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Working Paper 19673
http://www.nber.org/papers/w19673

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2013

We are particularly grateful to Gareth Austin, Emmanuel Akyeampong and Bill Summerhill for their detailed comments and suggestions. We also thank seminar participants at the WCFIA Conference on African Development in the Longue Durée at Akwapim, Ghana, and the Harvard Economic History Seminar, particularly Toke Aidt, Joseph Inikori, Noel Maurer, Joseph Miller, and Peter Temin. We also thank María Angélica Baustista and Leander Heldring for their invaluable research assistance. We thank the WCFIA for their financial support. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Reinventing the Wheel: The Economic Benefits of Wheeled Transportation in Early British Colonial West Africa

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NBER Working Paper No. 19673
November 2013
JEL No. N77,O33,R40

ABSTRACT

One of the great puzzles of Sub-Saharan African economic history is that wheeled transportation was barely used prior to the colonial period. Instead, head porterage was the main method of transportation. The consensus among historians is that this was a rational adaption to the underlying conditions and factor endowments. In this paper we undertake the first systematic investigation of the relative costs of the different forms of wheeled transportation in Africa. We focus on calculating the social savings and social rate of return associated with the introduction of the railway into colonial British West Africa. We provide more speculative estimates of the social savings of other forms of wheeled transportation. We find that all forms of wheeled transportation were economically efficient in the sense that they increased national income, though the estimated social savings of railways were modest when compared to GDP. However, we also find that the social rate of return of railways was exceedingly high, with annual social returns being equivalent to the entire capital outlays in Nigeria, i.e., railways there had a social rate of return of around 100%. Contrary to the conventional wisdom, railways appear to have been a very good social investment in West Africa because they were cheap to build. We discuss some alternative hypotheses that may nevertheless account for why they were not adopted.

Isaías N. Chaves
Stanford University
Department of Economics
579 Serra Mall.
Stanford, CA 94305
isa.chaves.v@gmail.com

Stanley L. Engerman
Department of Economics
University of Rochester
Rochester, NY 14627-0156
and NBER
s.engerman@rochester.edu

James A. Robinson
Harvard University
Department of Government
N309, 1737 Cambridge Street
Cambridge, MA 02138
and NBER
jrobinson@gov.harvard.edu

1 Introduction

Today Sub-Saharan Africa is the poorest part of the planet. Though it is debated just when the gap between Africa and the rest of the World developed it is clear that Africa lagged behind Eurasia in terms of many of the key building blocks of economic growth. One can see this in the factors that go to determine income, for example literacy and human capital, but it is perhaps most evident in technology. The basis of the modern economic growth which emerged in Britain in the late 18th century was technological innovation and the Industrial Revolution had itself built on a long incremental series of innovations in agriculture, transportation and elsewhere in the economy which had made it possible. Many of these innovations did not take place in Africa. For example, outside of Ethiopia, no African country innovated the plow and systems of writing were also restricted to the same region, though also encompassing the Sudan and Somalia. Also absent was the wheel.

The fact that wheeled transportation was not used in Sub-Saharan Africa until the early colonial period is paradoxical because it is well established that African societies knew about the wheel from the early modern period onwards.[1] They did not have to reinvent the wheel, only adopt it. Law (1980) documents many cases where Europeans gave gifts of wheeled transportation to different African kings and wheeled carriages were in use in Dahomey from at least the 18th century and were even produced there. Nevertheless, wheeled vehicles did not spread out of ceremonial uses with the exception of a small amount of military use.

Why did African societies not adopt a technology which seems to promise huge economic benefits in terms of reduced costs of transportation?[2] That such cost savings existed was certainly believed by early colonial officials and Europeans in the 19th century who noted this failure to adopt the wheel. In the absence of wheeled transportation the majority of goods were transported by head poterage. British colonial diplomat Sir Gerald Portal noted in 1903

> "As an animal of burden man is out and out the worst. He eats more, carries less, is more liable to sickness, gets over less ground, is more expensive, more troublesome, and in every way less satisfactory than the meanest four-footed creature that can be trained, induced, or forced to carry a load." (quoted in Clifford, 1920,

[1] See Piggott (1983) for a history of the use of wheeled transportation and Bulliet (1975) for how the introduction of the camel into the trans-Saharan trade led to the abandonment of the use of wheeled transportation on that route.

[2] As Goody (1971) and Austen and Headrick (1983) point out this does not exhaust the puzzles surround the non-adoption of the wheel in Africa since neither potter's wheels nor spinning wheels were adopted either.

p. 151)

The consensus view about the absence of wheeled transportation on the development of West Africa is well summed up by the report that the then Secretary of State for the Colonies Ormsby-Gore made to Parliament in 1926. For instance commenting on transportation difficulties in various parts of Nigeria where he went he notes (1926, pp. 24-25)

> "The Province of Ogoja contains an estimated population of between 600,000 and 700,000 people who are producing little or nothing for export, and a low standard of life obtains. Until Ogoja is opened up by a network of roads ... there can be little trade with its consequent stimulus to production, and the real development of the Province has not yet begun."

Later he comments (p. 29)

> "In British West Africa there is still too much of the most obsolete and expensive form of transport. I refer to the wide use of head porterage."

Indeed, as late as 1980 one could read in a textbook treatment

> "At first, head porterage had to be used for carrying imports; and palm oil was sent to the coast by the curious and expensive method of barrel-rolling. Porterage was a social evil, a political danger and an economic waste." (Church, 1980, p. 152).

The fact that such an incredibly labor intensive system of transportation should be used in a continent widely argued to be 'labor scarce' (Herbst, 2000, Austin, 2008) only deepens the puzzle. Portal's view was widely shared by early colonial officials who not only took it for granted that the absence of wheeled transportation was disastrously inefficient but they produced numbers to prove it.

Most of these officials gave no explanation for why African's chose not to adopt a technology which they regarded as massively superior to the alternatives in use. The first attempt to provide such an explanation appears to be McPhee (1926). Though Portal notes how unhealthy human porters were, McPhee in essence argued that at least in the forest zone of Africa, the presence of the Tsetse fly meant that draught animals could not be used. This, he claimed,

made wheeled transportation uneconomical. His argument is rather equivocal however since the relevant chapter of his book attempts to show in some detail that road and rail transportation were far superior to head porterage. He seems to take it for granted that Africans could not have built motorable roads or railways. He also explicitly points out that on the basis of Lugard's 1919 report on the amalgamation of Northern and Southern Nigeria for Northern Nigeria

> "Strangely enough, although there are over 3,000,000 cattle, 176,000 donkeys, 113,000 horses and 4,000 cattle, yet such a thing as a cart may be said to be unknown." (McPhee, 1926, p. 121)

Therefore, though the argument about the Tsetse fly is obviously relevant, it can at best only be a very partial solution to the puzzle. McPhee's discussion was augmented by Hopkins (1973) who in addition argued that the cost of building roads through the forest zones was so high that this also made wheeled transportation uneconomical. Ogunremi (1975) also claims that head porterage was economically efficient since labor was not really scarce and he claims that the calculations made by Lugard and others are misleading because they ignore the huge capital costs involved in constructing railways. In essence McPhee to an extent, but certainly Hopkins and Ogunremi respond to the puzzle of the non-adoption of wheeled transportation by asserting that it is not a puzzle and that in fact it was an economically rational decision given the circumstances.[3]

There are some obvious problems with these existing explanations. First, and most obviously, none of them is based on any real calculation or what was or what was not economically rational. Second, while it is obviously correct that the impact of the Tsetse fly made it difficult to use draught animals in large parts of central Africa,[4] wheeled transportation was not used in areas where there was no Tsetse. This is true not just in Southern Africa but also in the Sahel or Northern Nigeria. Third, as Portal's remark notes, humans were very unhealthy as well, so what is relevant is the relative health of animals compared to humans not the absolute health of animals in the Tsetse zone. Finally, Hopkins's claim that wheeled transportation was not adopted in the forest zone because roads were uneconomical to build runs into the problem that African polities in the forest zone did indeed build such roads. Most notably,

[3]See Basu and Weil (1998) and Acemoglu and Zilibotti (2001) for formalizations of the idea of appropriate technology.

[4]Witness the enormous and costly lengths which the Oyo Empire had to go to to keep thier cavalry safe from the ravages of Tsetse (see Law, 1977).

Wilks (1989) discusses in detail the great roads of the Asante Empire in the Gold Coast in the first half of the 19th century,[5] and Reid (2002) does the same for the roads built by the Buganda state. Yet neither the Asante nor the Buganda states used wheeled transportation.

In this paper we conduct to our knowledge the first attempt to bring systematic evidence to bear on the question of whether wheeled transportation was economically rational in Sub-Saharan Africa. We focus on the three British West Africa colonies of the Gold Coast, Nigeria and Sierra Leone because the British colonial state recorded in great detail the costs of constructing and maintaining different transportation systems. Though we examine the efficiency of various types of wheeled transportation, including carts and motor vehicles, the bulk of our analysis focuses on railways. Railways of course embody not just wheels, but also other technologies, such as iron smelting and casting and steam engines. Our focus is motivated by the fact that we have very comprehensive information for the amount of goods and passengers which the railways carried, which we do not have for any other method of transportation. We also know a great deal about the capital expenditures, the neglect of which has been used as a critique of earlier estimates that head porterage was inefficient. In addition, this focus allows us to make comparisons with the rich literature in economic history which has examined the economic impact of railways. Our methodology is the canonical one based on that of Fogel (1964).[6]

Our basic findings are very contrary to the conventional wisdom. First, all forms of wheeled transportation were economically rational in the sense that they generated positive social savings, implying that their adoption would have increased national income. In the case of railways the social savings for goods traffic as a % of GDP range from a low of 0.8% in the Gold Coast in 1909 to a high 12.5% for Nigeria in the same year. For passenger traffic the numbers are smaller, basically zero. Second, and more important, the social rate of return on railway construction was incredibly high. This calculation explicitly takes into account the capital expenditures, one the bones of contention in the existing literature. We find that social rates of return were uniformly high averaging over 100% in Nigeria, implying that the social

[5]The early colonial officials who deplored the backward state of transportation in Africa seem not to have been aware of these roads. In his discussion McPhee (1926, pp. 106-107) for example notes "At the beginning of the last century no proper roads existed anywhere in West Africa ... The earliest roads, not much better than rough tracks which were liable to be obliterated within a year by forest growths, were military roads. Thus Sir Garnet ... Wolsley constructed a road into the heart of Ashanti during the War of 1873-1974. Throughout the whole century very little progress was made."

[6]Tsey (1986) in his analysis of the expansion of railways in the colonial Gold Coast observed that one could undertake such an exercise but he chose not to do so.

savings in any year were equivalent to the entire capital outlays up until then. Elsewhere they were lower but were close to 50% for both the Gold Coast and Sierra Leone for much of the period. Our estimates therefore provide no support for the idea that wheeled transportation was not adopted in Sub-Saharan Africa because it was not an appropriate technology.[7] Indeed, far from it being the case that railways were not appropriate because they were expensive to build in African conditions, in fact they were cheap to build, and this is why the social rates of return are so high. This is consistent with the recent findings of Jedwab and Moradi (2011) who find that colonial railway construction in the Gold Coast had a powerful effect on exports and development.

If wheeled transportation was economically efficient and generated very high social rates of return, why was it not adopted? In the case of railways at least we can identify three types of explanation. The first is the obvious one that it was very difficult to construct such large public works as railways without sufficient political centralization. We illustrate this argument in Sierra Leone. The second, comes from thwarted attempts by a mission from the Asante state in Ghana to contract British engineers in London to build a railway in 1895. This attempt, part of a larger program of modernization in Asante after 1874 was blocked by the British colonial secretary Joseph Chamberlain. The likely explanation is that Britain did not want autonomous modernization of African polities. African states considering adopting railways needed to rely on foreign capital, engineers and expertise. This was normal in the 19th century, railways in Latin American and the Middle East were built with foreign capital and expertise. But at the time of the scramble for Africa European powers wished to control this type of technology adoption, whereas they had much less interest in doing so in Latin America and the Middle East. The third explanation comes from the rich evidence on the one independent African polity which actually built a railway, Ethiopia. Here the evidence clearly shows that the Ethiopians were very concerned that the construction of the railways from Djibouti up to Addis Ababa ran the risk of precipitating a process of colonial domination and conquest.

The paper proceeds as follows. In the next section we discuss some of the estimates of the costs of transportation made by colonial officials and administrators in the early 20th century. This evidence, which certainly suggests that head porterage was inefficient, is typically very incomplete since it is not clear exactly what is involved in the calculation or how representative

[7]At some level this is not very surprising. Technological differences today, as captured by total factor productivity, are at the heart of differences in income per-capita between Africa and the rest of the world (Hall and Jones, 1999, Acemoglu, Johnson and Robinson, 2001) and few believe that such differences are efficient.

any of the information is. In section 3 we discuss what data is available to undertake this calculations in the British colonies of the Gold Coast, Nigeria and Sierra Leone. Section 4 then uses this data to provide estimates of the social savings from the introduction of the railways in these three colonies and we also provide some more speculative estimates of the social savings associated with other simpler forms of wheeled transportation. Section 5 then focuses on the social rate of return of the railways. Section 6 then discusses in more detail the evidence for why African states in the 19th Century did not adopted economically superior transportation technology. Section 7 concludes.

2 Contemporary Discussion and Existing Evidence

British colonial officials were in little doubt that the lack of wheeled transportation was a major impediment to economic progress in West Africa. To demonstrate this they produced a whole range of different numbers which were then constantly repeated over the years. Some of these are summarized in Table 1.

Unfortunately, in all the cases we have found it is never clear exactly how these estimates were constructed and therefore what went into them. Ormsby-Gore's numbers, for example, are introduced by noting that (1926, pp. 29-30)

> "At Zaria, in Northern Nigeria, I was provided with some carefully compiled figures regarding the cost of different forms of transportation per ton mile. Head porterage in an area where labour is plentiful and cheap works out at 2/6 per ton mile; motor transport at 1/- per ton mile; donkey transport at 11d; camel transport at between 9d and 10d; while the railway takes baled cotton from Zaria to Lagos at under 2d per ton mile."[8]

These numbers were widely reproduced, for example Hailey (1938, p. 1540). Yet Ormsby-Gore gives no further information about who gave him these figures or what sources they used to calculate them. Clearly, taken at face value, these numbers suggest that head porterage was extremely inefficient. According to these numbers, while the cost of shipping freight by railway was 2 pence per ton mile, head porterage cost 2 shillings and 6 pence, or was 15 times more costly!

[8]The notation d. means pence, s. means shillings, there were 12 pence in a shilling and 20 shillings in a pound.

Sir Frederick Lugard (1922, p. 461) similarly regarded head porterage as extremely inefficient

> "For uncounted centuries the African has been his own beast of burden, and a simple calculation shows that the cost of land transport by such means with a wage rate of 9d. per day is about 3 shillings per ton mile."

This number is also very widely reproduced. In a footnote Lugard notes that this calculation is based on assuming that a porter carried 65lbs and could walk 12 miles a day and is then adjusted upwards to allow for sickness and supervision. He also observes that "for bulky loads the cost is much more". Elsewhere Lugard (1922, pp. 462-463) remarks that "a railway train of average capacity and engine power will do the work of 13,000 carriers at one twentieth of the cost."

Other calculations suggest similar things about the relative efficiency of different forms of transportation. For example, the numbers taken from House of Commons (1909) come from an extensive survey of methods of transportation in the entire British empire undertaken by the Secretary of State for the Colonies. In this survey, undertaken in 1907, the Governors of the different colonies were requested to provide information to a standardized set of questions about the nature of transportation in their colonies. The information provided for the Gold Coast, presented by E.F.W. Wilkinson, acting director of public works suggests that transportation by head porterage cost 3 shillings and one pence to 5 shillings per ton mile (House of Commons, 1909, p. 43). These figures are as much as twice those for Zaria, perhaps indicating the relatively labor scarcity of the Gold Coast in that period. They are however consistent with Lugard's numbers.

For our purposes at the moment the most interesting comparison is between head porterage and the railways.[9] These oft quoted numbers suggest that head porterage was about 15 to 20 times as costly as the railway. Yet it is not clear how these numbers were constructed. Most crucially, it is not clear whether they factor in the large fixed cost of constructing the railway or whether they are based just on the variable cost. Since it is precisely the large cost of constructing modern transportation systems in West African conditions which Hopkins (1973) argued made them economically irrational we need to assess the efficiency of different systems

[9]Forms of transportation other than head porterage were very important in different pre-colonial contexts. For instance Hill (1972) describes how tobacco produced in Katsina in Northern Nigeria was shipped as far south as Ilorin using donkeys and the great kola trade between Nigeria and Ghana was carried out mostly by donkey (Lovejoy, 1982).

of transportation taking these costs into account - something we will do by calculating the social rate of return.

3 The Data

3.1 Railways

The survey for a railway was carried out in 1893-94 in Sierra Leone and during the tour of Governor Sir Gilbert Carter in Lagos in early 1893. Both the Sierra Leone and Lagos railways were started in 1896 and construction on the Gold Coast railway was begun in 1898. The Sierra Leone railway ran Southeast from Freetown and reached Pendembu in 1908. The first railway in the Gold Coast went inland from the port of Sekondi towards the Asante goldfields and reached Kumase in 1903. The second line, linking Kumase and Accra was started in 1909 and completed in 1923. The first railway in Nigeria was from Lagos and reached Jebba on the Niger river in 1909. The second railway liked Kano to the port of Baro on the Niger and was completed in 1911. All the lines were build and operated by the colonial government.[10]

Our main source of data on the costs of constructing, maintaining and running the railway, the amount of freight hauled, the number of passengers carried, and the revenues generated from freight and passengers are the various reports of the colonial governments, particularly the reports of the railways and transportation departments. We focus on three dates, 1909 (1911 for Sierra Leone because earlier reports did not present the appropriate data), 1924/25 and 1934/35. The financial year for all colonies started on January 1 for 1909/11 but for the Gold Coast and Nigeria it switched to April 1 in the 1920s and 1930s hence the fact that for our latter two colonies and dates the data on railways straddles two years. Our basic data on railways for the Gold Coast comes from the 1909 "Report of the General Manager upon the Government Railways," and the Gold Coast Railway Administrative Reports for 1924-1925 and 1934-35. For Nigeria we have the "Lagos Railway Annual Report 1909," the "Nigerian Railway and Udi Coalmines Administrative Report for the Year ending 31st March 1925," and for 1934/35 the "Annual Report on the Government Railway and Colliery of Nigeria for the Financial Year ending 31st March 1935." Finally for Sierra Leone we have the "Report on the Transport Department for the Year 1911," and the Administrative Reports of the Railway for 1925 and 1935.

These sources of information gives us extensive data to calculate the amount of freight and

[10]For a contemporary discussion of the pros and cons see House of Commons (1924).

passengers which was carried on the railways in these three years. They also report information on current receipts and expenditures as well as capital outlays to date on railway construction and maintenance.

An important advantage of the railway is that it moved people much faster than they could have moved by walking. We can estimate the social savings associated with this since for most years the railway reports tell us the total number of passenger miles travelled. We can estimate how long it took to travel this amount of miles if we know how fast the trains went and also how fast it took to walk. Unfortunately so far we have been unable to discover a railway timetable for either the Gold Coast, Nigeria or Sierra Leone and the reports of the Railway Department never mention how long it took trains to travel between stations (though they do assiduously report the percentage that were late). For a rough calculation of the speed of the trains we rely on the travel account of Alldridge (1910) who visited Sierra Leone. Alldridge travelled on the train from Freetown to Bo leaving at 7 in the morning and arriving at 5 in the evening. Since the distance between the stations is 136 miles we can say that the average speed in Sierra Leone was 13.6 miles per hour. This appears to be very slow but the Sierra Leone railway was a narrow gauge one which possibly meant that it had to go slower than one would have expected. We have no comparable account of travel from the Gold Coast or Nigerian railways. These used broader gauges so presumably could have gone faster and we choose 15 miles per hour as a conservative estimate. In terms of how fast someone could walk Wilks (1989, Chapter 1) has an extensive discussion of travel times between different parts of Asante in the 19th Century. All his estimates are close to 15 miles per-day, which is the modal estimate of how far a head porter could walk so we shall take this as the relevant travel speed of a passenger who had to walk implying a speed of 2 miles per hour.

To value the time saved in being able to travel on the railway it is natural to take the wage rate as the opportunity cost of time. Exactly which is the correct wage to take depends on who the traveller is. For example, in 1924-25 in the Gold Coast, of the 1,487,164 passengers who travelled by train, 14,851 travelled first class, 21,988 second class, while the rest travelled in third class. We do not have the information necessary to decompose the total passenger miles into components of different groups so we could assume that this happens in proportion to the numbers of each class (i.e. on average each type of person travelled the same distance). This implies that of the 41,751,573 total passenger miles, 416,936 (1%), were first class passenger miles, 617,305 (1.5%) were second class passenger miles, and the rest (97.5%) were third class

passenger miles. To value the time saved by the introduction of the railway we need to impute some opportunity cost to these different groups. For third class passengers we could choose the unskilled wage rate of 9d. per-day or 1d. per hour assuming a 9 hour work day. Skilled wages in the Blue Books range from 2s.6d. to 5s. To calculate the value of time we value that hours saved for people travelling in second and first class at 5s. per day. Unfortunately, this is the only year for which our sources document the breakdown between the different classes of passengers. However, as will be evident from the above, since first and second class travel was relatively so unimportant this is unlikely to really generate a lot of bias in our results. Therefore we proceed with the simple assumption that time can be valued at the unskilled wage rate. This is 9d. per day for all the colonies for the first two dates and then 12.d., 8.d. and 11.d. for the Gold Coast, Nigeria and Sierra Leone respectively for the mid 1930s.

3.2 Head Porters

To compare it to the cost of using head porters we need data on how much a head porter could carry and the rate of pay. Though information on this is much less systematic than the data from the railways, there seems to be a lot of consensus on what the right numbers are. Ormsby-Gore (1926, p. 133) notes

> "there is a considerable body of labour temporarily employed on road and railway construction. The supply of voluntary labour for the latter purposes has always provided inadequate in Nigeria, and recourse is had to compulsory or "enlisted" - sometimes called "political" - labour for these essential public works and services. All the railways and most of the roads in Nigeria have involved the use of this compulsory labour ... Such compulsory labour is recruited by the native authorities. It is only called upon to work for a definite period, usually, and never more than, one month at a time. It is paid, usually at a rate of 9d. per day ... Unpaid compulsory labour legalized under the Roads and Rivers Ordinance of Northern Nigeria is only used for keeping clean roads and rivers within local boundaries when called upon to do so by the Resident."

9d. a day is the figure which is widely quoted from all over British West Africa for the cost of a head porter from around 1910 right through to the middle of the 1920s, though head porterage was surely much less prevalent in 1925. In Sierra Leone Ormsby-Gore (1926, p. 58)

reports from his visit a higher number which was 1s.3d. per day in the Colony (the capital Freetown and its environs) and 1s. per day in the Protectorate (the hinterland and interior of what is now Sierra Leone).

Just as there is a consensus on wages, there is also a consensus that a head porter could carry seems to be 60 pounds. Indeed, this seems to have been more or less the official load used by colonial officials when they hired porters (Ogunremi, 1975, p. 47). In terms of how far a porter could walk in a day the numbers vary, with perhaps 15 miles being the consensus. In Sierra Leone Ormsby-Gore (1926, p. 58) reports that a porter usually carried 45 to 50lb of weight and could walk 12-15 miles per day. House of Commons (1909, p. 42) suggests that in the Gold Coast

> "The motor lorries carry about 1 ton to 2 1/2 tons; a cask of palm oil weighs 17 3/4 cwt.; a cask of cocoa weighs about 12 cwt.' a hand truck carries from 15 to 20 cwt with 6 to 8 men to a truck; head loads are about 60 lbs."

Moreover "casks, hand trucks and head loads get over 20 miles per day". The chief commissioner for the Northern Territories of the Gold Coasts reported that although "native rates impossible to gauge" the government paid "10d. a day for loads of 50 to 60 lbs., 1d. a day of which goes to the chief who provided the carriers." In terms of how far a porter walked, the commissioner noted "At present natives are content to do 10 to 15 miles a day." For Northern Nigeria (pp. 22-23) the situation was similar with 60 lbs being mentioned as the normal head load and wages for hammock men being 9d. and for a laborer 9d. to 1 shilling per day. In Sierra Leone "Head loads 60 to 100 lbs. Hand carts 1 ton to 30 cwts." (House of Commons, 1909, p. 102). Though no information is provided on the wage paid to head porters in Sierra Leone in this report it is noted that a barrel roller, a similarly unskilled job, is paid 1 shilling per day, identical to the wage Ormsby-Gore recorded for a head porter.

To judge if these wage rates are reasonable we can compare them to other information which is readily available. For example, Oyemakinde (1974, p. 318) notes that workers who were recruited by compulsion to build the railways in Northern Nigeria between 1911 and 1915 were paid 9 d. per day, while in Yorubaland, where workers freely took up such employment, they were usually paid 1s. per day. The report detailing the costs of railway construction in the Gold Coast, Nigeria and Sierra Leone (House of Commons, 1904) reports information of the daily wage rate of unskilled workers who were used in railway construction. These were 10d. a day in Sierra Leone, 1s. a day in Lagos and 1s. 3d. a day in the Gold Coast.

All in all these scattered numbers are quite consistent with each other and for the period around 1909 they suggest that Lugard's number of 3 shillings per ton mile is a reasonable figure for the cost of head porterage. Ormsby-Gore's 1926 figures suggest that this number is reasonable for 1924-25 as well. For our 1935 estimates we do not have contemporary information on the rates of pay of head porters. However, the Blue Books for the colonies report unskilled workers wages. Since the wage rates we have for head porters in earlier periods correspond closely to the wages for unskilled workers as stated in Blue Books, we can use the latter data to get a counterfactual wage for head porterage in 1935. In the Gold Coast these ranged from 9d to 15d, in Nigeria the range 3d. to 1s. per day is given, and in Sierra Leone unskilled workers wages are reported as being 11d. We therefore used the wage rates of 12d. for the Gold Coast, and 8d. for Nigeria and 11d. for Sierra Leone.

Rather than use Lugard's 3 shilling estimate we assume in our calculations for 1909/11 and 1924/25 that head porters could walk 15 miles in a day, carry 60 lbs. and were paid 9d in all the colonies. These numbers imply a cost of 1s. and 10d. per ton mile for head porterage. For 1934/35 this cost increases by one third in the Gold Coast to 2s. and 6d. per ton mile, falls to 1s. and 8d. per ton mile for Nigeria and increases to 2s. and 3d. per ton mile for Sierra Leone.

An important issue to be considered in thinking about the applicability of the social savings approach to colonial Africa is the nature of the labor market. Coerced, or 'political' labor was used to build roads and railways and slaves were also extensively used for head porters and no doubt supplied by chiefs to help railway and road construction as well. In the Gold Coast in particular there appears to have been a great labor shortage and the supply of Africans which were forthcoming at the wages that the British were prepared to pay was insufficient to get the work done. Colonial officials therefore induced local chiefs to provide labor (see Thomas, 1973, Mann, 1995, and Akurang-Parry, 2000, for studies of forced labor and Mason, 1978 and Swindell, 1992, for specific studies in the context of railway construction all in the context of British West Africa). One could argue that since labor could be coerced either to build and run railways or work as porters this should not influence the relative benefits of the two methods of transportation. Nevertheless, since head porterage is much more labor intensive compared to the railways a natural conjecture would be that the ability to repress labor would bias downwards the social savings from railways. We return to this when we discuss the West African colonies in comparative perspective. We note however, that coerced labor was not

everywhere used for head porterage, for example in East Africa Rockel (2006) shows that there was a basically free labor market for head porterage, so this issue may be much more important there (see Coquery-Vidrovitch and Lovejoy eds., 1985, for comparative studies)

3.3 GDP Estimates

To get some sense of how big the cost differences between different methods of transportation were it is useful to have something to compare the costs to. The most obvious normalization is with respect to GDP and this is the standard approach in the social savings literature. However, to our knowledge, with the exception of Szereszewski's (1965) pioneering construction of GDP estimates for the Gold Coast in 1891, 1901 and 1911, no estimates of GDP for the colonies of interest exist for this period. Szereszewski's approach was based on colonial Blue Books which contain extensive information about imports and exports and the public sector. He used a number of assumptions to construct estimates of consumption and capital formation. Most speculatively, he also constructed estimates of the consumption and investment made by the 'native economy' of which there are only population estimates during this period. Nevertheless, Szereszewski's approach uses the existing information in a very creative way and produces quite believable estimates. We therefore used it to construct from the Blue Books for the three colonies estimates of nominal GDP for all of the relevant periods. These calculations may be of independent interest and we discuss them in detail in the appendix to the paper.

4 Were the Railways Economically Efficient? A Social Savings Approach

Though the calculations discussed previously are interesting, they fall very far short of a systematic treatment of the issue. Moreover, one could easily imagine that colonial officers, anxious to legitimize their 'civilizing mission' in Africa, may have been inclined to over-emphasize the technological backwardness of Africa and therefore the advantages of 'modern' methods of transportation.

The conventional method for tackling the issues broached in this paper is that of social savings introduced by Fogel (1964) and Fishlow (1965). The social savings of a given method of transportation, such as the railways, is the difference between the actual cost of shipping the goods and people by that method of transportation and the cost of shipping them without that method of transportation. As Fogel (1979) points out the social savings associated with

a particular efficient method of transportation is the loss of national income associated with the substitution of an inefficient method of transportation for the efficient one. In our case we focus on the social savings associated with using railways to move goods and people rather than head porterage.

This approach has been heavily criticized, requires strong assumptions about the nature of the economy, and fails to capture important impacts of transportation innovations (see O'Brien, 1977, Fogel, 1979, Summerhill, 2003, Crafts, 2004 and Leunig, 2010, for extensive discussions of the pros and cons of the approach). From our point of view, one central problem with the method is that it requires the assumption that we are studying a perfectly competitive industry in long-run equilibrium so that price (average revenue) is equal to long-run average cost. Obviously, railways which involved a huge fixed cost, cannot be in such an equilibrium. Moreover, in all the West African colonies the prices charged for freight and passengers were not determined by competition but were set by the colonial administration.[11] Furthermore, basic social savings calculations cannot incorporate the potentially large externalities created by the construction of the railways. That colonial officials believed that these existed is evident from contemporary discussion. Harry Johnston, an avid colonizer of Africa noted in 1889 (quoted in McPhee, 1936, p. 111)

> "There is no civiliser like the railway, and to build a railway through an uncivilized country is to centuple its existing trade, or to create commerce if none exists: the railway saps race prejudices and dissolves fanaticism."

His views are echoed in many places and McPhee (1926, pp. 126-127) even argues that

> "Slavery in Northern Nigeria found its chief buttress in the demand for cheap transport in a region where animal transport was not feasible on account of the tse-tse fly .. the Government built railways, and slave carriage died a natural death, because it became uneconomical."

Lugard (1922, p. 463) also observed about the construction of the railway in Nigeria that "it has killed the slave trade" and Knowles (1928, pp. 138-152) extensively discusses externalities flowing from railway construction.

[11] Indeed, it is not just that the colonial administration regulated prices, they also regulated other activities in ways which heavily influenced the profitability of the railways. For example in 1936 the Gold Coast government passed Ordinance 38 which prevented the carriage by roads of key export goods, such as cocoa and also key imports because road transportation was competing with the railways. Sierra Leone adopted a similar measure the following year (Ordinance 6 of 1937) (see Hailey, 1938, pp. 1559-1560 and Church, 1956).

Nevertheless, despite these caveats, in the absence of sufficient data to calibrate a general equilibrium model, the social savings methodology does present us with a simple method of looking at the economic impact of the railways and since these caveats apply to all such studies the comparison between our results and those of others is interesting. To apply this methodology we also follow the simplest approach of Fogel (1964) in assuming a zero elasticity of demand for transportation services. Maybe more important in the present context we assume that in the counter factual scenario where the freight hauled by the railways was carried by head porter we assume that there was no impact on the labor market so that we can use the observed wages to calculate the counter-factual cost of moving the freight by head porter (hence we are assuming that labor supply is completely inelastic).

4.1 Results from the Gold Coast

Table 2 presents some basic data on the Gold Coast railways for the three dates of interest. In 1909 there was just 168 miles of track open from Secondi on the coast up to the Asante capital of Kumase. By 1924-25 this had expanded to 394 miles since there was now a railway linking Kumase to the colonial capital Accra and by 1934-35 there were 500 miles as the grid had been extended to a number of smaller feeder railways (Gould, 1959, gives a good overview). Between 1909 and 1924-25 there was a dramatic expansion of the amount of freight hauled with the number of ton miles expanding by over 1,000%. From there until 1934-35 there was a contraction however, no doubt representing the impact of the great depression since the economic collapse in Britain and elsewhere severely restricted the demand for tropical exports. The data for total passenger miles in less complete unfortunately and does not exist for the earlier date (or those near it) and we only have the breakdown into different classes for the year 1924-25. We also record here total freight and passenger receipts, which rose sharply but then fell quite significantly between 1924-25 and 1934-35. Finally we record total capital outlays to date for the three dates.

Table 3 contains our three sets of estimates of social savings from freight for 1909, 1924-1925 and 1934-35. In all columns the first set of calculations relate to our direct measure of the relative costs of the different methods of transportation. The first row reports total ton miles of freight transported in the different years taken from Table 2. The second row contains the information from Table 2 on total freight revenues. The third row shows how much it would have cost to move the observed ton miles of freight by head porters, given our assumptions that

a head porter walked 15miles a day and could carry 60lbs (there are 2,240 lbs in a British ton). As discussed above for the first two columns we assume a wage rate of 9d. per day increasing to 2s. 6d. a day in 1934-35. The social savings are then simply the difference between lines 3 and 2. In all cases these are positive, suggesting that the introduction of the railways did indeed increase national income. To get some sense of how big quantitatively these numbers are in row 5 we record our estimates of nominal GDP and the final row shows the measured social savings as a % of GDP. In 1909 as the railway was getting underway this was negligible, but by 1924-25 it was up to 5.9% with the number increasing further, mostly as a consequence of the assumed rise in head porter wages, to 7.8% of GDP. The numbers are not enormously large but are nevertheless significant.

In Table 4 we calculate the social savings from passenger transportation. For 1924-25 and 1934-35 the colonial sources record the total passenger miles travelled. The second row then calculates the total time that was used up in moving these passengers by rail based on the assumption that trains moved at 15 miles per hour. We then compare this to the amount of time it would have taken for passengers to walk this far on foot, rather than by train, on the assumption that they could walk at 2 miles per-hour. The third row shows how long it would have taken by foot, clearly much longer than it would have taken by rail. To calculate the social savings we then value the time difference using different wage rates, 1d. per hour for 1909 and 1924-25 and 1.33d. per hour for 1934-35, as we mentioned above. Row 5 shows the value of the time saved by being able to move people by rail instead of them having to walk. To calculate the social savings we compare this to total passenger revenues in the next line. It is clear that revenues were actually greater than the value of the time saved suggesting that the benefit of moving the people by rail did not compensate for the extra cost of doing so, hence the social savings are negative.

4.2 Results from Sierra Leone

Table 5 mimics for Sierra Leone the structure of Table 2 above. By 1911 the railway in Sierra Leone was 211 miles, longer than the amount of track open in the Gold Coast, but then it grew much slower. Row 3 also shows that the growth in freight haulage was also much lower. Though in 1911 the Sierra Leone railway hauled more freight than the Gold Coast railway by 1925 it was hauling less than 1/4 of the Gold Coast railway. This is a reflection of the rapid expansion of the cocoa economy in the Gold Coast over this period a development which

had no analogy in Sierra Leone. The railway also moved far fewer passengers, about 1/3 by the mid 1920s a pattern which, like the relative freight haulage, continued into the 1930s. Unsurprisingly, freight revenues were far lower in Sierra Leone.

These differences partially show up in Table 6 in the sense that total social savings in pounds are considerably lower by the mid 1920s in Sierra Leone and also round about one half the size relative to GDP (we do not have estimates for GDP in Sierra Leone in 1911).

In Table 7 we move to the social savings for passengers in Sierra Leone. The findings here are very similar to those for the Gold Coast. Social savings are negative but basically zero, as they were in Table 4. The methodology is identical except that we apply the wage rate of 1.22d. per hour to the last column to reflect the increase in nominal wages between the mid 1920s and the mid 1930s.

4.3 Results from Nigeria

Table 8 then records the basic data from Nigeria. Though in 1909 the length of track open in Nigeria was a bit more than Sierra Leone and around 2/3 greater than in the Gold Coast, it is already evident that Nigerian railways were much more active. The freight ton millage compared to Sierra Leone, for example, is about 3 times as great and freight revenues about double. This divergence becomes even greater by 1924-25. The amount of tons miles of freight is over 20 times that of Sierra Leone and over 5 times that of the Gold Coast and this gap is even bigger by 1934-35. By this time there were 2,184 miles of track open in Nigeria, over 4 times the amount in the Gold Coast and about 6 1/2 times the track length of Sierra Leone.

Table 9 reports the basic social savings calculations for freight. In absolute value these are much larger than those of either the Gold Coast or Sierra Leone and are 12.7% of GDP in 1909. Nevertheless, after that they drop to very similar levels to those we have seen in Sierra Leone.

Table 10 then examines the social savings associated with passenger travel. The findings here are very similar to those from the Gold Coast and Sierra Leone, though for 1934-35 we do actually find positive, though very small, social savings on passenger transportation.

Finally to give some comparative context, Table 11, adapted from Leunig (2010, Table 1, p. 791) records some benchmark estimates of the social savings of railways in different countries of the world using the same methodology that we have used here (particularly assuming zero elasticity of demand for transportation services so that the actual amount of passengers and

freight moved by the railways is what is moved by the less efficient method of transportation). This shows that the types of numbers we have found are quite normal in this literature though actually much less than the numbers Summerhill himself calculated for Brazil where social savings were not less than 18% of GDP and quite likely more. Similarly, Coatsworth (1979) found even larger numbers for Mexico in 1910. Both scholars attributed the size of these numbers to the very inefficient alternative means of transport. Since neither Mexico nor Brazil had a canal system like the US freight had to be moved by very inefficient (according to their calculations) mule cart. Fogel himself argued that in the US social savings might be as high as 30% of GDP were it not for the canal system. Hence one might have anticipated that head porterage would have been even less efficient than mule pulled carts so perhaps the relatively small size of our numbers is quite surprising. One likely reason is that the ability of both pre-colonial African rulers and colonial governments to coerce labor into head porterage at below market prices (something strongly suggested by the evidence) made head porterage cheaper than it would have been if wages had been at market clearing levels. There were no mechanisms of this type of keep down the costs of alternative methods of transportation in Brazil and Mexico.

4.4 Social Savings from other Forms of Transportation

Having made these calculations for the railways we can make some simpler calculations for other forms of transportation. From Table 12 we do have some estimates of the cost per ton mile of using simpler methods of transportation, in particular barrel rolling, hand cart and motor lorry. Using the data from the 1909 Parliamentary Report on these issues we can investigate the social savings of using these other methods of transportation compared to head porterage. We do this just for the Gold Coast. To calculate the social savings associated with barrel rolling, for example, we take the mid-point of the estimate presented in the Parliamentary Report on the cost per-ton mile of barrel rolling and assume that all of the freight moved by the railway was moved by barrel rolling (with the usual zero elasticity of demand for freight and zero supply of labor assumptions). These simple calculations suggest that all forms of wheeled transportation created positive social savings though the numbers are modest expressed relative to GDP.

5 The Social Rate of Return

We now turn to a different way of looking at this issue. Instead of asking what the social savings associated with the construction of railways was we ask what the social rate of return was. We can do this in the case of railway construction since we have detailed knowledge of the capital expenditures involved in building the railways. This methodology has the advantage that it explicitly takes into account the capital expenditures associated with the construction of the railways, a bone of contention in the literature. The construction of these numbers is straightforward since the social rate of return of the railways in any particular year is simply the social savings in that year plus the net railway revenues distressed as a percentage of the capital outlays to date. The findings of this calculation are reported in Table 13 and are very striking. They show that the social rate of return was remarkably high in these West African colonies, around 100% in Nigeria suggesting that the social savings in a single year were sufficient to cover the entire capital outlays until then. To give some sense of how large this is Summerhill (2003) found social rates of return of Brazilian railways of between 17 and 23% depending on various assumptions about the extent of social savings while Maurer and Yu (2011) recently calculated the social rate of return on the construction of the Panama canal to be between 3 and 16% depending on the year.

How could it be that while social savings are so modest, the social rate of return is so high? The obvious answer to this is that quite contrary to the argument that it was expensive to build railways in the forest zone of West Africa, in fact it was remarkably cheap by international standards. Possibly this is not that surprising. Though one did have to cut down trees, West Africa is mostly very flat and in all the three cases we consider there was not the problem of bridging large rivers (the railways skirted or went around what large rivers there were, such as the Volta or Niger). This topic deserves further investigation.

6 What Stopped Technology Adoption?

If wheeled transportation, particularly railways, was economically efficient, why did Africa societies not adopt it? Part of the explanation for this stems from the nature of Africa polities. In Sierra Leone, for example, Abraham (2003) shows how the south of the country, Mendeland, was divided into a system of nine competing and warring states in the second half of the 19th Century. He makes a distinction between territorial states, which had well defined territories,

such as the Sherbro, Lugbu, Gallinas, Bumpeh and Kpaa-Mende states, and which were not identified with a single person, and the Hegemonies, such as the Tikongoh state of Makavoray and the Luawa state of Kai Londo, which were. Nevertheless, even the territorial states were not bureaucratized and did not collect systematic taxes from their inhabitants, though they did collect tribute and organize compulsory labor and armies. It is difficult to imagine that these states could have cooperated sufficiently to create a large scale public works like a railway, even had they been able to raise the capital and attract the expertise. This lack of political centralization in much of Sub-Saharan Africa is plausibly part of the explanation for why railways were not built (though it does not explain the lack of use of much simpler wheeled technologies).

Nevertheless, this explanation can hardly apply to larger more bureaucratized and consolidated African states such as Asante and Ethiopia (see Warner, 1999, Hopkins, 2000a,b). In both these cases we have direct evidence relevant to the issue since Asante made a belated attempt to construct a railway to Kumase, and Ethiopia did build a railway.

In the case of Asante Wilks notes " from the reign of Mensa Bonsu onwards, the Asante government began to explore the possibilities of utilizing European capital and skills to create a railroad system in Asante" (1989, p. 41). Asantehene Mensa Bonsu came to the throne in 1874 and ruled until being deposed in 1883 being replaced by Agyeman Prempe in 1888. Prempe's chief of his 'foreign affairs bureau' was John Owusu Ansa who took up the task of developing a railway. To this aim he proposed setting up the 'Ashanti and Prah mining and Trading Company'. On April 26 1892 the Asantehene signed an agreement with Dr. J.W. Herivel to start the company which was to finance and manage the construction of railroads in cooperation with the Asante government which even agreed to immediately supply 400 laborers to begin laying track. As Wilks notes

> "Governor Griffith of the Gold Coast viewed the project with considerable alarm, and deemed it expedient to deter Herivel from pressing forward with a scheme which might greatly have strengthened the Asante economy. In 1893 the actual agreement between the Asantehene and Herivel was impounded by the High Court of the Gold Coast, and Herivel was harassed by the Customs Department until finally in 1894 he was obliged to abandon the scheme," (1989, p. 636).

This set-back did not deter the Asantahene however. In early 1895 he sent and embassy headed by Ansa to London. In October they entered into an agreement with George Reckless

giving him "a Charter for the opening up of Ashantee to British enterprise and skill" (Wilks, 1989, p. 650). Part of what Reckless agreed to do was to build a railway from the coast to Kumase. As Wilks puts it "Chamberlain's reaction was to refuse to accept the validity of the concession" (!989, p. 652). Ansa responded by hiring a barrister and Chamberlain was forced to concede the Charter was legal. Nevertheless, before Ansa was even on the boat back to West Africa Chamberlain cabled Governor Maxwell to inform him "expedition must go Kumasi at all events" (Wilks, 1989, p. 655). British military intervention blocked any last chance of autonomous adoption of the railway.

The evidence from Asante suggests that one reason that African states did not adopt railways in the 19th century was perhaps precisely because they were economically efficient. European powers, embarked on colonial expansion had an interest in blocking the diffusion of technology to places they considered might be valuable colonies. The modernization of Asante would have made it more difficult to colonize and so was opposed by the British colonial office. This mechanism seems likely to have operated quite widely in the 19th century.

The case of Ethiopia is just as revealing about the mechanisms which stopped African states building railways in the 19th century and independently paints a picture which is very consistent with the evidence from Asante (see Gilmour, 1906, for an entertaining contemporary account). Plans to build a railway from the coast to the capital city of Addis Ababa moved forward the moment that Menelik II came to the throne in 1889. In February 1893 Menelik empowered one of his advisers to create a company and Leon Chefneux, a French trader who had been living in Ethiopia since 1882 was sent to Europe to look for capital to build a railway between Djibouti, in French Somaliland, and Addis Ababa. By this time the Italians has already declared Ethiopia to be a protectorate of Italy, which made it difficult to raise capital and which also made the French government reluctant to allow the railway to be constructed across French territory. However, the military defeat of the Italians by the Ethiopians at the battle of Adowa in 1896 solved these problems. There was a great deal of internal opposition to the railways however. Ras Makonnen, a leading aristocrat told Menelik "When the railway reaches Harar, Harar will no longer be yours and when it reaches Addis Ababa, Shoa will no longer be yours" (Pankhurst, 1968, p. 307). A British diplomat Gleichen recorded that "a large number of the chiefs ... strongly object to such a new fangled idea ...on the grounds that it would introduce into the country the all-pervading white man" (Pankhurst, 1968, p. 308). Work began on the line in October of 1897 though it took until July 22, 1901 for the first train to run.

At that point the track going inland from Djibouti was 106 kilometers long and had just passed into Ethiopian territory at Dire Dawa. The fact that the railway was being run by a French private company was not to the liking of the British, whose colony of Somaliland was just next to Djibouti. With the encouragement of the colonial office British investors began buying up shares in the company and in response in 1902 the French government effectively nationalized it. In the process they unilaterally re-wrote the concessions violating both the original details and spirit. Menelik was incensed and "the Emperor, arguing that his original concession had been violated, withdrew various priviledges ... [and he] refused to grant permission to start on construction of the line between Dire Dawa and the capital" (Pankhurst, 1968, p. 323). Menelik announced that while he still wanted the railway "he would not permit the line to be built by a foreign government or by a company controlled by a foreign government" (quoted in Pankhurst, 1968, p. 323). In response to this various schemes were proposed, for example the internationalization of the railway and Menelik himself attempted to raise the needed capital directly. The reasoning behind the French take-over of 1902 surfaced in a remarkably frank debate in the French Senate on April 1, 1905 when the Comte d'Aunay remarked

> "we were able to cherish the finest hopes for our position in Abyssinia. We had the monopoly of the railway which gave us a precious instrument of penetration; one could say that the Empire of Menelik would become a colony for us from which we could gather the benefits without assuming any of the responsibilities." (quoted in Pankhurst, 1968, p. 327)

In exasperation in mid 1906 Menelik himself began the construction of the railway from Addis Ababa to Dire Dawa. In 1908 Chefneux's company finally went bankrupt. Menelik, being unable to really build the railway himself gave a second concession to the French and the French conceded that this could be again a private company run through the Banque de l'Indo-Chine. The new company was charged with extending the line up to Addis which it reached in 1917 after the death of Menelik and during the regency of Ras Tafai (later to become Haile Selassie).

The evidence from the Ethiopian case is pretty clear that a real problem for African polities in adopting the modern technology of the railway was that they feared it would accelerate colonization.

7 Conclusions

In this paper we have undertaken some preliminary calculations to examine the economic benefits of introducing modern methods of transportation into the British West African colonies of the Gold Coast, Nigeria and Sierra Leone in the early 20th century. We did this in the context of an academic literature that has argued that the reason that Africans did not adopt modern technologies, such as wheeled transportation, was that they were not appropriate technologies given the underlying factor endowments and circumstances. The bulk of the paper focused on the introduction of railways. Though this is not the cleanest case for examining the economic rationality of wheeled transportation, it is facilitated by the very rich data which the British colonial state collected on the construction and operation of the railways. The main question we ask is whether or not constructing the railways was economically rational compared to moving goods by head porterage and moving passengers by foot. We tackle this issue in two ways, first using the social savings approach of Fogel (1964) and secondly by calculating the social rate of return. Our results are very contrary to the conventional wisdom. Though it is true that the social savings created by railways were modest compared to estimates of national income, the more interesting concept, the social rate of return on capital, was very high. In the case of Nigeria it reached around 100% per annum suggesting that the social savings in one year were sufficient to cover the entire capital expenditures up until then.

Moreover, we would argue that in a sense these calculations almost certainly underestimate the economic impact of the adoption of the railway. This is for the simple reason that the British colonial government built the railways not simply as an economic activity, but also as part of a strategy of extending colonial rule. For instance Tsey (1986) points out that the first railway to be built in the Gold Coast, though it headed north into the Asante goldfields, which seems economically sensible, was extended to Kumase to allow the British to extent its military domination into the heart of the Asante state, not from any obvious economic motive. Similarly in the case of Sierra Leone, when construction of the first railway was started it was intended to run from Freetown to the north of the country. In 1898 however a massive rebellion "The Hut Tax Rebellion" (known in modern Sierra Leone as the Bai Bureh War) broke out. Though it started in the north it was most intense and started longest in Mendeland in the south. When the rebellion was defeated the British changed the route of the railway line and instead of going north it went south right into the heart of Mendeland. To the extent that military and strategic factors were important in determining the routes the railways took, and

to the extent that the relevant economic fundamentals were not perfectly correlated with the political fundamentals that made some places harder to govern, this implies that the railways could not have been built in the most sensible places from an economic point of view. Therefore our findings surely underestimate the economic potential for railway construction.

Nevertheless, the fact that railways were economically efficient but not adopted by Africans does not imply in any sense that Africans were irrational or not able to calculate according to the relevant costs and benefits. In fact, in the case of railways, we showed that there were three circumstances which inhibited African polities from adopting such technologies. First, when there was little political centralization (so that private costs and benefits diverged from social costs and benefits); second, when technology adoption was blocked by potential colonial powers who did not want autonomous African development; third, when the African polity itself feared that railway construction would itself accelerate colonization.

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Table 1: Some Contemporary Estimates of the Relative Cost of different methods of transportation (cost in shillings and pence per ton mile)

	House of Commons (1909)	Ormsby-Gore (1926)	Ogunremi (1982)
Cask Rolling	1s.21/2 d. – 1s.11d.		
Hand Trucks	1s. 10d		
Head Porterage	3s.1d – 5s.	2s.6d.	1s.10d. – 2s.
Motor Lorry	1s.8d.	1s.	
Railway		2d.	
Donkey		11d.	9d. – 10d.

Table 2: Some Basic Data on the Gold Coast Railways

	1909	1924-25	1934-1935
Mile of Track open	168	394	500
Total freight hauled (tons)	56, 454	796,888	730,382
Total freight in ton miles	3,763,552	43,170,885	42,952,026
Total Passengers moved	215,729	1,487,164	1,822,093
First Class		14,851	
Second Class		21,988	
Third Class		1,450,325	
Total passenger miles		41,751,573	44,704,654
Total Freight Revenues (£)	146,845	850,238	633,525
Total Passenger Revenues £)	38,565	214,703	150,840
Total Expenditures (£)	73,914	568,012	487,530
Total Capital Outlays (£)	1,808,323	7,419,086	9,241,698

Table 3: Estimates of Social Savings from Freight in the Gold Coast

	1909	1924-25	1934-35
Total Freight ton miles	3,763,552	43,170,885	42,952,026
Total Freight Revenues (£)	146,845	850,238	633,525
Total cost of Head Porterage (£)	344,992	3,957,331	5,369,003
Social Saving (£)	198,147	3,107,093	4,735,478
GDP (in current £)	26,266,269	53,108,142	61,068,569
Freight Social Saving (as a % of GDP)	0.8	5.9	7.8

Table 4: Estimates of the Social Savings from Passengers in the Gold Coast

	1909	1924-25	1934-35
Total passenger miles		41,751,573	44,704,654
Total time required to travel by rail (at 15 miles per-hour) (hours)		2,783,438	2,980,310
Total time required to travel by foot (at 2 miles per hour) (hours)		20,875,786	22,352,327
Travel time saved (hours)		18,092,348	19,372,017
Value of Time Saved (£)		85,939	118,653
Total Passenger Revenues (£)	38,565	214,703	150,840
Passenger Social Saving (£)		-128,764	-32,186
GDP (in current £)	26,266,269	53,108,142	61,068,569
Passenger Social Saving (as a % of GDP)		-0.24	-0.05

Table 5: Some Basic Data on the Sierra Leone Railways

	1911	1925	1935
Mile of Track open	255.5	338	341
Total freight hauled (tons)	55,540	72,298	71,628
Total freight in ton miles	5,971,693	9,437,472	10,569,611
Total Passengers moved	339,332	587,944	450,707
Total passenger miles		11,047,266	11,377,080
Total Freight Revenues (£)	82,086	167,687	107,868
Total Passenger Revenues (£)	22,644	52,305	28,383
Total Expenditures (£)	69,503	176,482	128,862
Total Capital Outlays (£)	989,194	1,359,680	6,994,715

Table 6: Estimates of the Social Savings from Freight in Sierra Leone

	1911	1925	1935
Total Freight ton miles	5,971,693	9,437,472	10,569,611
Total Freight Revenues (£)	82,086	167,687	107,868
Total cost of Head Porterage (£)	547,405	865,102	1,189,081
Social Saving (£)	474,774	697,415	1,081,213
GDP (in current £)		25,444,186	32,818,287
Social Saving as a % of GDP		2.7	3.3

Table 7: Estimates of the Social Savings from Passengers in Sierra Leone

	1911	1925	1935
Total passenger miles		11,047,266	11,377,080
Total time required to travel by rail (at 15 miles per-hour) (hours)		736,484	758,472
Total time required to travel by foot (at 2 miles per hour) (hours)		5,523,633	5,688,540
Travel time saved (hours)		4,787,149	4,930,068
Value of Time Saved (£)		19,946	25,061
Total Passenger Revenues (£)	22,644	52,305	28,383
Passenger Social Saving (£)		-32,359	-3,321
GDP (in current £)		25,444,186	32,818,287
Passenger Social Saving (as a % of GDP)		-0.13	-0.001

Table 8: Some Basic Data on Nigerian Railways

	1909	1924-25	1934-35
Mile of Track open	272	1,220	2,184
Total freight hauled (tons)	165,150	680,107	866,681
Total freight in ton miles	16,024,024	218,427,093	293,186,018
Total Passengers moved	285,202	1,922,580	5,080,016
Total passenger miles	13,353,158	92,283,840	148,165,399
Total Freight Revenues (£)	154,126	1,736,194	1,721,825
Total Passenger Revenues (£)	46,387	290,639	230,270
Total Expenditures (£)	131,820	970,446	1,038,758
Total Capital Outlays (£)	1,377,284	14,978,225	23,014,851

Table 9: Estimates of the Social Savings from Freight in Nigeria

	1909	1924-25	1934-35
Total Freight ton miles	16,024,024	218,427,093	293,186,018
Total Freight Revenues (£)	154,126	1,736,194	1,721,825
Total cost of Head Porterage (£)	1,468,869	20,022,480	24,432,170
Social Saving (£)	1,314,743	18,286,286	22,710,340
GDP (in current £)	105,316,616	300,260,499	300,859,733
Social Saving as a % of GDP	1.2	6.1	7.5

Table 10: Estimates of the Social Savings from Passengers in Nigeria

	1909	1924-25	1934-35
Total passenger miles	13,353,158	92,283,840	148,165,399
Total time required to travel by rail (at 15 miles per hour) (hours)	890,211	6,152,256	9,877,693
Total time required to travel by foot (at 2 miles per hour) (hours)	6,676,579	46,141,920	74,082,699
Travel time saved (hours)	5,786,368	39,989,664	64,205,006
Value of Time Saved (£)	24,109	166,624	238,094
Total Passenger Revenues (£)	46,387	290,639	230,270
Passenger Social Saving (£)	-22,277	-124,015	7,824
GDP (in current £)	105,316,616	300,260,499	300,859,733
Passenger Social Saving (as a % of GDP)	-0.02	-0.04	0.003

Table 11: Estimates of Social Savings for Various Countries

Belgium			
	1846	Freight and passenger	1%
	1865	Freight and passenger	2.5%
	1912	Freight and passenger	4.5%
Brazil			
	1913	Freight	18%-38%
		Passengers	4.6%
China			
	1933	Freight and passenger	0.5%
Colombia			
	1924	Freight	4.8%
England and Wales			
	1865	Freight	4.1%
	1890	Freight	29.1%-31.6%
	1843-1913	Passengers	1.5%-14%
France			
	1872	Freight	5.8%
		Passengers	1.7%
Germany			
	c1900	Freight	<5%
Mexico			
	1910	Freight	24.9%-38.5%
Russia			
	1907	Freight	4.6%
		Passengers	1.6%
Spain			
	1878	Freight	7.5%
	1912	Freight	11%
USA			
	1859	Freight	3.7%
	1859	Passengers	1.6%
	1890	Freight	4.9%
	1890	Passengers	4.8%

Table 12: Implied Social Savings relative to Head Porterage of different methods of transportation in 1909 in the Gold Coast

Total freight carried by the railways (in ton miles)	3,763,552
GDP (in current £)	26,266,269
Total cost of Head Porterage (£)	760,551
Total Cost of Cask Rolling (£)	258,744
Social Savings of Cask Rolling (£)	501,807
Relative to GDP (%)	1.9
Total cost of Hand Trucks (£)	344,992
Social Savings of Hand Trucks (£)	415,559
Relative to GDP (%)	1.6
Total cost of Motor Lorry (£)	313,629
Social Savings of Motor Lorry (£)	446,922
Relative to GDP (%)	1.7

Table 13: Social Rates of Return %

	1909/1911	1924-25	1934-1935
Gold Coast	11.0	41.9	51.2
Sierra Leone	48.0	51.3	15.5
Nigeria	95.5	122.0	98.7

Table 14: Estimates of Social Rates of Return (%) for Various Countries

Country/year	Social Rate of Return (%)	Source
Brazil		
1913[a]	17.9-23.1	Summerhill (2005, p. 87, Table 7).
England and Wales		
1854[b]	13.58	Constructed from Hawke (1970, p. 406, Table XV.01, column 5) and Kenwood (1965, p. 322, column 1).
1855	13.68	ibid.
1856	14.61	.
1857	14.54	.
1858	13.98	.
1859	15.15	.
1860	16.07	.
1861	15.77	.
1862	15.51	.
1863	15.98	.
1864	16.67	.
1865	16.46	.
1866	17.18	.
1867	17.62	.
1868	17.91	.
1869	18.43	.
1870	19.68	.
Mexico		
1881[c]	1.8	Coatsworth (1972, p. 141, Table IV.12).
1882	10.4	ibid.
1883	14.2	.
1884	9.7	.
1885	18.8	.
1886	14	.
1887	15.3	.
1888	18.9	.
1889	20.3	.
1890	26.6	.
1891	35.9	.
1892	34.9	.
1893	27.2	.
1894	25.3	.
1895	29.1	.
1896	30.3	.
1897	31.6	.
1898	33.4	.
1899	52	
USA		
1859	15	Fishlow (1965)
1890[d]	12.3-15.8	David (1969, p. 522-523), social savings from Fogel (1964)
1890[e]	15.8-20.4	ibid.

Notes: a) Uses demand elasticity of -1. b) See text. c)Refers only to the largest railroad company. d) Returns net of maintenance expenditures. e) Returns gross of maintenance expenditures.

Appendix: reconstructing colonial GDP

This appendix describes the procedure we followed to reconstruct the GDP for the Gold Coast, Sierra Leone and Nigeria. To the best of our knowledge, no other systematic attempts to reconstruct GDP for the pre-war era have been constructed for these countries, except for the pioneering work of Szerezsewski (1965). We largely follow his method, which we outline below for the Gold Coast together with our deviations from his method. We present a full result for the Gold Coast in 1909 in table A2. Finally, we briefly discuss diffences between reconstructing Gold Coast GPD and GDP for Sierra Leona and Nigeria.

Szereszewskis work

Szereszewski (1965) tries to understand the structure of the Ghanaian economy to investigate the process that transformed the Gold Coast from an agricultural society into the largest cocoa exporter in the world in 1911 . For 1891, 1901, 1911 (coinciding with census years), he constructs three

> "...successive accounting models which would assess quantitatively the structural changes of the economy over the two decades and the magnitude of its growth" (p. 128)

He considers an *introduced* and an *indigenous* sector, broadly corresponding to the coastal area and the hinterland in Ghana (and the Colony and Protectorate in Nigeria and Sierra Leone).

Data and methodology

All data are taken from the so-called Blue Books, which are colonial reports submitted to the British Government (British Government, 1909;1925;1935). These reports contain, aside from a short descriptive part, data on imports and exports and on government activity. From these data we constructed an estimate of GDP following a standard GDP from expenditure formula:

$$Y = C + G + I + E - M \tag{1}$$

where Y stands for GDP, C for consumption, G for government expenditure, I for investment, E for exports and M for imports. We break this formula down into two building blocks, the introduced part of the economy (G, I, $(E - M)$ and the introduced part of C) and the

Table A1: Components of colonial GDP

Symbol from (1)	Category
C	(2) Private consumption of Imported Goods
	(4) Consumption of Public and Related Services
	(6) Traditional Consumption
G	(3) Consumption of Government Services
I	(5) Gross Capital Formation
E	(1) Export Production
M	(7) Imports of Goods and Non-factor Services

traditional (indigenous) consumption (the indigenous part of C). The letters in equation one correspond to categories in our GDP calculation (see table A2). Table A1 lists the inputs in equation one and their equivalents in our calculation. The names of the equivalents have been chosen to conform to Szereszewski (1965) and to match closely to the Blue Books.

The indigenous consumption part (category (6)) accounts for the contribution of the indigenous population to GDP. Szereszewski computes a typical consumption basket for the Gold Coast and multiplies this by the population to arrive at the money value of traditional consumption. This measure is hard to replicate and it isn't easily transferable across countries. Therefore, we assume that the minimum unskilled labor daily wage rate is set such that the population was made indifferent between subsistence farming and unskilled day labor. We then find the minimum day labor wage from the Blue Books and multiply this with the population to arrive at a measure of the traditional expenditure on GDP. The other components of our analysis, the categories in table A1, will be dealt with below.

Export Production

Since exports are paid for from abroad, they add to GDP. The total figures for exports, including imports duties and c.i.f. (cost, insurance and freight) costs, in one particular year can be taken directly from the blue books. Overland exports were usually not measured in any coherent way. Therefore, we confine ourselves to seaborne exports.

Private Consumption of Imported Goods

Szerezsewski computed ratios between the import and the consumption of different classes of goods. With these ratios and the import figures from the Blue Books we can compute domes-

tic consumption of these goods. In the Blue Books, all imported commodities are listed with their respective import value and are taken from the home consumption categories in the Blue Books. We have aggregated the individual commodities into five categories; Spirits, Textiles, Tobacco, Provisions (food, paper, candles etc.) and Miscellaneous (tools, fuel, medicine etc). From Szerezsewski we take the following conversion factors.

Spirits, 1.7
Textiles, 1.6
Tobacco, 1.6
Provisions, 1.5
Miscellaneous, 1.4

This means that, for instance, in the Gold Coast in 1909 total spirit imports were worth 456.000 pounds and total consumption of spirits was worth 775.200 pounds.

Consumption of Government Services

This category records the expenditures of the government, given directly in the Blue Books. To this have been added the expenditures of the local governments such as, in the case of the Gold Coast, the governments in Accra, Cape Coast and Secondi. Traditional government is not included. Also, government expenditure on construction is considered separately below.

Consumption of Public and Related Services

This category records consumption of the services offered by the Postal Service and the Railway services. Both quantities can be recorded directly from the blue books. For the Gold Coast in 1909, we were able to include to expenditure on missionary schools as well.

Gross capital formation

As a means of accounting for investment, several capital formation categories are computed.

Buildings and construction. We have used government expenditure on construction works as a measure of the capital investment in building and construction. Szereszewski uses the money value of the imports of building and construction materials times a construction coefficient meant to capture the relation between the money value of the imports and the eventual investment value for GDP. He estimates this coefficient at 4. We have used this methodology

only for the Gold Coast in 1909, lacking detailed government expenditure data. To the government expenditure on buildings and construction, the government expenditure on railway plant and rolling stock is added.

Equipment. Spending on equipment is constructed from the import lists in the Blue Books. However, only for the Gold Coast in 1909 and Sierra Leone in 1925 could detailed figures on equipment import be found. For the other country/years the ratio between the construction spending and equipment spending (0.26) for the Gold Coast in 1909 has been assumed constant and has subsequently been applied to the construction figures to generate the data for the equipment category.

Agriculture. Although all agricultural output was created by labor inputs, there is one category, the establishment of new cocoa farms, that deserves attention. We measure the investment/expenditure on GDP by the extra acreage of Cocoa planted. The acreage we get from the tonnage of cocoa exported which is mentioned in the Blue Books. Using the average yield formula from Szereszewski of 420 lbs. per acre we can compute the total acreage that was used for growing the exported tonnage of cocoa. This is subsequently multiplied by the number of days it takes to bring an acre of cocoa to bearing age (170 days, sources are in Szerezsewski). Finally, we use the unskilled labor wage rate to assign a money value to these days worked. This gives the money value of the investment needed to grow the exported quantity of cocoa. This investment is recorded in the year of export, although it was actually invested seven years before, which is the time it takes for cocoa to grow to maturity. However, we record expenditures as they enter output, so the data of the year of inquiry can be used to trace the original investment and assign it to the current year. No other crops or agricultural investment can be assessed in a similar way.

Accumulation of specie. The category records the difference between the imports and exports of specie (foreign currency).

Changes in stocks of imported goods. This category records the difference between total imports and the imports cleared through consumption (in the home consumption categories in the Blue Books). The difference represents the goods stock in warehouses in the ports and

includes mainly spirits and textiles and can be seen as an stockpiling investment.

Traditional Consumption

This category records the traditional consumption as outlined above. It uses the population figures and unskilled wage figures from the Blue Books to assess the money value of the traditional consumption. We assume that the unskilled wage rate was set such that people were made indifferent between (subsistence) farming and unskilled labor.

Imports of Goods and non-Factor Services

This category records the money value of imports which are to be deducted from total GDP since the money to pay for the imports in added to the exporting countrys GDP. Also, the imports of specie are deducted here since they domestic currency to pay for the foreign currency accrues to the other nations GDP. As a last element, the remunerations for services performed by firms abroad are added here (f.i. the treatment of soldiers/officers in hospitals in England).

Table A2 gives a complete reconstruction using the above methodology for the GDP of the Gold Coast for the fiscal year 1909. This same methodology can be applied, mutatis mutandis, to Sierra Leone and Nigeria. Their total GDP figures, together with the remaining figures for the Gold Coast, are given in Table A3.

Nigeria and Sierra Leone

The main differences between the analysis for the gold coast and Sierra Leone and Nigeria come from two sources. The first source, that applies only to Nigeria, is that Nigeria was for administrative purposes split in Northern and Southern Nigeria in 1909. GDP figures for both colonies plus a total are given in Table A3. In 1925 the colonies have merged. The second source, that applies to both countries, has to do with population figures. In 1909 the population figures in the Blue Books give only the population figures for the Colony and not for the protectorate causing an underestimation of total GDP.

Table A2: Estimated Expenditures on GDP - Gold Coast 1909 - in pounds

Category from Table A1		Total
(1) Export Production		2.656.000
Sea-borne	2.656.000	
(2) Private Consumption of Imported Goods		3.490.178
Spirits	775.200	
Textiles	1.048.000	
Tobaccos	158.400	
Provisions	779.850	
Miscellaneous	728.728	
(3) Consumption of Government Services		746.000
(4) Consumption of Public and Related Services		199.000
Post and Telegraph	5.000	
Education	12.000	
Railway	182.000	
(5) Gross Capital Formation		746.240
Buildings and construction	820.000	
Equipment	512.400	
Cocoa	0	
Net accumulation of specie	133.000	
Changes in stock of imported goods	8.000	
(6) Traditional Consumption		20.646.650
(7) Imports of Good and Non-factor Services		2.217.800
Sea-borne	2.205.000	
Services other than insurance and freight	12.800	
New imports of specie	133.000	
GDP is the total of categories 1-5 minus 7.		
GDP including (6)		26.266.270
GDP excluding (6)		5.619.618
	Total Population	Unskilled wage (pence)
	1.696.985	8

Table A3: Colonial GDP for the Gold Coast, Nigeria and Sierra Leone, in pounds

	(Fiscal) Year	GDP with traditional consumption	GDP without	Population	Unskilled wage rate (pence)
Gold Coast	1909	26.266.270	5.619.620	1.696.985	8
Sierra Leone	1909	2.330.890	1.398.250	76.655*	8
Nigeria (North)	1909	94.832.020	29.336.230	6.714.038	9
Nigeria (South)	1909	10.484.600	9.937.100	60.000*	6
Nigeria (Total)	1909	105.316.620	39.27.330	6.774.038	
Gold Coast	1924/25	53.108.140	21.913.280	2.279.077	9
Sierra Leone	1924/25	25.444.1890	4.419.280	1.536.066	9
Nigeria	1924/25	300.26.500	14.561.340	18.900.391	9
Gold Coast	1934/35	61.068.570	17.969.230	3.163.568	9
Sierra Leone	1934/35	32.818.270	3.233.090	1.768.480	11
Nigeria	1934/35	300.859.730	28.225.050	19.918.516	9

*Population without Protectorate (Colony only)