiham, Peterborough, Plymouth, Pontypool, Pontypridd, Portsmouth, Preston, Radcliffe, Ramsgate, Reading, Reigate, Rochdale, Rochester, Rodwell, Rotherham, Rugby, Runcorn, Sale, Scarborough, Seaford, Selby, Sheffield, Shipley, Shrewsbury, Sleaford, Smethwick, South Shields, Southampton, Southport, Sowerby Bridge, St Annes, St Helens, St. Albans, St. Austell, Stafford, Stalybridge, Stockport, Stockton-on-Tees, Stoke on Trent, Stroud, Sunderland, Sutton Coldfield, Tamworth, Taunton, Tewkesbury, Torquay, Tredegar, Tunbridge Wells, Tunstall, Ulverston, Wakefield, Wallasey, Wallsend, Walsall, Warrington, Warwick, Watford, Wellingborough, West Bromwich, Weston super Mare, Widnes, Wigan, Wilmslow, Windermere, Wisbech, Woking, Wolverhampton, Worcester, Wrexham, Yarmouth, York

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