Investing in Early Public Works:

Financial Returns in English and Welsh Turnpikes 1820-1845

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Abstract

Private and local investors provided much of the capital to improve England's infrastructure during its industrialization. Their capital was pooled in thousands of small trusts and joint stock companies. This paper investigates the rate of return paid to investors. It focuses on turnpike road trusts—arguably the most precarious infrastructure authorities. It draws on parliamentary reports which provide comprehensive data on many aspects of financing in the early nineteenth century. The analysis shows that turnpikes paid investors a similar return to the yield on government bonds, but lower than railways and canals. Financial returns varied at the individual trust level with most paying 4.5 to 5 percent, and some paying zero interest. The 'financial losers' however were not the majority and many bondholders were able to recoup losses over the medium term. Investors appear to have understood the risks based on evidence that contracted interest rates were higher for newer trusts and those with higher debt.

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Infrastructure investment is one of the important drivers of economic growth and development. But the gains from infrastructure investment are often contested, especially if the private sector is the main source of funding. Historically the rich account for most private investment in infrastructure, and if the returns are low there can be redistribution to the rest of the society. However, if private investors earn large financial returns then infrastructure can contribute to greater income for the rich, especially if investors are local and already benefit from increased property values. The financial risks are also relevant for determining the terms of infrastructure investment. With high risks investors will generally demand a higher expected return at the outset. Success will generate higher rewards, even if failure is more likely.

This paper examines the financial returns to investing in turnpike road trusts in England and Wales in the early nineteenth century. A historical study of turnpike trusts is revealing for several reasons. First, the English and Welsh economy made substantial investments in transport infrastructure as it industrialized. Railways were the largest as a percentage of capital formation, but there were also significant investments from 1750 to 1830 in canals, roads, docks, and water supply.[2] Turnpike trusts are illustrative of the first wave of investment. Second, turnpike trusts mainly relied on bonds to finance investment, and as trusts they were restricted from earning profits. They make for an interesting comparison with joint stock companies, which came to dominate infrastructure in the nineteenth century. Third, local individuals, especially landowners and merchants, held most of the turnpike bonds. Governments provided little capital, except for a brief period in the 1820s. Thus turnpike trusts provide insights on infrastructure networks primarily financed by local and private investors. Fourth, there is excellent data on the finances of all turnpike trusts in England and Wales starting in 1820. Financial surveys were conducted by

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[2] Feinstein (1988, p. 444) gives estimates of gross capital formation in railways and other transport and communications by decade. Railways accounted for 28% of all gross capital formation in the 1840s. In the 1790s other transport and communications accounted for 20% of all gross capital formation.

parliamentary committees and provide a rare snapshot into the revenues, expenses, and liabilities for a *population* of infrastructure providers. Often scholars in this area are forced to work with potentially selected samples of company records.

The rich data sources summarize the interest payments made to all turnpike bondholders in 1820, 1829, 1834, 1838, 1842, and 1845. The reports also include information on payments and debt at the individual trust-level, and are fully digitized for 1820 and 1838. The aggregate figures show that interest payments as a percentage of turnpike debt were around 4 percent between 1820 and 1845. Unpaid interest was substantial in these years, but even when it is included in the debt, interest payments are still 3.3 percent of liabilities. By comparison, the yield on 3 percent Consols was 3.4 percent over the same period.

I also make estimates of total capital invested in turnpikes and its rate of return from 1820. The value of total turnpike capital was between 10 and 15 million £ in current prices, making it less than canals but still sizeable. The aggregate return measured as net turnpike revenues divided by total capital value averaged just over 3 percent from the 1820s to the 1840s. The similarity with bondholder returns suggests that most of the financial surplus went to bondholders. The estimates also imply that in the aggregate investing in turnpikes yielded a competitive financial return.

The preceding conclusion applies to the average investor, but outcomes varied at the individual turnpike trust and investor level. The data show that 16 percent of trusts paid no interest in 1820, yielding a zero percent return to bondholders. At the other end of the spectrum 60 percent of turnpike trusts paid a return above 4.5 percent. The distribution was similar in 1838. Notably though many trusts making zero interest payments in 1820 were paying the average interest by 1838.

The analysis of individual trusts shows there was clearly some risk in holding individual turnpike bonds. Investors possibly understood these risks and demanded a higher contracted rate at the outset of lending or when renegotiating. I test this claim by studying how proxies for risk affected the contracted rate across all trusts in 1838. Sources show that three quarters of trusts had contracted rates of 5 percent, the maximum allowed by usury law, but some were 4 or 4.5 percent. One hypothesis is that investors demanded the higher contracted rate for newer trusts and trusts with more debt in 1820 because they were perceived as riskier. The evidence is consistent with this view and shows that newer trusts and those with higher debt in 1820 were more likely to pay the maximum contracted rate. The rate of return in 1820 has no effect on the contracted rate by 1838, suggesting that investors did not necessarily perceive poor financial performance in a single year as indicative of greater long-term risk.

As a final exercise, I make comparisons between investing in a portfolio of turnpikes, canals, railways, or farmlands in the period from 1820 to 1850. For railways I draw on Arnold and McCartney (2005) who estimate the returns on capital employed for the top five and next 10 railway companies. For canals I use Arnold and McCartney (2011) and Ward (1974) who provide returns and dividend rates for two samples of companies. Returns on farmland are taken from Clark's (1998) data on charity records. I also extend the comparison to the British stock market from 1825 to 1870 using the returns in Acheson et. al. (2009). In each case, I calculate the Sharpe Ratio, which measures the returns per unit of risk in a portfolio. The Sharpe Ratio for the turnpike portfolio was higher than the farmland portfolio, but less than the canal, railway, and the stock market portfolios. Thus on purely financial terms assets in the new transportation and industrial economy performed better than turnpikes.

The findings contribute to studies measuring the historical returns to investing in infrastructure in developed economies.[3] They show that turnpike trusts in England and Wales yielded a competitive return to investors in the first half of the nineteenth century. This conclusion is at odds with the view that most trusts did not meet their interest obligations or were insolvent (see Albert 1972 and Webster 2016). The evidence shows that trusts were able to generate competitive returns in the aggregate because they borrowed at rates above government bonds, and enough trusts paid this high rate to offset those not paying interest. The findings also suggest that turnpikes contributed to higher incomes for the rich in England and Wales. Previous studies suggest that turnpike trusts increased local property income by 10 to 20 percent.[4] As most investors were local landowners and merchants, the financial returns were often an addition to the increased property values which came from turnpike trusts.

This paper also makes a contribution by showing the relative returns to investing in different assets in the early nineteenth century. Canal shares had the highest returns and highest risks; turnpike bonds had more moderate risks and returns; railway shares were the best of all, yielding high returns with reasonably low risks. Overall the infrastructure sector generated substantial rates of return, and larger than the economy as a whole which grew at 2 percent per year between 1820 and 1850.[5]

Finally, this paper contributes to the contemporary literature on infrastructure finance. The private sector plays a large role in infrastructure financing today, as it did in the past. But

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[3] For the literature on Britain, see Albert (1972), Pawson (1977), Buchanan (1986), Webster (2015) who study turnpike trusts, Ward (1974), Trew (2010), and Arnold and McCartney (2011) who study canals, Jackson (1983) who studies docks, Casson (2009), Mitchell, Chambers, and Crafts (2011) and Arnold and McCartney (2005, 2011) who study railways, and Goldsmith and Carter (2016) who study water supply. For the United States and Canada see Carlos and Lewis (1995) and White (2011) for railroads, Klein (1990) and Klein and Majewski (1992) for turnpikes, for canals see Majewski (2000). For a comparison on Britain and the US see Bogart and Majewski (2011). For a long-run perspective on Europe see the introduction in Cassis, De Luca, and Florio (2016).

[4] The economic returns from turnpikes are discussed by Albert (1972), Guldi (2012), Ward (1974), Klein (1990), and Majewski (2000). For econometric evidence on how trusts affected property values see Bogart (2009).

[5] I use as my estimate of GDP growth the figures from Broadberry et. Al. (2015).

today international agencies and central governments usually provide 'minimum income guarantees' to insure investors against default or large losses. Infrastructure policy also shuns competition due to concerns it will discourage investment. Despite these assurances the contemporary infrastructure sector is not always profitable. In the early 2000s, private returns to infrastructure concessions were modest and often below the cost of capital (Sirtaine et. Al. 2005, Estache and Pinglo 2005, Rothballer and Kaserer 2012). This paper provides a historical case where the infrastructure sector yielded competitive returns over a significant time span.

The paper is organized as follows. Section I provides background on turnpike trusts. Section II reviews the data sources. Sections III, IV, and V report the returns on investing in the turnpike sector, and across individual turnpike trusts. Section VI examines how risk factors affected the contracted rate. Section VII compares returns for turnpikes with canals, railways, and land. Section VIII concludes.

I.

Private financing was prominent in England's transport investment from an early stage. Parliament granted trusts and joint stock companies the powers to construct or improve transport infrastructure through acts of parliament. On the basis of these acts, capital was raised through bonds and stocks. Local individuals, like landowners, commercial interests, and urban savers, provided the capital with few financial guarantees from the central government in London. By the early nineteenth century, infrastructure trusts and joint stock companies numbered in the thousands. Most relied on the users in a single town or city to earn revenues.

Turnpike trusts are a prime example of the more general pattern.[6] Turnpike acts transferred authority over a road to a body of trustees for 21 years. It was typical for the trustees' authority to be renewed by subsequent acts, and thus for trusts to be long-lived. Trustees had to meet

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[6] For an overview of turnpike trusts see Albert (1972) and Pawson (1977).

property and income qualifications. Notably the requirements to be trustees were often lighter on landowners, making them the most common social group. Trustees had the right to levy tolls and they had a right to the labor of the residents in parishes near the road. It was called statute labor in England and *corvee* labor elsewhere. Turnpike trusts were also authorized to issue bonds secured on the toll income (the bonds are explained more below). Finally, most turnpike acts forbade the creation of tradeable shares and collection of profits. The revenues were to be devoted to manual labor, materials, officers' salaries, interest, and repayment of the principal on the debt. Surplus balances were to be held by the treasurer and applied to future expenses.

Turnpike trusts spread widely through the network from the 1690s to the 1830s. The 1750s and 1760s were the two decades with the largest numbers formed. Trusts managed all the major roads leading into London and between major cities and towns. They also managed the major roads between industrial towns and their hinterland, as well the market towns in rural areas. By the 1830s around 1000 trusts managed 20,000 miles or 20 percent of the total network. A map of the turnpike road network, the coalfields, and the largest towns in 1830 is shown in figure 1. The extraordinarily dense network is evident.

A prominent feature of turnpike trusts was their reliance on debt financing. [7] There were two types of debt. The first were bonds secured on the tolls (so-called mortgaged debt). The second were unsecured bonds (so-called called floating debt). The mortgage bonds were by far the largest. They had no set maturity date and the trustees could repay the principal in full at any time.[8] Each bond for a trust was generally treated equal, and so there were no first or second claims on the revenues. The exception was that if any individual bondholder did not receive their

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[7] See Albert (1972, pp. 93-97) for a discussion of turnpike debts.
[8] There is a caveat here. The bonds would expire when the trust was distinguished. The expiration date would have been a problem as most trusts operated under a temporary 21-year authority, but Parliament regularly renewed turnpike charters in order not to create defaults.

scheduled interest payment within six months they could foreclose on the tolls and become the first claimant on the revenues. The interest rates on the mortgage debt could not exceed 5 percent because of usury laws, and most ranged between 4 and 5 percent as will be shown below.

The overwhelming proportion of investors in turnpike bonds came from areas near the road. As an illustration, Buchanan's (1985) detailed study of the Bath turnpike trust shows that many investors were resident in Bath with a minority having neighboring Bristol or London addresses. Buchanan also shows that many investors were merchants, tradesman, and 'small urban savers' (p. 235). Webster's (2015, p. 67) analysis of 41 mortgage ledgers provides more general evidence on investor identities. Webster found that 42 percent of investors can be classified as landowners, 31 percent as commercial interests, and 27 percent as savers. Banks or other financial institutions contributed little.

There was a change in the level and character of trust borrowing starting around 1820. At this time, engineers like John Macadam and Thomas Telford developed new methods for making roads using crushed stones of different sizes in the road bed. Their methods were more expensive than traditional approaches used by turnpike trusts, and required a new wave of borrowing to be implemented. In the 1820s and 1830s total turnpike debt in England and Wales increased by approximately 75 percent from £4.4 million to £7.3 million as the new road making methods were implemented. [9]

Most of the lending in the 1820s came from local individuals, but for the first time in England a significant portion also came from the central government. The Public Works Loan Board (PWLB) was founded in 1817 by an act of parliament.[10] The PWLB's official aim was to provide financial stimulus to useful schemes. Local authorities like turnpike trusts had to apply

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[9] According to Guldi (2012, pp. 29-72), the civil engineers were partly successful because of earlier experiences with military roads in Scotland, and the building of the London Holyhead road in the late 1810s.
[10] See Webster (2015, pp. 59-91) for an analysis of PWLB and its relation to turnpikes.

for a loan, and if accepted the PWLB often insisted on the right of first payment. In most cases, the PWLB charged 5 percent interest, the maximum allowed by usury laws. The PWLB lent £401,000 to 107 trusts in England and Wales between 1817 and 1832. Most of the loans were granted in the years 1817, 1818, and 1826. PWLB loans look small compared to the £6.8 million in turnpike debt by 1829, but it did make a significant contribution to turnpike capital in the important decade of the 1820s (Webster 2015, p. 68).

After accounting for the PWLB, the typical investor in turnpike bonds was a local landowner, merchant, or manufacturer. They had an economic interest in financing the trust because good roads increased their property or asset values. In fact, there is evidence local property income rose by 15-20 percent near turnpikes (Bogart 2009). However, these local investors also had a financial interest in the trust through the returns on their turnpike bonds. They could instead invest in land or government bonds, and let others bear the risk of turnpike bonds. An interesting question thus arises: how well did turnpike investors do in terms of returns?

There is anecdotal evidence in the literature suggesting that some turnpike investors earned good returns, and were paid an interest rate that was larger than the local market rate. As one illustration, a farmer in northern England commented on a turnpike in his area stating that "the [toll] would continue indefinitely. This is because those who have loaned money for the repair of the road are not keen to be repaid as long as they enjoy 5 percent interest, an unusually high figure for this area…"[11]

Albert (1972) is one of the few studies on the financial performance of turnpikes before the arrival of railways. Albert lists interest rates for a sample of 100 trusts between 1730 and 1830 (pp. 247-261). Figure 2 plots the average interest rate in the sample along with a 90 percent

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[11] Quoted in Berg and Berg (2001) p. 240.

confidence interval for the average. It also reports the yield on 3 percent consols.[12] The interest rate on turnpike bonds was typically higher than consols. From 1730 to 1830, the average interest rate for turnpike bonds was 4.66 percent and the average yield on consols was 3.9 percent.

The Charity records provide additional information on rates of return for 114 turnpike bonds between 1752 and 1844 (see Clark 1998 for details on charities). The average rate of return in this sample was 4.74 percent. While the face value of the bonds is not stated, it is likely that many were valued at £25, 50, 100, or units divisible by 25. In the Charity sample, 68 percent of the turnpike bonds were purchased at prices exactly divisible by £25. The average ratio between the price and nearest number exactly divisible by 25 is 1.009, and is statistically indistinguishable from 1.

The picture which emerges is that turnpike trusts paid high interest rates. However, there are two problems in drawing this conclusion. First, it is not clear if the interest rates reported in Albert and the Charity records are contracted rates, or the effective rates paid to investors. The two may differ if trusts missed interest payments. Second, the two samples may not be representative of all trusts. If they are biased to trusts paying interest, then the effective rate of interest across the population of trusts might be less. This point has been made by Webster (2015, p. 75) who found that 50 percent of all turnpike trusts in 1834 were not meeting their full interest payments. In the same study, Webster examined the returns at the end of the turnpike system between 1850 and 1883. In this period, railways took a significant portion of the traffic from turnpike trusts, making many financially unviable. Parliament dictated that trusts wind

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[12] Yields are taken from Global Financial Data which draws on Neal (1990).

down their affairs and come to agreements with their creditors. Webster estimates that investors received 39 percent of what they were entitled in the end.

While turnpike bonds ultimately lost value, it is not clear that they were a poor financial investment from the point of view of investors in the early nineteenth century. To clarify matters, we need to measure the financial returns to all turnpike trusts, and compare them with a yardstick security like the 3 percent consol. The following section discusses the data sources for this task.

II.

Parliament began making serious inquiries into the finances of turnpike trusts in the early nineteenth century. They were driven by the aim of improving roads and to investigate whether trusts were being mismanaged.[13] The first parliamentary committee in 1821 required the officers of each turnpike trust to provide a financial summary and information on operations.[14] In total 1020 trusts from England and Wales submitted returns on annual revenues and expenses averaged over the years 1818, 1819, and 1820. They also reported the balances held by the treasurer, interest due, and the amount of debt in 1820. The 1821 Report also includes 'notes' for each trust sometimes describing how long interest was in arrears, the size of legal expenses, and road improvements. [15]

More detailed financial reports were made in 1829 and annually from 1834.[16] In the post-1821 reports, separate tabulations are made for interest payments, principal payments, purchases of land, and improvements. Also from 1829 revenues minus operating costs can be calculated for all trusts. Operating costs are defined as total expenses minus interest payments, debt repaid, and

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[13] See Albert (1972) for a discussion of Parliament's investigations of turnpike trusts in the early 1800s.
[14] 'Select Committee to consider the Acts now in Force Regarding Turnpike Roads and Highways,' published its report in the British Parliamentary Papers in 1821
[15] A summary of the 1821 report is in Marshall's (1835) Analysis and Compendium of all the Returns Made to Parliament. The full report is available in BPP (1821 IV).
[16] A summary of the reports up to 1838 is given in BPP (1840 XXVII).

investment expenditures. For the 1818-20 data some assumptions are needed to calculate operating costs. The main issue is that interest payments are not reported separately. Fortunately, data on the value of debt, interest due, and the reported notes can be combined to estimate interest payments. The details for the calculation are given in section V.

All the financial reports have one major limitation: no figures are given for the value of road capital either before the trust was formed or after due to its investments. There are some estimates in the literature derived from Ginarlis and Pollard's (1985) series on annual investment in turnpike roads from 1750 to 1810. For example, Harris (2000) uses these figures to estimate the values all turnpike capital in 1810 at £15.9 million in 1810. However, the Ginarlis and Pollard's series includes maintenance expenditures, and thus over-states capital spending. One indication is that estimated turnpike capital exceeds reported figures on total capital raised for canals.[17] Webster (2016, p. 64) improves on Ginarlis and Pollard and estimates that turnpike capital increased by £2.8 million between 1817 and 1826. But Webster does not give an estimate of total turnpike capital c.1820 or after, which is necessary to estimate the rate of return. Below I provide a new estimate for turnpike road capital in 1820, 1829, and several years after.

III.

Panel A of Table 1 shows the payments to turnpike bondholders at various dates in the 1820s, 30s, and 40s. They are based on summary figures for total interest payments and total debt among all turnpike trusts in England and Wales. The interest paid varies from 3.44 percent to 4.09. Averaging across all seven years gives an average interest paid of 3.92 percent. Arguably the stock of unpaid interest (or interest due) should be included in debt because missed interest was rarely written off trusts' books. In panel B interest due is added to the debt. The

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[17] Ward (1974, p. 73) estimates £12.4 million in capital was raised for canal projects between 1755 and 1815. English's (1827) list of joint stock canals in 1825 reports capital totaling £12.2 million. An anonymous writer in the Quarterly Review in 1825 also lists joint stock canals and puts the capital figure at £13.2 million.

average interest paid across the seven years is now 3.37 percent. For comparison, the average

yield on consols between 1818 and 1850 was 3.44 percent, and is similar to the 3.37 return.

The year 1829 is the only one where interest paid on turnpike bonds was quite low. This is

notable because large investments were made in the 1820s, following the innovations of

Macadam and Telford. In the short-run investing brought some losses to turnpike bondholders.

Over the medium-term it seems to have paid as returns increased in the 1830s and remained high

in the early 1840s.

The return on turnpike bonds started to fall again in 1848. At this point, railways began to

seriously scoop the traffic of turnpike trusts. Over the next few decades, interest payments would

continue to fall. Does this imply that turnpike bonds originated in the 1820s were a bad

investment? A plausible estimate of the internal rate of return suggests the answer no. Suppose

that an investor lent £100 to a turnpike trust in 1820 and received the average return of 3.92

percent until the year 1860 when a renegotiation with the trust forced them to accept a repayment

of £39. The internal rate of return for such an asset is 3.3 percent, essentially equal to the yield

on consols.[18] The overall conclusion is that the investor who purchased a diversified portfolio of

turnpike bonds at face value would have received a similar return as investing in government

bonds.

IV.

The rate of return on turnpike capital provides an alternative measure of the financial

returns. As stated earlier, it is first necessary to estimate the value of turnpike capital in 1820 and

then at other dates in the 1820s, 1830s and 1840s. Turnpike capital in 1820 is equal to average

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[18] The internal rate of return r solves the following equation: $100 = \sum_{t=0}^{39} \frac{3.92}{(1+r)^t} + \frac{39}{(1+r)^{40}}$. The 39 pound repayment in 40 years is based on Webster's estimate that turnpike bondholders were repaid 39 percent of their value when trusts wound down their operations between 1850 and 1883.

investment per mile multiplied by total turnpike mileage in 1820. The investment data come from an earlier study which reports average expenditure per-mile for a sample of 38 trusts covering the years from 1700 to 1820.[19] Figure 3 shows an estimate of average expenditure per mile during the first 40 years since a turnpike trust's founding. Expenditure includes all items: investment, maintenance, interest payments, etc. The ages of trusts in the sample varied and each trust's first year is standardized to 1. Based on the average age of trusts, the typical expenditure profile displayed is from 1764 to 1803. Lastly, all the expenditures are converted to 1819 prices using wages of unskilled labor, one of the main inputs into road repair.[20]

It is clear from Figure 3 that significant road spending occurred in the first two years of a trust's existence, less in years three to five, and then beyond year five expenditure per mile stabilizes and remains roughly constant. The figures are consistent with a story in which trusts improved their road and then maintained it afterwards so that net depreciation was zero. This characterization seems to work well for the pre-1820 period as many trusts did not significantly alter the road after making their initial improvement. For the purposes of estimating investment per mile, I assume that all spending by the turnpike trust in the first two years was investment in road capital, the difference between the average spending in years 3, 4, and 5 compared to years 6 to 20 was also investment, and none of the spending beyond year five was investment. These assumptions yield a capital value per mile of £502 in 1819 prices. Multiplied by total turnpike mileage in 1820 implies a value of turnpike capital around £10.5 million in 1819 prices.

One might be concerned that the £10.5 million estimate is too high given total turnpike debt in England and Wales stood at £4.4 million in 1820. That concern is lessened because debt should be lower than the replacement cost of capital due to the inflation that occurred from 1750

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[19] See Bogart (2005).
[20] Wages for unskilled labor come from Clark (2009).

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to 1815. For argument's sake suppose that all turnpike borrowing went to finance investment. Also assume that all debt in 1820 was incurred in the 1750s and 1760s when the vast majority of trusts were formed. In this plausible situation, £4.4 million in debt would amount to a capital of £8.8 million in 1819 at replacement cost because unskilled wages in 1820 were around twice their level in 1750 (see Clark 2009). Notice that £8.8 million is similar to my 1820 capital estimate of £10.5 million. It also makes sense if one incorporates some retirement of debt between 1750 and 1820, and some investment financed through toll income.

Two more steps are needed to estimate the capital stock in 1829, 1834, 1838, 1842, and 1845. First in each subsequent year I adjust the value of the previous year's capital stock to reflect the current replacement cost of the capital. The capital cost inflator is based on building laborers' wages, which rose at an average annual rate of 0.3% between 1820 and 1845. Second, an estimate of investment is added. From 1829 onwards I use the figure for "improvements" and "land purchased" in the parliamentary reports, which clearly reflect investments. From 1820 to 1829, where such data are lacking, I assume investment is equal to the increase in debt from 1820 to 1829, which is £2.1 million. Finally note that no depreciation in capital is assumed, which is justified because turnpike trusts spent regular sums on maintenance.

The capital stock estimates are reported in table 2 along with the inputs into the calculation like the replacement cost inflator and investment. To arrive at the estimate of turnpike capital, the previous period's capital stock value is multiplied by the replacement cost inflator and then investment is added. It is clear there was significant investment in the road network in the 1820s and 1830s. The value of turnpike capital grows from £10.5 million in 1820 to £16.5 million by 1845. Thus, I find sizeable increases in turnpike capital in the 1820s and 30s, again in the wake

of Macadam and Telford's innovations. Note also the similarity with Webster's estimate of a £2.7 million investment in the period from 1817-26, which further supports the estimates.

The next step is to construct an estimate of turnpike revenues minus operating costs, or so-called net revenues. As an illustration, the revenues in 1834 are shown in panel A of table 3. Tolls are the main source of monetary revenues. Parish payments for statute labor are a distant second. An estimate was also made for the value of statute labor performed, which represented around 5 percent of monetary revenues. I use the figure for all revenues, including the value of statute labor, in the net revenue calculation. Operating expenses are listed in panel B and generally cover labor, materials, and administration. They represent 62 percent of total expenditures. Non-operating expenses include investments, debts paid, and interest paid. The final figure at the bottom of table 3 is the net revenue. Similar calculations are made for other years. The only difference is that in 1820 investment and debt payments are assumed to be equal to interest paid in 1820, which is similar to the situation in 1829 and 1834.

Combining all this data yields new estimates of the rate of return on turnpike capital shown in table 4. The rate of return is estimated by the percentage of net revenues in total capital. It ranges between 1.61 and 3.83 percent, with an average of 3.06 percent. One immediate implication is that the rate of return on capital is similar to the estimate for the return to bondholders if unpaid interest is added to the trusts' debt. Thus there is little evidence for some form of quasi-profit. If there were profits, then the rate of return should have been higher than the return to bondholders.

The general conclusion thus far is that financial returns in the turnpike sector were broadly competitive. Turnpike bondholders received a return that was similar to holders of long-term government debt. The returns to turnpike capital are lower but still respectable. The

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perception in the literature that turnpike trusts did not pay good returns to investors is not borne out in the aggregate. But there is a different side to the story when considering the returns to individual turnpike trusts. Payments on individual turnpike bonds were variable, and even zero for some trusts. The following section examines the distribution of bondholder returns across turnpike trusts in 1820 and 1838.

V.

Estimating the returns to individual turnpike bondholders in 1820 requires some assumptions due to incomplete information. As noted above, the 1821 Report gives the value of debt and interest due averaged over the years 1818 to 1820. I combine these two in estimating interest payments. If there is no interest due from the trust, then the return on turnpike bonds is assumed to be 4.75 percent. In Albert's sample described above, the average contracted interest rate between 1816 and 1825 is very close to 4.75 percent. If there is interest due, then it is likely that interest payments in 1820 were less than 4.75. Figure 4 shows the distribution of interest due as a percentage of debt across 962 trusts with information reported. 615 of the 962 trusts had some interest in arrears. Most had interest due equal to less than 10 percent of the value of their debt, but a few had an interest due equal to more than 50 percent of their debt. The notes column of the 1821 Report specifies that interest payments were not made in the three previous years for 119 of 615 trusts with interest due. Here I assume the interest payment in 1820 was zero. For the remaining 496 trusts with interest due, I estimate the interest missing using two scenarios. First, the total interest due was accumulated evenly in every year since 1809. Second, the total interest due was accumulated evenly in every year since 1799. Essentially in scenario 1 missed interest is the total interest due divided by 11 since interest could have been missed in any of the eleven

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years from 1809 to 1820. Finally, I subtract the estimate of missed interest as a percentage of debt from 4.75 percent to get the estimated return for the remaining 496 trusts.

A summary is reported in table 5. Under scenario 1 the un-weighted average return is 3.48 percent and under scenario 2 the un-weighted average return is 3.70 percent. The averages are similar if returns are weighted by mileage (see the second scenario 2 in table 5). Also of interest is the standard deviation and coefficient of variation. The latter is between 0.46 and 0.53, and in the moderate range.

Figure 5 shows the full distribution of bondholder returns in 1820. Most trusts were at the two extremes: 0 and more than 4.5 percent. Under scenario 2, 60 percent of trusts (579 out of 962) have interest payments of more than 4.5 percent, while 15 percent of trusts (144 of 962) have no interest payments. In terms of total turnpike debt, the 15 percent of trusts making no interest payments accounted for 14 percent of the debt, and the 60 percent of trusts paying more than 4.5 percent accounted for 64 percent of the debt. The implication is that more than half of turnpike bondholders earned a premium over government bonds in 1820, but a minority (around 15 percent) earned no return.

A natural follow up question is whether the trusts paying no interest in 1820 were facing foreclosures by investors. The evidence suggests they were not. In the 1821 Report, there are only two mentioned cases of foreclosure: (1) the Aldermaston and Basingstoke Second District trust in Hampshire and (2) the Stockport and Marple trust in Cheshire.[21] The rarity of foreclosures indicates that bondholders bore downside risks. If the trust could not pay, there was little investors could do but wait until the trust's finances improved.

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[21] The evidence comes from the 'observations' column in the 1821 report. Although it is possible that some foreclosures were not noted in the observations, it is unlikely that it was prevalent. Explaining the absence of foreclosure is beyond the scope of this essay, but it is worth pointing out that it could be rationalized by the high legal costs, or investors may have believed that by not foreclosing they would ultimately collect more interest payments in the long-term. See Albert (1972, p. 97) for a brief discussion of foreclosure costs.

How were returns different at the beginning of the railway era? Fortunately, it is straightforward to answer this question because the parliamentary reports give the interest payments and debt for each trust from 1834 onwards. I focus on 1838 as there is a broader range of information on trusts in that year. The unweighted mean return was 4.26 percent with a standard deviation of 2.80, implying a 0.65 coefficient of variation. The full distribution of returns across trusts in 1838 is shown in figure 5. The data again reveal a range. 12 percent of the 1071 trusts were making zero interest payments in 1838, while 55 percent of trusts were paying more than 4.5 percent.[22] Also in the latter group 28 percent of trusts were paying more than 5 percent, which exceeds the usury cap. It is likely these trusts were repaying interest that was missed in some previous years.

Figure 6 also shows the contracted rate of interest stated in the 1840 report. Nearly 75 percent of trusts had a contracted rate of 5 percent, and 24 percent had a contract rate of 4 or 4.5 percent. But only 41 percent of trusts paid 5 percent or more in 1838, and 69 percent paid 4 percent or more. Thus while many trust paid less than the contracted rate, enough of them did to give turnpike bondholders a competitive return ex post.

The 1838 data suggest there was a recovery in financial performance for many trusts during the 1830s compared to the 1820s. Part of this recovery was felt by trusts who were previously 'financial losers.' To illustrate, I matched trusts in the 1821 and 1840 Reports based on trust name and county. For the moment, I focus on the 144 trusts in 1820 not making any interest payments. I was able to match 133, but five of these did not have information on interest payments.[23] Thus I am able to analyze interest payments for 128 trusts in the sub-group that were not making interest payments in 1820. There were 34 trusts or 26.5 percent of the sub-group still

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[22] The 12 percent of trusts paying zero interest represented 9.5 percent of total debt and the 55 percent of trusts paying more than 4.5 percent represent 53 percent of total debt.
[23] See BPP 1840 (XXVII) for the 1840 Report.

paying zero interest in 1838. But 76 trusts or just under 60 percent of the sub-group were paying 4 percent or more. Figure 7 shows the distribution of interest payments as a percentage of debt in 1838. The financially distressed trusts of 1820 are still more distressed compared to others in 1838, but a large number of trusts recovered financially by 1838. Thus, the losses incurred by some bondholders in 1820 were not permanent.

VI.

Thus far the focus has been on the ex post return to investing in turnpikes. It is still an open question whether investors understood the risks they faced ex ante. Presumably in the 1820s and 1830s investors had information about the financial performance of turnpike trusts, especially considering that the 1821 Report made them public. It is possible that investors demanded a higher contracted interest rate if the trust was newly established or if its financial performance in 1820 was worse. In order to test these theories, I analyze the relationship between the contracted rate in the 1840 report and the year a trust was founded. I also analyze the effect of trusts' returns and debt per mile in 1820. Trusts in the 1840 Report are matched to trusts in 1821 Report based on trust name and county. Of the 960 trusts with debt reported in 1821, 778 were successful matched in the 1840 Report.[24] The mean return was 3.66 percent and the mean debt per mile in £100 was 3.32.[25] As shown earlier most trusts had a contracted rate of 5 percent and a minority had either 4 or 4.5. The binary nature of contracted rates (5 percent or less) suggests that a binary choice model is appropriate. Therefore, I create a variable equal to

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[24] Special thanks go to Alan Rosevear for matching trust across parliamentary reports.
[25] The mean contracted interest rate for trusts whose first act was before 1820 and were not matched to the 1821 report is nearly identical to the mean for the contracted rate of all trusts, suggesting the attrition in matching does not lead to a biased sample.

one if the contracted rate is 5 percent and 0 otherwise, and estimate a logit model identifying the

effects of certain variables on the probability of a 5 percent rate.[26]

Table 6 reports the estimates. In column (1) the results show that younger trusts paid a

higher contracted rate. The marginal effects imply that adding a decade to the trust's founding

act—one third of a standard variation—increased the probability by 0.027. Thus there is some

evidence that investors regarded newer trusts as riskier than older trusts. In column (2) an

indicator for trusts paying zero interest in 1820 and the rate of return in 1820 are included.

Neither variables are significantly related to the contracted rate. The suggestion is that investors

did not regard poor performance in 1820 as indicative of greater risk over the next two decades.

Column (3) adds debt per mile. The results show that greater debt was associated with the higher

contracted rate. The marginal effects imply that increasing the debt per mile by £100—one fifth

of a standard deviation—increased the probability by 0.03. Thus there is evidence that greater

trust indebtedness raised perceived risks. Finally, in column (4) dummy variables for each trust's

county are included to control for unobserved heterogeneity at the county-level. The previous

results are unchanged, suggesting the conclusions are fairly robust.

VII.

The final section of this paper compares the return on turnpike bonds with a broader range

of securities available to the early 19$^{\text{th}}$ century investor, including land, canals, railways, and

banks. In order to make comparisons I calculate the Sharpe ratio for a portfolio of each type of

investment. The Sharpe ratio is the average return in the portfolio $r^{portfolio}$ minus the risk free

return $r^{risk\,free}$ divided by the standard deviation of the portfolio σ^2, or $\frac{r^{portfolio}-r^{risk\,free}}{\sigma^2}$. A

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[26] An alternative is to study a multinomial logit model where the base outcome is 4 percent, and the alternative
outcomes are 4.5 and 5 percent. The results are similar.

higher Sharpe ratio generally implies a superior portfolio because it offers more return per unit of risk (see Sharpe 1994 for more details).

The portfolio of turnpike bonds includes the population of trusts in 1820 and 1838 analyzed in the previous section. The portfolio for farmland is based on rates of return on properties held by charities reported by Clark (1998). The Charity records contain the returns for 82 properties between 1818 and 1845. Note they exclude housing which is a separate category. The mean return in the farmland portfolio is 3.61 percent and the standard deviation is 1.36 percent.

The railway portfolio is drawn from Arnold and McCartney (2005), who use accounting statements to measure rates of return on capital employed (ROCE) for the top 5 railway companies from 1838 and the top 10 companies from 1854. The ROCE uses the historical cost of capital rather than the replacement value of capital. The distinction is not as significant for railways because they were built in a low inflation environment. Arnold and McCartney's (2005) estimates show a highly variable ROCE for the top 5 British railways. Their estimates will be discussed momentarily.

Canals are difficult to analyze because there are no sources describing the entire population. The most detailed analysis is by Arnold and McCartney (2011), who estimate financial performance for five canal companies from 1770 to 1850. They find an average rate of return on capital (net earnings divided by debt plus equity) of 10.2 percent and average dividend rate of 23.9 percent in the early 1820s (p. 228). Based on these figures it would appear that canal investors did very well. However, there is a potential problem in extrapolating from Arnold and McCartney's sample to the canal sector as a whole because it is possible that their 5 canal companies had better financial performance than the average company.

Ward's list of canal dividends in 1825 provides another estimate (1974, pp. 177-178) and reports the dividend rate for nearly all canals. The unweighted average dividend rate in Ward's sample is 9.7 percent and the standard deviation is 15.73. It is clear that on average canal investors received a much larger return than turnpike investors in 1825. This conclusion is not surprisingly because as Arnold and McCartney point out, some canals were viewed as veritable gold mines before railways. However, the return on canals shares were more variable, which diminished their utility to investors.

Finally, I consider a portfolio of securities on the British stock market. Acheson et. al. (2009) report the average and standard deviation for a portfolio of 681 securities between 1825 and 1870. Railways feature prominently in the index, following by banks, mines, and insurance companies. Railways were the most capital intensive, and so Acheson et. al. report portfolio returns including and excluding railways. The unweighted average return including railways is 10.16 percent with a standard deviation of 9.7. The portfolio excluding railways is lower but broadly similar.

Table 7 summaries the returns for each portfolio, and reports the Sharpe ratio in the last column. In all cases, the risk free asset is the consol with a return of 3.44 percent. The two turnpike portfolios in 1820 and 1838 had higher Sharpe ratios than the farmland portfolio. Thus landowners who diversified into turnpikes earned a higher return per unit of risk. But turnpikes yielded less returns per unit of risk than canals. Thus it was arguably worth it to take the risk of investing in canals over turnpikes.

The Sharpe ratio for the top five railways is reported in four years. The Sharpe ratio was lower than turnpikes in 1838 but higher in the other three by a significant amount. The conclusion is similar for a portfolio consisting of the next ten railways. Thus after their initial

developmental phase in the 1830s the top 15 railways offered an entirely new level of returns compared to turnpikes and even canals.

Finally, the stock market portfolio had a higher Sharpe ratio than turnpikes, irrespective of whether railways are included. The mid-nineteenth century was a prosperous time for investors in a whole range of securities including banks, mines, insurance companies, and others.

Overall it appears that turnpike bonds were a transition asset for investors. They offered a better return than land which was the dominant investment in Britain before the industrial age. But turnpike bonds were eventually superseded by the new investments of the mid-nineteenth century, like railways, banks, and insurance companies.

VIII.

Much of the infrastructure in England and Wales was financed by local individuals during early industrialization. Parliament gave turnpike trusts and other statutory authorities' rights to improve or construct roads, rivers, canals, bridges, and dock works. Along with these rights came the opportunity to profit from public works. But there was also a potential to suffer financial losses, as has been the case in many modern infrastructure settings. This paper estimates financial returns in the turnpike sector. The return to turnpike bondholders was 3 to 4 percent depending on the year and whether unpaid interest was included. At the trust-level returns to bondholders varied. Around 15 percent of trusts were not making any interest payments by 1820. However, many investors being paid zero interest in 1820 were receiving interest of 4 percent or more by 1838. Overall it is clear that investors in early public works, like turnpikes, could earn a reasonable financial return. Many also earned an economic return through higher property values. Turnpike bonds, like canal shares, contributed to the growing wealth of England's elite in the early nineteenth century.

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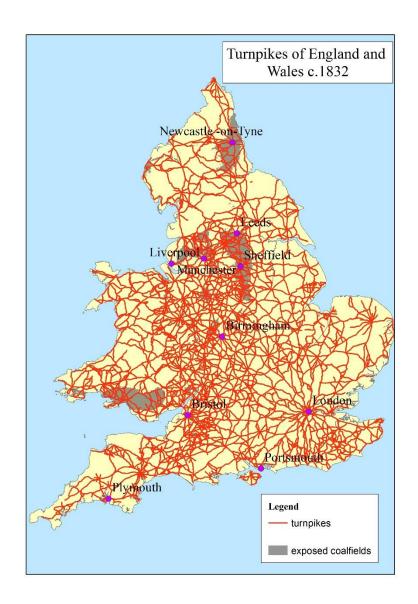
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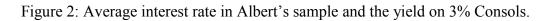
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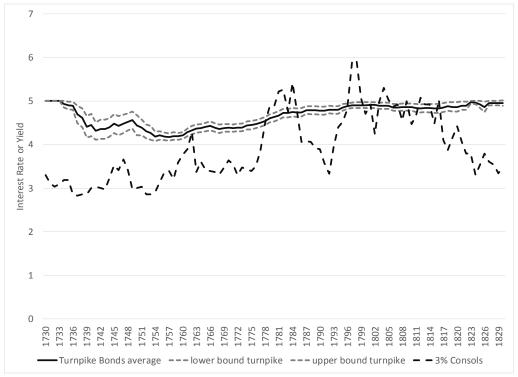
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Figure 1: A map of the English and Welsh turnpike network in 1830

Sources: Map produced by the transport, urbanization, and economic development in Britain, 1670-1911

project. See http://www.campop.geog.cam.ac.uk/research/projects/transport/

Figure 2: Average interest rate in Albert's sample and the yield on 3% Consols.
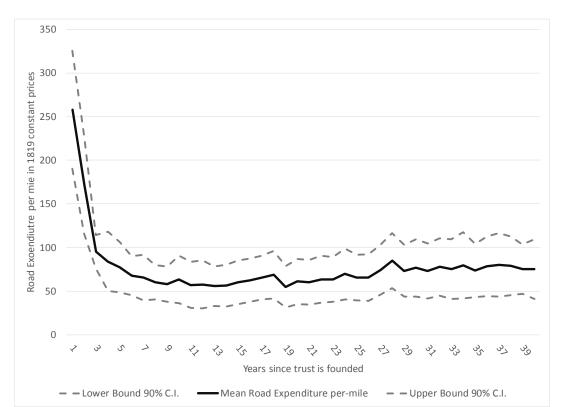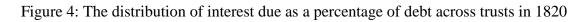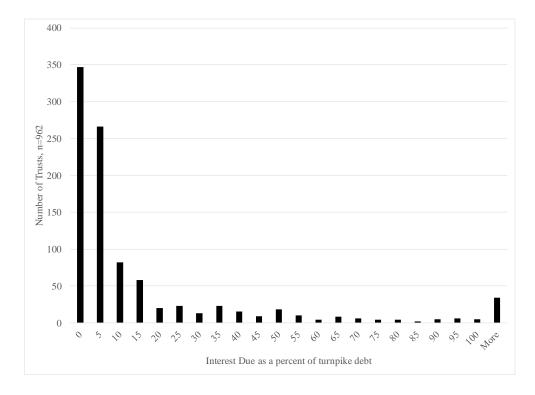

Sources: Albert (1972), p. 247-261.

Figure 3: Road Expenditure per mile for a sample of turnpike trusts

Sources: The data on road expenditure come from Bogart (2005).

Figure 4: The distribution of interest due as a percentage of debt across trusts in 1820

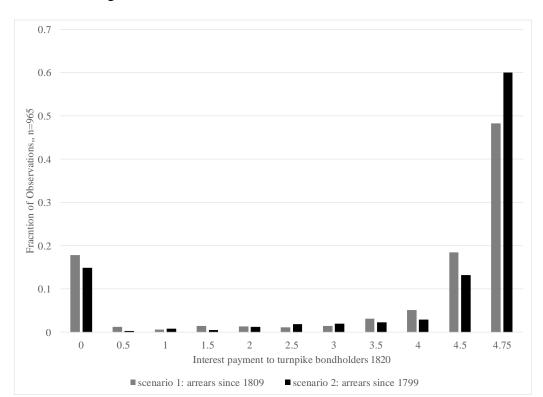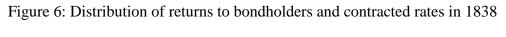Sources: authors calculations from 1821 turnpike report, BPP 1821 IV.
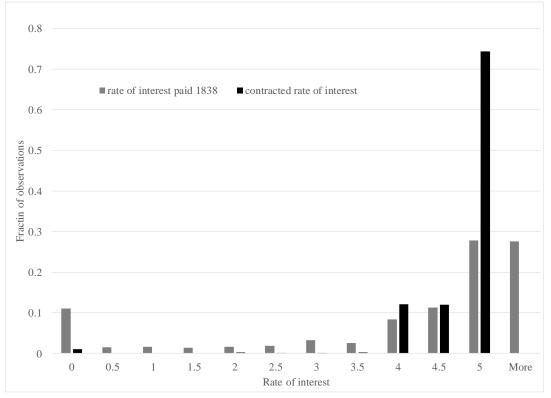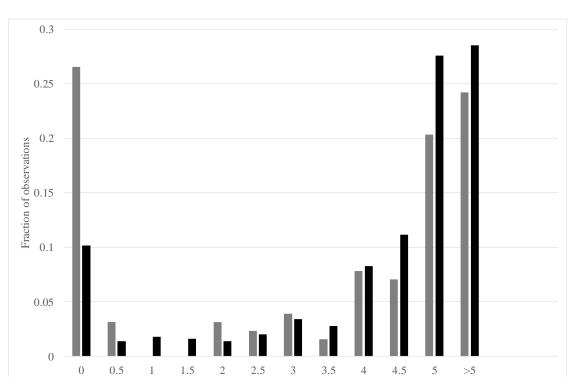
Figure 5: Distribution of returns to bondholders in 1820

Sources: Author's calculations based 1821 report BPP 1821 IV.

Figure 6: Distribution of returns to bondholders and contracted rates in 1838

Sources: see text.

Figure 7: Distribution of returns in 1838 depending on whether interest was paid in 1820

Sources: Based on author's calculations from BPP 1840 XXVII and BPP 1821 IV.

Table 1: Payments to Turnpike Bondholders in British pounds

Panel A: Excluding interest due

	1820	1829	1834	1838	1842	1845	1848
Total Mortgage and Floating Debt	4,402,466	6,882,356	7,342,210	7,463,027	7,238,705	6,964,960	6,685,954
Interest paid	173,660	236,619	289,376	301,462	295,934	282,439	264,321
Interest paid as percent of debt	3.94	3.44	3.94	4.04	4.09	4.06	3.95

Panel B: Including interest due

	1820	1829	1834	1838	1842	1845	1848
Total Mortgage, Floating Debt, and interest due	5,008,154	7,703,942	8,344,465	8,586,650	8,572,193	8,374,765	8,214,407
Interest paid	173,660	236,619	289,376	301,462	295,934	282,439	264,321
Interest paid as percent of debt	3.47	3.07	3.47	3.51	3.45	3.37	3.22

Sources: Data for 1820 come from Marshall (1835, p. 85) and from BPP (1821 IV). Data for 1829, 1834, and 1838 are from BPP 1840 (XXVII, p. 647.). Data for 1842 are from BPP (1844 XLII). Data for 1845 are from BPP (1847-48 LI). Data from 1848 are from BPP (1851 XLVIII).

Notes: Debt, interest paid, and interest due is taken from the reports in each year except 1820 where interest paid is estimated. (see section V for details).

Table 2: Estimate of turnpike road capital

	1820	1829	1834	1838	1842	1845
Estimate of value of turnpike capital (at current replacement cost)	10,500,125	13,051,030	14,471,323	15,567,232	16,037,446	16,514,329
Replacement cost inflator for previous period's capital		1.0370	1.0179	1.0175	1.0000	1.0172
Investments since previous period		2,162,400	1,186,680	854,612	477,444	201,039

Sources: see table 1.

Table 3: Categories of turnpike revenue and expenses in England and Wales, 1834

Panel A: Revenues

Category	value in pounds sterling	% of monetary revenues	% of all revenues
Tolls	1,434,069	93.9	89.4
Parish payments in lieu of statute labor	58,077	3.8	3.6
Incidental receipts	35,494	2.3	2.2
Total monetary revenues	1,527,640		
Estimated value of statue labor performed	75,758		4.7
Total revenues, including statute labor	1,603,398		

Panel B: Expenses

Category	value in pounds sterling	% of total expenditure
Labor (manual and team)	516,376	30.3
Materials for surface repairs	217,048	12.8
Salaries to trust officers	92,954	5.5
Tradesman's bills	67,098	3.9
Damages in obtaining materials	10,018	0.6
Incidental expenses	59,045	3.5
Legal	28,889	1.7
Estimated value of statute labor performed	75,758	4.5
Total operating expenses	1,067,186	62.7
Improvements	217,152	12.8
Land purchased	20,184	1.2
Interest	289,376	17
Debt Payments	107,810	6.3
Total non-operating expenses	634,522	37.3
Net Revenues (Revenues- operating expenses)	536,212	

Source: BPP 1840 (XXVII, p. 647).

Table 4: Estimated Rate of Return on Turnpike Capital

	1820	1829	1834	1838	1842	1845
Total revenues	1,088,767	1,407,865	1,603,398	1,573,893	1,446,215	1,393,898
Total expenditures	1,034,124	1,678,032	1,701,708	1,670,180	1,528,259	1,372,149
Operating Expenses	686,804	1,197,646	1,067,186	1,067,178	999,236	866,800
Net Revenues	401,963	210,219	536,212	506,715	446,979	527,098
Estimate of turnpike capital	10,500,125	13,051,419	14,471,160	15,579,652	16,057,096	16,534,981
net revenues as % of capital	3.83	1.61	3.71	3.25	2.78	3.19

Sources: see table 1 and text.

Table 5: Summary of Rates of Return for Turnpike bonds

Average return on turnpike bonds 1820	observations	Mean	standard deviation	coefficient of variation
scenario 1, un-weighted	965	3.48%	1.83%	0.53
scenario 2, un-weighted	965	3.70%	1.71%	0.46
scenario 2, mile-weighted	965	3.76%		

Sources: Author's calculation based on 1821 Report, BPP 1821 IV.
Notes: In scenario 1, the total interest due was accumulated evenly in every year since 1809. In scenario 2, the total interest due was accumulated evenly in every year since 1799.

Table 6: Determinants of trust's contracted interest rate being 5 percent in 1838

variable	(1) Coeff. (Rob. St. Err.) Marginal effect	(2) Coeff. (Rob. St. Err.) Marginal effect	(3) Coeff. (Rob. St. Err.) Marginal effect	(4) Coeff.. (Rob. St. Err.) Marginal effect
Year of trust's first act in 10s	0.137 (0.023)*** 0.027	0.152 (0.034)*** 0.031	0.115 (0.036)*** 0.031	0.141 (0.040)*** 0.026
Zero interest paid to bondholders in 1820		-0.472 (0.569) -0.102	-0.4 (0.578) -0.082	-0.441 (0.669) -0.087
Rate of return to bondholders 1820		-0.029 (0.124) -0.005	-0.009 (0.125) -0.001	-0.023 (0.145) -0.004
Debt per mile in 1820 in 100s			0.154 (0.054)*** 0.03	0.157 (0.056)*** 0.029
Constant	-23.485 (4.07)***	-25.91 (6.19)***	-19.86 (6.53)***	-24.41 (716)***
Dummy variables for county included	N	N	N	Y
N	1139	778	772	764
Pseudo R-square	0.028	0.024	0.048	0.147

Notes: The dependent variable is 1 if the contracted interest rate in 1838 was 5%, otherwise 0. Robust standard errors are reported. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table 7: A comparison of investment portfolios in the early nineteenth century

Portfolio	Mean return	Standard Dev.	Sharpe ratio
turnpike bonds 1820	3.70	1.71	0.152
turnpike bonds 1838	4.26	2.8	0.293
farmland, 1818-1845	3.61	1.36	0.125
canals 1825	9.71	15.7	0.399
railways, top five companies 1838	4.27	3.91	0.212
railways, top five companies 1844	7.73	1.75	2.451
railways, top five companies 1850	3.83	0.84	0.464
railways, top five companies 1854	4.06	0.76	0.816
railways, next ten companies 1854	4.21	1.2	0.642
British Stock market, including railways 1825-1870	10.16	9.7	0.693
British Stock market, excluding railways 1825-1870	8.54	8.19	0.623

Notes and sources: see text.