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Turnpike trusts and the transportation revolution in 18th century England

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Abstract

There is a long debate in economic history about the causes of the transportation revolution and its economic impact. This paper examines the effects of turnpike trusts in 18th century England. Turnpike trusts were organizations that financed road improvements by levying tolls. They replaced the authority of parishes, which financed road improvements using local taxes. The analysis shows that turnpike trusts contributed to lower freight charges and passenger travel times. It also shows that turnpike trusts, generated a social savings of at least 0.5% of national income in 1800 and 1820.

Keywords: Transportation revolution; Toll roads; Turnpike trusts; Institutional innovation

1. Introduction

The transport revolution of the 18th and 19th centuries embodied dramatic reductions in transport costs and improvements in the quality of services. It also had a profound effect on economic development by contributing to the growth of domestic and international trade.[1] Although the transport revolution has been the subject of

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[1] See O'Rourke and Williamson (1999) and Estevadeordal et al. (2003).

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much research, there are still questions about its causes. Some scholars argue that technological change was the key factor, whereas others point to a variety of alternative factors, including the elimination of piracy, changes in loading procedures, and greater coordination in scheduling.[2] This paper investigates the impact of an institutional innovation by examining the effect of turnpike trusts in 18th century England.

A turnpike trust was an organization that financed road improvements by levying tolls and issuing mortgage debt. They were created by Acts of Parliament, which named a body of trustees and gave them authority over a particular roadway that was previously maintained by parishes. Unlike turnpike trusts, parishes did not have access to external sources of funding, such as tolls or bonds. Instead, they financed road improvements by levying local property taxes and by claiming up to six days of labor per year from their residents. Parishes were also different because they were part of local government, whereas turnpike trusts were statutory authorities that were promoted and managed by local property owners.

The diffusion of turnpike trusts spanned the 17th, 18th, and early 19th centuries. The 1750s and 1760s were the most significant period of adoption as over 300 trusts were established along 10,000 miles of road. By the 1830s, the turnpike network expanded further and included around 1000 trusts managing 20,000 miles, or 17% of the entire road network in England and Wales.[3]

The adoption of turnpike trusts had an immediate effect on the economy by increasing road maintenance and investment. Turnpike trusts generally spent between 10 and 20 times more than the parishes they replaced. Trusts were also the driving force behind a fourfold increase in total road spending between 1730 and 1800.[4]

At the same time that turnpike trusts were increasing road expenditure, the road transport sector was experiencing a number of revolutionary changes, including a 40% reduction in freight charges and a 60% decline in passenger travel times. This coincidence has led many scholars to investigate whether turnpike trusts contributed to these developments. The studies by Jackman (1916), Albert (1972), and Pawson (1977) suggested that turnpike trusts were the key innovation because road improvements allowed horses to haul larger loads and travel faster. However, Gerhold (1996) has challenged this view by arguing that improvements in horse breeding and increases in the size of carriage firms were at least as important as better roads.

This debate has raised a number of questions about the relationship between turnpike trusts and the road transport revolution. One possibility is that turnpike trusts were responsible for the majority of the efficiency gains because road improvements had a large effect on transport costs. An alternative possibility is that turnpike trusts had little impact because improvements in horse breeding and the emergence of lar-

[2] See North (1968), Shepherd and Walton (1972), Harley (1988), Menard (1991), Kaukiainen (2001), and Mohammed and Williamson (2004).

[3] For information of the length of the road network in England and Wales, see Great Britain, House of Commons (1841).

[4] Bogart (Forthcoming).

ger carriage firms were the primary factors behind lower transport costs. Finally, there is a possibility that turnpike trusts may have reduced efficiency by levying tolls on road-users.

This paper examines these possibilities and reassesses the impact of turnpike trusts on the road transport sector. It shows that trusts reduced freight charges by an average of 20% and that they accounted for around half of the total decline in freight charges. It also demonstrates that freight charges were stable immediately before turnpike trusts were adopted and that winter freight charges converged to summer freight charges after trusts were established. The last two findings provide supporting evidence, because they show that the effects of turnpike trusts on freight charges cannot be attributed to improvements in horse breeding or larger carriage firms.

Overall, the analysis demonstrates that turnpike trusts were one of the key innovations that caused the road transport revolution. It also shows that turnpike trusts had a greater effect in the London transport market, which was the largest in the British economy. In addition, it shows that turnpike trusts generated a social savings of at least 0.5% of national income in 1800 and 1820. The last two results have more general implications because they indicate that turnpike trusts contributed to the process of economic development during the Industrial Revolution.

The paper is organized as follows. Sections 2 and 3 describe the adoption of turnpike trusts and the major changes in the road transport sector during the 18th century. Sections 4–6 examine the effects of turnpike trusts on the transport sector. Section 7 presents the social savings estimates and Section 8 concludes.

2. The rise of turnpike trusts

Before turnpike trusts, parishes were responsible for road improvements within their jurisdiction. Parishes were local governments that came under the authority of county magistrates, who were appointed by the crown. Magistrates were to ensure that parishes complied with their statutory responsibilities, which included the provision of local public goods, such as poor relief, constables, church construction, and road maintenance. Parishes financed these expenditures by levying taxes on property income. In the case of roads, parishes also had the authority to claim at most six days of unpaid labor from their residents per year.

By most accounts the parish system was generally unsuccessful in financing road improvements.[5] One problem was that parishes could not force through-travelers to contribute to the costs of road investment. The through-traffic problem was especially relevant along the highways leading into London, where wagons and carriages often passed through dozens of parishes along their route. In such cases, parishes would be forced to pay for all the maintenance and investment costs, even though they derived only a fraction of the benefits.

[5] Ginarlis and Pollard (1988) argued that parish road expenditure was substantial between 1750 and 1850; however, Bogart (Forthcoming) has shown that their estimates vastly over-state the road expenditures of parishes.

Borrowing constraints were another reason why the parish system was unsuccessful in financing road investment. Legal restrictions on issuing debt forced parishes to rely on current tax revenues. As a result, they had little incentive to undertake costly road investments with long gestation periods.

Parishes also provided few road improvements because of coordination problems. Coordination was necessary because the benefits associated with improving one road segment often depended on the investments in another segment. Therefore, some parishes may have decided to leave their roads unimproved because they expected that other parishes would not make similar investments along neighboring roads.

The shortcomings of the parish system became apparent during the 17th century as trade grew and the demand for better roads increased.[6] In 1663, an Act of Parliament introduced the first significant reform by granting magistrates in Hertfordshire and Cambridgeshire the authority to levy tolls along a section of the 'Great North Road.' In the 1690s, Parliament continued this policy by granting magistrates the right to levy tolls along certain highways in Essex, Norfolk, Gloucestershire, and Surrey.

In the early 1700s, Parliament began passing Acts that granted similar privileges to bodies of trustees composed of local landowners and merchants. Under this arrangement, trustees were authorized to finance improvements along a particular stretch of road by issuing debt and levying tolls. Trustees had to keep the tolls below a maximum schedule that distinguished between wagons, carriages, and livestock. Trustees were also required to devote all the toll revenues to road improvements and other expenses, which meant that they were not allowed to earn direct profits.[7]

Turnpike trusts gained popularity during 1710s and 1720s and eventually replaced the original trusts that were managed by magistrates. Each turnpike trust was created by an Act of Parliament and continued under a series of renewal Acts passed at least every 21 years. Turnpike Acts were initiated by local property owners, who petitioned Parliament for the right to create a trust. Early in the 18th century, it was common for petitions to fail in Parliament, but by the middle of the century, turnpike petitions were rarely unsuccessful.[8]

Fig. 1 plots the total number of trusts and the mileage under their control between 1700 and 1840. As the figure illustrates, there were three phases in the diffusion process. The first occurred between 1700 and 1750 and largely included the establishment of trusts along the major roads leading into London. The second diffusion phase occurred during the 1750s and 1760s and has become known as the 'turnpike boom' because over 300 trusts were created along 10,000 miles of road.[9] During this period, trusts assumed control over all of the major highways leading into London as well as most of the inter-city routes in the West Midlands and the North. The final phase lasted from 1770 to 1840 and largely included the adoption of trusts along secondary roads near major cities, such as London, Manchester, Leeds, and Birmingham.

[6] Chartres (1977).
[7] Albert (1972).
[8] Bogart (Forthcoming).
[9] Pawson (1977).

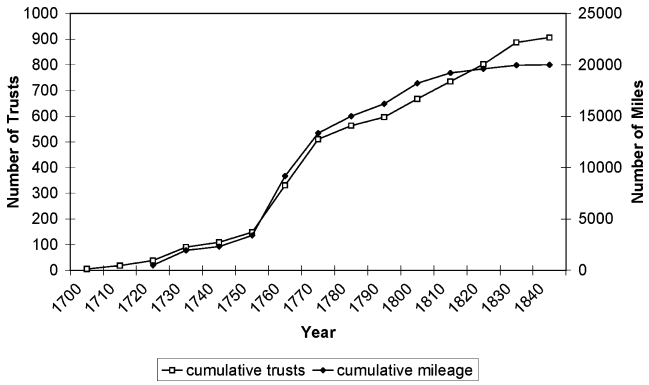

Fig. 1. The diffusion of turnpike trusts in England and Wales, 1700–1840.

The adoption of turnpike trusts resulted in a substantial increase in road expenditure. Prior to turnpike trusts, most parishes failed to levy any property taxes in order to finance highway improvements. As a result, most parishes never hired laborers to work on their roads, nor did they spend anything on land and materials. Instead, most parishes relied entirely on unpaid labor performed by their residents. When turnpike trusts were established, financial expenditures on labor, land, and materials increased by between 10 and 20 times. This resulted in a dramatic increase in aggregate road expenditure, particularly during the 1750s and 1760s when trusts became widely diffused throughout the network.[10]

Turnpike trusts were able to increase road expenditure because they addressed a variety of problems in the parish system. For example, trusts resolved the through traffic problem by levying tolls on road-users. They also relieved borrowing constraints because they were able to issue debt at a low cost. Finally, trusts addressed coordination problems by replacing a multitude of parishes with a single body of trustees, who could direct investment over an entire road or a network of roads.

During the same period that turnpike trusts were increasing infrastructure investment, the road transport sector was also experiencing significant changes. The following section reviews these developments and introduces the data sources that are used to evaluate the effects of turnpike trusts.

3. The road transportation revolution

There is a common perception that road transport experienced few changes during the 18th century and that canals and ocean shipping were the vanguard of the transport revolution. However, this view is not supported by the evidence, which shows substantial increases in passenger travel speeds, large reductions in freight charges, and a significant growth in road traffic. Fig. 2 illustrates the changes in pas-

[10] Bogart (Forthcoming).

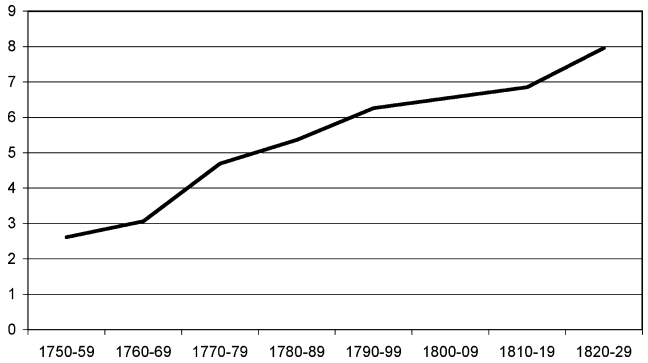

Fig. 2. Average journey miles per-hour in passenger services, 1750–1829.

senger travel speeds by plotting average journey miles per-hour between 1750 and 1829. The figures are based on a sample of 225 city-pairs drawn from the studies by Jackman (1916) and Pawson (1977).[11] Between 1750 and 1800, average journey miles per-hour increased from 2.6 to 6.2 and by 1829 it increased to 8.0. In a few cases, the change in travel times can also be measured over the entire 18th century. For instance, Eric Pawson has shown that travel times between London and Manchester decreased from around 90 hours in 1700 to 60 hours in 1760 and 24 hours in 1787.

The increase in passenger travel speeds is also supported by evidence on the diffusion of 'fly-machines.' Fly-machines were coach services that traveled at a higher speed because they continuously changed teams of horses.[12] Fly-machines were relatively rare before 1750, but by 1770 they comprised around 20% of all passenger services leaving from London and were available to all major cities.[13]

Increasing travel speeds were accompanied by relatively modest reductions in passenger fares. Fig. 3 plots an index of real fares between 1750 and 1830, after deflating a nominal fare series with Greg Clark's consumer price index (2001a). The nominal fare series is based on data from Jackman (1916) and Gerhold (1996) as well as new information on a large number of passenger fares in 1760 and 1770.[14] The new series shows that passenger fares fluctuated over time, but that they were lower by an average of 7.5% between 1790 and 1809. Therefore, it appears that passengers generally paid lower fares for faster services in the early 19th century.

The freight sector had a different experience than the passenger sector, because freight charges declined substantially, while travel speeds increased only modestly. The most comprehensive source on freight charges are land carriage rates, which represent the maximum price that a carrier could charge for the shipment of goods be-

[11] For information on the data see Third table of Appendix A.
[12] Gerhold (1996).
[13] The diffusion of fly-machines can be traced in London travel directories. See the end of this section for more details.
[14] For more information see Fourth table of Appendix A.

Fig. 3. An index of real passenger fares, 1750–1830.

tween two cities. Land carriage rates were introduced by legislation passed in the 1690s. The legislation gave county magistrates the authority to set maximum freight charges in order to prevent carriers from colluding and raising their prices. It also gave magistrates discretion over which markets to regulate. In most cases, magistrates set the rates on goods shipped from London to their major city, but in other cases they also set rates on goods shipped from other cities.

A number of scholars have shown that land carriage rates were binding on carriers and that they were adjusted when underlying costs changed. For example, Freeman (1977) has shown that between London and Portsmouth advertised and actual freight charges were very close to land carriage rates between 1775 and 1800. Turnbull (1985) has also provided evidence that carriers in the North of England charged freight rates that were identical to land carriage rates. Turnbull also documented that Yorkshire magistrates raised land carriage rates in 1800, because rising feed prices were forcing carriers to suspend services at the previous price ceiling.[15]

This study builds on the earlier literature and uses a new data set of over 5000 land carriage rates from 130 city-pairs between 1695 and 1827. Fig. 4 combines all the observations and plots an index of real land carriage rates between 1700 and 1819.[16] The new series shows that land carriage rates fell by approximately 40% in real terms between 1750 and 1800. As a result, it provides new evidence that freight charges fell substantially during the second half of the 18th century.[17]

The new dataset also reveals that there was variation across city-pairs in terms of the magnitude by which freight charges declined. For example, between London and Newcastle real land carriage rates fell by 50% between 1750 and 1800, while they fell by only 25% between Leeds and York over the same period.

[15] For more discussion of land carriage rates see Albert (1972) and Willan (1962).

[16] The series is equal to an index of average land carriage rates in each decade divided by Clark's consumer price index (2001a). See Second table of Appendix A for more information.

[17] Albert (1972) and Gerhold (1996) also used land carriage rates to argue that freight charges declined, but both of these studies relied on fewer observations, especially before 1750.

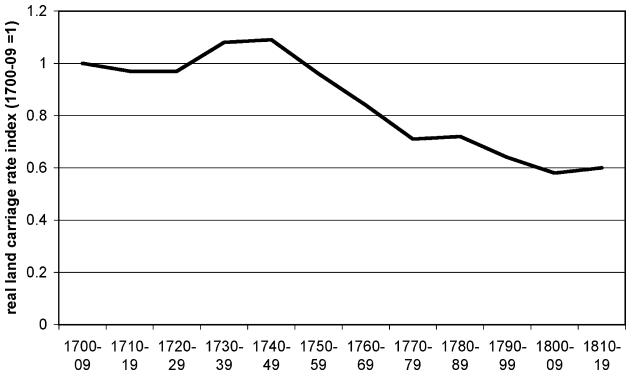

Fig. 4. Real land carriages, 1700–1819.

The changes in freight travel speeds were more modest than the changes in freight charges. In this case, the differences in speed can only be measured by the diffusion of fly-wagon services, which were the counterpart of fly-machines in the freight sector. For most of the 18th century, fly-wagons were rare and comprised less than 1% of all freight services leaving from London. As a result, their effect on travel speeds was much more limited than in the case of fly-machines.

Another development in the road transport sector was the increase in road traffic. Chartres and Turnbull (1983) provided the first estimates of traffic growth by comparing the number of weekly freight and passenger services listed in London travel directories. For example, if directories indicate that the number of listed weekly services between London and Birmingham increased from 2 to 3 between 1750 and 1760, then Chartres and Turnbull inferred that the number of trips between these cities grew by 50%. Using this methodology for a sample of cities, they estimated that freight and passenger traffic grew at an average annual rate of 1.2 and 2.9%, respectively, between 1715 and 1796.

Chartres and Turnbull's estimates have not gone unchallenged. In particular, Gerhold (1988) has suggested that their figures over-state the growth rate in road traffic because travel directories do not distinguish between services to a single city and services to multiple cities. As an illustration, consider a wagon service that traveled once a week from London to Birmingham and another service that traveled once a week to Leicester and the neighboring city of Harborough. In travel directories, all of these cities would be listed separately, and therefore it would appear as if there were three separate trips instead of two. Now imagine that the number of weekly trips to Leicester and Harborough increased from 1 to 2, while the number of weekly trips to Birmingham remained constant at 1. In this case, directories would suggest that total weekly trips increased from 3 to 5, even though the number of actual trips increased from 2 to 3.

As the previous example shows, the growth of listed services may not provide an accurate measure of traffic growth. Nevertheless, it is still possible to estimate a lower bound by focusing on the subset of services between London and 45 major cities

Table 1
The growth of listed passenger and freight services leaving from London, 1715–1800

Year	(1) Number of listed weekly freight services, major cities	(2) Number of listed weekly freight services, all cities	(3) Number of listed weekly passenger services, major cities	(4) Number of listed weekly passenger services, all cities
1715	140	840	150	620
1740	220	1570	110	780
1749	230	1610	140	760
1760	340	1950	210	940
1770	390	2960	410	1,960
1779	340	3100	820	3,190
1790	520	4590	1590	8,010
1800	970	7790	1960	12,210
	Average annual growth rate	Average annual growth rate	Average annual growth rate	Average annual growth rate
1715–1800	2.3%	2.7%	3.1%	3.6%
1760–1800	2.7%	3.5%	5.7%	6.6%

Sources. The figures for 1715 come from *the Merchant and Traders Necessary Companion*. The figures for 1740, 1749, 1760, and 1770 come from *the New and Complete Guide to all Persons who have any Trade or Concern with the City of London*. The figures for 1779, 1790, and 1800 come from *the Shopkeepers and Tradesman's Assistant*. *Notes*. Figures are rounded to the nearest ten and all years exclude services to cities in Middlesex County.

with a population above 2500 in 1700.[18] Among others, the major cities include Birmingham, Leeds, Manchester, Liverpool, and Bristol. These cities were presumably large enough to support their own wagon and coach services, and therefore they would be less likely to have overlapping services with other major cities.

Table 1 displays the number of listed weekly freight and passenger services between London and 45 major cities in 1715, 1740, 1749, 1760, 1770, 1779, 1790, and 1800. For comparison, it also lists the number of weekly services between London and all cities listed in travel directories. Column (1) shows that the average annual growth rate for listed freight services between London and major cities was 2.3% between 1715 and 1800, while column (2) shows that listed freight services between London and all cities grew at a higher average rate of 2.7%. Columns (3) and (4) reveal a similar pattern for passenger services, in which listed services between London and major cities grew at an average rate of 3.1% between 1715 and 1800, in comparison with a 3.6% growth rate between London and all cities. The lower growth rate across major cities suggests that the increases in listed services across all cities may indeed overstate the true growth in traffic. However, the differences are not large enough to overturn the conclusion that road traffic increased at a substantial rate. In fact, these figures imply that during the 18th century, output in the road transport sector grew by at least 2.3% per year for freight and 3.1% for passenger services, which is greater than the average growth rate for many sectors in the British economy.[19]

[18] The list of major cities is drawn from Corfield (1982).
[19] See Crafts (1985) for estimates of output growth across sectors.

The trends in freight and passenger services are also consistent with the earlier evidence on travel times and freight charges. In particular, they show that the growth rate in freight services was higher between 1760 and 1800, when freight charges were falling. Similarly, passenger services grew more rapidly after the 1760s, when travel speeds were increasing.

To summarize, the road transport sector increased in both size and efficiency between 1750 and 1800. The timing of these changes is significant because it coincides with the rise of turnpike trusts. The following section examines this relationship and discusses why turnpike trusts may (or may not) have contributed to lower transport costs and higher traffic volumes after 1750.

4. Turnpike trusts and the road transport revolution

There are a number of issues concerning the relationship between turnpike trusts and the road transport revolution. One issue is whether turnpike trusts lowered transport costs by improving roads, or whether they increased transport costs by levying tolls. Road improvements included three components: better surfaces, lower gradients, and wider roads.[20] Better surfaces and lower gradients reduced transport costs because they allowed horses to carry larger loads and travel faster.[21] Both of these effects were confirmed by the experiments of John MacNeill in the early 19th century. MacNeill showed that horsepower increased by 23% when a wagon hauling four tons moved along a dry paved road as opposed to a wet and muddy gravel road. He also showed that horsepower diminished by 50% when gradients increased from 1 to 5%.[22]

Wider roads also increased load sizes by encouraging the replacement of packhorses with large wagons.[23] Packhorses could not carry as many tons as wagons, but they had an advantage in that they could be used on narrow roads. Therefore, in some cases it was necessary that roads be widened before wagons could be adopted. In other cases, wider roads facilitated the use of wagons by increasing capacity and reducing the effects of congestion.

The tolls had the opposite effect as road improvements because they added to carriage costs. Each turnpike trust had the authority to set its own tolls, as long as they were below the maximum schedule defined in each Act of Parliament. In setting the tolls, trustees may have pursued a variety of objectives. For instance, they may have set the tolls just high enough to pay for maintenance and interest costs. This strategy made sense because trustees often owned property near the road, which could increase in value if transport costs were minimized.

Alternatively, trustees may have tried to extract monopoly rents by charging higher tolls. Trustees were legally prohibited from earning profits, but they could still

[20] Gerhold (1993, 1996).
[21] See Jackman (1916), Albert (1972), and Pawson (1977).
[22] For more information on McNeill's study see Great Britain, House of Lords (1834, p. 129).
[23] See Gerhold (1996) and Pawson (1977).

benefit by selling land and materials or by lending to the trust. There was great suspicion among contemporaries that trustees were indeed benefiting in this way. For example, in *The Wealth of Nations* Adam Smith suggested that abuses by trustees made the tolls twice as large as was necessary to properly maintain the road network.[24] Smith's views were shared by a farmer in Durhamshire, who complained that high tolls were likely to persist because turnpike bondholders were earning a 5% return, which was high for that area.[25]

The manner in which trustees set the tolls has implications for the effect of turnpike trusts on passenger fares and freight charges. If trustees tried to raise the tolls beyond the level necessary to pay for maintenance and interest, then fares and freight charges may have increased because the tolls more than offset the effects of better roads. On the other hand, if trustees were constrained by the maximum toll schedules or if they were interested in maximizing property values, then fares and freight charges may have declined because the effects of better roads dominated the tolls.

A second issue concerns the relationship between turnpike trusts and other innovations in the road transport sector. The two most significant innovations were improvements in horse breeding and the rise of large carriage firms.[26] According to Gerhold (1996), improvements in breeding allowed horses to haul bigger loads and travel faster. He also suggested that larger carriage firms made better use of capacity and were able to procure inputs more cheaply.

Gerhold also estimated the amount by which various innovations reduced costs. For example, he used records from carriage firms to show that better roads and horses could reduce feed expenses by 60%. He also used grain prices to show that large firms could reduce their feed expenses by 29%, if they bypassed innkeepers and stored feed in their own facilities. After tallying the effects of various improvements, Gerhold concluded that better horses and larger firms combined to reduce total costs by 33%, while road improvements lowered total costs by 31%.

The simultaneous emergence of turnpike trusts, new horse breeds, and larger firms raises a concern that the effects from at least one of these innovations are over-stated because they were induced by other innovations. For example, turnpike trusts may have been adopted only after new horse breeds and larger firms reduced transport costs and raised traffic volumes. Alternatively, new horse breeds may have been introduced once turnpike trusts raised their effectiveness by improving roads. Similarly, larger firms may have emerged only after turnpike trusts increased average load sizes.

The following section addresses this endogeneity problem by studying the trends in land carriage rates before trusts were adopted. It also exploits information on the

[24] See Smith (1976, p. 1726).

[25] The farmer's views come from the diary of the Swedish traveler R. Angerstein, which was translated by Berg and Berg (2001).

[26] There were also improvements in wagon and carriage design as well as innovations in road building techniques, but most of these developments occurred in the early 19th century, which is after most turnpike trusts were adopted (Straus, 1912).

relative changes in winter versus summer land carriage rates. But first, it focuses on the question of whether turnpike trusts raised land carriage rates by levying tolls.

5. Did turnpike trusts lower land carriage rates?

Land carriage rates are particularly useful for the evaluation of turnpike trusts because they measure freight charges for individual city-pairs over the 18th century. As a result, they can determine whether freight charges increased or decreased after trusts were established.[27] Measuring the effect of turnpike trusts is complicated by the fact that they were not adopted instantly along the entire route connecting city-pairs. For instance, along the 275-mile route between Newcastle and London, 17 separate turnpike trusts were established at various times between 1710 and 1776. To deal with this issue, adoption is measured by the fraction of route mileage managed by turnpike trusts in each year.[28] In the Newcastle to London case, the fraction of mileage managed by trusts was 0.51 in 1740, 0.87 in 1745, and 0.92 in 1750.

Eq. (1) describes one relationship between real land carriage rates and the fraction of route mileage managed by turnpike trusts:

$$\ln(\text{real land carriage rate}_{ijt}) = \beta(\text{fraction turnpike}_{it}) + \delta \ln(\text{real wage}_{jt}) + \rho \ln(\text{real feed price}_{jt}) + \gamma + \alpha_i + \varepsilon_{ijt}. \quad (1)$$

The subscript i represents each city-pair, j represents one of four regions (Southeast, Southwest, North, and Midlands), and t represents each year ($t = 1695, 1696, \ldots, 1827$). The variable $\ln(\text{real land carriage rate}_{ijt})$ is the natural log of the real land carriage rate for city-pair i in region j in year t; $\text{fraction turnpike}_{it}$ is the fraction of route mileage managed by turnpike trusts for city pair i in year t; $\ln(\text{real wage}_{jt})$ is the log of the real wage in region j in year t; $\ln(\text{real feed price}_{jt})$ is the log of the real price of horse feed in region j in year t; α_i is a city-pair dummy variable, and ε_{ijt} is the error term.[29]

The regression includes the real wage and real feed price because they were important determinates of carriage costs. It also includes a city-pair dummy variable, which captures all time-invariant, unobservable characteristics, such as the distance between cities and geographic factors. The coefficient on the variable, fraction turnpike, measures the percentage change in real land carriage rates after turnpike mileage increased for a particular city-pair. This coefficient also has a useful economic

[27] Ideally, we would like to determine the effects of trusts on both prices and quantities, but unfortunately, this information is not available at a route level.

[28] To link turnpike trusts with city-pairs, I first identified when and where turnpike trusts were established using the comprehensive studies of Albert (1972) and Pawson (1977). Next, I matched turnpike trusts with city-pairs using the travel guide, *Britannia Depicta* (Bowen, 1970) and *Paterson's Roads* (Mogg, 1826). In a few cases, a route could not be identified for a city-pair, in which case I used the maps from the *Phillimore Atlas* (Humphery-Smith, 1984).

[29] The variables are deflated using the price index from Clark (2001a). For more information on the data sources see Appendix A.

Table 2
The effect of turnpike trusts on land carriage rates: baseline specifications

Variable	(1) Coefficient	(2) Coefficient
Fraction turnpike	−0.500 (0.125)*	5.9131 (0.7710)*
(Fraction turnpike)* (year)		−0.0033784 (0.0004)*
Year		−0.0028437 (0.0009)*
ln(real wage)	0.557 (0.021)*	0.1943 (0.0374)*
ln(real feed price)	−0.269 (0.024)*	0.0609 (0.0400)
Constant	1.198 (0.082)*	5.7925 (1.6202)*
City-pair dummies	Yes	Yes
Year dummies	No	Yes
R^2	0.319	0.786
City-pairs	130	130
Total observations	5071	5071

Notes. Dependent variable is the natural log of the real land carriage rate for city-pair i in year t.
* Standard errors are in parentheses, * indicates statistical significance at the 95% level.

interpretation because it measures the percentage change after trusts were established along 100% of the route mileage. For instance, suppose that turnpike trusts were adopted along an entire route during the 1750s. Eq. (1) would imply that after accounting for differences in input prices, the log difference in carriage rates between 1760 and 1750 equals $\beta(1–0)$, because the fraction of turnpike mileage increased from 0 to 1.

The results are presented in column (1) of Table 2. They indicate that land carriage rates declined by 50% in real terms after turnpike trusts were established along 100% of the route mileage for a city-pair. Fig. 5 illustrates the result by plotting the evolution of land carriage rates per-mile against the fraction of turnpike mileage between Leeds and London, York and London, Newcastle and London, and Richmond and London. In all four cases, land carriage rates declined once turnpike trusts were established along at least 80% of the route. The most dramatic change occurred between Richmond and London, where land carriages rates declined from 0.12 pence per stone (14 lbs.) per mile in 1700 to 0.064 pence in 1758. The York to London case is also interesting because land carriage rates increased temporarily between 1741 and 1745, at the same time that several turnpike trusts were established along this route. The brief rise in carriage rates suggests that in some cases the tolls raised freight charges, but only in the short-run.

There is also evidence from the maximum schedules, which suggests that the tolls diminished over the 18th century. Across all Turnpike Acts that were passed between 1730 and 1744, the average maximum toll for a wagon drawing four horses was 0.98 shillings, while among all Acts that were passed between 1800 and 1801, the average toll for the same wagon was 1.8 shillings. These figures imply that average wagon tolls decreased by around 20% in real terms, because the general price level rose by 150% between 1740 and 1801.[30] Therefore, part of

[30] The difference in average tolls between 1730–1744 and 1800–1801 is statistically significant (t-statistic, 4.69). The data on inflation comes from the price index in Clark (2001a).

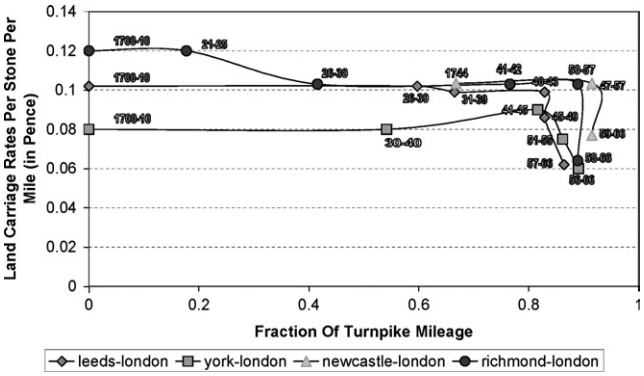

Fig. 5. Turnpike trusts and the evolution of land carriage rates in four cases.

the decline in freight charges may have been due to the lower tolls imposed by Parliament.

Overall, the estimates from regression Eq. (1) suggest that turnpike trusts decreased, rather than increased freight charges. However, the estimates probably over-state the impact of turnpike trusts, because the regression does not control for other factors that affected land carriage rates. For example, it does not account for the possibility that carriage rates declined because a new horse breed was introduced or because firm sizes increased. Therefore, it is necessary to estimate the following equation, which controls for some of these unobservable factors.

$$\begin{aligned}\ln(\text{real land carriage rate}_{ijt}) = {} & \beta(\text{fraction turnpike}_{it}) + \eta(\text{year}_t) \\ & + \mu(\text{year}_t) \times (\text{fraction turnpike}_{it}) \\ & + \delta \ln(\text{real wage}_{jt}) + \rho \ln(\text{real feed price}_{jt}) \\ & + \gamma + \lambda_t + \alpha_i + \varepsilon_{ijt}. \end{aligned} \tag{2}$$

The new variables include year_t (i.e., 1695, 1696, ..., 1827) and λ_t, which is a dummy variable for each year. The coefficient on year_t measures the trend reduction in real land carriage rates over time and captures the effects of innovations that were unrelated to turnpike trusts. The coefficients on the year dummies measure the annual variation around the trend and capture the impact of short-run factors, such as a brief rise in the price level. Finally, the coefficient on the interaction $(\text{year}_t) \times (\text{fraction turnpike}_{it})$ measures the trend change in real land carriage rates after turnpike trusts were adopted.

With this specification, the effects of turnpike trusts are measured over a particular time period. For example, if a city-pair had turnpike trusts adopted along its entire route during the 1750s, then the log difference in real land carriage rates between 1750 and 1800 equals $\beta + \eta(1800 - 1750) + \mu(1800)$, after deducting the impact of year specific effects and changes in real wages and feed prices. The change associated

with turnpike trusts is captured by $\beta + \mu(1800)$, whereas the effects of unobservable innovations are measured by $\eta(1800 - 1750)$.

The results from the second regression are reported in column (2) of Table 2. They indicate that if a city-pair had a turnpike trust established along its route during the 1750s, then it experienced a 31% reduction in real land carriage rates between 1750 and 1800 and a 43.4% reduction between 1750 and 1820. The estimates also imply that turnpike trusts accounted for 16.8% ($5.9131 - 1800 \times [0.0033784]$) of the change between 1750 and 1800 and 23.5% ($5.9131 - 1820 \times [0.0033784]$) between 1750 and 1820. In other words, turnpike trusts were responsible for around half of the total reduction in land carriage rates over the 18th century.[31]

These findings show that turnpike trusts still reduced land carriage rates, even after controlling for the effects of unobservable factors. Nevertheless, there is still a concern that the effects are over-stated because turnpike trusts may have been induced by other innovations, like larger carriage firms or improvements in horse breeding. The consistency of the results can be checked by studying the seasonal variation in land carriage rates. Seasonality is relevant because travelers often remarked on the poor condition of roads in the winter, when the rains were heavy. Therefore, if turnpike trusts lowered freight charges by improving road quality then winter freight charges should have declined relative to summer charges.

Fig. 6 illustrates the changes in seasonality by plotting the average ratio of winter and summer land carriage rates over the 18th century. During the 1730s and 1740s, winter rates were between 35 and 50% higher than summer rates, but by the 1750s and 1760s, they were only 20% higher and by 1800 they were generally equal to summer rates.[32] This finding cannot be explained by improvements in horse breeding or increases in firm size, because each of these factors affected freight charges similarly throughout the year. By contrast, this evidence is consistent with the argument that turnpike trusts lowered freight charges by improving road surfaces.

The land carriage rates between Leeds and Selby, in the West Riding of Yorkshire, provide an excellent example of the effect of turnpike trusts on seasonality. Beginning in the 1690s, the summer rate between Leeds and Selby was 6.5 shillings per four horseback (896 pounds), while the winter rate was 15.5 shillings. These rates continued until 1744, when the summer rate was reduced to 6 shillings and the winter rate was reduced to 10.5 shillings. The greater decline in winter rates (32% versus 8%) is significant because it came shortly after the adoption of the Leeds and Selby Turnpike Trust in 1741. The timing of these changes is unlikely to be coincidental, be-

[31] I tested for autocorrelation in the standard errors by using the Baltagi and Wu (1999) procedure for unbalanced panels. The test indicates that we cannot reject the hypothesis of first-order autocorrelation. However, if we assume that the errors follow an AR(1) process, the coefficients on the turnpike variables remain economically and statistically significant. In particular, they imply that turnpike trusts accounted for a 22.1% reduction in real land carriage rates by 1820.

[32] In an unreported regression of the ratio of winter to summer rates on a set of decade dummy variables, all decade dummies are negative and statistically significant beginning in the 1750s.

Fig. 6. Average ratio of winter to summer land carriage rates, 1730–1809.

cause the parishes which preceded the Leeds and Selby trust did not make any major road investments prior to 1741.[33]

The inducement hypothesis can also be addressed by testing whether land carriage rates fell during the five year period before turnpike trusts were established.[34] For instance, suppose that a city-pair had trusts established on 50% of its route in 1745 and along the other 50% of its route in 1755. If turnpike trusts were induced by the cost savings from other innovations then land carriage rates should decline in either the early 1740s or the early 1750s, just before new trusts were established.

Table 3 reports the estimates from regression Eqs. (1) and (2) after including a variable that measures the fraction of turnpike mileage that will be created within the next five years.[35] In column (1) the estimates indicate that land carriages were not any lower during the 5-year period preceding turnpike trusts. Similarly in column (2), the estimates show that the trend in land carriage rates did not change before trusts were established. As a result, there is no evidence that turnpike trusts were induced by other innovations. If fact, the findings suggest the opposite, namely that other innovations were induced by turnpike trusts.[36]

The results on the timing of rate reductions as well as the evidence on the relative decline of winter rates supports the view that turnpike trusts were one of the key innovations that caused the road transport revolution. In particular, they reaffirm the finding that turnpike trusts lowered freight charges by around 20% and that they accounted for around half of the total decline in freight charges.

[33] See Bogart (Forthcoming) for evidence on parish road expenditure before turnpike trusts.

[34] In other words, we can test whether the adoption of turnpike trusts in any of the years $t+1$, $t+2$, $t+3$, $t+4$, or $t+5$, implied lower land carriage rates for a city-pair at date t.

[35] For instance, in the previous example, this variable will take the value 0.5 from 1740 to 1744, 0 from 1745 to 1749, 0.5 from 1750 to 1754, and 0 for every year after 1755.

[36] It is possible that other innovations preceded turnpike trusts, but their effects are not apparent because rising traffic volumes raised transport costs. This possibility seems unlikely given that directories show that traffic growth increased the most during the 1760s and 1770s, which is after most trusts were adopted.

Table 3
Did land carriage rates fall before turnpike trusts were adopted?

Variable	(1) Coefficient	(2) Coefficient
Fraction turnpike	−0.4896 (0.0142)*	5.8779 (0.7761)*
Fraction turnpike within the next 5 years	0.0407 (0.0276)	
(Fraction turnpike)* (year)		−0.0033564 (0.0004)*
(Fraction turnpike within the next 5 years)* (year)		0.0000042 (0.00001)
Year		−0.002876 (0.0009)*
ln(real wage)	0.5521 (0.0210)*	0.1935 (0.0374)*
ln(real feed price)	−0.2724 (0.0238)*	0.0605 (0.0400)
Constant	1.2093 (0.0823)*	5.8497 (1.6268)*
City-pair dummies	Yes	Yes
Year dummies	No	Yes
R^2	0.319	0.801
City-pairs	130	130
Total observations	5071	5071

Notes. Dependent variable is the natural log of the real land carriage rate for city-pair i in year t.
* Standard errors are in parentheses, * indicates statistical significance at the 95% level.

The results are also consistent with Gerhold's (1996) argument that road improvements accounted for half of the reduction in carriage costs, while new horse breeds and larger firms accounted for the other half. However, the finding that turnpike trusts lowered freight charges by 20% is different from Gerhold's estimate that better roads reduced carriage costs by 31%. This inconsistency can be explained by the fact that Gerhold largely focused on the effects of turnpike trusts along the London routes, while the present results are based on their effects throughout the road network. The following section illustrates the different effects of turnpike trusts by focusing on their relationship with London transport services.

6. Turnpike trusts and London transport services

The London transport market deserves special attention because it was the largest and most important transport market in the British economy. It is also possible that turnpike trusts lowered freight charges by a greater amount along the London routes because they invested more and charged lower tolls. This hypothesis is evaluated in Table 4, which presents estimates from regression Eqs. (1) and (2), after including an interaction between the fraction of turnpike mileage and a dummy variable for London city-pairs. In column (1), the results indicate that London city-pairs experienced a 76.5% (45.8 + 30.7) reduction in real land carriage rates after trusts were established. While this estimate provides suggestive evidence, it likely overstates the effect because the regression does not include year dummies and a time trend. Column (2) presents the estimates after including these controls. They imply that turnpike trusts accounted for 24.1% of the reduction in real land carriage rates for London city-pairs by 1800 and 32.2% of the reduction by 1820. These findings provide evidence

Table 4
Did turnpike trusts have a larger effect along the roads leading into London?

Variable	(1) Coefficient	(2) Coefficient
Fraction turnpike	−0.4579 (0.0133)*	4.4440 (0.0793)*
(Fraction turnpike)* London dummy	−0.3076 (0.0276)*	2.5556 (0.4324)*
(Fraction turnpike)* (year)		−0.0025512 (0.0004)*
(Fraction turnpike)* (London dummy)* (year)		−0.0014714 (0.0002)*
Year		−0.0017917 (0.0009)*
ln(real wage)	0.5521 (0.0210)*	0.0873 (0.0400)*
ln(real feed price)	−0.2582 (0.0235)*	0.0575 (0.0398)
Constant	1.2227 (0.0814)*	4.19079 (1.6291)*
City-pair dummies	Yes	Yes
Year dummies	No	Yes
R^2	0.329	0.812
City-pairs	130	130
Total observations	5071	5071

Notes. Dependent variable is the natural log of the real land carriage rate for city-pair i in year t.
* Standard errors are in parentheses, * indicates statistical significance at the 95% level.

that the effects of trusts varied and were likely to be largest along the heavily traveled roads, such as the London routes.[37]

Turnpike trusts may have also contributed to the substantial increase in passenger travel speeds between London and the provinces (see Fig. 2). While there are not enough observations to perform a regression analysis, the available data indicates that travel times declined as the fraction of turnpike mileage increased. For example, in 1705 when there were no turnpike trusts between Birmingham and London, the journey time was 65 hours. By 1740, when turnpike trusts managed 62% of the route, the journey time was cut to 40 hours and by 1770 when trusts managed the entire route, the journey time had fallen to 25 hours.[38]

Another way of measuring the effect of turnpike trusts is to see whether they preceded the introduction of fly-machine services between London and various provincial cities. Recall that fly-machine services became widely diffused during the 1760s and that they were unique because they traveled a greater speed than standard coach services. Table 5 lists all cities where fly-machine services were first identified in the 1770 London directory, as well as the first year when trusts were established on at least 80% of their route mileage. The table shows that in 64 out of the 71 cities, turnpike trusts preceded the adoption of fly-machines. As a result, it appears that trusts made an additional contribution by making it more economical for coaches to travel at their maximum speed.

[37] The 24.1% figure comes from the calculation, $4.444 + 2.5556 - 1800 \times (0.0014714 + 0.0025512)$ and the 32.2%% figure comes from the calculation, $4.444 + 2.5556 - 1820 \times (0.0014714 + 0.0025512)$. However, the greater effect of turnpike trusts on London city-pairs is not significant, after assuming first order autocorrelation in the errors using the Baltagi and Wu (1999) procedure. Therefore, the hypothesis that turnpike trusts had a larger impact along the London routes is only partially supported by the evidence.
[38] For more discussion of the effects of trusts on passenger travel times see Pawson (1977).

Table 5
Turnpike trusts and the diffusion of fly-machine services

Cities with fly-machine Services to London beginning in 1770	First year when trusts were established on at least 80% of the route mileage	Cities with fly-machine Services to London beginning in 1770	First year when trusts were established on at least 80% of the route mileage
Maidenhead	1727	Peterborough	1754
Oakingham	1759	Newport Pagnell	1728
Reading	1736	Nottingham	1738
Windsor	1759	Oxford	1719
Sunninghill	1759	Burford	1751
Swaffam	1725	Ipswich	1785
Chester	1744	Falkenham	1785
Stockport	1738	Shrewsbury	1748
Blandford	1766	Ludlow	1751
Derby	1738	Bath	1727
Buxton	1738	Taunton	1753
Chelmsford	1725	Wells	1753
Harlow	1725	Wolverhampton	1727
Stifford	1808	Walsall	1766
Cheltenham	1751	Brighton	1770
Tewkesbury	1756	Chichester	1749
Portsmouth	1749	Horsham	1756
Southampton	1758	Epsom	1755
Winchester	1762	Godalming	1757
Romsey	1764	Guildford	1749
Ware	1725	Kingston	1718
Deal	1802	Weybridge	1767
Maidstone	1752	Witney	1751
Margate	1802	Birmingham	1724
Sittingbourne	1738	Marlborough	1728
Asfhord	1793	Salisbury	1753
Manchester	1738	Trowbridge	1728
Warrington	1753	Devizes	1728
Lincoln	1756	Hull	1765
Sleaford	1756	Leeds	1739
Stamford	1749	Wakefield	1739
Barton Humber	1765	Sheffield	1765
Bourne	1756	Tadcaster	1739
Norwich	1769	Chestnut	1725
Yarmouth	1769	Worcester	1731
Northampton	1728		
Total number of cities			71
Number of cites where turnpike trusts preceded fly machine services			64

Source. Information on fly-machine services comes from the London Directory, *The New and Complete Guide*.

The impact of turnpike trusts along the London routes has broader implications because London was the focal point for the English economy. It was by far the largest market for agricultural and manufactured goods. It was also the major port city

as well as the financial center. The fact that turnpike trusts increased the efficiency of London transport services implies that they had an impact on the entire English economy. The following section quantifies their impact, by estimating the social savings.

7. The social savings from turnpike trusts

A number of scholars have estimated the social savings of railroads or canals, but none have examined the effects of an institutional innovation like turnpike trusts.[39] This study takes the first step by estimating the social savings from all road transport innovations along turnpike roads in 1800 and 1820. Then it provides a lower bound for the proportion of social savings associated with turnpike trusts.

A social savings calculation minimally requires data on ton-miles and passenger-miles as well as the change in freight charges, fares, and travel times.[40] In this case, there is no direct information on passenger-miles and ton-miles and therefore, it is necessary to develop new estimates.[41] The output figures are based on an estimate of the total cost of freight and passenger services. According to Barker and Gerhold (1995), the tolls equaled between 10 and 15% of total costs for freight and passenger firms in the 1820s. These figures imply that the total cost of transport services using turnpike roads is equal to aggregate toll revenues divided by either 0.1 or 0.15. In 1800, aggregate toll revenues in England and Wales were around £0.76 million, which would imply that the total cost of transport services along turnpike roads was between £5.09 million and £7.64 million. A similar calculation suggests that the total cost was between £7.43 million and £11.14 million in 1820.[42] These estimates are reasonable, because they imply that the total cost of road transport services equaled between 2.2 and 3.4% of national income in 1800 or 1820.[43]

If total costs are assumed to equal the total value of services, then ton-miles will equal the total cost of freight services divided by the average freight charge per-mile. Similarly, passenger-miles will equal the total cost of passenger services divided by the average passenger fare per-mile.[44] To perform these calculations we need an estimate of the relative value of freight and passenger services. The data from London

[39] The social savings measures the amount of national income that would be lost had the transport innovation not been developed. For the development of this methodology see the well-known studies by Fogel (1964), Fishlow (1965), O'Brien (1983), and Hawke and Higgins (1983).

[40] Ideally, it would also include information on the elasticity of demand. However, in our case this information is not available.

[41] Baxter (1866) has provided estimates of passenger miles and ton miles in 1834. However, these figures are too late to properly evaluate the impact of road transport innovations because canals had claimed a large portion of freight traffic by 1834.

[42] The figures on turnpike revenues and expenditure come from Bogart (Forthcoming).

[43] National income in 1800 is taken to be 229 million and 322 million in 1820 (Clark, 2001b).

[44] The average freight rate per ton-mile was £0.0855 in 1800 and £0.082 in 1820. The average passenger fare per-mile was taken to be £0.02015 in 1800 and £0.0165 in 1820. These figures come from the land carriage rate and passenger fare data sets. See Appendix A for more information.

Table 6
Estimates of the social savings from all road transport innovations: 1800 and 1820

	1800	1820
Freight sector		
(1) Ton miles along turnpike roads	29,785,575	45,284,553
(2) Change in freight charges per mile	£0.03839	£0.06289
(3) Social savings from lower freight charges $\approx (1) \times (2)$	£1,143,000	£2,848,000
Passenger sector		
(4) Passenger miles along turnpike roads	126,385,443	225,050,505
(5) Change in fares per-mile	£0.00163	£0.00134
(6) Social savings from lower fares $\approx (4) \times (5)$	£206,000	£301,000
(7) Change in passenger hours traveled	28,338,115	56,145,656
(8) Income per hour for passengers	£0.02972	£0.03863
(9) Social savings from lower travel times $\approx (7) \times (8)$	£844,000	£2,169,000
(10) Total social savings $= (3) + (6) + (9)$	£2,193,000	£5,318,000

Notes. See the text.

travel directories indicates that the ratio of passenger services to freight services was 1.58 in 1800. In addition, the freight charge and fare data indicates that the typical wagon loaded with four tons earned £0.342 per-mile in 1800, whereas a standard coach with six passengers earned £0.12 per-mile. Therefore, after adjusting for the different ratio of coaches and wagons, passenger services would represent 35% of the total value. However, this figure understates the value of passenger services because coaches often traveled more than 50 miles, whereas wagons generally traveled shorter distances. Therefore, if it is assumed that coaches traveled twice as far as wagons, then passenger services would equal approximately 50% of the total value. Using the lower bound estimate for total costs in 1800 and 1820, this would imply that ton-miles were around 30 million in 1800 and 45 million in 1820, while passenger miles were 126 million in 1800 and 225 million in 1820.

Table 6 describes the social savings calculations using the new output estimates. Row (2) lists the change in freight charges for 1800 and 1820 based on the regression estimates from Table 2. They assume that without any innovations, freight charges would not have declined by 31% along turnpike roads between 1750 and 1800 or 43.4% between 1750 and 1820. Row (3) lists the social savings for freight services after multiplying the change in freight charges by the number of ton-miles. The savings amount to £1.14 million in 1800 and £2.85 million in 1820 or around 0.5% of national income in 1800 and 0.9% in 1820.

Turning to the passenger sector, row (5) lists the change in passenger fares after assuming that they did not decline by 7.5% between 1750 and the 1790–1809 period. Row (6) lists the social savings after multiplying the change in fares by the number of passenger miles. Not surprisingly, the savings were fairly low and

[44] The average freight rate per ton-mile was £0.0855 in 1800 and £0.082 in 1820. The average passenger fare per-mile was taken to be £0.02015 in 1800 and £0.0165 in 1820. These figures come from the land carriage rate and passenger fare data sets. See Appendix A for more information.

equaled only £0.2 million in 1800 and £0.3 million in 1820. Row (7) lists the change in passenger hours traveled if journey miles per hour remained at 2.6 rather than increasing to 6.2 in 1800 and 7.4 in 1820. Row (8) provides an estimate of the hourly income for the typical passenger by using Lindert and Williamson's (1983) estimate of annual income for white collar workers and Voth's (2001) estimate of annual hours for professionals.[45] Row (9) lists the social savings from lower travel times after multiplying the hours saved by the hourly wage. The savings equaled £0.84 million in 1800 and £2.17 million in 1820, which amounts to 0.4 and 0.7% of national income in 1800 and 1820. After combining these savings with those arising from lower fares and freight charges, the total equals £2.19 million in 1800 and £5.32 million in 1820, which represents approximately 1.0 and 1.7% of national income respectively.

It should be noted that the social savings estimates contain an upward bias because they implicitly assume that the number of ton-miles and passenger miles would be unchanged despite higher freight charges, fares, and travel times. At the same time, the estimates also contain a downward bias because they are based on the lower bound estimate for ton-miles and passenger miles. If it is assumed that the tolls represented 10% of total costs rather than 15%, then ton-miles would increase to 45 million in 1800 and passenger miles would increase to 190 million. This would increase the total social savings to around 1.5% of national income in 1800, rather than 1%. Therefore, it is possible that the downward bias in the output estimates offsets the upward bias resulting from the assumption of an inelastic demand.

The magnitude of the social savings confirms that road transport innovations had an important effect on economic growth. To put the figures into perspective, Antras and Voth (2003) estimate that total factor productivity growth averaged 0.27% per year in the English economy between 1770 and 1800. This would imply that a 1% social savings from road transport innovations accounted for around one eighth of all productivity growth between 1770 and 1800.[46]

How much did turnpike trusts contribute to the total social savings? In the case of the freight sector, the contribution of trusts can be measured by their effect on freight charges. Recall that the estimates in Table 2 indicate that turnpike trusts lowered freight charges by 16.8% as of 1800 and 23.5% by 1820. This would imply that trusts generated a savings on freight equal to £0.62 million in 1800 and £1.54 million in 1820, or 0.3 and 0.5% of national income in the respective years.

These figures represent a lower bound estimate of the social savings from turnpike trusts because they do not include their effects on the passenger sector. While there is

[45] Nominal annual income was assumed to be £100 in 1800 and £130 in 1820. The Lindert and Williamson series reveals that the distribution of white collar incomes was substantially skewed. Therefore, I used 2/3 of the average income in 1805 and 1819. To arrive at an estimate of the hourly wage, these figures were divided by 3365, which is Voth's (2001) estimate of the annual hours for professionals in 1800.

[46] Over 30 years, an average annual TFP growth rate of 0.27% would generate a social savings of $[(1.0027)^{30} - 1]$ or 8.4%. Therefore, roads innovations would account for 1%/8.4% or around one eight of all productivity growth.

not enough data to identify the specific contribution of turnpike trusts versus other innovations, it is plausible that they contributed to half of the reduction in passenger fares and travel times. This would raise the total contribution of turnpike trusts to around 0.5% of national income in 1800 and 0.9% in 1820. However, even these figures understate the impact of turnpike trusts because they omit the effect of lower transport costs on market integration and the adoption of new technologies.[47] Therefore, after including these broader effects, along with the gains in the passenger sector, it is possible that turnpike trusts generated a social saving equal to 1% of national income in 1800 or 1820.

8. Conclusion

The rise of turnpike trusts transformed the organization and financing of road infrastructure in 18th century England. In total, nearly 1000 turnpike trusts were established along 20,000 miles of road, resulting in one of the most expansive toll road networks in history. At the same time, the road transport sector experienced a number of revolutionary changes, including a 40% reduction in freight charges and a 60% reduction in passenger travel times.

This paper reassesses the link between turnpike trusts and the transport revolution by using a number of new data sets. It shows that turnpike trusts did not raise freight charges by levying tolls, and that trusts were not induced by other innovations that lowered transport costs. Instead, it demonstrates that turnpike trusts contributed to a 20% reduction in freight charges. In addition, it provides evidence that turnpike trusts had their greatest impact on London transport services, which were the largest and most important in the British economy. Finally, it shows that turnpike trusts generated a social savings of at least 0.5% of national income in 1800 and 1820.

These findings have implications for the general debate about the causes of the transport revolution. The key conclusion is that institutional innovations were one of the factors that contributed to lower transport costs and improvements in the quality of services. In this particular case, turnpike trusts were able to generate greater efficiency because they addressed a variety of issues in the parish system, including fiscal constraints and coordination problems. The turnpike system was also successful because the tolls failed to offset the effects of road improvements. The tolls were low because Parliament imposed maximum schedules and because trustees had an incentive to keep the tolls low, given that they were local property owners.

The turnpike trust system also illustrates how institutional changes were linked with the process of economic development during the 18th and 19th centuries. Ever since the work of North (1991), economic historians have debated whether institutional changes cause economic development or whether they are simply a

[47] For a detailed discussion of these effects see Szostak (1991).

consequence of it. Turnpike trusts clearly responded to the expanding economy by satisfying existing or potential demand for road transport services. However, they also created demand for such services by lowering freight charges and travel times. As a result, they made an independent contribution to the process of development.

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Appendix A. Data sources

Information on land carriage rates are drawn from Quarter Session Order Books and the Returns submitted to the clerks of the peace in Middlesex. The Returns are held at the London Metropolitan Archives (MR/WC/1-970), while Quarter Sessions Order Books are available on microfilm in the Family History Library in Salt Lake City. The references are York (#2045901-5, #2045938-9), West Riding of Yorkshire (#1657872-4, #1657913-5), North Riding of Yorkshire (#469697-99, #547724-27), Newcastle (#1886204-05), Hull (#1894997-98), Leicestershire (#1470041-42), and Cheshire (#1502213-28). Additional information was drawn from Order Books in the Northamptonshire Record Office and the Shropshire Record offices as well as the studies by Freeman (1977) and Albert (1972). The first table lists all city-pairs, including the first and last years when land carriage rates are observed. The second table lists average land carriage in shillings per ton-mile, along with the standard deviation and the number of unique observations. I averaged over unique observations in order to avoid biases from city-pairs with more observations.

The land carriage rate data set

City one	City two	First year	Last year	City one	City two	First year	Last year
Askrigg	York	1719	1825	Manchester	Newcastle	1800	1821
Beverley	York	1697	1825	Berwick	Newcastle	1802	1821
Barnsley	York	1814	1825	Alnwick	Newcastle	1802	1821
Bradford	York	1697	1825	Morpeth	Newcastle	1802	1821
Bedale	York	1697	1825	Durham	Newcastle	1802	1821
Bridlington	York	1730	1825	Darlington	Newcastle	1802	1821
Carlisle	York	1814	1815	Barnard	Newcastle	1821	1821
Coln	York	1757	1825	London	Richmond	1695	1820
Driffield	York	1814	1825	London	Leeds	1695	1821
Durham	York	1719	1825	London	Boroughbridge	1695	1820
Doncaster	York	1719	1825	London	Settle	1731	1805
Darlington	York	1810	1825	York	Wakefield	1695	1820
Easingwold	York	1814	1825	Newcastle	Pontefract	1763	1820
Gainsbrough	York	1757	1825	Sheffield	Wakefield	1763	1820
Halifax	York	1697	1825	Skipton	Leeds	1773	1820
Hull	York	1697	1825	Skipton	Tadcaster	1773	1820
Huddersfield	York	1757	1825	Leeds	Sheffield	1773	1820
Howden	York	1757	1825	Sheffield	Pontefract	1773	1820
Helmsley	York	1757	1825	Leeds	Selby	1695	1799
Kendal	York	1757	1825	Selby	Leeds	1695	1799
Keighley	York	1814	1825	Wakefield	Tunbridge	1695	1799
Knaresborough	York	1757	1825	Tunbridge	Wakefield	1695	1799
Lancaster	York	1814	1825	York	Hull	1707	1795
London	York	1697	1825	Scarborough	Hull	1717	1795
Leeds	York	1697	1825	Leeds	Hull	1725	1795
Middleham	York	1697	1825	Wakefield	Hull	1725	1795
Masham	York	1757	1825	London	Hull	1749	1795
Nottingham	York	1765	1825	Lincoln	Hull	1749	1795
Newcastle	York	1705	1825	Beverley	Hull	1795	1795
North Allerton	York	1810	1825	Brigg	Hull	1795	1795
Otley	York	1757	1825	Bridlington	Hull	1795	1795
Pontefract	York	1785	1825	North Cave	Hull	1795	1795
Pocklington	York	1814	1825	Hedon	Hull	1795	1795

(*continued on next page*)

Appendix Table (*continued*)

City one	City two	First year	Last year	City one	City two	First year	Last year
Pickerington	York	1814	1825	Hornsea	Hull	1795	1795
Rochdale	York	1814	1825	Louth	Hull	1795	1795
Rotherham	York	1815	1825	Patrington	Hull	1795	1795
Ripon	York	1697	1825	Weighton	Hull	1795	1795
Richmond	York	1697	1825	Welton	Hull	1795	1795
Snaith	York	1814	1825	London	Boston	1749	1780
Selby	York	1815	1825	London	Horncastle	1752	1823
Sheffield	York	1787	1825	London	Lincoln	1764	1825
Stockton	York	1814	1825	London	Louth	1751	1827
Skipton	York	1697	1825	London	Spalding	1749	1826
Scarborough	York	1719	1825	Boston	Spilsby	1752	1821
Stamford	York	1795	1813	Barton	Lincoln	1765	1821
Stokesley	York	1757	1825	Horncastle	Spilsby	1795	1821
Tadcaster	York	1814	1825	Boston	Alford	1751	1821
Thorne	York	1814	1825	Horncastle	Alford	1795	1821
Thirsk	York	1757	1825	Boston	Louth	1763	1821
Wakefield	York	1697	1825	Lincoln	Horncastle	1752	1821
Weighton	York	1803	1825	Chester	London	1695	1814
Wetherby	York	1814	1825	Shrewsbury	London	1695	1794
Whitby	York	1719	1825	Leicester	London	1695	1824
Yarm	York	1719	1825	Harborough	London	1695	1824
London	Newcastle	1744	1826	Lutterworth	London	1695	1824
Doncaster	Newcastle	1766	1821	Hinckley	London	1695	1824
York	Newcastle	1755	1821	Ashby	London	1695	1824
Pontefract	Newcastle	1768	1821	Melton	London	1695	1824
Leeds	Newcastle	1758	1821	Northampton	London	1710	1781
Ripon	Newcastle	1774	1821	Wellingborough	London	1754	1781
Hexham	Newcastle	1772	1821	Daventry	London	1754	1781
Carlisle	Newcastle	1772	1821	Tiverton	London	1758	1782
Dorchester	London	1750	1786	Bridgport	London	1758	1786
				Portsmouth	London	1718	1786

Average land carriage rates per-mile, 1700–1825

Decade	Average land carriage rates in shillings per-ton per mile current prices	Standard deviation	Number of observations	Consumer price index, 1700–1709 = 1, from Clark (2001a,b)	Real land carriage rate index (1700–1709 = 1)
1700–1709	1.22	0.37	52	1	1
1710–1719	1.23	0.32	32	1.04	0.97
1720–1729	1.23	0.31	34	1.04	0.97
1730–1739	1.25	0.25	45	0.95	1.08
1740–1749	1.26	0.30	58	0.95	1.09
1750–1759	1.24	0.31	97	1.06	0.96
1760–1769	1.16	0.27	92	1.13	0.84
1770–1779	1.13	0.25	97	1.30	0.71
1780–1789	1.14	0.25	95	1.30	0.72
1790–1799	1.20	0.28	121	1.53	0.64
1800–1809	1.46	0.34	157	2.08	0.58
1810–1819	1.66	0.40	206	2.26	0.60
1820–1827	1.74	0.45	109	1.69	0.84

Notes. The average is un-weighted across city-pairs. It also includes only one observation for each city-pair per decade, unless land carriage rates changed, in which each unique observation is included.

For the regressions, the wage data come from Greg Clark's farm laborer wage series (2001). Horse feed prices come from Quarter sessions records for Hull and from secondary sources, such as Thirsk (1985), Hill (1966), and Rogers (1963). Feed prices are assumed to be equal to an average of oat prices and bean prices. The general procedure was to match city-pairs with wage and feed prices from one of four regions: the Southeast, the Southwest, the Midlands, and the North. All city-pairs that included London were matched with the input price series from the Southeast, regardless of the final destination.

The information on average passenger travel times and fares comes from Jackman (1916), Pawson (1977), and Gerhold (1996). Additional information on fares comes from the 1760 and 1770 London travel directory, *A New and Complete Guide to all persons who have any trade or Concern with the City of London*. The third table provides summary statistics on average journey miles per-hour, while the fourth table provides summary statistics on average passenger fares.

Average journey miles per-hour in the passenger sector, 1750–1830

Decade	Average journey miles per-hour (journey distance/ total journey time)	Standard deviation	Number of observations
1750–1759	2.61	1.12	20
1760–1769	3.06	1.01	20
1770–1779	4.69	1.19	41
1780–1789	5.36	1.66	51
1790–1799	6.26	1.96	28
1800–1809	5.05	0.56	3
1810–1819	6.85	2.42	21
1820–1829	7.96	1.55	41

Sources. Jackman (1916) and Pawson (1977). *Notes:* Average journey miles per-hour are equal to the total distance traveled divided by the total journey time.

Average passenger fares per-mile, 1750–1799

Decade	Average passenger fare per-mile in shillings	Standard deviation	Number of observations	Consumer price index, 1750–1759 = 1, from Clark (2001a,b)	Real passenger fare index (1750–1759 = 1)
1750–1759	0.216	0.06	14	1.00	1.00
1760–1769	0.216	0.06	215	1.06	0.94
1770–1779	0.223	0.08	418	1.22	0.85
1780–1789	0.265	0.08	140	1.22	1.00
1790–1799	0.278	0.11	37	1.44	0.89
1800–1809	0.403	0.11	13	1.95	0.96
1810–1819	0.327	0.09	15	2.21	0.71
1820–1830	0.337	0.06	8	1.59	0.98

Sources. Most of the observations for the 1760s and 1770s come from the London directory, *the New and Complete Guide to all persons who have any trade or Concern with the City of London*, (1760) and (1770). All other observations come from Jackman (1916) and Gerhold (1996). The consumer price index comes from Clark (2001a,b). *Notes.* The averages are un-weighted across city-pairs.

The information on freight and passenger services comes from a series of London directories including, *The Merchant and Trader's Necessary Companion* (1715), *The New and Complete Guide* (1740, 1749, 1760, 1770), and *The Shopkeeper's and Tradesman's Assistant* (1779, 1790, and 1800). All of these directories are available in the microfilm series, *the 18th Century.*

The information on toll schedules comes from the series, *Acts of Parliament*, available in the Clark Library in Los Angeles and *Local and Personal Acts*, which is available in the University of Minnesota, Law Library.

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