THE STROUDWATER CANAL COMPANY AND ITS ROLE IN THE MECHANISATION OF THE GLOUCESTERSHIRE WOOLLEN INDUSTRY, 1779-1840

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It has been established that the decline of the Gloucestershire woollen industry coincided with, and was to a large extent due to, the rise of the West Riding industry, which produced considerably cheaper cloth than the high quality broadcloth traditionally produced in the west of England.[1] It is accepted that this was due, in large part, to the greater employment of steam power and the faster mechanisation of the Yorkshire industry.[2] What is unclear, however, is to what extent transport costs were significant in the decline of the industry in the west of England. This article will examine the role of the Stroudwater Canal in the late eighteenth and early nineteenth centuries and will, by using previously ignored documents, suggest that this transport link was one of the central factors determining the extent of the decline in the Gloucestershire woollen industry in the early nineteenth century. This examination of the role of the Stroudwater Canal in the employment of steam power in Gloucestershire brings out once again the importance of local transport links for regional economic growth.[3]

Tann has shown that during the early stages of mechanisation in the late eighteenth century the Gloucestershire woollen industry did not lag significantly behind that of the West Riding.[4] The initial move towards a factory system gave the Gloucestershire mills a locational advantage, situated as they were by the Stroudwater, which provided a larger and more regular source of power than the streams of Somerset and Wiltshire.[5] Early enquiries about the rotative steam engines produced by Boulton and Watt produced a similar number for both the West and Yorkshire. However, partly due to steam power in the west of England only being used as a supplement to water power rather than a more efficient substitute[6], the woollen industry there declined while the industry in Yorkshire rose to prominence.

One of the factors that mill owners had to take into account when considering any decision to transfer power, either partially or completely, to a steam-driven system would have been the reliability of access to coal reserves. If Boulton and Watt captured as large a share of the market in the west of England as elsewhere in the country during the early stages of mechanisation, the question must be asked why it was that in the longer term steam power failed to be adopted to the extent that it was by manufacturers in the West Riding. The disparity between the industries in the West and in Yorkshire can be seen only two generations after the Boulton and Watt patent had ended and steam technology had become cheaper and more widespread.[7] By 1838 the West employed only 20 per cent of the total power in use in the woollen industry against 55 per cent for Yorkshire.[8] Gloucestershire manufacturers depended on steam power for only 34 per cent of their total power requirements, less than half the figure for Yorkshire, and even less than the Somerset and Wiltshire industries.[9]

It has been suggested that a move to steam power in Gloucestershire was bound to be restricted because of a lack of access to coal reserves and the high price that this meant for the sale of coal:

> Forest of Dean and Staffordshire coal had to be transported to central Gloucestershire... [C]oal was considerably more expensive than in Yorkshire... Clothiers were well aware of the difference that an increased coal consumption might make to their production costs...[but the] running costs of water power were negligible...and with coal prices greatly exceeding those of Yorkshire the west-of-England woollen manufacturer faced the prospect of obtaining a more reliable power source at the expense of increased production costs.[10]

Mann sums up by concluding that it 'was not only the low price of coal but better facilities for transport which made for cheaper production in Yorkshire'.[11] It was commonly assumed in the eighteenth century that land carriage of coal doubled its pithead price in ten miles, and that it could be carried 20 times as far by water for the same unit cost. There is no reliable information on the price of coal in Gloucestershire, but in 1755 John Dallaway estimated that the bringing of coal from Framilode (on the River Severn) to Stroud cost 7s. per ton in the summer and 8s. in winter. With canal transport he reckoned that the cost would only be 3s. 6d.[12] In the late eighteenth and early nineteenth centuries, when transport costs were much higher than they later became, the location of suitable resources was crucial. Clearly the West Riding would have had an advantage in this respect, but was there a real lack of access to coal in Gloucestershire that would have led the industry there into decline?

There certainly were coal reserves located in Gloucestershire. The coal field that was closest was in the Forest of Dean. While this had a relatively small output it was, even in 1788, claimed that its coalmines supplied 'the lower part of Gloucestershire beyond Severn and some across the Severn about Berkeley, the greatest part of Herefordshire, the town of Monmouth, and the part of the county of Monmouth'.[13] The late eighteenth century saw an increase in coal production in Shropshire, Staffordshire and increasingly South Wales.

TABLE 1

COAL OUTPUT IN GREAT BRITAIN (‘000 TONS), 1750-1856

Years	Forest of Dean	Shropshire	Staffordshire (a)	South Wales	Yorkshire
1750-55	-	300	250	80	500
1761-65	-	350	350	100	600
1771-75	-	350	500	200	750
1781-85	90	400	650	500	850
1791-95	90	400	850	800	950
1801-05	90	500	1,600	1,200	1,500
1811-15	110	700	2,400	1,800	1,800
1821-25	280	800	3,400	2,500	2,400
1831-35	360	800	4,000	4,000	3,600
1841-45	450	900	4,800	5,000	4,500
1846-50	-	900	5,600	6,500	5,500
1856	1,492 (b)	1,080	7,500	8,500	7,260

Source: S. Pollard, ‘A New Estimate of British Coal Production, 1750-1850’, Economic History Review, 2nd series, Vol.XXXIII (1980), p.229.

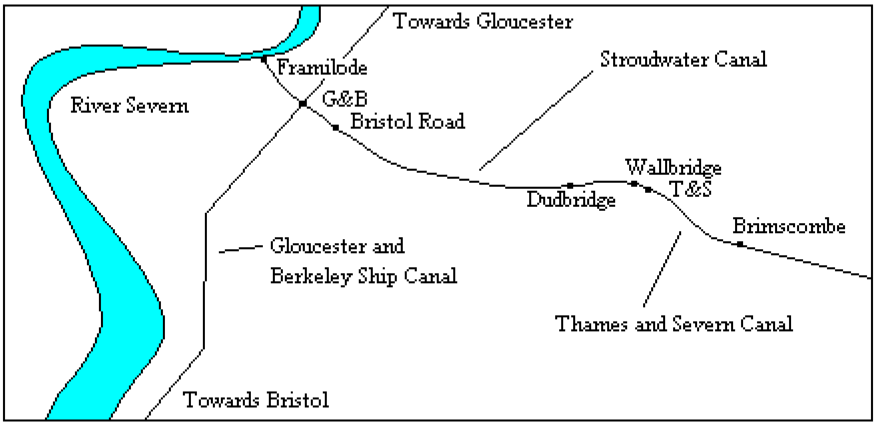
Notes:
(a) The Staffordshire figures include North Staffordshire, South Staffordshire and Worcestershire.
(b) The 1856 figure for the Forest of Dean’s output also includes the output of Bristol and Somerset.

With the rapidly growing network of canals in these regions allowing access to the River Severn, in particular the Staffordshire and Worcestershire Canal which opened in 1772, these sources of coal were accessible enough to be made use of by Gloucestershire’s clothiers. The opening of the Stroudwater Canal in 1779 made this a real possibility. Section II will examine the tolls set by the Stroudwater Canal Company and the impact of these tolls on the volume of coal carried on the canal. Section III will then explore the relationship between the cost of coal transport and the rate at which steam-powered machinery was introduced by the Gloucestershire woollen industry.

II

There had been several schemes to make the Stroudwater navigable during the eighteenth century, but it was not until a fifth act[14] was passed that the Stroudwater Canal was constructed between 1775 and 1779, from Framilode on the River Severn to Wallbridge on the edge of Stroud, a route of eight and a quarter miles. The clothiers were the main impetus behind its construction, since they desperately wanted a link to Stroud to help bring raw materials to the mills more easily and at more competitive prices. It was claimed in 1775 that coal which was sold at 13s. per ton at Wallbridge would, with the completion of the Stroudwater Canal, be sold at 8s. per ton.[15] Most of the capital raised to build the canal originated from local clothiers; seventy per cent of the shares were held by individuals who were connected in some way with the woollen industry, including clothiers, gentlemen who had made their money in the industry, dyers and woolstaplers.[16] They were the ones who were most likely to benefit from the connection. The Thames and Severn Canal opened in 1789 to much the same praise and optimism as had the Stroudwater Canal and, with the two canals being linked at Wallbridge, a through route was established which allowed direct access to the London markets.

Figure 1. Plan of Stroudwater Canal (not to scale).



Subsequent to the building of the Stroudwater Canal, with the real growth of the factory system at the turn of the century, mills became more concentrated along its path. The limited data of the time makes it difficult to be precise about the extent to which it helped reduce the cost of coal in the area, but one account suggests that as early as 1786 the Stroudwater Canal had affected the sale of coal from the Mayshill colliery near Bristol.[17] Another account suggests that the canal was a major success:

> This canal has been of infinite advantage to the town of Stroud, and the clothing district in the neighbourhood, by furnishing them with coal at a cheap rate, and conveying their heavy and bulky goods to various markets, and from its connection with the Thames and Severn, was the means of forming the first communication by inland navigation between London and Bristol, and the counties of Gloucester, Worcester and Hereford.[18]

Water transport was indeed a much used and very viable proposition for the transport of both raw materials and finished goods in the west of England.

It is the aim of this section to analyse the importance of the canal in the movement of coal along its route to Stroud. This can be done because the records of the Stroudwater Canal Company still exist and, being mainly account books, provide extensive information on the operation of one of the earliest canal companies.[19] Table 2 presents a summary of the records for the period 1807-40.[20]

TABLE 2

TONNAGE AND RECEIPTS OF THE STROUDWATER CANAL COMPANY, 1807-40 (a)

(1) Year	(2) Coal trade	(3) Receipts on coal trade	(4) Profit on coal trade	(5) Total trade	(6) Receipts on total trade	(7) Grand total for money received	(8) Grand total for expenditure	(9) Profit
	(tons)	(£)	(£)	(tons)	(£)	(£)	(£)	(£)
1807-8	25,055	2,403	-	44,253	3,424	3,424	3,643	-129
1808-9	31,129	2,918	-	51,848	4,034	4,034	4,003	31
1809-10	32,238	2,850	-	54,979	4,121	4,121	4,252	-131
1810-11	26,846	2,294	-	44,475	3,242	3,242	3,372	-130
1811-12	36,079	3,119	-	51,832	4,065	4,065	3,530	535
1812-13	31,507	2,966	-	47,514	3,954	3,954	4,266	-312
1813-14	30,901	2,863	260	45,985	3,753	4,058	3,271	787
1814-15	42,255	3,812	446	60,304	5,004	5,556	4,845	711
1815-16	37,067	3,351	274	52,095	4,323	4,593	5,389	-796
1817-18	45,087	3,973	391	58,976	4,830	5,219	5,003	216
1818-19	50,337	4,432	474	70,780	5,704	6,125	5,679	446
1819-20	44,485	3,928	309	59,479	4,805	5,156	5,766	-610
1820-21	59,282	5,013	310	77,177	6,012	6,361	5,388	973
1822-23	59,163	5,408	120	75,349	6,485	6,678	5,889	789
1829-30	57,278	4,030	-	74,754	5,307	5,641	6,309	-668
1834-35	66,530	4,363	-	89,881	5,875	6,113	6,804	-691
1835-36	61,863	4,483	-	84,963	5,901	6,099	5,666	433
1839-40	76,191	4,357	-	105,407	6,201	6,427	6,173	254

Source: Gloucestershire Record Office, D1180 2/2.

Notes:
(a) The manuscript source from which this table is drawn presents the totals for intervals of six months: April to October, October to April. The figures for these two periods show large fluctuations, with considerably less coal and merchandise moved through the winter months. The table here presents the figures for the whole year: April to April. For certain of the years, not included here, the records are missing or no longer exist. All figures are rounded to the nearest ton or pound.

One can conclude from Table 2 that the years 1807-40 saw a three-fold increase in the amount of coal being moved along the canal, while other merchandise (mainly other raw materials such as stone, wood, metallic goods, bricks and salt) increased by around only half.[21] The canal was therefore, and increasingly, being used for exactly what it had been built, the movement of coal to the Stroud valley.[22] Clearly the Stroudwater Canal had ‘coal at the heel of it’.[23] However, due to extremely generous share dividends and the fact that receipts on the coal trade did not increase at the same rate as the tonnage moved, the profit of the Stroudwater Canal Company fluctuated quite significantly during the period. In fact the share dividend made up the largest part of the Company’s expenditure[24], and it was these excessive returns, decided upon by the proprietors the year before they were to be paid, that often pushed the Company into making a loss. It is interesting to note at this stage that the

Canal Company was actively involved not only in the running of the canal, but also operated as a coal-carrying company, owning its own boats[25], buying coal and carrying it along the canal for profit.[26] One of the initial aims of the proprietors had been to form a coal importing company, and an advertisement to this effect had appeared in the Gloucester Journal on 6 January 1777.[27] The main objective of this policy appears to have been the establishment of a regular supply of coal at the reduced prices that a large-scale movement would allow. It was hoped that this would ease the Company's early cash flow problems. There was, however, a steady drop in profits from the period of April to October 1819 onwards. The reason the figures stop in 1823 is that the Stroudwater, like other canals at this time, no longer found it either profitable or, with the extensive work that was involved, expedient to continue acting as a carrier.

Coal was not only used for powering steam engines, but a major reason why the Stroudwater coal trade did not increase more than it did was that while steam engines were purchased by the various mills along the Stroudwater, the size of these engines was often very small with most supplying between ten h.p. and 30 h.p.[28] The real growth in the purchase of steam engines occurred after 1820.[29] It is the aim of this article to assess how important transport costs were in any movement of coal, and how significant they were in allowing clothiers to utilise fully steam power. An analysis can be conducted into whether clothiers close to the River Severn were advantaged in the use of steam power over those further inland and nearer to Stroud, because we not only know the extent of steam power employed in 1838, but the records of the Stroudwater Canal Company detail exactly how much coal was moved to each wharf along its length.

TABLE 3

TONS OF COAL MOVED TO WHARVES ALONG THE STROUDWATER CANAL AND THE THAMES AND SEVERN CANAL, INCLUDING TOLLS, 1807-40 (a)

	On Stroudwater Canal					On Thames and Severn Canal		
Wharves (b)	G&B	Bristol Road	Places below Dudbridge	Dudbridge	Wallbridge	T&S	Places below Brimscombe	Brimscombe
Distance (c) **along canal**	1.40	4.05	7.80	11.55	13.20	13.55	15.50	17.45
Toll to S.C.	5d.	1s. 4d.	1s. 6d.	3s. 4d.	3s. 6d.	2s. 3d.	2s. 3d.	1s. 0d.
Toll to T&S	-	-	-	-	-	1s. 3d.	1s. 3d.	1s. 3d.
Total toll (d)	5d.	1s. 4d.	1s. 6d.	3s. 4d.	3s. 6d.	3s. 6d.	3s. 6d.	2s. 3d.
Coal moved								
1807-8	-	1,803	2,483	3,585	2,239	2,158	969	11,817
1812-13	-	1,385	3,637	4,501	2,405	2,587	1,255	15,740
1817-18	-	2,467	3,472	6,236	2,830	2,119	3,608	24,355
1822-23	-	1,330	8,133	8,182	4,721	2,940	4,717	27,640
1829-30	-	541	11,268	8,695	3,831	4,451	5,834	22,658
1834-35	5,272	390	7,797	8,068	4,238	4,807	7,987	27,971
1839-40	11,355	396	8,216	5,478	3,706	5,263	5,952	35,825

Source: GRO, D1180 2/2.

Notes:
(a) Refer to note (a) of Table 2. Figures are presented at intervals of five years where possible.
(b) The names of the wharves are taken from the accounts: Gloucester and Berkeley Ship Canal (G&B), Bristol Road, places below Dudbridge, Dudbridge, Wallbridge, Thames and Severn Canal (T&S), places below Brimscombe, Brimscombe. These last three wharves were all on the Thames and Severn Canal, but the account books include all tonnages to these places. This was because the 1783 Act limited the tolls charged by the Stroudwater Canal Company for coal moved along the Stroudwater Canal to these places (see below).
(c) The distance (km) that coal had to be brought eastwards along the canals from Framilode on the River Severn. Represents the midpoint for 'places below Dudbridge' and 'places below Brimscombe'. Distances have been measured from the 1883 Ordnance Survey.
(c) For places on the Stroudwater Canal tolls were payable to the Stroudwater Canal Company ('Toll to S.C.'). For places on the Thames and Severn Canal tolls were payable to the Stroudwater Canal Company for use of its canal to Wallbridge and to the Thames and Severn Canal Company ('Toll to T&S') for the stretch thereafter. The toll is the amount payable for one ton of coal to move along the canal to each point. All tolls stay the same over the period 1807-40. The toll for 'places below Dudbridge' is not explicitly given in the accounts, but can be worked out from the tonnage and toll receipts. This stands at 1s. 6d. in 1839-40, the period upon which the analysis is based.

Table 3 shows that as the distance of the wharves from the River Severn increased, so did the toll that was charged for a laden boat to move up the canal to each wharf up to Wallbridge. The records are surprising in one respect. They include a number of wharves that were not actually under the jurisdiction of the proprietors of the Stroudwater Canal, but were instead on the Thames and Severn Canal. This was due to the decision to join the Thames and Severn Canal to the Stroudwater Canal. A determining factor in the choice of routes was the decision of the proprietors of the Stroudwater Canal to reduce their tonnage rates. These were to be 'reduced and made satisfactory to the undertakers of the proposed junction' if the route that would extend the Stroudwater Canal towards London was chosen.[30] The proposed tolls became law in the Act of 1783 which set up The Company of Proprietors of the Thames and Severn Navigation.[31] The tolls payable to the Stroudwater Canal Company for coal moved along the length of the Stroudwater Canal to the three wharves on the Thames and Severn Canal were considerably less than that for even the destination point on the Stroudwater Canal. In fact the total toll for coal moved to the Thames and Severn Canal wharf and for the wharves below Brimscombe was 3s. 6d., and for Brimscombe it was 2s. 3d.[32] The total toll for coal taken along the Stroudwater Canal, then along the Thames and Severn Canal and onto the River Thames (which the Thames and Severn Canal afforded access to at Lechlade and which was the through route to London) was only 3s.[33] This puts into perspective the high tolls that were charged by the Stroudwater Canal Company. In terms of tolls it was cheaper to bring coal to London (with the total cost of tolls being 3s.) than even as far as Dudbridge (with a toll of 3s. 4d.), less than 8km along the Stroudwater Canal. Places on the Thames and Severn Canal therefore had a considerable advantage over those on the Stroudwater Canal. The question of whether these reduced tolls provided a boost to the coal trade beyond Stroud will now be investigated, and on this basis it will be possible to evaluate the toll policy and the success of the Stroudwater Canal.

By 1839, the year upon which the analysis will focus, it is clear from Table 3 that for the Stroudwater Canal there was an inverse relationship between the toll and the amount of coal that was moved along the canal.[34] Considerably more coal was being moved to the wharf at the Gloucester and Berkeley Ship Canal (completed in 1827) for which there was a toll of only 5d. than to Wallbridge with a toll of 3s. 6d. This picture, however, must be modified when also considering the three wharves on the Thames and Severn Canal. It can be seen from Table 3 that the reduced tolls that the Stroudwater Canal Company was obliged to give for coal moving on to the Thames and Severn Canal beyond Stroud gave these wharves a considerable advantage over those on the Stroudwater Canal. Certainly much of the coal and merchandise moved to Brimscombe would have been destined for places nearer to London, but it was still the case that throughout this period Brimscombe imported considerably more coal than any of the other places along both canals. In 1839 more coal was moved to Brimscombe (and beyond) than to all the wharves on the Stroudwater Canal. While coal had to be moved further to reach these points, more of it was indeed brought this far. The reduced tolls for these reaches of the Thames and Severn Canal were therefore making a considerable impact on the coal trade beyond Stroud. With total tolls of 3s. 6d., 3s. 6d. and 2s. 3d. (all considerably less in terms of toll per kilometre than the toll charged by Stroudwater Canal Company for coal taken as far as Wallbridge), the wharves on the Thames and Severn Canal saw a much larger trade in coal. Clearly, with these reduced rates, the transport of coal from the River Severn was a worthwhile undertaking for mills and factories in Brimscombe and further east.

As the next section of this article will make clear, the tolls for the five main wharves on the Stroudwater Canal were at a high enough level to dissuade clothiers from employing steam engines as a significant source of power. The impression given is that the proprietors of the Stroudwater Canal were overcharging for coal moved to the various wharves on Stroudwater section. One can say that on average the toll for coal moved to wharves on the Stroudwater Canal rose by approximately 3d. for every kilometre it was carried.[35] If the pricing policy that was employed for wharves on the Stroudwater Canal had been extended to include the Thames and Severn Canal, one would expect considerably different tolls for these three wharves. The toll on coal moved to the wharf at the start of the Thames and Severn Canal would have been approximately 3s. 7d., that on coal moved to places below Brimscombe would have been on average 4s. 1½d., and for Brimscombe the toll would have been 4s. 7½d. The total tolls for coal moved to wharves on the Thames and Severn Canal were lower than these results. Since the total toll fell in real terms as well as in terms of toll per kilometre, the coal trade for places on the Thames and Severn Canal and beyond enjoyed a considerable advantage over the coal trade on the Stroudwater Canal.

The results of this section therefore suggest that distance was not the primary factor in determining the amount of coal moved along the canal, but that it was the toll that was more important. By determining the toll for the various wharves along the canal, the proprietors of the Stroudwater Canal were able to influence the import of coal into Gloucestershire and hence, with transport costs being so high, indirectly the level of steam power employed by the woollen mills in the area.

III

The main focus of this section is to analyse to what extent access to coal supplies affected the level of steam mechanisation in the Gloucestershire woollen industry. By looking at this in conjunction with the Stroudwater Canal the importance of this local transport link in the early eighteenth century will be seen.

One is able to conduct such an analysis because the mill and factory returns for 1838 give a comprehensive account of the degree of mechanisation at this time.[36] Table 4 presents the main results.

TABLE 4

GLOUCESTERSHIRE PARISHES WITH WOOLLEN MILLS, THEIR PROXIMITY TO COAL SUPPLIES, AND THE LEVEL OF POWER EMPLOYED, 1838

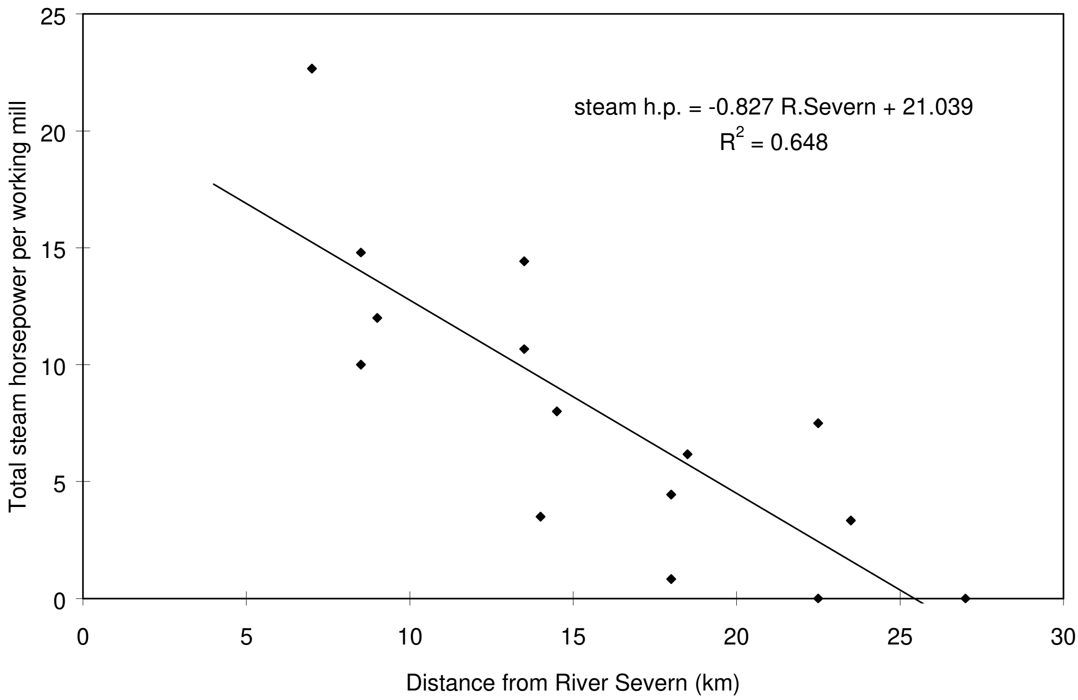
(1) Parish	(2) Working woollen mills	(3) Distance along canal (km)	(4) Distance from River Severn (km)	(5) Number of water wheels	(6) Total water power (h.p.)	(7) Number of steam engines	(8) Total steam power (h.p.)	(9) Steam power per working mill (h.p.)
Avening	4	18.0	22.5	7	44	2	30	7.5
Bisley	3	20.0	23.5	4	35	1	10	3.33
Cranham	0	13.0	22.5	0	0	0	0	0
Eastington	3	6.0	7.0	11	76	3	68	22.67
Horseley	9	11.0	18.0	13	50.5	2	7.5	0.83
King Stanley	1	9.0	9.5	5	130	1	50	50
Leonard Stanley	2	8.0	8.5	0	0	3	20	10
Minchinhampton	12	17.0	18.5	36	264	6	74	6.16
Miserden	0	19.5	27.0	0	0	0	0	0
Painswick	9	13.0	18.0	22	112	3	40	4.44
Rodborough	6	12.0	13.5	17	144	2	64	10.67
Standish	1	6.0	9	3	12	1	12	12
Stonehouse	5	8.0	8.5	17	248	3	74	14.8
Stroud	14	13.0	13.5	27	206	8	202	14.42
Uley	2	8.0	14.5	5	24	1	16	8
Woodchester	4	11.0	14.0	7	49	1	14	3.5

Sources: Columns 1,2,5,6,7, and 8: Returns of Mills and Factories, (P.P. 1839, XLII), pp.148-51; Columns 3,4, and 9 are explained below.

In order to test the hypothesis that those parishes furthest from a source of coal supply were less mechanised than those closer to it, it is necessary to have a variable that places the parishes in relation to a source of coal. The coal, whether it came from the Forest of Dean, Shropshire, Staffordshire or South Wales, would have been brought along the nearest available water transport in the attempt to cut transport costs. To the data presented in the mill and factory returns, I have therefore added two variables that place a parish in relation to any possible water transport. The 'distance along canal' variable shows how far coal would have been brought along the Stroudwater and Thames and Severn Canals before being unloaded and transported overland to the mills. The 'distance from River Severn' variable shows the total distance any raw material would have been brought from the River Severn, by canal and then overland.[37] The information as it is presented in the returns is of little use. A parish like Stroud, with eight steam engines, might seem highly mechanised until it is remembered that it also had 14 working mills at this time, more than any other parish. To take this into account figures have been presented for the total steam horsepower per working mill ('steam power per working mill'), so that comparisons between parishes can be more readily made.

Figure 2 plots the distance that parishes were from the River Severn against the number of steam engines per working mill.[38]

Figure 2. Distance from River Severn against total steam horsepower per working mill, 1838.



There is a clear inverse relationship between the steam power that a mill employed and the distance that raw materials had to be brought. Since all the coal used in Gloucestershire's woollen mills was transported down the River Severn (whether it came from the nearest source of supply in the Forest of Dean across the estuary, or further afield from South Wales, Shropshire or increasingly Staffordshire), one would expect that the further a parish was from the River Severn, the less employment of steam power there would have been. Figure 2 suggests this to be the case. The best-fit regression line is represented by the equation:

$$\text{steam h.p.} = -0.827 \text{ Distance from River Severn} + 21.039 \quad (R^2 = 0.648)$$

This says that on average the mills in each parish would reduce their employment of steam horsepower by one unit for every extra 0.827km distance from the River Severn. Table 5 shows the relationship between steam power and distance in more detail, presenting correlations of steam horsepower per working mill with the distance variables that have already been presented.[39]

TABLE 5

CORRELATIONS

	Distance along canal	Distance from canal	Distance from River Severn
Steam horsepower per working mill	-0.60 (-2.70)*	-0.75 (-4.09)*	-0.81 (-4.98)*

Key: T statistics in brackets; * Significant at the five per cent level or below.

There is a clear negative correlation (-0.60) between steam horsepower per working mill and the distance that a mill had to transport goods along the canal. This result is mirrored by the negative correlation (-0.81) between steam horsepower per working mill and the distance that the mills were from the River Severn. The negative correlation (-0.75) between steam horsepower per working mill and the distance that the mills were from the canal confirms Turnbull's point that the 'path of a canal would thus create a narrow corridor of superior locational space yet impart little benefit to sites only a short distance away'.[40] This helps to explain why those mills further from the Stroudwater Canal employed less steam power than those on its banks, and why the industry gravitated towards this local transport link. The clear indication is that the distance that coal had to be brought, both along the canal and overland, did affect the degree to which a mill used steam power.

IV

These results therefore suggest that it was not only entrepreneurial failings which led Gloucestershire woollen mills to employ considerably less steam power than those of the West Riding. The analysis presented here suggests that transport costs were indeed prohibitive in the Stroudwater region of the Gloucestershire woollen industry. It has been seen that in 1838 the Gloucestershire cloth industry had developed to a point where those mills that employed the largest relative amount of steam power were those closest to the River Severn. For these mills coal had to be brought a considerably shorter distance than those nearer to Stroud. However, it was not distance that was the primary factor in the movement of coal but the toll for its movement along the Stroudwater Canal. This can be seen from the fact that more coal was moved to Brimscombe and beyond in 1839 than to all the places on the Stroudwater Canal. The success of the Stroudwater Canal in moving coal through the county can therefore be put down to the 1783 Act which restrained the Stroudwater Canal Company from taking more than 2s. 3d. per ton for coal carried to the Thames and Severn Canal wharf and places below Brimscombe, and not more than 1*s.* per ton for coal going on to Brimscombe or further. Coal was brought in abundance to these places (and beyond), for which the tolls were considerably lower than those on trade solely on the Stroudwater Canal. For the mills in Stroud, having to pay a toll of 3s. 6d. to bring coal to Wallbridge clearly acted in a way that dissuaded clothiers from employing steam power.

It is difficult to know why the tolls on the Stroudwater Canal were set at the level they were. The proprietors must certainly have understood that they had a monopoly position, but whether the high tolls were set in order to exploit this position it is difficult to ascertain. It might have been that the proprietors hoped to make a short-term profit in order to pay off the debts that had been built up during the canal's construction.[41] If this was the case, then they failed to recognise that such a policy prevented the growth of long-term trade since tolls, once set, tended in practice to be inflexible.[42] Only a generation after its construction and while the Stroudwater Canal was still the main transport link in the region[43], the profits of the Canal Company were fluctuating dramatically, as Table 2 has shown. The ultimate collapse of the Stroudwater woollen industry meant that its future could never be assured.

If one accepts the standard analysis that, in large part, it was a failure to employ steam power that led the West's cloth industry into decline, then it can now be seen that the failure to mechanise was in turn linked to the pricing policy of the Stroudwater Canal Company. It could be suggested that if tolls had been reduced for those places along the Stroudwater Canal, perhaps at the expense of the high share dividends, more steam power may have been employed and the decline of the cloth industry in the region slowed.

NOTES

1. P. Deane, 'The Output of the British Woolen Industry in the Eighteenth Century', Journal of Economic History, Vol.XVI (1957); R.G. Wilson, 'The Supremacy of the Yorkshire Cloth Industry in the Eighteenth Century', in N.B. Harte and K.G. Ponting (eds.), Textile History and Economic History (Manchester, 1973)
2. J.de L. Mann, The Cloth Industry in the West of England from 1640 to 1880 (Oxford, 1971); J. Tann, 'The Employment of Power in the West of England Wool Textile Industry, 1790-1840', in Harte and Ponting, Textile History
3. G. Turnbull, 'Canals, Coal and Regional Growth During the Industrial Revolution', Economic History Review, 2nd series, Vol.XL (1987)
4. Tann, 'Employment of Power'. Also see Mann, Cloth Industry, pp.123-156.
5. Gloucestershire had become dominant in the production of cloth in the west of England by the end of the eighteenth century.
6. A.M. Urdank, 'Economic Decline in the English Industrial Revolution: The Gloucester Wool Trade, 1800-1840', Journal of Economic History, Vol.XCV (1985)
7. James Watt's patent of 1769 ran out in 1800, when there was a sudden increase in the numbers of firms manufacturing steam engines. Engines by the firms of Trevithick, Wolff and Perkins were all considered by clothiers in Gloucestershire. Certainly by the early nineteenth century steam engines were vastly more

efficient than the earlier Newcomen or the first Boulton and Watt engines had been, Hills and Pacey suggesting that even 'by 1784 relatively efficient rotative engines were becoming available'; Tann, 'Employment of Power', p.214; R.L. Hills and A.J. Pacey, 'The Measurement of Power in Early Steam-Driven Textile Mills', Technology and Culture, Vol.XIII (1972), p.25.

8. Mann, Cloth Industry, p.185.
9. Tann, 'Employment of Power', p.219.
10. Ibid., pp.217-20.
11. Mann, Cloth Industry, p.192.
12. The pamphlet also claimed that 25 times more manpower was needed to move 70 tons of coal from the River Severn to Stroud by road than by water; J. Dallaway, A Scheme to Make the River Stroudwater Navigable (Glocester, 1755)
13. Quoted in C. Hart, The Industrial History of Dean (Newton Abbot, 1971), p.109.
14. 16 Geo. 3, c.21. The Act became law in 1776, after the canal had already been begun, but in effect it was only an amendment to the 1730 Act (An Act for making navigable the River Stroud-water etc. (3 Geo. 2, c.13) which allowed for the construction of the canal.
15. Gloucester Journal, 5 June 1775; R.P. Beckinsale, 'A Geographical Survey of the Textile Industries of the West of England' (unpublished D.Phil. thesis, University of Oxford, 1949), p.74.
16. M. Handford, The Stroudwater Canal (Gloucester, 1979), pp.144-7.
17. Lord Middleton to Thomas Smythe, 11 Nov. 1786. Cited in M.W. Flinn, The History of the British Coal Industry, Volume 2, 1700-1830 (Oxford, 1984), p.185. In 1817 there were protests in Somerset against the exemption from the coastwise duty of Forest of Dean producers, who were able to send coal across the River Severn and up the Stroudwater Canal, thus gaining an unfair advantage in Wiltshire and Berkshire over Somerset coal. Newcastle's miners were similarly aggrieved by the exemption from duty of the West's coal, and in 1804 it was claimed that 'from Staffordshire immense quantities are brought down the canals and smuggled into London where they can be bought and sold at a much cheaper rate than the sea coals, no duty being paid on them...' Clearly the Stroudwater Canal played a significant role in opening up the exploitation of the pits in the west of England; Flinn, Coal Industry, pp.185,187.
18. Quoted in J. Priestley, Historical Account of the Navigable Rivers, Canals and Railways Throughout Britain (2nd ed. 1967), p.645.
19. Gloucestershire Record Office (hereafter GRO), Records of The Company of Proprietors of the Stroudwater Navigation, 1729-1947, D1180. The records have been used previously, but only for early studies of the canal focusing upon its construction, rather than any analysis inquiring into the operation of the canal; R.A. Taylor, 'The Construction of the Stroudwater Canal', Gloucestershire Historical Studies, Vol.III (1969); J. James, 'The Construction of the Stroudwater Canal', Gloucestershire Historical Studies, Vol.V (1972); Handford, Stroudwater Canal
20. As well as such data being of importance in understanding a local transport link, Wilson has suggested that it can record with a high degree of accuracy the level of economic activity in a region. His analysis of the navigation receipts of the Aire and Calder between 1775 and 1826 led to the conclusion that they 'follow very closely the pattern of the turnpike leases in their movements, and that they again record with remarkable accuracy the level of economic activity within the West Riding woollen area in these fifty

years'; R.G. Wilson, 'Transport Dues as Indices of Economic Growth, 1775-1820', Economic History Review, 2nd series, Vol.XIX (1966), p.120. It is difficult to test such a hypothesis for Gloucestershire since there is no reliable time series data for the state of economic activity (either general or relating to the woollen industry) in Gloucestershire prior to 1823. However, with the dominance of the woollen industry within Gloucestershire being comparable to that of the woollen and worsted industries within the West Riding, the conclusions that one can draw for the economic success of the Stroudwater Canal can be assumed to represent, at least in part, the pattern of economic activity in Gloucestershire over the same time period.

21. The figures for 'merchandise trade' can be worked out from Table 2 by subtracting column 2 from column 5, 'receipts on merchandise trade' by subtracting column 3 from column 6.
22. Similarly virtually all movement of goods appears to have been in an eastwards direction from the River Severn towards Stroud.
23. This was the third Duke of Bridgewater's test of viability for a canal. Quoted in Flinn, Coal Industry, p.187.
24. The expenditure generally comprised of the share dividends, repairs to the canal and locks, parliamentary and parish taxes, the clerks' salaries, committee expenses and a few small miscellaneous expenses. For the eighteen years that Table 2 covers, a total of £65,450 was paid in share dividends, a remarkable return on the £30,000 that had initially been raised by share subscription to build the canal.
25. The records also include figures for 'capital employed in the coal trade'. This rises from £1,400 in 1807 to £1,700 by 1815.
26. Household writes that the proprietors 'engaged in carrying quite openly in their corporate capacity'; H. Household, The Thames and Severn Canal (Newton Abbot, 1969), p.91.
27. Handford, Stroudwater Canal, p.278.
28. 'A Boulton & Watt engine consumed approximately 12½ lb of coal per h.p. per hour in the period 1790-1820, a figure which, according to Boulton & Watt, was more or less constant for all types of engine'; Tann, 'Employment of Power', p.218. If the steam engines installed in Gloucestershire in 1838, which totalled 681.5 h.p., were run for 12 hours per day in a 310 day working year (as Tann assumes) they would have required 14,147 tons of coal. Since Urdank suggests that much of the steam power available would often only be used during busy periods or when water power became unreliable, the actual amount of coal used in these 38 steam engines would have been considerably less than this. In 1839 29,151 tons of coal were moved to the five wharves on the Stroudwater Canal. Clearly the Stroudwater Canal was able to supply the amounts of coal that an increased amount of steam power might have required. Much of what was moved to these wharves would have been used in other processes of the textile industry, such as scouring, dyeing, bleaching and drying, and in the household trade.
29. Tann, 'Employment of Power', pp.220-23.
30. W.T. Jackman, The Development of Transportation in Modern England (3rd ed. 1966), pp.373-4.
31. An Abstract of a Act for making and maintaining a Navigable Canal from the River Thames etc., (23 Geo. 3, c.38). The tolls of 3s. 6d. for the wharf at the entrance to the Thames and Severn Canal, and for the wharves at places below Brimscombe were able to be imposed effectively because there was be a 5s. fine (payable to the Stroudwater Canal Company) if coal was moved to Brimscombe for 2s. 3d. and then brought back to places west of Brimscombe nearer to Stroud.

32. 23 Geo. 3, c.38, p.108.
33. This total toll comprised of the 1s. toll payable to the Stroudwater Canal Company for coal taken beyond Brimscombe and the 2s. toll payable to the Thames and Severn Canal Company due on coal taken as far as Lechlade. The tolls payable to the proprietors of the Thames and Severn Canal for coal taken along the Thames and Severn Canal, a canal more than twice the length of the Stroudwater Canal, were set at lower levels than the tolls for the Stroudwater: Stroud to Sapperton Tunnel (1s. 3d.), Sapperton Tunnel to Cirencester (1s.), Cirencester to Lechlade (2s.); 23 Geo. 3, c.38, p.108.
34. The wharf at the Bristol Road imported very small amounts of coal throughout the period 1807-40. The wharf was at the point where the Stroudwater Canal crossed the road to Bristol, allowing overland transport of goods from this point. With fewer mills in the vicinity of the Bristol Road wharf than the other wharves along the canal, and with overland transport of coal being expensive, the Bristol Road wharf was little used, and therefore shows up as an outlier.
35. The best-fit regression equation for the five points on the Stroudwater Canal is represented by:

$$\text{toll} = 0.265 \text{ distance along canal} \quad (R^2 = 0.936)$$

Hence the toll for coal rose by approximately 3d. (0.265 shillings in decimal terms) for every kilometre carried.
36. Returns of Mills and Factories, (P.P 1839, XLII), pp.148-51. Data is given for twenty-four parishes. I present the data for only those parishes that would have had reasonable access to the Stroudwater Canal. Similar analysis on other canal links, would allow an opportunity to evaluate the conclusions presented here.
37. By subtracting one variable from the other, one has a measure for how far from the canal the parishes were. This is represented by ‘distance from canal’ in Table 5. These three location variables (found by measuring the distances from the centres of the parishes) are not precise indicators for each mill - the available information for the period precludes it - but are reliable indicators upon which to base analysis.
38. The parish of King Stanley has not been included in Figure 2 or the correlations presented in Table 5, since it appears throughout as an outlier. The reason for this can be easily understood. While there was only one mill in the parish in 1838, this was the largest in the district, rebuilt after a fire in 1813 as one of the first fire-proof mills. Already having extensive water power, it is perhaps not surprising that it was the first mill to purchase a steam engine of 50 h.p. (as stated in the mill and factory returns. The Boulton and Watt papers suggest that a steam engine of 40 h.p. was purchased in 1822; Tann, ‘Employment of Power’, p.223. Whether it was 40 h.p. or 50 h.p., it remained the largest single steam engine in a Gloucestershire woollen mill even in 1838.) This large purchase therefore shows up throughout as an outlier but does not, however, make the results any less valid. In fact Ebley Mill, employing a large amount of steam power, was one of the most successful mills in the area, and continued producing long after many of the other mills represented in Table 4 had closed.
39. The correlations have been worked out from the data presented in Table 4.
40. Turnbull, ‘Canals, Coal and Regional Growth’, p.544.
41. An original capital of £30,000 was raised by share subscription, initially £20,000, then a further £10,000 when it was realised that this would not be enough. Even by the end of 1778, before the canal had been completed, construction costs had exceeded £28,000, so that the decision was taken to concentrate the

remaining available resources on completing the canal itself before secondary works such as the further construction of wharves were begun; Handford, Stroudwater Canal, p.315.

42. Tolls (for both navigations and turnpikes) could only be changed by the costly procedure of parliamentary legislation; Wilson, 'Transport Dues', p.120.
43. The GWR rail link did not reach Stroud until 1845.