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March 1985

THE ECONOMICS AND POLITICS OF TOLLS ON BRITISH ESTUARIAL CROSSINGS, WITH PARTICULAR REFERENCE TO THE HUMBER BRIDGE

David Simon

EVIDENCE SUBMITTED TO THE HOUSE OF COMMONS TRANSPORT COMMITTEE'S INQUIRY INTO TOLLED ESTUARIAL CROSSINGS. THIS SUBMISSION REMAINS CONFIDENTIAL UNTIL THE COMMITTEE'S FINDINGS HAVE BEEN REPORTED TO THE HOUSE.

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1. INTRODUCTION

The whole principle of levying tolls on certain highway links in the UK has become controversial in recent years. Many of the salient arguments assume particular relevance for the Humber Bridge because of its low traffic volumes and toll charges which are by far the highest in the country. Nevertheless, it is instructive to begin this section with an overview of the toll issue as a whole.

One of the main government justifications for road investment is to provide benefits for commerce and industry. The underlying principle is thus maximization of user benefits, with the costs being borne by the exchequer. It is argued, however, that estuarial crossings provide exceptionally great benefits to users and at a far higher unit cost than other parts of the highway network. Consequently the direct beneficiaries are required to pay for these facilities. The 'user pays' principle, which is thus given precedence over that of maximizing user benefits, forms the basis for levying tolls on estuarial crossings.

The high capital construction costs are not in themselves necessarily controversial. What is disputed by road users and the freight lobby as exemplified by umbrella organizations such as the Confederation of British Industry (CBI), Freight Transport Association (FTA) and Road Haulage Association (RHA), is the precedence given to the 'user pays' principle on estuarial crossings.

Anomalies currently exist at two levels:

(i) Trunk roads are free of tolls, except where they cross certain estuaries, despite the rapid increase in the capital costs of road construction and maintenance over recent years.

Figure 1 MAJOR ESTUARIAL CROSSINGS IN BRITAIN

(ii) Government policy is not consistent even with regard to estuarial crossings. As Figure 1 illustrates, there are eleven tolled crossings in Britain, but at least eleven others remain untolled. Several of these are located close to tolled facilities e.g. Clyde Tunnel near the Erskine Bridge and Blackwall Tunnel (and projected East London River Crossing) near the Dartford Tunnel. They are likely to divert a fair volume of traffic away from the tolled crossings, generating potential congestion at the former while simultaneously undermining toll revenue maximization on the latter. How this anomalous situation in both principle and practice arose is unclear but it is surely self-defeating in the cases just cited, quite apart from the obvious equity considerations involved.

Clearly, then, the status quo requires revision. Two broad alternatives for achieving a consistent policy exist. Either tolls should be abolished so that all trunk roads are toll free; or, if the principle of levying tolls is felt to be valid, the practice should be extended to all estuarial crossings at the very least, and possibly also to additional categories of road.

Several other factors have relevance to the policy debate, and this analysis now moves to consider briefly the economic theory underlying tolls, and then the economic position of existing tolled estuarial crossings.

2. TOLLS AND ECONOMIC THEORY

(a) In conventional neoclassical economic theory, roads are classed as public goods because no profit maximizing individual or firm will provide them voluntarily. The chief characteristics of such public goods are:

(i) indivisibility: they have high capital thresholds and must be provided in large parcels or not at all.

(ii) non-excludability: if the goods are provided, they are available to all members of society even if the latter do not desire them. No market pricing mechanism operates since people unwilling to pay cannot be prevented from using or benefitting from such goods and services*. The level of provision must therefore be collectively decided and is inevitably a compromise. In practice this - and the actual provision - is undertaken by the government or its agents and financed out of tax revenue.

This second characteristic is the more relevant here. Levying road tolls represents a market pricing mechanism, but it is normally impossible to implement in practice because the numerous entry and exit points on most routes or area networks make the costs of toll collection prohibitive. Instead a tax is levied on all road users in the form of road fund/licence fees.

The distinguishing feature of estuarial crossings (and some stretches of motorway and trunk road) is that they have single access and exit points at each end. Toll collection and the simultaneous exclusion of people unwilling to pay thus become practicable.

(b) The effect of charging tolls is to appropriate a portion of the consumer surplus which would be enjoyed by road users under

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* Conversely, up to some (usually very high) threshold, use by one or more individuals does not preclude others from using them. This is the characteristic known technically as "non-rivalry in consumption".

the social benefit maximization principle. The total consumer surplus is represented by the triangle C_nC_0A in Figure 2. An increase in journey costs above C_0 through levying a toll would reduce the overall level of traffic using the crossing in question.

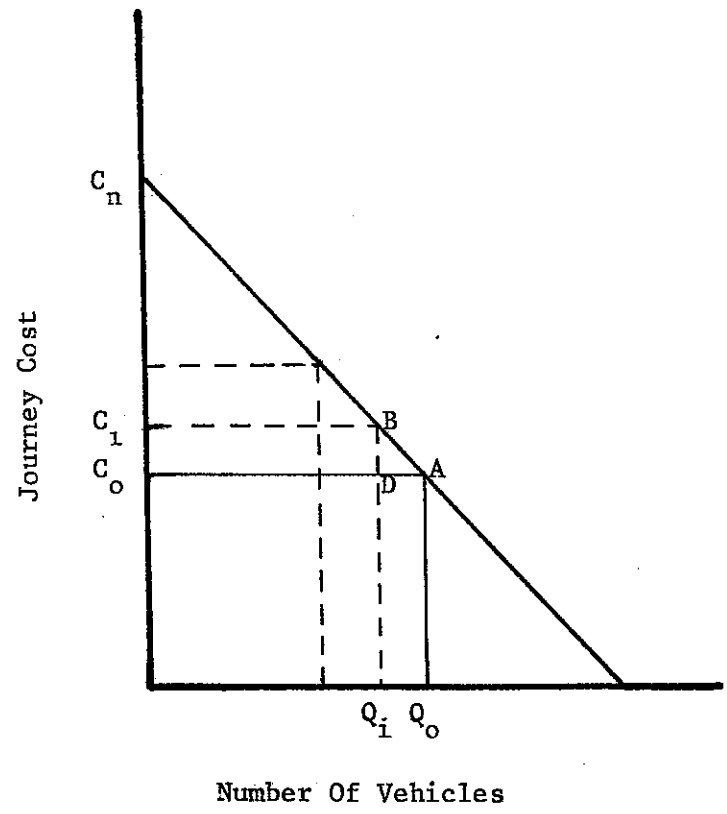


Figure 2
Consumer Surplus

A toll which raised costs to C_1 would reduce traffic to Q_1, and consumer surplus to C_nC_1B. The portion of former consumer surplus C_1C_0D B has been appropriated by the toll authority, and BDA lost to society. Some users will be willing to pay up to C_n, however. Thus if the toll authority were able to charge each user the maximum he/she were willing to pay i.e. engage in perfect price discrimination, the entire consumer surplus C_nC_0A could be appropriated.

In practice this is of course not possible, because

(i) individuals' utility functions (which determine what they are willing to pay) cannot be ascertained quickly or reliably;

(ii) it is in the individuals' interests not to divulge this information; and

(iii) because of the sheer administrative headaches and traffic delays that would arise if the utility functions could be ascertained.

Consequently, toll authorities can engage only in a limited form of price discrimination, charging different tolls for certain readily identifiable vehicle categories on the assumption that consumer surplus is somehow related to vehicle type. As can be seen from Table 1 different tolls apply to the respective vehicle categories on each of the estuarial crossings in question, supposedly because of differences in capital costs and the traffic volumes which have to repay them. This rationale will be called into question in a later section, in view of the economics of tolled crossings.

Table 1 Current Toll on Estuarial Crossings

Crossing	Cars	Light/medium goods vehicles	heavy goods vehicles	income £m
Severn Bridge	20p	20p	40p	2.76
Itchen Bridge	30p	30-40p	£1.60	1.03
Tay Bridge	20p	60p	60p	1.08
Tamar Bridge	40p	40p	80p-£1.40	1.06
Forth Bridge	30p	80p	80p	1.93
Humber Bridge	£1.00	£2.00	£4.50-£7.50	4.20
Cleddau Bridge	35p	35p	70p	0.59
Erskine Bridge	30p	30p	80p	0.68
Mersey Tunnel	40p	40p	£1.00	6.47
Dartford Tunnel	50p	80p	£1.30	5.70
Tyne Tunnel	40p	80p	80p	2.55

Notes:

1. 2-axled lorries; multi-axled lorries charged £15.00.
2. Toll payable one direction only, west to east.
3. 1980-81, others 1981-82 actual or estimated.
4. 20p concessionary toll.
5. A 20% toll increase was approved in early 1985.

Source: FTA 1982.

(c) In strict neoclassical economic terms, levying of tolls is justified only as a form of rationing where congestion exists, i.e. a facility's capacity constraint has been reached. Whatever one's theoretical perspective, this condition is also not being consistently met. For while some crossings e.g. the Itchen and Severn bridges and Dartford Tunnel do arguably experience at least peak time congestion, this is patently untrue in other cases, most notably the Humber Bridge.

In such circumstances the toll may be regarded as an inefficient stifler of traffic, thereby reducing the bridge's overall economic benefit. With price discrimination, the degree of retardation will vary between crossings and across the respective vehicle classes on any one crossing.

The extent of retardation in each case is determined by the elasticity of demand exhibited by operators of different vehicle categories for a particular estuarial crossing. As will be explained in Section 5 below, these elasticities are very difficult to measure in practice.

3. AN ANALYSIS OF THE HEAVY GOODS VEHICLE CONTRIBUTION TO HUMBER BRIDGE TRAFFIC AND REVENUE 1981-1984

Attention now focuses more narrowly on a case study of the Humber Bridge. Its financial status has particular importance for your Committee's investigation since

(i) it is the most recently completed tolled estuarial crossing.

(ii) its current debt burden accounts for at least 38% of the accumulated debt of all eleven tolled crossings, by virtue of its higher than expected construction costs and lower than expected traffic volumes.

The material presented here derives from an ESRC-sponsored study 'The Economic Impact of the Humber Bridge on the Carriage of Goods', being conducted by Peter Mackie and the present author at the Institute for Transport Studies, University of Leeds. This

Table 2

Current Humber Bridge Tolls

Vehicle Class	Toll Payable (each way)	
1. Motor cycles with or without sidecar	£0.50	(£0.70)
2. (Cars including 3-wheelers) (Light vans up to 30 cwt capacity)	£1.00	(£1.50)
3. Cars and light vans with trailers	£2.00	(£2.90)
Heavy goods vehicles over 3t :		
4. 2 axles	£4.50	(£5.20)
5. 3 axles	£6.00	(£6.60)
6. 4 and 5 axles	£7.50	(£8.00)
7. (Light commercial vehicles (30cwt-3t)) (Minibuses seating 9-16 passengers)	£2.00	(£2.90)
8. Buses/coaches seating 17 or more	£4.50	(£5.20)

Notes:

a. The figures in brackets show the maximum tolls currently approved by the Secretary of State for Transport.

b. Certain vehicles e.g. military, police and emergency services, are exempt from tolls.

c. A discount of 5% is given on books of 20 tickets purchased in advance.

section assembles the available information on commercial traffic flows over the Humber Bridge and their revenue contribution, as the basis for subsequent analysis of the potential impact of toll level changes or complete toll abolition.

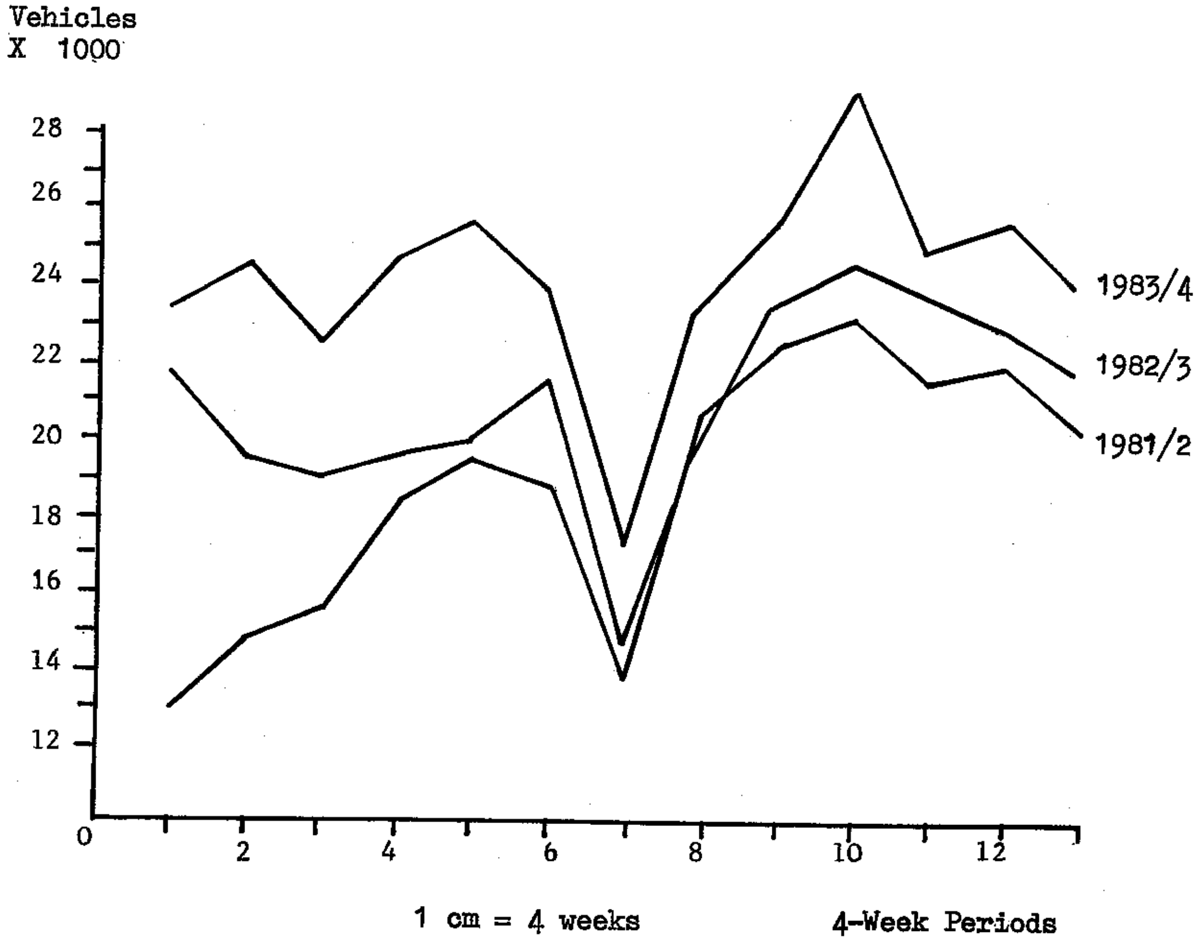
All traffic over the bridge is recorded by the Humber Bridge Board (HBB). The eight vehicle classes distinguished for toll purposes, together with the appropriate tolls, are given in Table 2.

Since vehicle classes 2 and 3 each contain both commercial and non-commercial vehicles in unknown proportions, the analysis here is limited to HGVs (classes 4-6) and thus somewhat understates total commercial vehicle traffic and its contribution to bridge revenue.

HGV flows over the bridge in the first three full years since its opening in June 1981 are shown in Figure 3. There has been noticeable secular growth over the period, notwithstanding marked seasonal variation within each year (see also Simon 1984a).

Although the Humber Bridge opened in June 1981, the HBB keep their records on the basis of an April-March financial year. Because of the need to include pre-paid discount vouchers in this analysis, the following data refer to financial years. 1981/2 was thus only 9 months long, and growth rates using this data are correspondingly misleading. No complete data are yet available for the current (1984/5) financial year, so this analysis covers only the period to 31 March 1984.

By that date, 775,065 HGV bridge crossings had been recorded, yielding £4,529,101 in revenue (Table 3). These figures represent 9.59% of total traffic and 38.34% of total revenue respectively. The stark fourfold discrepancy between these two variables hs been a source of protest by the commercial operator lobby, claiming inequity and an unfair toll burden. This is seen



HGV FLOWS OVER THE HUMBER BRIDGE BY FOUR WEEK PERIOD

DURING THE FIRST THREE YEARS OF OPERATION

JUNE 1981 - JUNE 1984

FIGURE 3

Table 3

Contribution of HGVs to Humber Bridge Toll Revenue 1981-84

Variable		1981/2 24/6/81-31/3/82	1982/3 1/4/82-31/3/83	1983/4 1/4/83-31/3/84
CLASS 4 traffic	Voucher	25,862 = 40.52%	41,026 = 40.94%	53,038 = 42.75%
	Cash	37,960	59,178	71,018
	Total	63,822	100,204	124,056
CLASS 4 revenue	Voucher	£110,560 = 39.29%	£175,386 = 39.71%	£226,737 = 41.50%
	Cash	£170,820	£266,301	£319,581
	Total	£281,380	£441,687	£546,318
% traffic growth		-	57% *	23.8%
% revenue growth		-	56.97% *	23.69%
CLASS 5 traffic	Voucher	14,665 = 60.66%	21,723 = 68.53%	23,404 = 69.16%
	Cash	9,511	9,976	10,435
	Total	24,176	31,699	33,839
CLASS 5 revenue	Voucher	£ 83,590 = 59.43%	£123,821 = 67.41%	£133,403 = 68.06%
	Cash	£ 57,066	£ 59,856	£ 62,610
	Total	£140,656	£183,677	£196,013
% traffic growth			31.12% *	6.75%
% revenue growth			30.59% *	6.72%
CLASS 6 traffic	Voucher	53,418 = 58.99%	87,275 = 63.13%	99,701 = 67.15%
	Cash	37,135	50,968	48,772
	Total	90,553	138,243	148,473
CLASS 6 revenue	Voucher	£380,603 = 57.74%	£621,834 = 61.93%	£710,370 = 66.01%
	Cash	£278,512	£382,260	£365,790
	Total	£659,115	£1,004,094	£1,076,160
% traffic growth			52.67% *	7.4%
% revenue growth			52.34% *	7.17%
Total HGV traffic		178,551	270,146	306,368
Total HGV revenue		£1,081,151	£1,629,458	£1,818,491

* NB: 81/82 not a full year.

Table 3 cont/d.,

		Class 4	Class 5	Class 6
% of all HGVs	1981/2	35.74	13.54	50.72
	1982/3	37.09	11.73	51.17
	1983/4	40.49	11.05	48.46
% of all HGV revenue	1981/2	26.03	13.01	60.96
	1982/3	27.11	11.27	61.62
	1983/4	30.04	10.78	59.18
% of all HGVs	1981/2-1983/4	38.15	11.88	49.97
% of all HGV revenue	1981/2-1983/4	28.03	11.49	60.48
Total HGV traffic and revenue 1981/2-1983/4	Voucher	119,926	59,792	240,394
	Revenue	£512,684	£340,814	£1,712,807
	Cash	168,156	29,922	136,875
		£756,702	£179,532	£1,026,562
	Total Traffic	288,082	89,714	377,269
	Total Revenue	£1,269,386	£520,346	£2,739,369
HGV Grand Total Traffic			755,065	
HGV Grand Total Revenue			£4,529,101	
HGVs using vouchers as % all HGVs and revenue 1981/2-1983/4	Traffic	41.63	66.65	63.72
	Revenue	40.39	65.50	62.53
Total HGVs using vouchers 1981/2-1983/4: traffic				420,112 = 55.64%
revenue				£2,566,305 = 56.66%
Total HGVs using cash 1981/2-1983/4: traffic				334,953 = 44.36%
revenue				£1,962,796 = 43.34%
HGVs as % of all traffic and revenue	1981/2	traffic 7.8)		
		revenue 33.6)		
	1982/3	traffic 9.9)	traffic 9.59	
		revenue 39.25)	revenue 38.34	
	1983/4	traffic 10.7)		
		revenue 40.92)		

1981/2-1983/4 Total Traffic 7,866,049
Total Revenue £11,813,482

Source: Calculated from HBB traffic data.

as effectively another form of tax, coming on top of high HGV road fund and operator's licence fees (see also previous section). Whatever the merits of the equity argument, it is indisputable that HGVs provide a major proportion of current toll revenue, and operators' demand elasticity (responsiveness) to changes in the level of tolls is thus of the utmost concern to the HBB. At a wider level the evidence has great potential relevance to the current debate on the toll issue as a whole.

It is thus instructive to examine growth trends in HGV traffic under the existing toll regime, which has remained unchanged since the bridge opened.

(a) Overall HGV traffic and revenue

As revealed in Figure 3, HGV traffic has grown progressively over the first three years. As a proportion of total traffic the figure rose from 7.8% in 1981/2 to 9.9% in 1982/3 and 10.7% in 1983/4. The HGV contribution to revenue rose from 33.6% to 39.25% and 40.92% respectively (Table 3).

The Humber Bridge Toll Study (Halcrow Fox 1977) predicted a 7-year learning period during which drivers would gradually adjust their behaviour (routeing, scheduling, organization) to take full advantage of the bridge. Private motorists would, it was hypothesized, respond most quickly on leisure trips, then regular commuting or shopping trips, while commercial operators would react more slowly as they require time to perceive the benefits and readjust their operations accordingly.

There certainly was a remarkable 'novelty effect' boom in cars crossing the bridge during its first five or six months, but this tapered off quite rapidly*. As shown above, HGV traffic began slowly and has grown steadily. While thus possibly consistent with the learning curve hypothesis, the rising percentages do also partly reflect the fall off in private car crossings, which was not predicted.

Evidence from our 1984 interview survey suggested a range of both the rate and extent of adjustment by regular commercial bridge users (Simon 1984b). A number of large firms, particularly distributive branches of national or multinational corporations, performed relatively sophisticated cost comparisons, and in several cases reorganised in anticipation of the bridge's opening. Because of the construction delays, some firms were able to take full advantage from day one. Conversely, several hauliers and smaller operators initially resisted the high toll charges, preferring to go round the estuary as before. This response also occurred in cases where drivers' payment systems include a mileage element. Once the excitement died down, and mileage/cost comparisons were made on the alternative routes or extra vehicle revenue was shown to offset the reduced mileage, more firms began using the bridge. This aspect of the evidence would appear to support the notion of a progressive 'learning curve'.

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* Class 2 (car and van) traffic, while increasing in absolute terms, declined from 83.6% of total traffic in 1981/2 to 81.3% in 1982/3 and 81.2% in 1983/4. Their revenue contribution fell from 59% in 1981/2 to 53.2% in 1982/3 and 52% in 1983/4. The remaining vehicle categories form an insignificant proportion of traffic.

(b) <u>Composition of HGV traffic</u>

Since HGVs are not a homogeneous group and three different toll charges are levied according to the number of vehicle axles, it is instructive to examine the composition of HGV flows over the Humber Bridge in more detail.

Class 4 (2-axled) HGVs increased steadily in importance from 35.7% in 1981/2 to 40.5% in 1983/4, while Class 5 (3-axled) HGVs declined from 13.5% to 11% of the total over the same period. Class 6 vehicles (4 and 5-axles) increased marginally from 50.7% in 1981/2 to 51.2% the following year, but then fell back to 48.5% in 1983/4 (Table 3). This last trend is somewhat surprising in view of the fact that 5-axle 38-tonne HGVs were legalised in April 1983 and they are proving relatively popular with operators. Five-axled vehicles comprised a higher proportion of vehicles in the October 1983 roadside survey we undertook on the Humber Bridge than in the May 1982 survey which predated 38 tonners (Simon 1984a).

Closer analysis of Table 3 shows, however, that the <u>absolute</u> number of HGVs in all classes grew substantially each year. The changing <u>proportional</u> composition of HGV traffic is attributable to the remarkable 23.8% rise in Class 4 vehicles in 1983/4 over the previous year, whereas Classes 5 and 6 grew by only 6.8% and 7.4% respectively. While the latter two could reasonably be attributed to the combined effects of natural traffic growth, the progressive shift to heavier vehicles known to be occurring nationally and perhaps some 'learning curve' behaviour, this is not true for Class 4. Unless there has been a hitherto unreported large scale shift from vehicles under 3 tons (Class 7) to Class 4 HGVs as part of the progressive increase in vehicle size, the trend could seemingly be explained only in terms of learning curve growth far in excess of expectations. This would take two possible forms:

(i) increased usage by firms initially making only limited crossings on an experimental basis, and

(ii) new traffic from previous non-users.

The growth of HGV traffic over the bridge in both absolute and proportional terms is contrary to national traffic growth indices (DTp 1984). This could perhaps be interpreted as evidence that local commerce and industry are deriving particular benefit from it, which in turn would lend validity to the original justifications for the bridge. This could perhaps also be used to justify HGVs bearing a disproportionately high share of the toll burden.

(c) Composition of HGV revenue

Because of the three-tier HGV toll structure, classes 4-6 do not contribute to bridge revenue in direct proportion to their respective traffics*. From Table 3 it is evident that Class 4 contributes approximately 10% less to HGV revenue than to HGV traffic; Class 5 only 0.5% less; while Class 6 adds 10% more to HGV revenue than to traffic. That said, toll revenues and traffics do naturally move in the same direction. In 1983/4 Class 4 contributed 30% of HGV revenue, Class 5 10.8% and Class 6 59.2%.

Given this differential between traffic share and revenue contribution, it appears likely that the responsiveness to changes in the toll level (i.e. toll elasticities of demand) may vary between HGV classes. Such a result would have great policy relevance. All other things being equal, there would undoubtedly be elasticity differences. In reality the equation is much more

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* The same point was made earlier with respect to HGVs as a whole versus other vehicle categories.

complex however, since operating costs also vary with vehicle size. Without data on the relevant variables it is thus impossible to be more precise, since economically rational operators will base their decision whether to use the bridge on the relationship between toll charges and overall vehicle operating costs. This is well illustrated in the cost comparison for different vehicle sizes on the alternative Hull-Grimsby routes provided by a respondent in our operator survey (Simon 1984b: 28). In addition, force of habit may result in drivers continuing to use the bridge after a toll increase, even if the alternative route is now cheaper (i.e. "behavioural inertia"). This is discussed in detail in Section 5.

(d) Use of Pre-paid Toll Tickets

The HBB sell books of 20 bridge tickets at a 5% discount (i.e. 20 for the price of 19) as an incentive to regular bridge users, and to reduce stopping time at the toll booths. From the Bridge Board's point of view they represent a secure form of revenue with advance payment*.

Our 1984 interview survey revealed that regular commercial bridge users avail themselves of these tickets for several reasons: direct cost savings, administrative convenience and obviation of the need for drivers to carry large amounts of cash (Simon 1984b: 35-36). Voucher sales may thus be regarded as a reasonable indicator of the level of regular bridge usage.

Table 3 shows, firstly, that substantial proportions of traffic in all HGV classes use tickets, and secondly, that ticket usage has increased noticeably over the period of analysis. To what extent the latter trend reflects higher levels of regular bridge

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* Eight large bridge users maintain accounts with the HBB. These are also subject to the discount and are thus included in the data here.

use, or simply greater awareness of the tickets' availability through HBB advertisements and by word of mouth, is impossible to discern. Class 4 voucher usage rose from 40.5% in 1981/2 to 42.8% in 1983/4, while the increases in Classes 5 and 6 were much greater, from 60.7% to 69.2% and from 59% to 67.2% respectively. It is noteworthy that two thirds of traffic in these classes were using vouchers by 1983/4, suggesting that their convenience is widely appreciated or that in the upper toll bands even a 5% saving is regarded as worthwhile. For all three classes over the period as a whole, 55.6% of HGV traffic paid by ticket rather than cash.

The contribution of tickets to revenue in each class was 1.2%-1.5% lower than the percentage of traffic using them by virtue of the discount. For HGVs as a whole, however, the voucher revenue contribution of 56.66% was 1% higher than the proportion of traffic using vouchers. This apparently perverse result merely reflects the different tolls applicable to the respective HGV classes, and could be corrected by using a weighted average.

Nevertheless, the implication of this finding is relevant to the toll debate: since voucher-using HGVs contribute more to Humber Bridge revenue than to total HGV traffic, the issuing of HGV vouchers is rational in terms of the Bridge Board's revenue maximization objective. This is quite distinct from the likely role of vouchers in attracting extra traffic by virtue of the discount. A greater discount might arguably generate more traffic.

4. COMPARATIVE ROUTE COSTS OVER THE HUMBER BRIDGE AND ROUND THE ESTUARY

The data in Table 4, which exclude bridge tolls and thus represent the toll-free situation, reveal that the greatest cost savings are achieved on the Hull to Grimsby and Immingham routes,

Table 4

Cost Matrix for Alternative Routes (£)

Routes	Estuary (A) Van	Estuary (A) 38t	Bridge (B) Van	Bridge (B) 38t	Difference (A-B) Van	Difference (A-B) 38t
From Hull to						
Scunthorpe	26.92	58.53	14.05	30.55	-12.87	-27.98
Immingham	36.66	79.72	13.23	28.76	-23.43	-50.96
Grimsby	40.35	87.74	16.82	36.57	-23.53	-51.17
Lincoln	43.53	94.66	24.81	53.96	-18.72	-40.70
Grantham	49.32	107.25	37.38	81.28	-11.94	-26.97
Boston	60.55	131.67	42.91	93.32	-17.64	-38.35
Peterborough	66.86	145.38	50.71	110.26	-16.15	-35.12
Kings Lynn	74.09	161.10	56.45	122.75	-17.64	-38.35
Norwich	96.34	209.49	78.70	171.14	-17.64	-38.35
From Scunthorpe to						
Beverley	25.02	54.41	16.36	35.57	-8.66	-18.84
Bridlington	35.17	76.48	30.35	66.00	-4.82	-10.48
Driffield	28.25	61.43	23.79	51.73	-4.46	-9.70
York	23.48	51.06	29.53	64.22	+6.05	+13.16
Middlesborough	52.76	114.72	54.96	119.52	+2.20	+4.80
From Grimsby to						
Beverley	38.76	84.29	18.76	40.81	-20.00	-43.38
Bridlington	48.91	106.36	32.76	71.24	-16.15	-35.12
Driffield	42.91	93.32	26.20	56.97	-16.71	-36.35
York	37.22	80.94	31.94	69.46	-5.28	-11.48
Middlesborough	66.24	144.05	57.37	124.76	-8.87	-19.29

Source: Calculated from distance data provided by the AA (Simon 1984: 9), and operating cost figures in Motor Transport June 21 and July 5, 1984.

Notes:

1) Total operating costs have been calculated for 25,000 miles p.a. in the case of vans, and 75,000 miles for 38-tonners, the highest mileages cited in the tables, thus yielding the lowest unit mile costs. These vehicle types have been used to give the maximum range in costs.
2) Motor Transport data are somewhat on the high side, since they incorporate substantial 'establishment costs', an item few firms include in practice.
3) Per mile cost for van = 51.27p; for 38t HGV = 111.49p.
4) Humber Bridge tolls are not included here.

followed by Beverley-Grimsby and Hull-Lincoln. The first two represent a saving of over £100 on a round trip in a 38 tonner and £47 in a panel van and the latter two over £80 and £37 respectively. More generally, then, savings accrue on routes within the region, especially if both origin and destination lie to the east of the bridge. Since Scunthorpe lies closest to the bridge of all the major local centres, savings to/from it over the bridge are relatively small. From Scunthorpe to York or Middlesborough it is actually costlier over the bridge than round the estuary. These two destinations therefore lie outside the bridge's catchment area in cost terms.

Incorporation of current tolls into the analysis does not affect the ranking of respective routes (origin-destination pairs), but does reduce the cost advantage of the bridge route over the estuary route for each O-D pair. The relevant tolls are £1 per crossing (i.e. £2 per round trip) for light vans and £7.50 per crossing (£15 per round trip) for 38t HGVs.

The greater the cost saving from use of the bridge, the proportionately less important the tolls. Thus on the Hull-Grimsby route, for example, one way savings are reduced only from £23.53 to £22.53 for vans, and from £51.17 to £43.67 for 38-tonners. At the opposite extreme, savings on the Scunthorpe-Driffield route are cut from £4.46 to £3.46 for vans and from £9.70 to £2.20 for 38-tonners, making the differences very marginal. Inclusion of tolls increases the cost disadvantage of the bridge route between Scunthorpe and York or Middlesborough from £6.05 to £7.05 and from £2.20 to £3.20 respectively for vans, and for 38-tonners from £13.16 to £20.66 and from £4.80 to £12.30 on the respective routes.

Although inclusion of tolls does not remove any centre in Table 4 from the bridge's catchment area, such cases will exist, and they form the effective boundary in cost terms. The actual hinterland may be somewhat larger, since firms in our operator survey regarded time as the crucial variable. If use of the bridge enabled additional productive work to be done in the same time, it would be used even if slightly costlier. Furthermore, service boundaries of local depots of national distributors (particularly in the petroleum products and brewing sectors) are determined by company HQ. These interdepot boundaries, usually based on equicost (i.e. equal delivery cost) lines, may not be responsive to cost changes such as that induced by the Humber Bridge (Simon 1984b).

Nevertheless, it is on these marginal routes that tolls may be hypothesized to have potentially their greatest impact for firms already using the bridge. In other words, if a firm finds it profitable to use the bridge now for a given O-D pair or set of pairs, it is likely that business at that/those destination(s) is at an optimal level for current operations unless some hitherto unperceived opportunity for reorganization exists.

Abolition of tolls would thus represent a windfall gain to these operators, but would be unlikely to generate much additional traffic by them on that/those route(s). Time is widely regarded as the critical variable by firms, and the tolls do not affect time at all (i.e. no extra journeys could be made per shift). The major exceptions here are:

(i) the haulage industry, an important component of our survey sample. Haulage rates are very competitive and would probably reflect toll abolition, thus potentially generating significant new cross-bridge haulage business.

(ii) transport of high bulk - low value (= low unit value) commodities e.g. sand, which cannot stand current toll levels (see Simon 1984b).

It is where reduction or abolition of tolls shifts the bridge's geographical catchment area outwards to include more centres, that additional bridge traffic is likelier to be generated among firms already using the bridge. Some will be diverted from circum-estuarial routes and a portion will be newly generated.

For firms not currently using the bridge, however, current tolls are likely to represent a significant deterrent. Strong opposition to tolls on principle, coupled with experience in our survey which indicated that many firms base their calculations on simple fuel or running costs rather than full operating costs, suggest that the bridge is either avoided in favour of alternative routes or that some business potential is not being exploited across the estuary.

Quantification of these effects requires calculation of the respective demand elasticities in order to derive a demand curve for bridge crossings. This will be attempted in the next section, although data base limitations pose some significant problems.

5. THE IMPACT OF TOLLS AND TOLL CHANGES ON TRAFFIC LEVELS

(a) General Considerations

As will have become clear from the preceding paragraphs, the impact of tolls on traffic is both complex and important. Five interrelated variables can be distinguished:

- toll levels
- traffic volumes
- toll revenues
- direct user benefits
- overall social benefits.

For present purposes we shall regard toll levels as the independent variable, since it forms the subject of your Committee's inquiry and since we wish to explore the effect of tolls on the other variables.

Introduction of a toll on a hitherto free facility, abolition of an existing toll, or a change in toll level is likely to induce behavioural adaptations by drivers/operators, involving changes to one or more of the following:

- route used
- frequency of the trip in question
- vehicle occupancy
- mode of transport used
- destination(s) to which the facility is used
- land use (a longer term indirect effect).

The way in which ~~in~~ individual - and by aggregation society as a whole - responds, is determined by a range of factors. The response is measured by the individual or social elasticity of demand, which is defined in this context as the percentage change in demand (trips) caused by a particular percentage change in trip costs. These changes may, of course, be either positive or negative.

The range of factors determining this responsiveness includes:

(i) the category of vehicle involved, as this affects both operating costs and toll level;

(ii) journey purpose, in particular whether it is revenue producing or not;

(iii) the toll change in both absolute and percentage terms;

(iv) distance - and hence cost - difference between the tolled and nearest alternative untolled route;

(v) the value of time e.g. between leisure and business or more specifically between directly and non-directly productive work travel (for HGV drivers, travel IS work);

(vi) perceptions of:
- operating costs : whether full operating cost or just running cost is taken into account;
- the relative aesthetic quality of tolled and alternative untolled routes;
- the uncertainties of experimenting with alternative routes.

It is thus to be expected that toll elasticities of demand will vary from crossing to crossing between groups of users and vehicle classes on any given crossing, and over time on a given crossing. These variations may well be substantial, depending on the balance of factors (i) to (vi) above. Any single toll policy measure will thus have differing effects on the respective estuarial crossings.

(b) Available Evidence

There has been surprisingly little empirical study of toll elasticities of demand. This is perhaps a reflection of the small number of tolled estuarial crossings and also several practical difficulties. In order to measure traffic responsiveness it is necessary to monitor a change in toll levels, something which has not yet occurred on several crossings including the Humber Bridge. The important findings of the few available studies on the subject are presented below.

(i) Itchen Bridge: Atkins (1981) has analyzed the impact of the December 1979 toll increase on Southampton's Itchen Bridge. This study is particularly pertinent because the bridge, like that over the Humber, does not form part of the national motorway system. In order both to cover inflation and control local traffic congestion (as required by the Southampton Corporation Act of 1973), toll charges rose by 33% for cars and vans at peak times and 50% at off-peak times, and by 20% for commercial vehicles. The overall observed toll elasticities were low:

0.21 at peak times
0.14 at off-peak times,

compared with earlier consultants' predictions of 0.88 and 1.51 respectively. Atkins suggests the results to reflect habit and inertia in travel behaviour. By implication the revenue maximising toll would also be higher than predicted. Unfortunately Atkins does not provide separate elasticities for private and heavy goods vehicles.

(ii) Bosporos Bridge: This bridge, opened in 1973, forms the main element of a scheme to link western Istanbul and Europe with eastern Istanbul and Asia. The tolls were originally set at a level comparable to pre-existing ferry charges to attract traffic and as a compromise between economic and financial criteria. The toll increase of September 1977, necessitated by high inflation, revealed an overall traffic elasticity of 0.25 (Jennings 1978). Although the context is different this figure is very similar to that obtained on the Itchen Bridge. Again no breakdown of the elasticity was given, perhaps because HGVs comprised only 8% of all goods vehicle traffic and less than 1% of total bridge traffic.

(iii) Humber Bridge: Because toll charges on this bridge have not changed since it opened in June 1981, no direct elasticity study has been possible. The available evidence to be presented is thus perforce indirect and consists of two types: consultants' initial predictions, and opinions expressed by current regular commercial bridge users.

(iiia) Consultants' predictions

The 1977 Humber Bridge Toll Study (HBTS) was commissioned to establish the optimal (i.e. revenue maximizing) toll for each vehicle class (HFA 1977). Using questionable assumptions and cost equations, a sensitivity analysis was performed on projected traffic flows to assess the effect of different tolls. Assumed elasticities of 1.0 for car users and 0.1 for work trips were used in their traffic generation model, but this has been severely criticized (HFA 1977: 30; DTp/MVA 1979: 9). As would be expected, graphs produced in the HBTS showed HGVs to be the least elastic category, followed by light goods vehicles, and then cars.

In view of the HBTS's shortcomings, the DTp commissioned another review from Martin Voorhees Associates (1979). Using updated data and revised assumptions, this study found lower traffic flows at higher tolls in each category than the HBTS. All vehicle types appeared to have relatively elastic demand curves over the relevant toll ranges. Thus their recommended optimal tolls were in fact slightly below the actual revenue maximizing level, raising 99.1% of true maximum revenue but encouraging 21% more traffic to use the bridge. From the data presented in this report, the following toll elasticities have been calculated for each vehicle category, between the optimal toll and the next highest and lowest toll level considered, respectively (Table 5):

Table 5

Imputed Humber Bridge Toll Elasticities

Vehicle Category	Elasticity: Between optimal and next lowest	Elasticity: Between optimal and next highest
Cars	.67	.90
LGVs	.87	1.00
HGVs	.85	1.08

Source: Calculated from DTp/MVA 1979.

These figures clearly indicate that imposition of a higher toll would increase car revenue marginally, have no effect on LGVs, and actually reduce HGV revenue.

(iiib) Survey of regular commercial bridge users

As part of our research into the impact of the Humber Bridge, a sample interview survey of 52 regular bridge-using firms was conducted during 1984. One aspect of the interviews dealt with toll issues.

Fully 72% of respondents felt current toll levels to be excessive. Almost half of these complained at both the monetary cost and the underlying principle, while the remainder objected to one or the other. Only 28% of interviewees had no such complaints, saying that the toll charges were far outweighed by the time and vehicle operating cost savings derived from use of the bridge.

The tolls have remained constant since the bridge opened in June 1981, with the result that in real terms their value has fallen considerably. Since the HBB set toll levels somewhat lower than the ceiling currently permitted by the relevant legislation, an increase to compensate for inflation is possible at fairly short notice. No interviewee responses indicated an appreciation of this fact, however.

Firms were asked what the effect of a change in toll levels would be on their operations for at least two reasons:

(i) to obtain some information on the putative demand curve of individual user firms (from which some aggregation might be possible) for use of the bridge;

(ii) to investigate whether such demand elasticity is sector-specific or dependent on current levels of transestuarine activity.

It should be noted that the response categories in Table 6, discussed below, are not all mutually exclusive, but merely reflect interviewees' reactions to the open ended question. Notwithstanding the aforementioned sentiments on current toll levels, 62% of respondents said that their firms would be unaffected by any change in this level. They already use the bridge for all potential destinations or business under present operating constraints and economic circumstances, and derive significant savings in comparison to driving around the estuary. Their demand curves can therefore be regarded as perfectly inelastic, at least over a reasonable range. Most importantly, this range includes complete abolition of the toll. This section of the sample represents a true captive market to the bridge. Equally significant from a policy point of view, this group could not be distinguished on any of the relevant variables of location relative to the bridge, economic sector, level of bridge usage/transestuarine business, or geographical scale of operation. The complete range is represented in each case*.

27% of firms said that their use of the bridge would increase if tolls were reduced or abolished. This would represent either generation of additional business on existing routes by virtue of improved competitiveness with firms on the far bank of the estuary, or a switch to serving additional centres via the bridge instead of via present routes. The latter applies more to south bank firms, and would mean inclusion of Driffield, Bridlington and in some cases York as bridge-served centres. The likely increase in business would invariably be under 25%.

One important exception is a Hull distributor of sand, roadstone and related aggregates. Because of the products' high bulk and low unit value, the market range is effectively limited to a 20-mile radius from their depot. With present tolls, the only south bank penetration that has been possible is sale of a specialized aggregate in Scunthorpe, since this alone could stand the tolls. If tolls were halved, south bank business would increase by 500%, and if abolished, by 1000%, because competition with Lincoln-based rivals would be possible anywhere within a 20mile radius of Hull. This was the only firm in the sample so dependent on low value to bulk products, but is nevertheless important in pointing to one commodity area for which the level of tolls is very much more significant and elasticity of demand commensurately higher, than emerges from the rest of the analysis. Perhaps further investigation is warranted.

No firms said exclusively that a rise in tolls would cause them

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* It is possible, though, that these firms had not fully considered potential reorganizational opportunities if tolls were abolished. Their response would thus have reflected a lack of perceived expansion possibilities given their current pattern of work.

to cut their present level of bridge use, athough 6% of respondents indicated that they were sensitive either to an increase or a decrease. Their demand elasticity therefore appears relatively high. Another 4% indicated that any significant toll rise would force them to reorganize operations by establishing depots or subdepots across the estuary while 2% would close such a depot if tolls were abolished. These firms were all local operations, distributing parcels, milk and dairy produce, and petroleum products respectively, with no other depot/branch to which to reallocate services for the affected area.

Table 6

Firms' Responses to Toll Levels and Potential Toll Level Changes

Present tolls: Response	No	%	Effect of change in toll: Response	No	%
Reasonable in view of the savings made	11	21	None	32	62
Beneficial and principle fair	2	4	Fall would increase our usage*	14	27
Beneficial w.r.t. savings, but principle wrong	2	4	Rise would cut usage	0	0
Too high	17	33	Fall: increase usage: Rise: cut usage	3	6
Too high but the principle is fair	2	4	Other	3	6
Too high and the principle is wrong	18	35			
Total	52	101		52	101

NB * This could refer to market penetration or the range of places served.

Taken as a whole, the elasticities of these firms are certain to be far lower for a toll decrease than those of firms NOT currently using the bridge because they deem the tolls too high. Halving or abolishing the tolls would certainly enhance traffic flows over the bridge, both by diversion from circumestuarial routes and by generation of new traffic. The likely magnitude of such effects is difficult to gauge without large data collection exercises.

(c) Conclusion

The empirical evidence cited above is both too limited and too diverse to permit firm conclusions to be drawn. Observed toll elasticities on the Itchen and Bosporos bridges are comparable, and much lower than consultants' predictions for the Itchen Bridge. These in turn, are similar to those envisaged on the Humber Bridge. Given the large distance and operating cost savings made by Humber Bridge users, reduction or abolition of the very high tolls would undoubtedly generate significantly greater use of this facility, thus enhancing the overall social benefits.

6. THE ECONOMICS OF TOLLED ESTUARIAL CROSSINGS

In this final section we return to the macro-scale, examining briefly the overall economic position of Britain's eleven tolled estuarial crossings.

Recent data compiled by the Freight Transport Association (1982) show convincingly that no toll authority with an outstanding debt is currently in a position to meet its statutory requirement of repaying the capital costs of construction from toll revenue. Although all crossings yield a net current operating surplus (Table 7), this is insufficient in all but two cases to cover interest charges on the initial capital, let alone repay the principal loan. Overall therefore, the tolled crossings had a final deficit of £37.5m in the most recent year for which data are to hand. As in previous years, this deficit was perforce capitalized, thus adding to the outstanding accumulated loan debt which rose accordingly to £438m.

Table 7

Recent Accounts of Tolled Estuarial Crossings

Crossing	Income	Operating Costs	Operating surplus/ deficit	debt/ capital charges	final surplus/ deficit	current total debt
1980/1	£m	£m	£m	£m	£m	£m
Erskine Bridge	0.68	0.51	+0.17	4.58	-4.41	29.13
Severn Bridge	2.76	2.65	+0.11	2.62	-2.51	43.11
Itchen Bridge	1.03	0.23	+0.80	1.69	-0.89	11.18
Mersey Tunnel	6.47	3.81	+2.66	8.72	-6.06	72.00
Sub-total	10.94	7.20	+3.74	17.61	-13.87	155.42
1981/2						
Tay Bridge	1.08	0.53	+0.55	0.48	+0.07	6.31
Tamar Bridge	1.06	0.41	+0.65	-	+0.65	-
Forth Bridge	1.93	1.37	+0.56	3.25	-2.69	19.29
Humber Bridge	4.20	1.00	+3.20	20.00	-16.80	166.00
Cleddau Bridge	0.59	0.23	+0.36	0.66	-0.30	7.67
Dartford Tunnel	5.70	1.97	+3.73	7.37	-3.64	62.70
Tyne Tunnel	2.55	1.44	+1.11	2.03	-0.92	20.26
Total	28.05	14.15	+13.90	51.40	-37.50	437.65

Source: FTA (1982): Tolls: a case for abolition.

It is important to point out, however, that the incurring of an operating deficit - which is then capitalized - in any particular year does not necessarily constitute evidence that the debt cannot eventually be repaid. For example, the 13-year grace period (possibly extendable to 18 years) before debt repayment on the Humber Bridge need commence, was permitted precisely because initial revenues were not expected to cover operating costs until traffic had built up and was growing at the national rate. In fact, the 1979 DTp/MVA review calculated that the debt would rise at a declining rate to a maximum of over £295m in 1999 before declining at an accelerating rate until eliminated in 2009. This assumed long run inflation of 8% p.a. and triannual toll increases to preserve their real value. The crucial long run determinant of ability to repay the debt within the 60-year limit is that the rate of traffic growth exceeds the rate of debt accumulation.

With the exception of the Erskine Bridge (1971), Cleddau Bridge (1975) and Humber Bridge (1981), most tolled estuarial crossings opened in the early or mid sixties, and should by now therefore be showing operating surpluses large enough to reduce their accumulated debt. Table 7 suggests that this is not, in fact, occurring in most cases, while the Humber Bridge's debt has risen at an increasing rate even since it opened.

Thus it does appear evident that the finances of tolled estuarial crossings are in an unsatisfactory state, with little prospect of revenues being able to reduce or eliminate the vast accumulated debt. Tolls have generally been raised periodically in line with inflation; any substantial real increase in their level would further inhibit traffic volumes at uncongested crossings.

Abolition of tolls under such circumstances would be attractive in economic, financial and equity, as well as purely political, terms. The actual cost of such a move would be only the annual toll revenue less its collection costs, i.e. £28m-£6m = £22m in terms of the figures cited by the Freight Transport Association (FTA 1982). By extension, since most of the initial capital was provided in the form of government loans through the DTp, this element could be written off. Then only repayment of the small commercial loan component would be necessary.

Such a move would relieve the public of the toll burden and bring estuarial crossings into line with the rest of the road network as regards funding and maintenance. In this context it is worth noting that some of the crossings, particularly suspension bridges (e.g. Forth, Humber, Severn) require more frequent and specialized maintenance than ordinary structures or roads. This explains in part why their operating costs are so high relative to revenue (Table 7).

The second policy alternative raised in Section 1 above was the extension of tolls to other parts of the highway network. However, the foregoing analysis must cast serious doubt on the practicality (cost-effectiveness) of doing this, especially since toll collection costs are likely to be still higher than on estuarial crossings because of the numerous access and exit points. Given the current anomalous situation, abolition of existing tolls thus appears the optimal course of action.

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