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Road User Charges Model

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This Technical Note presents a Road User Charges Model [1] developed by the World Bank based on the methodology described in the World Bank Technical Paper number 275 titled "Management and Financing of Roads—An Agenda for Reform" by Ian G. Heggie [2]. The note gives an overview of the objectives, structure, and results of the model by taking as an example a hypothetical road network, and presents some lessons learned while applying the model in developing countries. The model will soon be made available in the SSATP external Web Site.

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The Model

The Road User Charges Model (RUC) is setup on an Excel 97 workbook and evaluates, for a particular country, the annual funding needs of the entire road network and the annual revenues collected from user charges. The model takes an aggregated view of a country's road network and vehicle fleet, evaluating representative road classes and vehicle types. The main model objectives are the following:

- ensure that road user charges fully cover the costs of operating and maintaining the inter-urban and urban road networks;
- ensure that all vehicle classes cover their attributable variable costs of road usage;
- compare the funding needs of the country road networks (primary, secondary, urban, etc.);
- assess the distribution of revenues from road user charges among road networks administrations (main road agency, municipalities, etc.);
- define gasoline and diesel levies needed to finance a road fund;
- compute financing and revenues indicators; and
- estimate the magnitude of fuel emissions and other externalities.

Usually the entire road network of a country is divided into a series of road networks through a functional classification and these networks are managed by different entities. For example, the entire road network could include main trunk roads managed by the main road agency; secondary roads managed by states, provinces or municipalities; and urban streets and avenues managed by municipalities or urban district councils. The RUC model estimates the annual costs of operating and maintaining each of these networks on a sustainable basis —which means considering that a network is in good to fair condition— without the need of rehabilitation due to a backlog of deferred maintenance. The maintenance costs are estimated by defining the most advantageous maintenance strategy for a series of road classes. Note that the actual expenditures may be lower than these costs, since maintenance may be underfunded. The maintenance costs are divided into annual maintenance, which consists of routine maintenance and recurrent annual activities such as patching and gradings, and periodic maintenance, which consists of periodic activities such as overlays and regravellings. In case of periodic activities, the model estimates the annualized average costs. Costs are broken down into fixed and variable costs, which vary with traffic and traffic loading. For example, for a hypothetical country, one has the following considering that the main roads network includes all paved roads and the main unpaved roads and the secondary roads network includes mostly low volume feeder roads.

An estimate of the annual investments needed to rehabilitate and develop each network could be optionally added to the recurrent expenditures to define the total funding needs

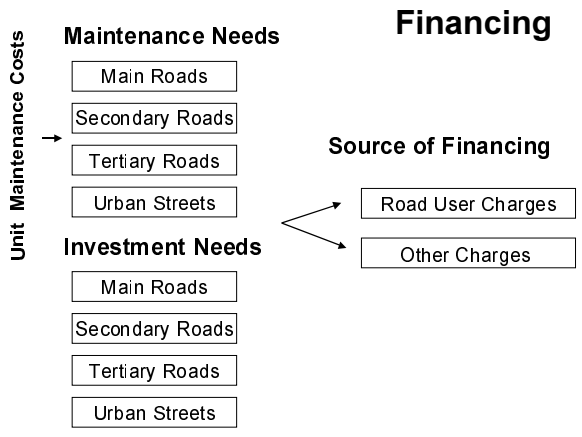
Road Network	Length (km)	Vehicle Utilization (M veh-km Per yr)	Annual Maintenance Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)
Main Roads	8568	1903	2.8	3.1	5.9
Secondary Roads	8277	76	1.2	1.1	2.3
Streets & Avenues	3448	1162	1.0	0.7	1.7
Entire Network	20293	3141	5.0	4.9	9.9

Road Network	Periodic Maintenance Fixed (M$/yr)	Variable (M$/yr)	Total (M$/yr)	Operating Costs (M$/yr)	Total (M$/yr)
Main Roads	19.5	5.7	25.3	2.3	33.4
Secondary Roads	0.0	0.0	0.0	0.0	2.3
Streets & Avenues	6.7	1.9	8.5	0.0	10.2
Entire Network	26.2	7.6	33.8	2.3	46.0

of the entire network. The next step is to define the source of funding . The model considers that all variable costs should be met through user charges and the model user defines the proportion of fixed costs to be met through user charges. The remaining fixed costs are assumed to be met with other revenues, such as parking charges and local property taxes. For example, one could have the following considering that all fixed costs of secondary roads and urban roads are met by other revenues.

Proposed Financing Table

Road Network	By User Charges (M$/yr)	By Other Revenues (M$/yr)	Total (M$/yr)
Main Roads	33.4	0.0	33.4
Secondary Roads	1.1	1.2	2.3
Streets & Avenues	2.6	7.7	10.2
Entire Network	37.1	8.9	46.0



The calculations regarding road network funding are outlined below.

The model estimates road user charges revenues collected from the following road user charges instruments:

- gasoline levy;
- diesel levy;
- alcohol levy (whenever applicable);
- annual license fees;
- annual load damage fees; and
- tolls.

The characteristics of the vehicles using the road network are defined as well as the current unit user charges. For example, one has the following for the hypothetical country under consideration.

Vehicle Type	Number of vehicles (veh)	Kilometers Driven Per year (km/yr)	Equivalent Standard Axle per vehicle (ESA/veh)	Fuel Consumption (l/ veh-km)
Car Gasoline	58,801	22,400	0.000	0.10
Car Diesel	14,700	11,200	0.000	0.10
Taxi Gasoline	6,400	25,600	0.000	0.10
Taxi Diesel	1,600	12,800	0.000	0.10
Utility	52,273	12,800	0.001	0.13
Light Truck	3,863	14,000	0.030	0.18
Medium Truck	14,166	14,000	1.150	0.29
Heavy Truck	2,576	14,000	1.250	0.43
Articulated Truck	5,151	19,200	2.000	0.53
Bus	6,272	28,000	0.750	0.38
Total	165802			

Current Annual License Fee		Current Fuel Levy	
Vehicle Type	($/veh/yr)	Fuel Type	($/liter)
Car (Gasoline)	25	Gasoline	0.20
Car (Diesel)	25	Diesel	0.10
Taxi (Gasoline)	18		
Taxi (Diesel)	18		
Utility	25		
Light Truck	30	**Resulting Revenues (M$/yr)**	
Medium Truck	50	Diesel Levy	30.7
Heavy Truck	60	Gasoline Levy	29.6
Articulated Truck	90	License Fees	5.0
Bus	50	Total	65.3

If there are no toll roads or annual load damage fees, the resulting user revenues will be US$65.3 M per year, which is higher than the financing needs of US$ 37.1 M per year.

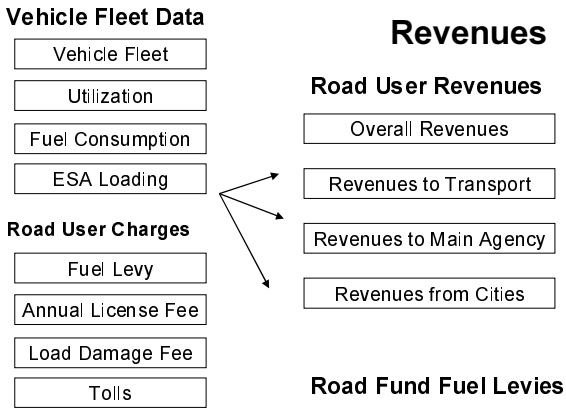
Thus, road user charges fully cover the costs of operating and maintaining the inter-urban and urban road networks. The model computes, for each vehicle type, the unit charges needed to be applied to a vehicle type in order to cover its variable costs, in US cents per vehicle-km. The model also computes the current unit user charges being charged, in US cents per vehicle-km, which can be compared with the required charges to ensure that each vehicle type covers its attributable variable costs of road usage. For example, one has the following.

Vehicle Type	Charges Needed to Cover Variable Costs (c/veh-km)	Current User Charges (c/veh-km)	Current User Charges > Charges Needed	Current User Charges over Charges Needed
Car (Gasoline)	0.17	2.11	Yes	13
Car (Diesel)	0.17	1.22	Yes	7
Taxi (Gasoline)	0.17	2.07	Yes	12
Taxi (Diesel)	0.17	1.14	Yes	7
Utility	0.17	1.50	Yes	9
Light Truck	0.21	2.01	Yes	10
Medium Truck	1.61	3.26	Yes	2
Heavy Truck	1.74	4.73	Yes	3
Articulated Truck	2.68	5.77	Yes	2
Bus	1.11	3.98	Yes	4

The results indicate that cars, taxis and utilities should be charged at least US cents 17 per vehicle-km to cover their variable costs and trucks and buses at least from US cents 0.21 to 2.68 per vehicle-km. The current user charges, based on the license fees and the gasoline and diesel levies of US cents 20/liter and of US cents 10 /liter respectively, yield revenues from road user charges 2 to 13 times above the required charges. Gasoline cars are paying 13 times the requirements, diesel cars 7 times, and trucks and buses from 2 to 4 times. Thus, in this case, all vehicle classes cover their variable costs and one can observe that cars are paying more than trucks in relation to their imposed variable costs of road usage .

Considering that road user charges are collected by the government but not necessary allocated to the road agencies in charge of managing the road networks, the model computes the revenues being allocated to each road network administrator. For example, if currently only US cents 5/liter of the diesel and gasoline levies are being assigned to the main road agency, the agency receives only US$22.8 M per year, which is not enough to cover the US$33.4 M per year needed to operate and maintain the main roads network, yielding a deficit of US$10.6 M per year.

A road fund is often created to finance the needs of the main roads network. For this purpose, the model finds the most desirable set of gasoline and diesel levies that would: (a) equilibrate the revenues with the financing needs; and



(b) minimize the unit variable user costs surplus for each vehicle type. For example, the model finds that to obtain US$33.4 M per year, a gasoline levy of US cents 8 /liter and a diesel levy of US cents 7 /liter will be needed. In this case, cars will pay 4 to 5 times their variable costs requirements and trucks and buses 1 to 2 times their variable costs requirements.

Considering that the GPD of the hypothetical country is US$ 2,000 M, the road maintenance financing needed for the main roads is 1.7 percent of the GDP and the actual road user charges revenues being collected by the government are 3.3 percent of the GDP. The emissions of carbon dioxide are estimated to be around 1.2 million tons per year and the network congestion and accident costs are estimated to be around US$24 M per year and US$ 34 M per year respectively. The calculations regarding road user charges and revenues are outlined above.

Lessons learned

The application of the model in eight developing countries, mostly in Latin America, produced some initial lessons outlined below, but due to the small sample, care should be taken extrapolating these results to other countries.

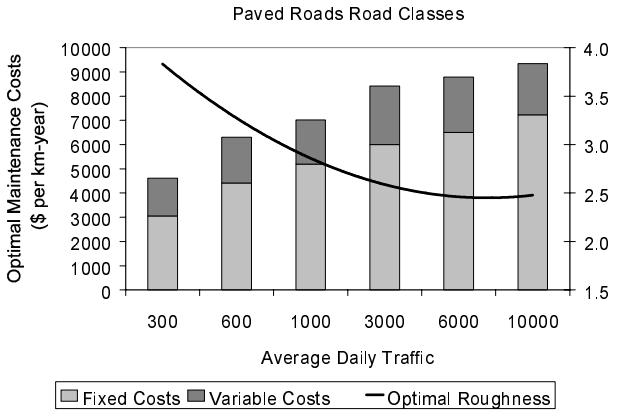
Countries classify their road networks under different functional classifications schemes and assign the responsibility of managing the networks to different agencies. Typically there is a national main road agency in charge of the main trunk roads and the states, provinces, municipalities or district councils manage the rest of the inter-urban road network, while the municipalities or district councils manage the urban network. It was found that some main road agencies manage up to 50 percent of inter-urban roads but most of the main road agencies surveyed manage around 17 percent of the inter-urban roads, which represents around 64 percent of the inter-urban vehicle utilization, in million vehicles-km per year. The around 50 percent of inter-urban roads managed by some main road agencies, represent almost 95 percent of the vehicle utilization. These results are summarized below.

		Network length (km)	Network utilization (M v-km per year)	Maintenance needs (M$ per year)
Some Cases	Main Roads	50%	95%	90%
	Other Roads	50%	5%	10%
Most Cases	Main Roads	17%	64%	35%
	Other Roads	83%	36%	65%

For the countries where the main road agencies manage 17 percent of the inter-urban network, the maintenance needs of the network managed by the main road agency represents 35 percent of the total inter-urban maintenance needs, while for the countries that manage 50 percent of the inter-urban network, the main roads needs is around 90 percent. These results show that (a) a distribution of resources among road networks based only on the proportion of network length, or network utilization does not yield the same results as a technical evaluation, and (b) if the distribution of resources is based only in terms of network utilization, the main inter-urban roads network receive preferential treatment.

It was found that the annualized maintenance needs (including annual and periodic activities) of the main inter-urban roads networks vary from US$3,300 to US$8,300 per km-year, with an average of US$5,500 per km-year. For the other inter-urban roads networks, which consists of mostly unpaved low traffic roads, the annualized maintenance needs vary from US$300 to US$2,300 per km-year, with an average of US$1,500 per km-year. For the main inter-urban roads networks, the annualized maintenance needs represent on average US cents 1 per vehicle-km, while for the other inter-urban roads networks, the needs represent on average US cents 5 per vehicle-km. The total inter-urban annual maintenance needs represent from 0.2 percent to 1.7 percent of the GDP, with an average of 0.8 percent of GDP.

The actual diesel levy varies from USc 10 per liter to US cents 16 per liter with an average of US cents 13 per liter, while the gasoline levy varies from US cents 13 per liter to US cents 57 per liter with an average of US cents 29 per liter. A passenger car license fees vary from US$25 per year to US$270 per year with an average of US$140 per year, while a medium truck license fee varies from US$50 per year to US$2,200 per year with an average of US$ 820 per year. These road user charges generate revenues that are, on average, twice the funding needs of the maintenance of the entire road network, but that does not mean that revenues being collected are necessarily being allocated to the road sector. It was also found that cars pay, on average, 16 times their attributable variable costs of road usage and medium trucks pay 5 time their variable costs.



To estimate the network maintenance funding needs, the model needs as an input the unit maintenance costs for a series of road classes, in US$ per km-year, which are broken down into fixed and variable costs. The chart above presents representative maintenance costs found for paved roads with different traffic levels. These costs were estimated by finding the most desirable maintenance strategy per road class, which is the one that yields the least present value of total life-cycle society costs (road agency plus road user costs). Note that, for these roads, the fixed costs represent around 74 percent of the total costs and the chart also shows the resulting average road roughness if the recommended maintenance strategy is implemented.

Conclusion

The model has proven to be a useful tool for an aggregate assessment of the entire road network of a country both in terms of the network maintenance and development financing side and of the road user charges and revenues side. It can be used to evaluate the total financing needs of the entire network, proper allocation of funds among road networks, and road user revenues and its distribution among network administrations . The model is particularly useful to set road user charges as a dedicated revenue source for a proposed road fund.

To learn more

1. Ian Heggie, Rodrigo Archondo-Callao. 1999. Road User Charges Model. Version 3.0. 4/4/99. Transportation, Water and Urban Development Department. The World Bank, Washington, DC
2. Ian Heggie. 1995. Management and Financing of Roads – An Agenda for Reform. World Bank Technical Paper Number 275. The World Bank, Washington, DC.
3. Ian Heggie, Piers Vickers. 1998. Commercial Management and Financing of Roads. World Bank Technical Paper Number 409. The World Bank, Washington, DC.