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Are Ghana's Roads Paying Their Way?

Assessing Road Use Cost and User Charges in Ghana

Reuben Gronau

The study of road use costs in Ghana showed, first, that such studies are in fact feasible in LDCs, notwithstanding gaps in the data, and second, that they can reveal important inefficiencies in the tax system.

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This paper — a product of the Transport Division, Infrastructure and Urban Development Department — is part of a larger effort in PRE to study and demonstrate methods for designing transport user charges and efficient transport prices. This research was funded by the World Bank's Research Support Budget, RPO 674-37, "Transport Taxation and Road User Charges in Sub-Saharan Africa." Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Jennifer Francis, room S10-063, extension 35205 (44 pages). September 1991.

Gronau studied how much road damage contributes to road use costs in Ghana and how the marginal social costs should be recovered. This required understanding the road deterioration process better and analyzing the implications for vehicle operating costs and road user charges.

The most important thing Gronau learned is that studies of road-user costs are feasible in reputedly data-poor countries. In Ghana, the problem was not so much missing data as conflicting sources of data. Many of these data sources did not exist a few years ago and have been established as part of the transport rehabilitation program. The data sources need consolidating, but the experience in Ghana proves the feasibility of information gathering and its importance as part of any major transport program. An important component missing in Ghana is data on the axle-loading of heavy vehicles — as different types of axle-load inflict significantly different degrees of damage.

Gronau found that to bridge the gap between road-user costs (including the cost of road maintenance) and charges, the annual fee for heavy trucks should be raised tenfold — to about $800 per vehicle. Fuel taxes alone are not adequate to distinguish fully the large difference in road damage costs incurred by heavy trucks and private cars. The taxing instrument most deficient in Ghana is the annual licensing fee. Not only should licensing fees for heavy trucks be ten times higher than they are now, but exemptions from the licensing fee should be canceled and registration rules strictly enforced.

Even then, charges on heavy vehicles will not cover costs unless current legal limits of axle loading are obeyed. A more efficient means of reducing the damaging effects of heavy vehicles lies in structuring the annual fees to reflect how much more damaging two-axle heavy vehicles are than multiaxle vehicles.

If raising the licensing fee for heavy trucks is not feasible, certainly the government should cancel heavy trucks' exemption from import duties. An import tax of 15 percent and a 10 percent purchase tax (the standard rate on consumption imports) will go a long way toward recovering the marginal cost of road use — and will be much harder to evade than the license fee.

Gronau found the issue of redistribution of costs and fees of secondary importance in Ghana, because of the country's low fuel consumption, the current low level of fuel taxes, and the fact that expenditures on fuels are proportionately the same for the poor and the nonpoor.

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* This research was funded by the World Bank's Research Support Budget, RPO 674-37, "Transport Taxation and Road User Charges in Sub-Saharan Africa."

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I. INTRODUCTION

Low population densities and low income per capita put Sub-Sahara Africa (SSA) at a natural disadvantage where investment in transport infrastructure is concerned. Since demand for transport increases with area and with population dispersion, the burden of the investment in and maintenance of the transport network on the economy's resources is inversely related to output per unit of area (GDP per square km, i.e., the product of GDP per capita and population per square km). SSA is in a unique position: low levels of income per capita increase this burden compared with the better-off Latin American countries (e.g., Brazil and Argentina) although the latter are more sparsely populated, and low population densities result in a higher burden compared with densely populated countries in Asia (e.g., India and China) although they are poorer (Table 1).

Table 1. Population Density, GDP per Capita and GDP per Square km

	Population / km^2	GDP per capita 1987 (US$)	GDP / km^2
Sub-Sahara	20.3	340	6,902
Sub-Sahara, excluding Nigeria	16.2	330	5,346
Brazil	16.6	1,960	32,536
Argentina	11.2	2,400	26,880
India	242.6	310	75,206
China	111.7	300	34,627
Japan	322.8	15,800	5,100,240
France	101.7	12,910	1,312,947
Germany, Fed. Rep.	245.8	14,440	3,549,352
U. K.	232.7	10,540	2,452,658
U. S. A.	25.9	18,580	481,222

Sources: Sub-Saharan Africa - From Crisis to Sustainable Growth, Long-term Perspective Study, 1989.
The World Bank Atlas, 1989.
World Tables, 1991.
World Development Report, 1989.

As a result, SSA has fewer roads per km² than Asia or Latin America, and a larger percentage of these roads is unpaved. Still, it has the highest ratio of roads per dollar of output (Table 2). Crude estimates of the stock of capital embodied in roads, based on a sample of 85 developing countries, indicate that this capital-output ratio (stock per dollar GDP) is substantially higher in Africa than in the other two regions (World Bank, 1988). If one excludes Nigeria, the maintenance of this stock imposes a burden which is twice as high in the Sub-Sahara as in the other two regions. The difference between the regions in the burden imposed by the maintenance of unpaved roads is even higher (by a factor of 5).

Table 2. Basic Characteristics of Regional Road Networks

	Sub-Sahara	Sub-Sahara excluding Nigeria	East Asia & Pacific	South Asia	Latin America
Number of countries	39	38	7	6	19
Area (mil km²)	20.0	19.1	13.2	5.1	18.9
GNP (1983) (bill. US$)	155.9	85.5	600.4	257.5	583.9
Estimated total road network ('000 km)	1,019	911	1,540	1,680	2,212
Main road network ('000 km)	335	306	451	217	512
Density per 100 km²	1.7	1.6	3.4	4.2	2.7
Density per mil $	2.1	3.6	0.8	0.8	0.9
Main paved roads ('000 km)	101	79	277	174	252
Density per 100 km²	0.5	0.4	2.1	3.4	1.3
Density per mil $	0.6	0.9	0.5	0.7	0.4
Replacement value of main network (bill. US$):					
Paved	25.2	19.9	83.1	31.4	65.5
Unpaved	9.3	9.0	7.0	1.7	10.4
Total	*34.5*	*28.9*	*90.1*	*33.1*	*75.9*
Replacement value / GNP:					
Paved	0.16	0.23	0.14	0.12	0.11
Unpaved	0.06	0.11	0.01	0.01	0.02
Total	*0.22*	*0.34*	*0.15*	*0.12*	*0.13*

Source: World Bank (1988), Table A-1.

Road deterioration has been shown (World Bank, 1988) to be a major (currently, perhaps, the most acute) problem of the transport sector in developing countries. Sub-Sahara's situation in this respect is about the same as that of the rest of the developing world. On average one quarter of its paved road system is in poor condition and needs major rehabilitation. But the situation in some countries (Ghana, Guinea, Zaire) is even worse: almost two thirds of the system are up for rehabilitation (or abandonment). More important, almost 30 percent of the system (Nigeria excluded) is in only fair condition. This part of the system will soon reach the critical stage where resurfacing is required as periodic maintenance to prevent the system from deteriorating to the point of disrepair and expensive reconstruction.

Excluding Nigeria, routine and periodic maintenance call for the diversion of about half a percent of domestic resources to prevent the situation from deteriorating. Clearing up the backlog, according to the Bank's estimates, would require close to 5 percent of the GDP. Even if clearing this backlog is spread over 5-10 years, 16 countries (out of the 28 investigated) will have to marshal over 1.25 percent of their resources to get their system back on track. Eleven of the 28 countries will face severe financing problems — even if they increase their road budgets by 50 percent and restrict new construction to one fifth of the new budget, they will not be able to solve their road maintenance problem within the next 10 years. The best way to marshal the additional resources is therefore a problem of utmost urgency in the Sub-Saharan countries. The economic situation facing many of them, however, is not propitious for this effort. Twenty-three of the countries experienced a decline in real income per capita between 1980 and 1985: in 11, real income declined in absolute terms. It is thus more important than ever to economize in the consumption of infrastructure without interfering with the structural change and the growth of the economies. The power of the price mechanism can be harnessed to this purpose, through an appropriately structured system of road user charges.

The recovery of maintenance and capital costs of the inter-urban road system is only one problem that road user charges are supposed to solve. Urban congestion is another. In 1960 only one tenth of the population of SSA lived in urban centers; by 1982 this share doubled. The average growth rate of the urban population in the 1960s was 5.5 percent, and it accelerated to 6.1 percent in the 1970s. Whereas in 1960 only 4 percent of the urban population lived in cities of half a million or more, this share grew to 40 percent in 1980. The number of large cities grew from 3 to 28.

The Bank policy study on urban transport (World Bank, 1986, Table A-1) sheds additional light on the urban congestion problem in the SSA. Motorization, though still low, is increasing rapidly. The share of traffic using private cars in Nairobi is about the same as in most Western capitals. The speed at which traffic moves in Lagos is only half that of London or Frankfurt. The recent slowdown in income growth has tended to slow down this process, but the rapid expansion of urban population (it is expected to quadruple in the next two decades) cannot but worsen the problems of urban mobility and congestion in Sub-Saharan Africa over the next decade. Road user charges can serve as a major policy tool in addressing this problem.

The major role of road user charges is assigning the right signals to users and operators of the system. One of the salient features of the motor transport production process is the split ownership of the factors entering this process: the government (or some other public authority) builds and maintains the road system, private or public operators own the equipment (i.e., the motor vehicles), and the passengers (or shippers) provide their time. Each of these parties acts according to the prices (i.e., the signals) they face. The passengers base their decisions on the pecuniary cost of travel and their evaluation of their value of time; the firms and households operating the vehicles base their decisions on their costs (and revenues), ignoring the effect their decisions may have on the cost of others; the road authority makes its decisions on the basis of current (and future) traffic volume, regardless of whether this volume is socially optimum or not (often ignoring the travelers' value of time). A prerequisite for an efficient resource allocation is that all parties face the same prices which equal marginal social costs.

The two most prominent cases where private marginal costs diverge from the social marginal cost in the road sector (Figure 1) relate to congestion and road damage (other cases such as air pollution, noise, road accidents, etc. are not discussed in this paper). The case of congestion has been discussed at length in the literature (Walters, 1961; Mohring, 1976; and others). The traveler entering a congested route bases his decision on the cost he faces (including his costs of time) but ignores the cost he imposes on other travelers. Formally, let the marginal private costs of travel (π) equal

$$\pi = P + VT(X)$$

where P denotes pecuniary costs, T - travel time, V - the value of time and X - traffic volume. For simplicity it is assumed that only travel time is sensitive to traffic volume (the effect of congestion on operating expenses is dismissed as of secondary importance). The total cost of travel equals πX, and the marginal social costs:

$$MSC = \partial(\pi X)/\partial X = \pi + XV(\partial T/\partial X) .$$

The second term, $XV(\partial T/\partial X)$, is the externality imposed on all other travelers; it equals the change in travel time *times* the number of travelers. To attain the optimum traffic level the road authority has to impose a charge which equals this externality, $A = XV(\partial T/\partial X)$.

A second externality, which may be more important in less-developed countries, is the road damage externality (RDE). It has two aspects: the damage caused to the road and the effect the damaged road has on the operating costs (and travel time) of the other vehicles using the road. Engineering data can be used to evaluate the first component of this externality. But it is much more difficult to evaluate, both conceptually and technically, the second component.

The impact of road deterioration on the operating costs of the vehicles using it depends on the maintenance strategy. The deterioration of the road and the increased pavement roughness are associated with cyclical changes in the vehicle operating costs (Figure 2). The costs increase as the road deteriorates and decline sharply when the road is repaved and restored to its original condition. Additional vehicles change the shape of this cycle. When the road authority adopts a maintenance strategy that is condition-responsive, i.e., the road is resurfaced when the road roughness reaches a critical value, R, an additional vehicle moves the whole cycle forwards. The road is going to be resurfaced at time $T - \Delta T$ instead of at time T. Consequently, if an additional vehicle enters the system at time t, all vehicles using the road between t and $T - \Delta T$ are going to encounter increased costs. However, those using the system between $T - \Delta T$ and T are going to face substantially lower costs. The answer to the question whether over the life cycle, operating costs are going to increase or decline depends on the timing of entry, t. The closer t is to the date of the rehabilitation, T, the smaller the increase in operating costs (which may even decline). It was Newbery's (1988) major contribution to show that if the age distribution of the roads (the time elapsed since the last rehabilitation) is uniform (i.e., the distribution of t over the cycle has a uniform distribution), if traffic is the sole source of road deterioration, and if traffic volumes do not grow over time, then on average an additional vehicle imposes no externality on the other vehicles (the positive and negative effects offset each other). Newbery also suggested a formula how to correct this conclusion when weather contributes to the road damage, or when traffic is growing over time.

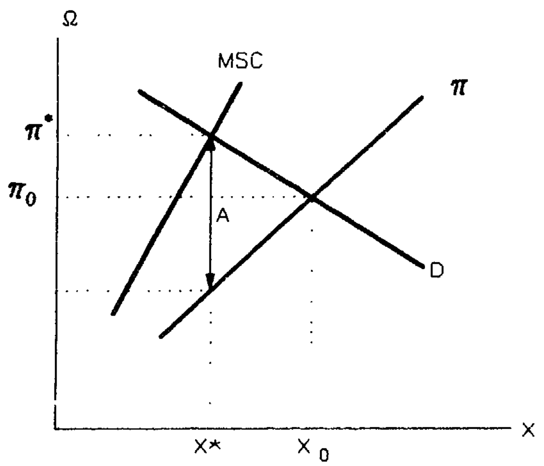

Figure 1: Private and social cost of traffic congestion

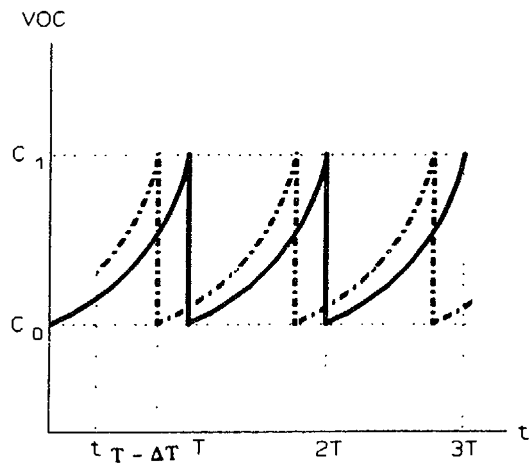

Figure 2: Vehicle Operating Cost as Function of Road Deterioration

When the timing of overlay is determined arbitrarily (e.g., by budgetary considerations), and is insensitive to the state of the road, the externality an additional vehicle imposes on the system is composed of the additional costs of overlay, and the increased operating costs of vehicles using the system between time t and the time of the overlay, T. In this case one cannot escape from estimating the effect of road conditions on vehicle operating costs.

Regardless of the maintenance policy, users should be charged for the externality they impose on the system. It should be emphasized that from the efficiency perspective there is no difference between the user charge for road damage and for congestion. Whereas the first charge is intended to confront heavy vehicle owners with the right prices when they decide on the type of equipment (e.g., axle configuration), size of shipment (overloading), etc., the second charge should lead to better decisions on whether to travel, and on the choice of travel mode.

A second issue is the question how the road authority should finance the investment and upkeep of the road system. It is only natural to question whether an optimum road-user charge system suffices to cover the annual capital and maintenance costs. This question can be shown to be equivalent to the question whether a pricing system based on short-run marginal (social) costs is sufficient to cover average (social) costs. The answer depends on the returns to scale of this 'multiproduct production process'.

Given the increasing returns to scale associated with road strengthening, the road user charge associated with road damage will cover only a small fraction of the capital costs of an optimally designed road; if the weather plays an important role in road deterioration, one cannot expect the user charge to cover the total maintenance costs. On the other hand, if one adds the revenues from the congestion charge, the revenue may more than cover capital and maintenance costs. The answer depends on the relative importance of the various components of the road user charge.

Even if road user charges do not cover the capital and maintenance costs, it may be decided for motives of 'fairness' or income distribution to finance these costs through transport taxes. The criteria for such taxes, however, should be similar to other taxes.

Road-user charges are an instrument for a more efficient resource allocation in the road sector and for raising funds for the capital and maintenance costs of the road system. These charges (or their proxies) should be imposed irrespective of the tax policy. Can this instrument be used to solve some of the transport problems of SSA? A prerequisite for implementing this tool is information on the proper level of these charges. This raises a series of questions. What are the essential pieces of information needed for the evaluation of road-user charges? Are the necessary data available in SSA? If certain pieces of information are missing, can they be replaced by information gathered in other countries in the region? To what extent is information collected outside the region relevant to the SSA experience? How sensitive are the results to changes in assumptions? Can one generalize from the experience of a few SSA countries to the region as a whole?

The approach used in our research is a case-study approach: we focus on two countries, Ghana and Zimbabwe. The two cases differ in terms of their development status, state of the roads, competitive modes of travel, taxation policy, and enforcement. Hopefully, these differences will also shed light on the experience of other countries.

The model for this study is Newbery's work on road-user charges in Tunisia (1988). Our study tries to adapt Newbery's study to the sub-Sahara scene. It aims at simplicity, providing the decision maker with easy-to-use tools. Simplification is often dictated by the nature of the data. The crudeness and unreliability of some of the existing data makes oversophistication inappropriate.

The first case study is discussed in this paper and deals with Ghana.

Ghana is a typical example of the malaise that plagues SSA, and its transport sector is a microcosm of the country's economy as a whole. The extensive road system built before and during the first years of Ghana's independence shared the fate of the rest of the economy, and fell into serious disrepair in the 1970s and 1980s. By the mid-1980s it was found (Kocks Consults, 1986, pp. 3-6) that only 15 percent of the roads could be deemed in good condition, only 40 percent are in fair condition, and over 45 percent are in poor condition — some of them are barely motorable. The condition of feeder roads is even worse: some have 'disappeared' altogether.

Ghana has embarked on an ambitious 7-year program of road rehabilitation: to clear the backlog of maintenance and establish a maintenance system that will stabilize road conditions thereafter. At this point it is only natural to ask whether the resources marshaled by government in the form of transport taxes or road user charges will prevent the reoccurrence of this scenario.

The questions have been asked before. David Walker conducted a survey of transport taxation in Ghana (TecnEcon, 1988b) with emphasis on the administrative costs of raising these funds. A more comprehensive study was conducted by Kocks Consultants as part of the Fourth Highway Project (1986). The study tried to estimate the size of the road fund required to finance current and periodic maintenance once the maintenance backlog was cleared, and the most effective way of raising these funds. In the absence of data, Kocks did not try to estimate road user costs; instead, they focused on road maintenance costs, traffic forecasts (and forecasts of the vehicle stock and fuel consumption) to derive the tax rates that would generate the target revenue.

This study tries to pick up the trail where earlier studies left off. It tries to estimate road user costs, including not only the road damage component but also the cost of congestion (urban and inter-urban). Given these estimates, it evaluates the adequacy of the current transport tax system.

The study opens with background discussion of the Ghanaian road sector, followed by the estimation of road user costs. The next section examines the adequacy of the current tax system, and the paper closes with concluding remarks.

II. BACKGROUND

The Ghana road system consists of 31,700 kms, of which 14,400 kms are trunk roads and 1,800 kms are town roads. Over the years the system suffered from inadequate maintenance, resulting in a deterioration to the point at which, at the time of writing, 36 percent of the trunk roads are defined by the Ghana Highway Authority (GHA) as being in poor condition and 42 percent are regarded as fair; only 40 percent of the rural network are regarded as motorable. (According to GHA, two thirds of the feeder roads are in poor condition; see Table 3.)

Table 3. Distribution of Roads by Region and Condition, 1989

	Trunk roads				Feeder roads			
	Total length (km)	Condition (%)			Total length (km)	Condition (%)		
		Good	Fair	Poor		Good	Fair	Poor
Greater Accra	468	37	45	18	817	1	43	56
Volta	1,511	38	20	42	1,855	11	26	63
Eastern	1,890	23	35	42	2,337	19	36	45
Central	1,409	7	67	26	1,634	12	21	67
Western	1,502	12	48	40	1,076	21	5	74
Ashanti	1,395	24	17	59	3,284	14	5	81
Brong Ahafo	1,839	31	48	21	1,790	16	26	58
Northern	2,790	25	45	30	1,991	15	16	69
Upper East	535	--	94	6	1,071	8	14	78
Upper West	1,091	7	27	66	1,404	9	11	80
Total	**14,430**	**22**	**42**	**37**	**17,262**	**13**	**20**	**67**

Source: Bhandari (1990).

The exact number of motor vehicles using this road system is unknown. In the second half of 1987 the Vehicle Examining and Licensing Department issued roadworthiness certificates to 76,000 vehicles (the number for the first half of 1987 was 68,500, and incomplete data for the first half of 1988 show 67,100 applications for certification). Government vehicles are exempt from the roadworthiness test, and the rules of certification are rarely enforced. The prevailing feeling is, therefore, that the number of certificates issued is nowhere near the real size of the vehicle fleet. Crude estimates prepared by TecnEcon for 1986 (1987, Appendix A-3) claim that only 80 percent of the non-government fleet obtain certificates, and that the government fleet includes over 18,000 vehicles (of which 7,000 are private cars, 5,000 are trucks, and 3,000 are buses). By this estimate, the total number of vehicles operating in 1987-88 stands at around 110,000. As Table 4b indicates, the vehicle fleet is expanding rapidly: 11,600 vehicles registered in 1985, 12,200 in 1986, and 14,800 in 1987. Customs data indicate that 9,400 cars were imported in 1987 and 12,100 in the first 9 months of 1988.

Table 4a. The Licensed Vehicle Fleet by Type and Size, 1987

Type		Number
Cycles		4,244
Cars		39,952
Taxis		8,396
Buses	0-33 seater	12,794
	34+ seater	2,790
Rigid trucks		
GVW	0-7 t	2,707
	8-16 t	2,915
	17-20 t	359
	22+ t	247
Road tractors		
GVW	0-24 t	652
	25+ t	625
	3-axle	261
Total		**75,942**

Source: Vehicle examination and Licensing Department, July - December 1987.

Table 4b. New Registration of Motor Vehicles, 1978 to 1987

	Cars	Motor-cycles	Public convey-ance	Goods vehicles	Trailers and cara-vans	Special pur-pose vehicles	Public ser-vice vehicles	Tractors and mecha-nized equipment	Total
1978	8,052	3,011	1,451	3,328	14	783	55	1,024	17,718
1979	8,513	3,528	1,154	2,313	5	366	53	563	16,495
1980	7,283	3,335	1,166	2,079	1	201	81	422	14,568
1981	11,128	1,852	1,764	2,361	69	219	27	827	18,247
1982	5,993	1,616	1,046	1,893	3	237	15	645	11,448
1983	2,908	1,965	1,952	1,864	4	159	26	386	9,264
1984	3,121	2,270	369	1,991	10	83	3	377	8,224
1985	5,192	2,155	852	2,734	40	300	7	319	11,599
1986	4,199	2,793	4,270		7	488	30	385	12,172
1987	6,414	2,589	4,875		16	517	25	413	14,849
Total 1978–87	62,803	25,114	37,462		169	3,353	323	5,361	134,584
Total 1980–87	46,238	18,575	29,216		150	2,204	214	2,774	100,371

Source: Quarterly Digest of Statistics (1978–85) and Statistical Service Accra (1986–7).

The vehicle fleet is very unevenly distributed throughout Ghana. Over half the vehicles obtain certification in Accra; another 7 percent in Tema, and one sixth in Kumasi. Less than one quarter of all vehicles are scattered over the rest of the country. The uneven geographical distribution of vehicle ownership is accompanied by a skewed distribution of road utilization. The Ghana Highway Authority is in charge of preparing the traffic report. The reliability of their data in the past was questionable, and independent counts on certain sections indicate that the GHA figures are understated by 25–30 percent. Steps have recently been taken to ensure greater scrutiny and reliability.

Traffic on interurban roads is quite sparse. The 1988 traffic counts (Table 5) indicate that only 14 percent of trunk roads carried over 750 vehicles per day, contributing 60 percent of veh-km (the most traveled 2 percent, with average daily traffic (ADT) in excess of 3,000 vehicles, contributed 15 percent of traffic). On the other hand, the two-thirds least traveled roads (with an ADT of less than 300 vehicles) accounted for less than one fifth of traffic. Most of the heavily traveled roads are surfaced, but only half of them are in good condition. There is a positive association between traffic and the paving of the road and its condition (ADT for paved roads is 720 vs. 150 for unpaved ones; the ADT for good and poor roads are 680 and 290, respectively), but a quarter of the traffic uses unpaved and poor roads.

Table 5. Distribution of Trunk Roads by Traffic Volume and Condition of Road, 1988

Average daily traffic (AADT)	Total		Condition of road: Good		Condition of road: Fair		Condition of road: Poor		Road paving: Paved		Road paving: Not paved	
	Length (km)	Volume ('000 veh-km/yr)	Length (km)	Volume ('000 veh-km/yr)	Length (km)	Volume ('000 veh-km/yr)	Length (km)	Volume ('000 veh-km/yr)	Length (km)	Volume ('000 veh-km/yr)	Length (km)	Volume ('000 veh-km/yr)
A.												
Unknown	915	0	52	0	610	0	253	0	539	0	376	0
Under 300	8,919	998	1,618	210	3,676	421	3,625	367	1,979	347	6,940	651
301-750	2,665	1,267	584	285	998	475	1,084	507	1,722	844	943	423
751-1500	965	1,052	359	382	443	490	163	180	829	907	135	145
1501-3000	725	1,449	412	848	195	383	118	218	692	1,395	32	55
3001-6000	241	813	112	378	76	251	54	184	241	813	0	0
Total	**14,430**	**5,580**	**3,136**	**2,103**	**5,999**	**2,020**	**5,296**	**1,475**	**6,004**	**4,306**	**8,426**	**1,274**
B. Percent												
Under 300	66.0	17.9	52.5	10.0	68.2	20.8	71.9	26.1	36.2	8.1	86.2	51.1
301-750	19.7	22.7	18.9	13.6	18.5	23.5	21.5	34.4	31.5	19.6	11.7	33.2
751-1500	7.1	18.9	11.6	18.2	8.2	24.3	3.2	12.2	15.2	21.1	1.7	11.4
1501-3000	5.4	26.0	13.3	40.3	3.6	19.0	2.3	14.8	12.7	32.4	0.4	4.3
3001-6000	1.8	14.6	3.6	18.0	1.4	12.4	1.1	12.5	4.4	18.9	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

The skewed distribution of traffic coincides with an uneven geographical distribution (Table 6): whereas the ADT on roads in the Greater Accra region is close to 2,000 vehicles, in the Eastern, Central and Ashanti regions it is 600–750; the average in the rest of the country is only 200 vehicles (in the Upper West and Northern regions it is less than 100 vehicles).

Table 6. Average Daily Traffic by Region, 1980–1988

Region	1980	1981	1982	1983	1984	1985	1986	1987	1988
Greater Accra	2,318	1,103	1,772	n.a.	1,310	1,828	1,823	1,787	1,976
Volta	281	296	269	218	224	257	213	232	297
Eastern	750	831	744	636	492	510	623	656	764
Central	603	668	653	571	594	654	624	628	615
Western	259	229	246	182	190	296	295	327	334
Ashanti	597	594	674	550	647	727	751	739	756
Brong Ahafo	259	230	243	230	250	253	239	221	236
Northern	137	107	94	62	n.a.	75	83	91	82
Upper East.	202	230	171	125	n.a.	129	203	214	182
Upper West.	57	75	101	63	64	n.a.	57	47	82
Total*	**417**	**381**	**395**	**288**	**397**	**383**	**382**	**390**	**421**
Greater Accra	2,318	1,103	1,772	n.a.	1,310	1,828	1,823	1,787	1,976
Ashanti, Central, Eastern	664	714	699	592	567	616	665	676	725
Other	212	196	191	152	209	197	184	193	208

* Mean of available data.

Data on urban traffic is much more limited. A recent study by DeLeuw-Cather International indicates that the average traffic volume on Accra inner streets is about 840 vehicles per hour (slightly higher in the afternoon peak hours and lower at noon). The distribution of traffic in different parts of Accra is far from even. Thus, whereas traffic on major arteries in peak hours reaches 1,600–2,300 vehicles per hour, traffic on non-circumferent city streets is much lower. Accra has by far the most dense concentration of vehicles. Traffic counts in Tema and Sekondi-Takoradi indicate an average hourly traffic volume in peak hours of 450 and 360, respectively.

The differences between urban and interurban traffic are not confined only to volume; it is also reflected in the mode distribution (Table 7). Whereas cars and pickups constitute less than 40 percent of interurban traffic, they (including taxis) account for 70 percent of urban travel. The share of buses and trucks, on the other hand, is one half of interurban travel, but only about one fifth of urban travel. The share of cars is even higher in Accra, whereas heavy vehicles play a somewhat more important role in the smaller cities.

The volume of traffic (and its distribution) is one of the determinants of the road externality, the other determinant is the traffic loading. The destructive effect of the vehicle on the road paving is an increasing function of the axle load. It is measured in terms of Equivalent Standard Axle Loads (ESALs).[1] The average ESAL per vehicle depends on the fleet composition (i.e., the share of heavy trucks), the legal axle-load limits and the prevalence of overloading. Early studies (TecnEcon, 1988a) found that overloading on heavily-trafficked routes was rampant and that the average equivalent axle load for 4- and 5-axle articulated trucks exceeded 20 ESAL per vehicle. Later surveys conducted by SWKP (1988a) reported lower values of 11 ESAL per truck. Needless to say, these loadings are much higher than results reported for other countries. Given the high share of heavy trucks in interurban traffic (14 percent), even the low SWKP estimate results in an average ESAL per vehicle of 1.5.

More recent studies reported by Bhandari (1990) indicate that the problem of overloading may not be as extreme as originally conceived (Table 8). Still, although the axle load of heavy trucks is comparable to the experience of other countries, their large share results in an average per vehicle which is very high. The 0.9 average, based on Bhandari's figures, is 2.5 times that reported by Newbery for Tunisia (0.38 ESAL).

Transport taxes in Ghana are in a state of constant flux. The government employs the whole spectrum of standard taxes — on vehicle acquisition, on inputs (fuel, tires, parts, etc.) — levies license fees, and collects tolls. Although the tax structure changes annually, the overall trend since the early 1980s has been one of lowering transport taxes. The SWKP (1984) estimate for 1981 is that the tax component in the price of private cars exceeded 75 percent, for light commercial vehicles — over 50 percent, for buses — 33 percent, and for trucks — 33 percent to 60 percent. The tax component in the retail price of fuel was 25 percent to 30 percent, and in the price of tires — 40 percent. In comparison, customs data for 1988 reveal that the average effective combined import tax (duties, purchase tax and penalties) per vehicle imported during the first 9 months of 1988 ranged around $450 for pickup trucks and cross-country vehicles and around $720 for saloon cars, i.e., less than 10 percent of their retail prices. The tax component in the price of fuel has dropped to 15 percent (for premium gasoline and diesel oil) and in the price of tires to less than 20 percent.

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[1] The standard unit is an axle load of 8.2t per axle. It is generally accepted that the destructive impact of the axle is proportionate to the fourth power of the axle load [i.e., the ESAL equals $(\text{axle load} / 8.2)^4$].

Table 7. The Distribution of Traffic by Vehicle Class and Distance Travelled (1987)

A. Interurban

	Percent distribution of VKT						
	Cars	Pickups	Buses	Mammy wagons	Trucks		
					Light	Medium	Heavy
Greater Accra	25	16	22	11	9	6	11
Volta	20	25	22	14	9	3	7
Eastern	21	16	22	18	8	6	9
Central	20	16	20	15	10	8	11
Western	18	15	19	17	10	7	14
Ashanti	22	14	24	13	9	7	11
Brong Ahafo	16	19	15	15	13	5	17
Northern	10	15	11	14	12	9	29
Upper West	15	28	11	10	15	5	16
Upper East	19	27	15	5	13	6	15
National average	**19**	**19**	**18**	**13**	**11**	**6**	**14**

B. Urban

	Total length of roads (km)	Average hourly traffic	Percent distribution of VKT			
			Cars	Taxis	Mammy wagon	Buses and trucks
Accra — Inner city	150	800	50	25	10	15
Accra — Outer city	800	440	45	25	12	18
Tema	155	450	40	30	10	20
Sekondi-Takoradi	195	360	30	30	10	30

Note: VKT = Vehicle-km traveled per year.

Source: Bhandari (1990).

Table 8. Average Axle Loads by Vehicle Type (tons)

Vehicle type	Sample size	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	GVW	Equiv. Std. Axles
Pick-up	2	1.6	3.2				4.7	0.03
Light bus	47	2.3	3.6				5.9	0.16
Heavy bus	196	4.0	6.6				10.5	0.79
M-wagon	123	2.7	4.4				7.0	0.21
Light truck 490	3.7	5.2				8.9	0.85	
Medium truck	132	4.1	4.8	4.1			13.0	1.13
Heavy truck	192	5.1	7.6	5.6	5.7		24.0	3.98
Heavy truck	34	5.2	5.7	5.4	5.6	5.8	27.6	4.12
Other	2						26.0	7.88

Source: Bhandari, 1990.

Current transport taxes have been surveyed in a TecnEcon report for the World Bank (1988b) and will not be replicated here. The main conclusions of the report were as follows:

(a) The duty and purchase taxes on imported vehicles at the rate of 25-35 percent (depending on age and engine size) do not exceed — in fact, are less than the rates for other imported consumption goods.

(b) Commercial vehicles (trucks, vans, buses) are tax exempt, as are motorized vehicles whose engine capacity does not exceed 1,600cc (if petrol driven) or 1,800cc (if diesel driven). Furthermore, returning expatriates who were away for over two years are exempt, as are lumber companies, foreign construction companies and companies with government contracts. The effective rates are consequently much lower than the official ones, even in the case of high-capacity saloon cars (or cars that are over 5 years old).

(c) Vehicle inspections (and licensing fees) are performed once every 6 months (in conjunction with the roadworthiness tests). The fees are based on a progressive scale: US$4-36 for private motorcars, US$13-36 for rigid trucks, and US$71-133 for road tractors. The enforcement of the rules is, however, lax, and government vehicles are exempt.

(d) Fuel taxes include a 'road fund' component (about 3 percent of the retail price of gasoline and 5 percent of the price of diesel oil), which is the main source of the fund (other sources are licensing fees and tolls).

(e) Tolls are imposed on the main artery connecting Accra and Tema and on selected bridges. The revenue from this source, however, is significantly lower than one would expect on the basis of traffic polls.

III. ROAD USER COSTS

A. Road Damage Externality (RDE)

As discussed earlier, the analysis of the road damage externality depends heavily on the maintenance strategy adopted by the road authority: whether the timing of the periodic overlay is triggered by the road condition or whether it is fixed.

In the first case, Newbery's method allows for an easy calculation of the road damage externality. When traffic is the sole source of road deterioration, when traffic flows are constant, and when the age distribution of roads is uniform, additional traffic has no effect (on average) on the operating costs of other vehicles. In this case, the only externality associated with road damage is the advancement of the resurfacing date. This externality can be measured by the cost of the overlay divided by the number of vehicles that will reduce the road to a state requiring its repair. In this case it is sufficient to know the cost of the periodic overlay and the marginal effect of a vehicle on road condition to measure the externality costs.

The effect of an additional standard axle load depends on the standard of the road. The heavier the traffic (both in terms of its volume and loading) the more efficient it is to build a stronger (and more costly) road. The higher the standard of the road, the lower the damage caused by each passing axle. Hence, the volume of traffic and the marginal damage are negatively correlated.

Our first estimate of the RDE is based on Newbery's method, allowing for road deterioration due to weather and for growth of traffic. Following Newbery, this calculation ignores the effect of road deterioration on vehicle operating costs.[2] Table 9 is based on Newbery's estimates of RDE. The computations are based on a traffic growth rate of 7 percent, a pavement deterioration rate (associated with weather) of 2 percent, and a discount rate of 12 percent. As the table indicates, road user costs range from 1.76 to 0.36 ¢ per ESAL-km and decline sharply as the pavement loading (and pavement strength) increase.

The overlay costs of paved road in Tunisia ($20,000–50,000) are very similar to those prevailing in Ghana, so Newbery's findings for paved roads can be easily adapted by using the Ghanaian loading distribution. In Ghana, the volume of heavy vehicles is lower due to the lower traffic volumes, but in the total loading this factor is more than offset by the heavier axle loads. In Table 9 two estimates of the average axle load are used: the first (based on Bhandari, 1990) of 0.9 ESAL per vehicle, and the second (based on SWKP, 1988a)

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[2] Newbery has shown that even if one allows for traffic growth the externality associated with increased vehicle operating costs is only of negligible importance (about US¢0.02-0.06 per ESAL-km).

of 1.5 ESAL per vehicle. In either case, the heavier axle loading in Ghana (compared with Tunisia) contributes to a lower estimate of the average RDE, the estimate being in the range of 0.5–0.6 per ESAL-km (compared with Newbery's estimate of 0.8).

Table 9. The Estimation of Road Damage Externality (¢/esal-km)

Annual ESAL ('000)	RDE (¢/ESAL-km)	Percent of traffic volume		
		Tunisia	Ghana	
			(a)	(b)
(1)	(2)	(3)	(4)	(5)
Under 40	1.76	3.1	1.1	0.3
40–100	1.44	22.1	8.2	2.1
100–200	0.87	21.4	15.0	9.4
200–400	0.50	24.1	19.4	16.0
400–850	0.39	14.4	33.2	21.1
850+	0.36	14.9	23.1	51.3
Average RDE (¢/ESAL-km)	0.79	0.58	0.46	0.46

Sources: Columns (1), (2) (3) — Newbery (1986b), assuming ESAL/veh. in Tunisia is 0.38. Columns (4), (5) — Ghana 1988 traffic count, assuming ESAL/veh. is (a) 0.9 and (b) 1.5.

An alternative crude estimate is based on the estimate of long-run maintenance costs of paved roads. Abbey-Sam and Bhandari (1988) estimate that a 7-year rehabilitation program that will increase the percentage of paved trunk roads in good condition from 30 to 70 percent, keep 20 percent of the roads in fair condition, and cut the fraction of poor roads from 40 to 10 percent may cost about $180 million for periodic maintenance *plus* $365 million for major rehabilitation. (There is, of course, no merit in imposing these large, non-recurrent costs on present and future travelers.) However, once this goal is achieved, the cost stabilizes at $25.5 million annually, i.e., $4,400 per kilometer of paved trunk road.[3] Given Ghana's weather conditions, heavy traffic loading, and poor maintenance record, about 70 percent of these costs ($3,100) can be attributed to traffic. Average daily traffic on paved roads was 788 vehicles. Assuming that the average loading is 1.2 ESAL per vehicle (an average of the high and low estimates), the annual pavement loading is on average about 350,000 ESALs. Thus, our second estimate of road user costs is about US¢0.9 per ESAL-km driven on paved roads.

The two estimates presented above share the common assumption that the timing of pavement resurfacing/strengthening is responsive to the state of the road. Given this assumption, additional traffic imposes only a minor externality on the rest of traffic, since the increased operating costs due to road damage are offset to a large extent by the reduced costs once the road has been overhauled. Unfortunately, the African experience indicates that this basic assumption is not always valid, and the timing of the road improvement is determined by budgetary, financial or political considerations which are only loosely related to the state of the road.

In this case, one cannot assume that additional traffic will advance the time of even overlay. An increase in traffic may involve an increase in the cost of strengthening or any required rehabilitation, and will definitely result in a serious road-damage externality in the form of increased vehicle operating costs.

The third estimate attempts to measure this externality directly. For this purpose one must estimate the effect of an additional vehicle on road roughness, and the effect of the increase in roughness on vehicle operation costs. Both estimates involve large inaccuracies. Local consultants (SWKP, 1988b) estimated that in 1988 a one-unit increase in roughness (International Roughness Index, IRI) increases average vehicle operating costs by ¢1.4 per km.[4] The number of vehicles affected by the deterioration of the road depends on the state of the road, since the state of the road and the volume of traffic are negatively correlated. The average vehicle uses a road that is traveled by another 1,930 vehicles a day.[5] If it is a

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[3] The program (incorporated in the 1987 Transport Rehabilitation Program) envisages the annual resealing of 285 km of fair roads (at a cost of $22,000 per km), the resurfacing of 83 km of poor roads (at a cost of $50,000 per km), and a major rehabilitation of 60 km (at a cost of $250,000 per km). This program will preserve the steady state distribution of 70:30:10 of good, fair, and poor roads.

[4] This estimate is considerably higher than Paterson's estimates for Tunisia (1985) and slightly higher than Chesher and Harrison's estimates (1987) for Brazil and India. It is lower than the estimates reported by Chesher and Harrison for Kenya and is in line with the GHA 1987 estimates (Bhandari and Abbey-Sam, 1988), which show a marginal effect of ¢1.23 per IRI.

[5] Note that this average differs from the annual average daily traffic. The average daily volume per km ADTK per km is obtained by weighting the first column in Table 5 (panel B) by the percentage in column (2). The average daily volume per vehicle (ADTV) is obtained by weighting column (1) by the percentages in column (3). To demonstrate this difference, let a system consist of 1,000 km, 999 of which are traveled by 1 car and 1 km traveled by 1,001 vehicles. The ADTK is two vehicles per km. However, the average vehicle travels on a road which is traveled by 501.5 vehicles or the ADTV is approximately: $0.5 \times 1 + 0.5 \times 1{,}001$.

good road, it is used by another 2,180 vehicles; and if it is only in fair or poor condition, it is used by another 1,730 vehicles. Thus, the externality imposed by an additional vehicle on a good road affects close to 800,000 vehicles annually, and the externality on other paved roads affects 630,000 vehicles. The annual impact on vehicle operating costs of a one-unit increase in roughness (at ¢1.4 per veh./km) is $11,100 and $8,800, respectively.

The damage caused by additional traffic to the road surface increases as the state of the road deteriorates. SWKP (1988a) assume the marginal damage to be 0.14 IRI per million ESAL when the road surface has a roughness of IRI = 2.5, it increases to 0.22 when the roughness increases to IRI = 4.0 and to 0.37 when the road reaches a state of crisis, 6.5 < IRI < 9 (the assumptions are consistent with Paterson's 1985 formula, allowing for the low pavement structural number of Ghanaian roads). The externality imposed by an additional ESAL on good roads is therefore ¢0.15 annually (= $11,100 × 0.14 × 10^{-6}). The annual externality on fair and poor roads is ¢0.19 and ¢0.33, respectively.

The total externality depends on the length of time until the next overhaul, the rate of growth of traffic, and the discount factor. Assuming a traffic growth rate of 3 percent, a discount factor of 12 percent, and that the residual life of good roads is 10 years, that fair roads are going to be resurfaced within the next five years, and that roads in a state of crisis are going to be rehabilitated within three years, the present value of the externality for the three types of roads is ¢0.8–¢1.0 per ESAL-km.[6]

Admittedly, all three estimates provided here are very crude, but they point at road user costs associated with road damage on paved roads of ¢0.5-1.0 per ESAL-km. In the long run, when the rehabilitation program is finished, and if the road maintenance policy adopted is responsive to road conditions, road user costs are estimated to be about ¢0.7 per ESAL-km, while in the short run, or if maintenance policy is not condition-responsive, road user costs are in the upper range of ¢0.9.

About three-quarters of the vehicle-km traveled on interurban roads are on paved roads, the rest on unpaved roads. The annual long-run maintenance costs of the latter are estimated by Bhandari and Sam at $5.3 million (they assume that each year 765 km of gravel roads will be regraveled at a cost of $7,000 per km). Half of this cost can be attributed to traffic and the other half to weather. The network of gravel roads comprises 8,400 km, so the annual maintenance due to traffic is $315 per km of gravel road.

The most costly damage inflicted by vehicles on unpaved roads is the loss of gravel. This loss is a function of the number of axles passing on the road. Light vehicles and buses have 2 axles; medium trucks — 3; and heavy trucks (on average) — 4.15, yielding an

[6] The accumulation factor is defined as $[1 - e^{-(r-g)T}/(r - g)]$, where r is the interest rate (r = 0.12), g is the traffic growth rate (g = 0.03), and T is the time until resurfacing (T = 10, 5, 3, for good, fair, and poor roads). The accumulation factors for good, fair, and poor roads are 6.59, 4.03, and 2.63, respectively. These factors are multiplied by the annual damage (¢0.15, 0.19, and 0.33) to derive the cumulative damage until the next treatment. The estimates ignore the effect that increased traffic may have on the investment required to repair the road and the effect of weather, which may exacerbate the eroding process.

average (given the distribution of Table 7) of 2.36 axles per vehicle. The average daily volume of traffic passing on each km of unpaved road annually is 136,400. The RDE on unpaved roads is, by this estimate, ¢0.23 per axle-km (i.e., ¢0.5 per veh.-km for light vehicles and buses, ¢0.7 for medium trucks, and ¢1.0 for heavy trucks).

An alternative estimate is based on the assumption that the damage associated with the passage of an axle of a heavy truck is three times that of a lighter vehicle. The adaption of this assumption generates a different allocation of the maintenance costs: ¢0.31 and ¢0.46 per veh.-km of light and medium vehicles, and a doubling of the RDE attributed to heavy vehicles to ¢1.9 per veh.-km.

B. Marginal Congestion Costs (MCC)

A second component of the road user cost is the congestion cost. Newbery (1988) estimated the cost of interurban congestion on Tunisian roads at ¢0.20 per passenger car equivalent (PCE). Although this estimate was admittedly crude, requiring many approximations.

Whereas road damage costs are long-lasting, affecting operating costs of all future users until the damage is repaired, congestion costs have an immediate effect on all those who use the road at the same time. The externality depends on the number of users and the additional costs imposed on each one due to the slowdown of traffic.

To obtain an estimate of these costs one has to know the relevant speed function, an estimate of the value of time, the composition of traffic, and the passenger load factor of the different types of vehicles. The existing information on each of these components is quite sketchy.

A crude estimate of the interurban speed function for Ghana's trunk roads is provided by SWKP (1988b):

$$S = 72 - 0.02X$$

where S denotes speed measured in kph and X denotes the number of vehicles per hour. This estimate is based on speed measurements undertaken on a relatively highly traveled road (an ADT of 4,750 vehicles). It is based, however, only on two points: the free flow speed (72 kph) and the existing speed and traffic volume. The GHA estimated the same linear speed-flow relationship for a 2-lane 2-way suburban road in Accra, and the estimated function (with over 50 observations) was:

$$S = 71.9 - 0.0115X \qquad (R^2 = 0.34).$$

Both estimates are within the range of speed functions used by Newbery for different types of roads.

The average vehicle in 1988 traveled a trunk road that was shared by another 1,600 vehicles that day.[7] Information on the distribution of traffic flows over the hours of the day is scarce. Available data (SWKP, 1988b) indicate that interurban traffic in daytime (6 a.m. to 6 p.m.) is almost evenly distributed over all hours, constituting about 80 percent of daily traffic (about 20 percent travel by night). According to this estimate, the average hourly traffic is about 110 vehicles in the daytime and negligible (28 vehicles per hour) at night.

The major component of congestion is travel time. The value of travel time in Ghana is naturally low, given the low income per capita (about $500). The hourly crew costs (assuming 2,000 annual working hours) are ¢25 for cars (i.e., taxis), ¢50 for minibuses and pickup trucks, ¢85 for buses, $1.00 for medium trucks and $1.10 for heavy trucks (SWKP, 1988b, Appendix 4). Given the distribution of traffic, average crew costs are about ¢60 per hour. Data on the passenger load factor of different types of cars are unavailable. A crude estimate places the average number of passengers per vehicle at 10. It is customary to assume that the value of time of passengers is 25-33 percent of their hourly earnings. Assuming hourly earnings of ¢25 ($500/2,000), the value of passenger time is ¢62.5-83.3 per vehicle hour.

Given the linear speed function,

$$S = \alpha - \beta X ,$$

the marginal congestion costs (MCC) are:

$$\text{MCC} = v\beta X/S^2,$$

where v is the value of time per vehicle-hour.

Given the interurban speed function (i.e., $\beta = 0.02$) and $X = 110$, then MCC = ¢0.03 per vehicle/km if one allows only for the travel time of the crew, and MCC = ¢0.06 if one also takes into account the travel time of passengers (assigning it a value of 1/3 of hourly earnings, v = 143.3¢/hour). Since congestion conditions exist only in the daytime (i.e., apply to only 80 percent of traffic), the average MCC is in the range of ¢0.02-0.05 per vehicle. Had we used the 2-lane suburban speed function, these estimates would halved.

Our estimate depends heavily on the number of vehicles and on the estimate of hourly earnings (the large difference between Newbery's estimates and ours is explained mainly by these two factors: hourly earnings in Tunisia are six times higher than in Ghana and average traffic volume is twice as large). The estimate is, however, also sensitive to the assumptions about the parameters of the speed function. The speed function used in our calculation was estimated for a road in relatively good condition (IRI = 3.35), with an average speed of 65 kph (traffic volume being 350). In view of the poor condition of Ghanaian roads, it is clear that the estimate described above may relate to the long run, once the highway system is restructured. In the short run, average speed in Ghana is much lower and constrained by the

[7] See footnote 5 for the calculation of this average. Our method of calculating the congestion costs is equivalent to a procedure where these costs are computed separately for each AADT class and then weighed by the veh.-km 'belonging' to that class.

state of the road. SWKP (1987) note that when the road deteriorates to a level of roughness of 10–13 IRI, speed slows down to 30–50 kph.

The slowdown *per se* tends to increase marginal congestion costs, but it is not clear how the marginal effect of traffic on speed (β) is affected by the state of the road. On the one hand, overtaking is much more complicated on a poor road, which will tend to increase β, but on the other hand, on seriously damaged roads all traffic (regardless of type of vehicle) tend to maintain the same slow pace and marginal changes in the volume have no effect on travel time. The sign of the interaction term between road roughness and traffic volume cannot, therefore, be ascertained: it can be either positive or negative. Assuming the estimate of β is unchanged by the state of the road, and that it affects only the free flow speed of vehicles, the estimates of MCC should be doubled when average speed in the system is 50 km/h (rather than 70 km/h) and quadrupled when average speed falls to 35 km/h. In either case, interurban congestion costs are low compared with the road damage estimates (and low compared with Newbery's estimate).

Different types of vehicles contribute differently to congestion, the effect increasing with the slowness and size of the vehicle. It is customary to assign values reflecting these differences (compared to private cars). The weight assigned to pickup trucks is 1.00 to 1.50, to minibuses--1.5, to heavy buses--2.0, to medium trucks--1.7 to 2.0, and to heavy trucks--2.0 to 3.0. Given the distribution of traffic, the average passenger car equivalent (PCE) per vehicle on Ghanaian trunk roads is 1.4–1.9. Assuming a factor of 1.65, the long-run marginal congestion costs per PCE are ¢0.01–0.03. The short-run MCC may be 2–4 times higher than that.

Urban congestion is in general a much more serious problem compared with the congestion on interurban roads, as is the difficulty encountered in its measurement. Transport economists disagree on the relevant speed function, traffic counts on urban streets are much more scarce and so is the information on travel time. Thus Newbery, noting the high sensitivity of the results to the speed flow function, adopted arbitrary measures for the marginal time costs (MTC). Assuming this value is 0.1 per PCE-km in highly congested areas, 0.04 for moderately congested areas, and 0.02 for lightly congested areas, and assigning weights of 0.1, 0.1 and 0.8, respectively, to each of these congestion conditions, the average MTC estimated for Tunisia was 0.03 hours per PCE-km (i.e., each additional vehicle imposes an overall 2-minute delay on the traffic on the road traveled).

This study was unusually fortunate in having at its disposal a study of speed-flow relationships on urban roads in Ghana. Following an extensive study of urban traffic by the GHA with the help of the University of Science and Technology (Kumasi), Bhandari (1990) estimated three speed functions for different congestion conditions on Accra roads:

(a) $S = 71.9 - 0.0115X$ $(R^2 = 0.34)$

(b) $S = 62.6 - 0.0219X$ $(R^2 = 0.74)$

(c) $S = 45.7 - 0.0084X$ $(R^2 = 0.46)$.

The first of these functions applies to a 2-lane, 2-way suburban road, the second to a 2-lane, 2-way urban street, and the third to a 2-lane, 2-way CBD (Central Business District) street (the regressions are presented in Figure 3).

To estimate the marginal time costs one has to know the average traffic volume (or, alternatively, the average speed) and the distribution of traffic conditions (i.e., the fraction of traffic subject to the various speed-flow conditions). Traffic counts indicate that the average traffic volume on Accra streets is 800 vehicles per hour, the average for Tema is 500 and for Takoradi: 300-400 (we could not obtain the data for Kumasi, the second largest urban center was not available). It was assumed that the first function is typical of traffic conditions in the outskirts of most big towns (about 10 percent of urban traffic), the second of traffic conditions in the CBDs of most towns and the inner circle of Accra (80 percent of traffic), and the third to Accra's CBD (10 percent of traffic), and that the traffic volume is $X = 500$, 500, and 800, respectively. Applying these traffic volumes to the three speed-flow equations one obtains estimates of the average speed of 66.2, 51.7 and 39.0 km/hour. The marginal time costs are accordingly 0.0013 hours per vehicle for the low-congestion conditions, 0.0041 for the medium case, and 0.0044 for the center of Accra. By this estimate the average MTC is 0.00385 hours per vehicle (i.e., each additional vehicle imposes on the rest of the traffic a delay of 0.23 minutes). This value is 1/8 of the value assumed by Newbery in the Tunisian case.

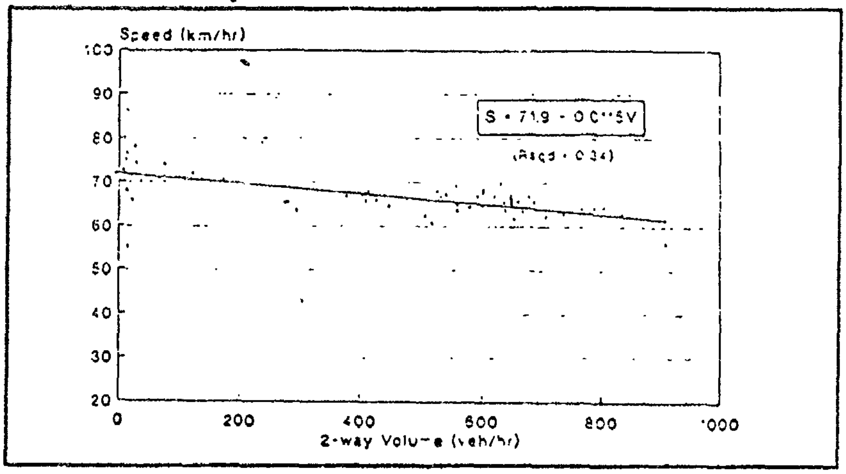
Given the composition of urban traffic, average crew costs are 40¢ per hour. An evaluation of the value of lost passenger time requires knowledge of the distribution of traffic and the load factors of the various types of vehicles. Table 10 contains data on the occupancy rate of the different vehicles, based on an origin-destination survey conducted by DeLeuw-Cather in Accra. According to these data the average occupancy rate is 5.6 passengers per vehicle. Assigning a value of one third of hourly earnings to the value of time implies a value of 47¢ per vehicle-hour (= 25¢ × 0.33 × 5.6).

Using an estimate of MTC of 0.00385 hour per vehicle, the implied marginal congestion costs are 0.15¢ per vehicle-km, if one allows only for crew time, and 0.34¢ if one also allows for the value of passenger time.

Finally, the effect of the different vehicles on urban congestion is not the same. A light truck counts as 1.5 cars, a medium truck as 2.0, and heavy trucks and basis as 2.5-3.0. Given the distribution of traffic on urban roads (and specifically, the large share of light vehicles in urban traffic), the average vehicle counts as 1.16 private cars (PCE). The marginal congestion costs are, therefore, 0.13-0.29¢ per PCE-km (depending on whether one allows for the value of passengers' time or not). By comparison, Newbery's estimate was almost 15 times higher (i.e., 4.6¢ per PCE-km), reflecting both the greater congestion on Tunisian urban roads and the higher value of time. Newbery's estimate is 23 times the estimate of the interurban MCC. In the Ghanaian case, given the lower congestion on urban streets, the ratio is 10:1.

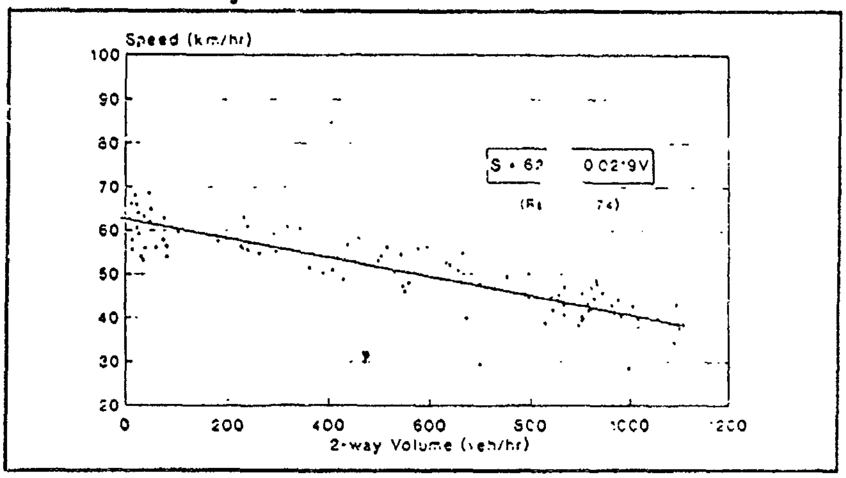
Figure 3. Speed-Flow Relationship

3.1 2-lane 2-way suburban A/C road



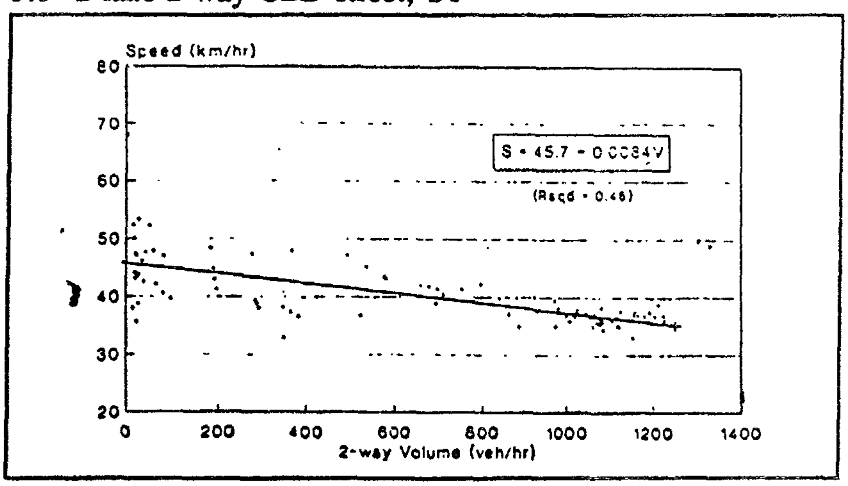
Motorway Phase II (Accra)

3.2 2-lane 2-way urban ST road



Independence Ave. (Accra)

3.3 2-lane 2-way CBD street, ST



Kojo Thompson (with significant side friction and development, Accra)

Table 10. Average Occupancy of Vehicles in Accra, by Type of Vehicle, 1988

	Vehicle trips	Percent	Average occupancy
Cars	15,275	40.8	2.2
Taxis	11,951	31.9	3.7
Light buses	5,376	14.4	17.2
Heavy buses	645	1.7	33.6
Light trucks (incl. vans)	3,416	9.1	4.0
Medium trucks	515	1.4	4.5
Heavy trucks	235	0.6	7.3
Total	**37,433**	**100.0**	**5.6**

Source: DeLeuw-Cather Int., O-D Survey (1988, p. IV-14).

C. Road-User Costs (RUC)

The final steps in the computation are the estimation of the externalities associated with each type of vehicle and the weighting of these externalities, given the vehicles' different distribution of travel between urban and interurban roads. The estimate of the externality imposed by the different types of vehicles depends primarily on the evaluation of the damage they inflict on paved and unpaved roads. The recent GHA survey indicates that the number of ESAL per vehicle is 0.8 for buses, 1.1 for medium trucks, and 4.0 for heavy trucks. Earlier estimates were much higher. Adapting SWKP estimates, the weights are 1.5, 2.5 and 12 (Newbery's weights were 0.5, 0.6 and 5.5). Furthermore, some studies assume that the damage inflicted on unpaved roads is proportionate to the number of axles (i.e., 2, 3, and 4.15 for light, medium and heavy trucks), whereas others assume that the damaging effect of the axle of a heavy truck is three times that of other vehicles.

The two sets of assumptions are incorporated in the upper and lower panels of Table 11, which presents the different externalities by type of vehicle. To compute these externalities it is assumed that RDE per km driven on paved roads is ¢0.9 per ESAL-km, and for unpaved roads ¢0.23 per axle-km (¢0.155 for the second panel). The MCC are ¢0.03 per PCE-km on interurban roads and ¢0.3 on urban roads.

To compute the average road damage externality it is assumed that the shares of travel on paved and unpaved roads for each type of vehicle are 75:25, respectively (based on Table 5). To compute the average congestion costs one needs the shares of travel on urban and interurban roads. Unfortunately, this important information is unavailable. An attempt was made to reconstruct the distribution from data on the stock of vehicles, annual utilization rates, interurban traffic counts, and the distribution of interurban traffic by type of vehicle, but the results are inconsistent (see Appendix). Consequently, two alternative assumptions: (a) a 40:60 split and (b) a 60:40 split (in Tunisia the share of urban traffic was one third) were adopted. Under both assumptions, the share of urban travel for private cars, taxis and pickups exceeds one half, while the other modes travel mostly on the interurban roads. Given the great difference between the urban and interurban congestion costs, the marginal congestion costs of the light vehicles increases with the share of urban travel.

Table 11. The Road Damage Externality and the Marginal Congestion Costs by Type of Vehicle and Type of Road (US¢ per veh.-Km)[a]

Type of vehicle	ESAL per vehicle	Axles per vehicle	PCE	Marginal damage costs per veh.-km		Marginal congestion costs per veh.-km	
				Paved roads	Unpaved roads	Urban	Inter-Urban
A. Assumption: GHA estimates of ESAL							
Car	0.0001	2	1.0	0.00	0.46	0.03	0.30
Light bus	0.15	2	1.5	0.14	0.46	0.05	0.45
Heavy bus	0.80	2	2.0	0.72	0.46	0.06	0.60
Light truck	0.80	2	1.5	0.72	0.46	0.05	0.45
Medium truck	1.10	3	1.8	0.89	0.69	0.05	0.54
Heavy truck	4.00	4.15	2.5	3.60	0.96	0.08	0.75
B. Assumption: SWKP estimate of ESAL							
Car	0.0001	2	1.0	0.00	0.31	0.03	0.30
Light bus	0.09	2	1.5	0.08	0.31	0.05	0.45
Heavy bus	1.50	2	2.0	1.35	0.31	0.06	0.60
Light truck	0.09	2	1.5	0.08	0.31	0.05	0.45
Medium truck	2.50	3	1.8	2.25	0.47	0.05	0.54
Heavy truck	12.00	12.45	2.5	10.80	1.93	0.08	0.75

[a] The estimates are based on the assumption that the marginal damage costs are ¢0.9 per ESAL on paved roads and ¢0.23 per axle on unpaved roads (¢0.16 for Panel B). The urban and interurban congestion costs are ¢0.3 and ¢0.03 per PCE, respectively.

Table 12 spans this range of assumptions: the upper part is based on the assumption that urban travel is 40 percent of all travel and that the GHA weights apply, while the lower part is based on an urban share of 60 percent and the SWKP weights. A comparison of the two panels indicates that differences in the assumption concerning the share of urban travel have only a minor effect on the estimate of the road user costs; on the other hand, the results are very sensitive to the estimate of the damaging factor of the heavy vehicles. Whereas the estimated RUC of cars and light buses is about 0.4¢ per vehicle-km, the estimate for heavy buses is 0.8–1.2¢ per vehicle-km, for medium trucks: 1.1–2.0¢. Heavy trucks are associated, by far, with the largest costs: 3.1–8.7¢ per vehicle-km. The prevalence of excess axle loading becomes a major determinant of the heavy trucks' externality.

Table 12. The Estimation of Road User Costs (US¢/veh.-Km)[a]

	Percent of urban km	Marginal damage costs	Marginal congestion costs		Total
			Urban	Interurban	
	(1)	(2)	(3)	(4)	(5)
A. Assumption: Urban transport — 40% of annual km, GHA estimates of ESAL					
Car	58	0.11	0.17	0.01	0.29
Light bus	34	0.22	0.15	0.03	0.40
Heavy bus	7	0.66	0.04	0.06	0.76
Light truck	23	0.66	0.10	0.03	0.79
Medium truck	18	0.92	0.10	0.04	1.06
Heavy truck	5	2.94	0.04	0.07	3.05
B. Assumption: Urban transport — 60% of annual km, SWKP estimates of ESAL					
Car	76	0.08	0.23	0.01	0.32
Light bus	54	0.14	0.24	0.02	0.40
Heavy bus	14	1.09	0.08	0.05	1.22
Light truck	41	0.14	0.18	0.03	0.35
Medium truck	33	1.81	0.18	0.04	2.03
Heavy truck	10	8.58	0.08	0.07	8.73

[a] Based on the estimates of RDE and MCC per vehicle presented in Table 11. The shares of travel on paved and unpaved roads is 75:25, respectively, and the share of urban travel is given by column (1).

To estimate the annual road-user costs to the economy, one needs the data on annual urban and interurban travel. Given the inaccuracy of these data, the estimate is only a crude approximation. In Table 13 I apply the estimates of travel (derived in the Appendix) to the estimates of the road damage costs and marginal congestion costs. Given the two estimates of the damage associated with heavy trucks, the estimate of RUC to the economy is $39-64 million. Damage costs constitute 65-80 percent of these costs. The share of costs that can be attributed to heavy trucks is 33-55 percent.

Table 13. The Estimation of Annual Road-User Costs by Type of Vehicle and Type of Externality, 1988 ($ millions)

		Car	Light bus	Heavy bus	Light truck	Medium truck	Heavy truck	Total
1. Vehicle fleet ('000)		68	16	7	4	5	5	100
2. Vehicle-km (millions)		2,720	880	525	280	400	400	5,205
RDE per veh.-km (¢/km)								
3.	(a)	0.115	0.220	0.655	0.655	0.915	2.940	
4.	(b)	0.078	0.138	1.090	0.138	1.805	8.583	
Road damage costs ($ mil)								
5.	(a)	3.1	1.9	3.4	1.8	3.7	11.8	25.7
6.	(b)	2.1	1.2	5.7	0.4	7.2	34.3	51.0
7. Urban veh.-km (mil)		1,960	620	165	60	280	120	3,205
8. Urban MCC per veh.-km (¢/km)		0.30	0.45	0.60	0.45	0.54	0.75	
9. Urban congestion costs ($ mil)		5.9	2.8	1.0	0.3	1.5	0.9	12.3
10. Interurban veh.-km (mil)		760	260	360	220	120	280	2,000
11. Interurban MCC per veh.-km (¢/km)		0.030	0.045	0.060	0.045	0.054	0.075	
12. Interurban congestion costs ($ mil)		0.2	0.1	0.2	0.1	0.1	0.2	0.9
13. Total RUC ($ mil)	(a)	9.2	4.8	4.6	2.2	5.3	12.9	38.9
14.	(b)	8.2	4.1	6.9	0.8	8.8	35.4	64.2

Sources:

Lines 1, 2, 7, 10 — Appendix.
Line 3 — Table 12, Panel A, column (2)
Line 4 — Table 12, Panel B, column (8)
Line 5 = [2. × 3.].
Line 6 = [2. × 4.].
Line 8 — Table 11, column (8)
Line 9 = [7. × 8.].
Line 11 — Table 11, column (7)
Line 12 = [10. × 11.].
Line 13 = [5. + 9. + 12.].
Line 14 = [6. + 12. + 13.]

Newbery, in the Tunisian case, considers urban congestion to be sufficiently important, involving externalities that are almost as serious as the damage caused by heavy trucks to the interurban road system. This is reflected in the ratio of the estimated RUC of cars and heavy trucks of 1:3. In the Ghanaian case, where urban congestion seems to be much less important, this ratio is estimated at 1:10 or perhaps even 1:25. The difference between Tunisia and Ghana has far-reaching implications for transport taxation policy.

IV. THE ADEQUACY OF TRANSPORT TAXES

As mentioned earlier, motor transportation is subject to a whole range of taxes imposed on the acquisition, periodic inspection and use of vehicles. The real burden of these taxes and the resources generated change constantly with inflation and with changes in the nominal rate of taxation. This chapter discusses the rates of taxation in effect in 1988, assuming a rate of exchange of 225 cedi/U.S. dollar.

Acquisition (import) taxes range between 0 and 65 percent, depending on type, engine capacity and age of vehicle (imported private cars aged 10 years or more are subject to prohibitive taxes). But given the long list of vehicles that are exempt (small and medium-sized private cars and all commercial vehicles), and of other exemptions, and since the standard rate (15 percent import duty *plus* 10 percent purchase tax) does not exceed the average import tax on consumption goods, import taxes in Ghana cannot be regarded as a form of 'road user' charge.

The main periodic charges are the annual examination and the licensing fee. These fees have been amended over the years to adjust them to inflation and to bring them in line with the vehicles' relative damage factor. Thus, whereas the fee for small and medium sized private cars (up to 1,000 and 1,001-1,500 cc) is $4.4 and $8.8, respectively, the fee for 3-axle heavy trucks (32 tons and up) is $133.3. The 1:30 and 1:15 differential, although large, cannot capture the differential in axle loads.

The major user tax is the fuel tax. Other user taxes (i.e., import duty and purchase tax on tires and spare parts) cannot be regarded as user charges since they are the same as or even lower than other taxes on imported consumer goods. The fuel tax is made up of several components (e.g., energy fund, stocks levy, excise duty), one of which is the component earmarked for the road fund. This component constitutes about 20 percent of the tax on premium gasoline (14 percent of regular) and 40 percent of the tax on diesel oil. It is imposed on road users and non-users alike (e.g., it applies also to kerosene, industrial diesel and fuel oil not used by road vehicles).

It is claimed (TecnEcon, 1988b, p. 2-12) that Ghana's ex-refinery prices are well below world prices (77¢ per gallon of premium gasoline and 75¢ for diesel), and the tax may partly correct for the discrepancy between the domestic and world ex-refinery prices. There is little evidence to support this claim, in spite of Ghana's significantly lower fuel prices (compared with its neighbors) .

Oil prices in Ghana were the subject of investigation of an energy assessment mission which visited the country in November 1985 (UNDP/World Bank, 1986). The mission found that in the 1970s fuel prices were kept artificially low as part of the explicit government policy of keeping fuel prices low and because of the overvalued cedi. This policy was changed in the early 1980s. Since 1983 the government has adjusted oil prices to reflect the rate of exchange and world prices, raising energy prices more than twelve fold. By 1985 (indirect) oil subsidies shrunk to $35 million and in 1986 they disappeared altogether. Whereas in 1985 all petroleum product ex-refinery prices were below world prices (that was true even if one compares retail prices with world prices), by 1986 gasoline and gas oil ex-refinery prices exceeded world prices by 50 and 25 percent, respectively (local prices increasing, in spite of the decline in world prices; Table 14). The only petroleum products still subsidized by December 1986 were kerosene and LPG (whose prices were 70 percent of the world price).

Table 14. Economic and Ex-refinery Prices of Petroleum Products, 1985–86

	Premium gasoline	Regular gasoline	Gas oil	Kero-sene	LPG	Jet fuel	Indus-trial diesel	Inland fuel oil	Residual fuel oil
August-November 1985									
CIF import cost									
1. $/M.T.	280	265	246	267	230	267	223	176	168
2. ¢/gl	96.8	89.1	89.8	98.2	10.5	98.2	85.0	73.9	71.8
3. Ex-refinery price (¢/gl)	90.5	76.0	53.6	42.2	6.2	67.1	52.6	39.4	37.5
4. Difference (¢/gl) [3. – 2.]	-6.3	-13.1	-36.2	-56.0	-4.3	-31.1	-32.4	-34.5	-34.3
5. Tax (¢/gl)	3.4	12.9	20.3	1.6	0.3	12.9	17.4	13.7	2.5
September 1986									
CIF import cost									
6. $/M.T.	171	156	154	163	200	163	135	96	89
7. ¢/gl	59.0	52.4	56.2	59.9	9.1	59.9	53.0	40.3	38.0
8. Ex-refinery price (¢/gl)	86.7	83.3	70.0	42.7	6.2	80.0	61.3	43.0	40.0
9. Difference (¢/gl) [8. – 7.]	27.7	30.9	13.8	-17.2	-2.9	20.1	8.3	2.7	2.0
10. Tax (¢/gl)	4.0	4.0	7.3	1.3	0.7	10.0	5.3	3.7	3.3

Source: UNDP / World Bank (1986) — Lines 1, 2, 6, 7: Table 2.2, p. 22; lines 3, 5, 8, 10: Table 2.1, p. 20. Taxes include the special and the energy fund.

In the period September 1986 to April 1988 world prices resumed their climb, while local ex-refinery prices (given the free market exchange rate) declined in U.S. dollar terms. By April 1988 ex-refinery prices in Ghana (at the free market exchange rate) of gasoline and gas oil were about equal to the world prices, while the price of kerosene continued to be subsidized, being only two thirds the world market price.

Fuel taxes are regarded as the closest substitute for road user charges. The tax per km depends on the rate of the fuel tax (¢ per gallon) and on fuel consumption (km per gallon). The tax varies among different types of vehicles to the extent that they use different kinds of fuel and that they differ in their fuel consumption. In the absence of agreement on fuel consumption, two estimates were used: the high one, used by SWKP in their road project evaluations (1987, Vol. 2, pp. 61-62) and the low one adopted by GHA (1990). The results are presented in Table 15.

Table 15. The Fuel Tax and Road Fund Levy, 1988 (¢/km)*

		Car	Light bus	Heavy bus	Light truck	Medium truck	Heavy truck
Total taxes							
Cedi/gallon		34.81	30.73	30.73	30.73	30.73	30.73
¢/gallon		15.5	13.7	13.7	13.7	13.7	13.7
Road fund levy							
Cedi/gallon		7.50	12.00	12.00	12.00	12.00	12.00
¢/gallon		3.3	5.3	5.3	5.3	5.3	5.3
Fuel consumption (km/gallon)							
	a.	42.04	34.14	20.25	28.74	18.39	10.00
	b.	35.50	23.27	14.78	16.87	7.53	7.22
Taxes per km (¢)							
Total	a.	0.37	0.40	0.68	0.48	0.74	1.37
	b.	0.44	0.59	0.93	0.81	1.82	1.90
Road fund	a.	0.08	0.15	0.26	0.18	0.29	0.53
	b.	0.09	0.22	0.36	0.31	0.70	0.73

* It is assumed that cars use only premium gasoline and that all other vehicles use only diesel oil. Rate of exchange: 225 cedi per $.

a. Based on SWKP estimates (SWKP, 1987, Vol. 2, pp. 61-62).
b. Based on GHA estimates (1990).

Given the difference in the estimates of fuel consumption, the estimated tax per km varies by 50 percent or more. The differences among vehicles (about 0.4¢ for private cars vs. 1.6¢ for heavy trucks) can capture the difference in their disruptive effect on the flow of traffic, but not their damaging effect on the road surface.

One way to overcome the limitation of the fuel tax as a discriminatory taxing device is to supplement it with a sharply differentiated scheme of annual license fees. The Ghanaian scheme is not sufficiently differentiated, and the existing differences are almost completely offset by differences in the annual utilization rates.

Table 16 describes the annual license fee, annual utilization rates (based on GHA, 1990), and the fee per km. There is hardly any difference among the different modes, and even in the case of the most heavily taxed modes (private cars and heavy trucks), the fee per km is only a small fraction of the road user costs.

Table 16. The Annual Vehicle Examination and Licensing Fee, 1988

	1988 average fee		Annual utilization ('000 km)	Fee per km (¢)
	Cedi	U.S.$[a]		
Private car	3,211	14.27	25	0.06
Taxi	2,000	8.89	80	0.01
Light bus	2,400	10.67	55	0.02
Heavy bus	3,200	14.22	75	0.02
Light truck	3,000	13.33	70	0.02
Medium truck	4,500	20.00	80	0.03
Heavy truck	20,000	88.90	80	0.11

[a] Rate of exchange: 225 cedi per $.

These conclusions are hardly affected by use of other estimates of the rate of utilization [e.g., those by SWKP (1988b, App. 4), which are slightly lower, or those by Kocks (1984), which are only half as large].

As noted, the damaging power to paved roads of heavy trucks is 2,000 times that of the private car, the annual fee is six times as large, but the fee per km is only twice as large. This narrow differential clearly increases the risk of undercharging the heavy trucks.

The final table (Table 17) combines the data on road user costs and road user charges, presenting both the lower and higher estimate of the costs and charges. The results underline our previous conclusions:

(a) The annual license fee constitutes only a minuscule fraction of road user charges.

(b) Current fuel taxes (if they continue to be adjusted to world energy prices and changes in the rate of exchange) are adequate to cover road user costs for most modes, and specifically private cars.

(c) The only mode where the charges do not cover costs is the heavy trucks, where the charge is only 1/4 to 1/2 of the estimated costs.

Table 17. Road-User Costs and Road-User Charges, 1988 (¢/km)

	Road user costs		Road-user charges				
			Annual fee	Fuel taxes		Total	
	a (1)	b (2)	(3)	a (4)	b (5)	a (6)	b (7)
Car	0.29	0.32	0.06	0.37	0.44	0.43	0.50
Buses:							
Light	0.40	0.40	0.02	0.40	0.59	0.42	0.61
Heavy	0.76	1.22	0.02	0.68	0.93	0.70	0.95
Trucks:							
Light	0.79	0.35	0.02	0.48	0.81	0.50	0.83
Medium	1.06	2.03	0.03	0.74	1.82	0.77	1.85
Heavy	3.05	8.73	0.11	1.37	1.90	1.48	2.01

Sources: Col. (1) — Table 12, panel A; Col. (2) — Table 12, panel B; Col. (3) — Table 16; Col. (4) — Table 15, estimate (a); Col. (5) — Table 15, estimate (b); Col. (6) = (3) + (4); Col. (7) = (3) + (5).

V. CONCLUDING COMMENTS

The deterioration of the interurban road system in the LDCs has focused the attention of researchers on the road damage component in user costs. Consequently, considerable effort was devoted to a better understanding of the deterioration process, its impact on vehicle operating costs and the implications for road user charges. Although many of the parameters in this equation are still in dispute, one can draw on international and local experience to estimate the road damage costs in the range of ¢0.5 to ¢1.0 per ESAL-km for paved roads, and about ¢0.2 per axle-km for unpaved roads.

Much less is known about congestion costs. To estimate these costs one has to know the speed function, to evaluate the effect of spee[illegible] vehicle operating costs, to evaluate the average load of passenger vehicles and th[illegible] of passengers' time. Each component of this estimate is subject to gross uncertainties. Still, crude estimates indicate that interurban congestion is only a minor problem compared with the road damage effect.

Newbery estimated in the Tunisian case that interurban congestion costs are one fourth the marginal damage costs (for paved roads). In the Ghanaian case, the ratio is much lower, 1:30. The ratio is sensitive to differences in traffic (the Tunisian average volume is more than three times that of Ghana) and the value of time (the value used for Tunisia was $2.85 per veh.-hour, which is exactly twice the value used for Ghana).

A looming problem in the LDC context is that of urban congestion. Rapid urbanization and motorization and an inadequate infrastructure accelerate the pace at which this problem may reach its critical stage (World Bank, 1986). Relatively little is known about the extent of the problem, and for most cases the researcher has to rely on crude guesswork. (It is noteworthy that the only study mentioned in the World Bank Policy Study is the seminal work by Churchill *et al.*, published in 1972.)

Ghana may, therefore, be considered an exception. As part of its transport rehabilitation program a series of studies has been conducted on urban transport. These studies indicate that the problem in Ghana has not yet reached the ominous proportions encountered in the developed countries. It is even far from the level witnessed in lower-middle-income countries such as Tunisia. The Ghanaian estimate of marginal congestion costs is only 1/15 that of Tunisia. Part of it is explained by differences in the value of time: Ghana's GNP per capita was $390 in 1987 (compared to $1,180 for Tunisia), but to a large extent it is explained by the differences in the marginal time costs. Still, the cost of urban congestion is 10 times that of interurban congestion.

Urban marginal congestion costs (per PCE-km) are estimated at one third the marginal damage costs (per ESAL-km). As a consequence, estimates of the road user costs for private cars are much lower than those of medium and heavy trucks. The exact difference depends on the estimates of the share of travel of private cars on urban roads and on the damaging factor (i.e., ESAL per vehicle) of the trucks. Our results turn out to be especially sensitive to the second of these weights, i.e., to the assumptions concerning the degree of overloading. Even if one uses the most moderate estimates (4 ESAL per heavy truck), the ratio of the estimated marginal user costs of private cars and heavy trucks is 1:10. If one uses a higher estimate for the damaging factor of trucks, this ratio almost triples. (By contrast, in Tunisia Newbery estimated the urban MCC to be almost six times the RDE, yielding a ratio of about 1:3.)

Fuel taxes are the closest proxy for road user charges. In Ghana the tax (per gallon) on gasoline and diesel oil is almost the same. Consequently, the differential tax on the various vehicle types depends on their fuel consumption. The fuel efficiency (km. per gallon) of private cars is 4–5 times that of heavy trucks. Given the 1:10 ratio in RUC, this precludes fuel taxes from being the sole instrument of user charges and calls for supplementary taxation devices.

Although fuel prices in Ghana are much lower than in neighboring countries, there is no evidence to suggest that ex-refinery prices of gasoline and diesel oil are below world prices (although they have been so in the past, may be so again in the future, if not constantly adjusted to changes in the rate of exchange and world prices). The major conclusion relating to transport taxation is that fuel taxes are adequate where road user charges are concerned. The taxing instrument found to be deficient is the annual licensing fee. To bridge the gap between road user costs and charges, the annual fee for heavy trucks has to be raised ten-fold. Exemptions from the licensing fee shouid be canceled, and registration rules should be abided by. Even then, charges on heavy vehicles will not cover costs unless current legal limits of axle loading are strictly enforced. A more efficient means of reducing the load-damaging effects of heavy vehicles lies in structuring the annual fees to reflect the much lower damaging impact of multiaxle vehicles compared with the high damaging 2-axle heavy vehicles.

Taxation is naturally associated with the issue of redistribution. The issue in this case is of secondary importance, given the low fuel consumption and the current low level of fuel taxes. Ghana is in the fortunate situation where oil imports constitute less than one quarter of its energy consumption. Almost three quarters of energy consumption are provided by biomass (UNDP / World Bank, 1986) and most electricity (4 percent of consumption) is generated by two hydroelectric power stations. Half of the petroleum is consumed by the transport sector; the other half by industry and the household sector. The low level of commercial energy consumption makes fuel taxation a problem of secondary importance, the reliance on woodfuel exempts a large fraction of households from these taxes, and the misallocations created by transport taxes in other sectors of the economy are minor.

A recent study of poverty in Ghana (Oti Boateng *et al.*, 1990) examined the expenditures on fuel. It found that the expenditures on charcoal, wood, kerosene, gasoline and other fuel constitute 3.2 percent of total expenditures (including home production). It is almost identical for the poor and the not-poor. Charcoal and wood constitute half of this expenditure, and gasoline a minuscule fraction (0.43 percent for the non-poor and 0.005 percent for the poor). Public transport constitutes 1.6 percent, and (in contrast to developed countries) its share increases with income (it is 1.7 percent for the non-poor vs. 1.3 percent for the poor).

A second issue which a study of transport taxation is supposed to answer is cost recovery. Abbey-Sam and Bhandari (1988) estimated the long-run maintenance costs of the interurban system (including rehabilitation) at $31 million annually. The tax revenues in 1987 from the annual licensing fees are estimated at $0.9 million (at the official exchange rate; TecnEcon, 1988, p. 2-6) and the 1988 expected revenue from fuel taxes at $26.8 million (the TecnEcon estimate is based on 1988 rates given 1987 consumption), of which $7.4 million are earmarked for the road fund. Revenues from toll roads and bridges are minuscule. Total tax revenues fall only slightly short of the $31 million target. However, the tax fraction earmarked for the road fund covers less than one quarter of the needs. Furthermore, almost 40 percent of the revenue comes from non-road users (the railway, boats and non-transport users).

When weather is an important contributor to road damage costs, optimal road user charges may not cover the total costs and cost recovery depends on the share of charges due to congestion costs. By Table 13, even if one adopts the low estimates of the trucks' damaging factor, the estimate of total RUC exceeds $31 million. Thus, a transport tax system that is structured to cover user costs should be adequate to cover annual maintenance. For that purpose one has to substantially raise the annual licensing fees of the heavy trucks (to a level of $800 per vehicle) and strictly enforce both the licensing rules and the rules pertaining to axle loading. Alternatively, if such a sharp increase in the license fee is deemed politically unfeasible, one should cancel the exemption of heavy trucks from import duties. An import tax of 15 percent and a 10 percent purchase tax (the standard rate on consumption imports) will go a long way to covering RUC (and will be much harder to evade, compared with the license fee).[8]

The final question this study is supposed to answer is what lessons can be learned from the Ghanaian experience (and from that of Tunisia) on the estimation of road user charges in LDCs. In many respects, the Ghana experience is typical of many other LDCs in the Sub-Sahara and other regions. International standards can be applied with few adjustments to estimate the road damage costs. The required price matrix is often available and, if not, can be estimated at relatively modest cost. The only important component in this equation which is often missing is the average axle load of freight transport. Countries that have not yet developed sufficient awareness of the excess axle-load problem may lack data on the magnitude of this problem. The Ghanaian data show that excess axle loads may vary not only among countries but also on different roads, and in different samples. The error's order of magnitude may exceed 100 percent, making it futile to graft external estimates in order to allocate the costs among different types of vehicle. Extensive research is required in order to evaluate the severity of the problem in Ghana and elsewhere.

Ghana is not typical where the measurement of congestion costs is concerned. As indicated above, accepted international standards in this field are nonexistent and even had they existed they would be insufficient to allow the estimation of congestion costs on urban and interurban roads. The Ghanaian case may prove unique, given the wealth of information

[8] Slightly lower rates should be placed on medium trucks.

on urban traffic conditions. These data indicate that the application of 'borrowed' estimates (such as Newbery's Tunisian estimates of the MTC) may lead to gross mistakes and erroneous policy recommendations. In Ghana's case, urban congestion costs are estimated to be only one half of the damage costs (they are only one quarter if one adopts the higher estimates of the damage costs). However, rapid urbanization and motorization, on the one hand, and improved road standards, on the other hand, may change the relative importance of the two problems in the future (as was shown in Tunisia). Recent research of road-user charges in LDCs has emphasized the damages externality, playing down the importance of congestion. This may have been the right research policy in the past, but it may have to be reevaluated in the future.

Finally, to estimate average road user costs and to weigh the importance of damage and urban and interurban congestion costs for the various types of vehicles one has to know the distribution of the vehicles' annual km between urban and interurban roads. These data are not collected routinely (as, for example, are interurban road traffic counts). Their collection requires special surveys. These surveys are lacking in Ghana as in most other SSA countries.

The most important lesson relates to the feasibility of road-user costs studies. In this study the sensitivity of the results to different assumptions was strongly emphasized, but this is not unique to a study of RUC in LDCs or sub-Saharan Africa; it applies as well to the developed countries (as demonstrated by Newbery's study). More important is the fact that this study, with all its inaccuracies and reservations, was at all feasible.

Embarking on this study, Ghana was chosen as an example of a data-poor country. This impression was dispelled. Though in a few cases (mentioned above) the data are missing, very often the problem was the existence of several conflicting sources of data. Most of these sources did not exist a few years ago and have been established as part of the transport rehabilitation program. A lot of work has to go into the consolidation of these data sources, and to assure the continuation of the information collection process, but the Ghanaian experience (although, perhaps, still rare in SSA) proves the importance and feasibility of information gathering as part of any major transport program.

Appendix

The Distribution of Travel between Urban and Interurban Travel

Information on the distribution of travel between urban and interurban travel can be obtained from direct surveys on traveling habits. In the absence of such surveys one has to use an indirect method. Information on the vehicle fleet, and vehicle utilization allows estimation of total travel. Highway traffic counts yield data on interurban travel. Urban travel, on which little is usually known, is derived as the difference between total and interurban travel. By this method the estimate of urban travel compounds the errors of all other estimates. Unfortunately, it sometimes yields inconsistent results.

For example, the 1987 data on the vehicle fleet (Table 4a) show 2,140 heavy trucks [multi-axle or gross vehicle weight (GVW) in excess of 16 tons]. By GHA estimates the annual utilization of these trucks is 80,000 km per vehicle. Total distance traveled, by this estimate, is therefore 170 million km. The daily traffic counts generate an estimate of 5.58 million km (Table 5) or an annual estimate of about 2,000 million vehicle-kms. The GHA estimates (Table 7) that heavy trucks constitute 14 percent of interurban travel, i.e., 280 million veh-kms, which exceeds the estimate of total travel by this type of vehicle. Similar problems are encountered in the case of heavy buses and light trucks.

The source of this problem possibly lies in the underestimate of the vehicle fleet. In Table A1 it is assumed that the vehicle fleet consists of 105 thousand vehicles. Their distribution by type is based on the VEL (Vehicle Examination and Licensing) data (Table 4a) and the evaluation of TecnEcon on the size of the bias (1987, Appendix 3). The annual utilization is based on the GHA estimates, total interurban travel is assumed to be 2,000 million veh-kms, and the distribution is based on GHA estimates (Table 7). According to this method, total veh-km is 5,200 million, of which over 60 percent (3,200 million) are traveled on urban roads. This method, however, generates an urban traffic distribution (column 8) which is inconsistent with the one reported by DeLeuw-Cather (Table 7).

The distribution of travel used in Table 11 is derived under the assumption that total veh-km is 5,000 million, that the share of urban travel is either 60 or 40 percent (Table A2, panels A and B, respectively), and that within urban and interurban travel the distribution is given by Table 7. Given urban and interurban travel by type of vehicle, one can derive the distribution of total travel by mode and annual utilization. The latter is quite close (especially panel B) to the GHA figures.

Table A1. Distribution of Travel by Urban and Interurban and by Type of Vehicle (a)

	Vehicle fleet ('000) (1)	Annual utili-zation ('000 km) (2)	Total Veh-km (mil) (3)	Per-cent (4)	Interurban Veh-km (mil) (5)	Interurban % (6)	Urban Veh-km (mil) (7)	Urban % (8)
Cars (incl. taxis and P/U)	68	40	2,720	52	760	38	1,960	61
Light buses	16	55	880	17	260	13	620	19
Heavy buses	7	75	525	10	360	18	165	5
Light trucks	4	70	280	5	220	11	60	2
Medium trucks	5	80	400	7	120	6	280	9
Heavy trucks	5	80	400	7	280	14	120	4
Total	**105**	**49.6**	**5,205**	**100**	**2,000**	**100**	**3,205**	**100**

Sources: Col. (1) — Adjusted figures; col. (2) — GHA estimate; col. (3) = (1) × (2); col. (5) = 2,000 × (6); col. (6) — Table 7; (7) = (3) × (5).

Table A2. Distribution of Travel, Urban and Interurban, and by Type of Vehicle (b)*

	Veh-km (mil)			Vehicle fleet	Annual utilization ('000 km)	Share of urban travel (%)
	Inter-urban	Urban	Total			
A. Share of urban travel 60 percent of total travel						
Cars	760	2,400	3,160	68	46.5	76
Light buses	260	300	560	16	35.0	54
Heavy buses	360	60	420	7	60.0	14
Light trucks	220	150	370	6	61.6	41
Medium trucks	120	60	180	4	45.0	33
Heavy trucks	280	30	310	4	77.5	10
Total	**2,000**	**3,000**	**5,000**	**105**	**47.6**	**60**
B. Share of urban travel 40 percent of total travel						
Cars	1,140	1,600	2,740	69	39.7	58
Light buses	390	200	590	15	39.3	34
Heavy buses	540	40	580	7	82.9	7
Light trucks	330	100	430	6	61.4	23
Medium trucks	180	40	220	3	73.3	18
Heavy trucks	420	20	440	5	88.0	5
Total	**3,000**	**2,000**	**5,000**	**105**	**47.6**	**40**

* It is assumed that total travel is 5,000 million veh-km and that the distribution by type is given by Table 7.

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