

Financing of Low-Volume Roads in Argentina

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Considering the wide spectrum of problems that needs to be addressed in the administration of road systems in developing countries, the financing of low-volume roads in Argentina deserves particular attention. In dealing with the overall problem of improving the efficiency in the assignment of resources within the public sector of the Argentine economy, an analysis of the economic objectives of road financing is presented through a proposal leading to the implementation of a road pricing mechanism. One purpose is to present a cost structure model of the Argentine road system to identify the optimal objective that would lead to an efficient and equitable system of road financing. This analysis would make it possible to channel private resources to the maintenance of the road network that the country needs, as well as to return the concession of public works to a private sector as an instrument available for the financing of roads in Argentina. On the other hand, this same analysis can be used to compare road system costs and revenues by type of vehicle and surface of road, from which it can be deduced that the present system of road user fees in Argentina is producing an important hidden cross-subsidization from low-volume to primary-road users. This process, in turn, causes the overutilization of paved roads and the underutilization of rural—generally nonpaved—low-volume roads. This inefficiency in the assignment of the resources for roads calls for a profound revision of the present revenue system, which is unjust to the users. It is necessary to turn to a taxing policy that would function like an incentive—pricing to marginal costs, for example—for a more rational utilization of the roads in the country.

“There are no free roads in the world, there are just different ways of paying for them.”—William J. Miller, Jr., United States.

In view of problems that the growth of road systems has given rise to in developing countries, special attention is needed to the financing of road management and maintenance. For example, in Argentina motor vehicle registrations have increased six times in the last 25 years without a similar increase in road maintenance sources.

The experience in the evolution of road transport in Argentina since 1960—responsible in the short term for most passenger and goods transport—has clearly shown that it is much more difficult to develop an institutional capacity for proper road maintenance than to build the road networks themselves.

In Argentina during the last 10 years at least, roads have been built but not maintained. That situation is important in this country, where rural production makes intensive use of roads: 90 percent of grain transport and almost 100 percent of livestock transport are by trucks.

This research, which purports to be a needs analysis and a pricing study, presents an analysis of the costs that Argentine

road agencies should expend to maintain properly not only rural and secondary roads, which are usually gravel or earth roads, but also paved interurban roads. Likewise, these costs of road infrastructure are broken up among the various users according to their utilization of the roads (1).

In the same way, this provides an analysis of the revenues that road organizations should receive as specific resources; it implies dedication of user fees. These taxes for the utilization of roads, or an indirect toll, represented by charges on different vehicle inputs, are also broken up among the users (2).

Interesting information arises from the comparison of these road costs and the user taxation hypothesis, identified by type of vehicle and road. Analysis shows that the present road tax system produces an unfair participation of the users in the financing of the various types of roads and thus generates a clearly inefficient resource allocation.

The main inputs on which road taxes are imposed—gasoline, oils, and tires—do not appropriately reflect the road consumption of the users, making these charges invalid as road prices or inefficient as assigners of road resources. This would produce an important hidden cross subsidy from gravel and earth road users to paved road users, giving rise to a detrimental effect of overuse of high-volume roads and underuse of rural low-volume roads.

In Argentina, the average daily traffic (ADT) on primary paved roads is 1,650 vehicles per day (vpd), on gravel roads it is over 100 vpd, and on earth roads it is almost 50 vpd. The study focuses primarily on the interurban network and on the inequity between road user charges and the actual costs of different classes of vehicles on that network. However, there are also inequities in the allocation of costs caused by urban traffic congestion and by the combination of all user taxes into a central, single fund. The incorrect allocation of resources based on the current processes has impaired the maintenance of the primary network and has resulted in a critical need to rebuild 10 000 km of primary roads.

The realization of serious inefficiency in the allocation of road resources, the relevant unfairness toward low-volume road users, and the recent program for the reconversion of the road network should lead to a profound conceptual revision of the road resources collecting system. This should result in a criterion of user taxation on marginal road costs and a more equitable cost-allocation policy because it would promote the idea of user taxation and rational utilization of the entire road network (3).

Finally, within the present context of restructure of the role of the public authorities in the road transport sector, it is considered that this scheme of analysis establishes conceptual

foundations (4) to favor the canalization of resources from the private sector towards the road infrastructure that the country imperatively needs in the short term, and to place the concession of public work (5,6) and road toll back into the frame of available means (7,8) for the financing of the maintenance and improvement of roads in Argentina.

COSTS OF ARGENTINE ROAD AGENCIES

The treatment of the costs of Argentine road agencies follows the research approach developed by authors (9–11) who support the concept of user taxation on the basis of marginal costs of road use.

This concept shows that taxes should be charged on the economic costs of user trips and not on the costs of the construction or maintenance of the facility. Neither of these costs can be reduced when road users do not use the road. With the aim of achieving efficient allocation of the existing and available road resources, it would be a mistake to charge them at a fraction of the costs of the trips of the road system users.

The costs of the road system that have to be paid by the users vary with the volume of traffic. This concept of collection—known as the “marginalist” economic criterion—leads to the maximization of the net social benefits and ensures an efficient allocation of the scanty productive goods (12,13), but it also implies revenues lower than expenditures in the budgets.

To keep the concept of the research and the character of the methodology of the model used, the following simple relevant assumptions are made:

1. The initial assumption made is that the land transport sector is in a state described in economics as “first best” (14), and the criterion is that road transport—both passengers and goods—should neither take up nor generate resources in relation to other means of transport and to the rest of the economy.

2. The costs of the roads to any agency are related to the management, construction, maintenance, and right of way. They are classified as variable and invariable—whether they depend on the traffic or not—to allow the treatment of the costs of road organizations by means of an economic analysis, in accordance with the traditional approach of the theory of the firm.

3. The differentiation of the construction, rehabilitation, and maintenance costs into invariable and variable is a highly problematic matter. A criterion—life cycle cost—based on the observed periodicity in the investments during a road’s useful life was used.

4. Although the climate and topography are highly important variables in determining road costs, at this stage of the study the temporal and regional variability of road costs are not considered, assuming that such costs depend only on transit through the concept of the ADT.

5. At first, this transit is seen through the criterion of a hypothetical standard vehicle, and then it is assumed that there are four types of vehicles: automobile, bus, and light and heavy truck. Likewise, the model considers three categories of roads: paved, gravel, and earth or dust, thus shaping a 3×4 matrix on which the analysis will be based.

In order to determine the costs of the road agencies in Argentina, it was necessary to process not only their expenditures as a result of the contracts with the private sector to execute the rebuilding, improvement, and maintenance works—through price tenders and private and public biddings—but also to estimate the costs of routine maintenance works, generally carried out under the supervision of the road agencies themselves.

The concept of marginal cost is defined as “long-term marginal costs,” so it includes as variables the short-term fixed costs. Starting from the generally accepted expression of costs C of any road agency, with their components (fixed A and variable B) in terms of transit ADT,

$$C \text{ (\$/km-year)} = A \text{ (\$/km-year)} + B \text{ (\$/ADT/km-year)} * \text{ADT} \quad (1)$$

From the analysis and statistical treatment of correlations of the investments done in the different categories of roads (paved, gravel, and earth) as well as the transit assessed on the same, the estimated values of the annual fixed road agency Cost A and annual variable road agency Cost B are presented in Table 1.

By replacing the values obtained in the general expression of agency road costs, the following system of equations is inferred for 1989:

$$C_{\text{pavement}} \text{ (\$/km-year)} = \$1,800.00 + \$1.25 * \text{ADT} \quad (2)$$

$$C_{\text{gravel}} \text{ (\$/km-year)} = \$350.00 + \$4.15 * \text{ADT} \quad (3)$$

$$C_{\text{earth}} \text{ (\$/km-year)} = \$150.00 + \$10.00 * \text{ADT} \quad (4)$$

By equating the expressions, it is possible to estimate the break-even ADT values when the agency road costs of maintenance become equal for two categories of roads. Strictly, for initiating improvements like paving a gravel road, it has to be determined by equating life cycle costs, including user costs, for the two categories of roads. In fact, the break-even values (ADT 500 and 34) coincide approximately with those obtained in similar analyses in other Latin-American countries (15), and they would validate the results and their cost relations.

The variable agency road costs detected have been estimated for the hypothetical standard automobile referred to, also called “equivalent.” According to the analysis of the range of vehicles using the Argentine road network, users can

TABLE 1 ESTIMATE OF COSTS OF ARGENTINE ROAD AGENCIES

Road Category	Invariable Cost A (US\$/km-year)	Variable Cost B (US\$/km-year-ADT)
Paved road	1 800.00	1.25
Gravel road	350.00	4.15
Dust road	150.00	10.00

NOTE: Invariable costs include all the road investments that do not change with the transit in the short term. Variable costs are the road agency’s expenditures that change with the traffic stream.

be grouped in the four categories mentioned: automobiles and pickups, buses, light trucks (without trailer), and heavy trucks (semitrailer and trailer).

In order to determine the incidence of each of these categories of vehicles in the costs of road agencies, there are basically two possible concepts to be used: A fundamentally geometric criterion, called road space occupation (16), based on mechanical and operational characteristics of the vehicles, and other structural criterion, or road consumption, which takes into account mainly the destructive effect of loads through axles on the road (17).

In the present analysis, a mix of both concepts is chosen, predominating the incidence of the structural criterion on paved roads and that of road space occupation on gravel and earth roads, resulting in costs allocated to each type of users over each road category as presented in Table 2.

It is appropriate to emphasize that, for automobiles and buses, the marginal costs of road agencies are increasing from paved roads to natural soil roads; conversely, for light and heavy trucks, marginal costs are decreasing in this sense, although they are ever higher than formerly. This can be explained by the mainly superficial consequences of light transit on gravel and dust roads and by the effects on lower layers of heavy transport, which affects pavements to a greater extent.

A large portion of ADT consists of automobiles, and the cost per kilometer of operation declines in dust roads, which are cheap to build, deteriorate rapidly with use, and must be bladed often. Light and heavy trucks do about the same damage as a car on dust roads, but they are a small portion of the vehicle stream, so the damage done per passage is less expensive to repair than the damage to paved roads.

The estimative character of the long-term marginal costs allocated to the various users should be especially considered, in view of the simplifying assumptions that have to be done to modelize the cost structure of Argentina's road agencies, as well as numerous conflicts that have been overcome by means of hypotheses and solutions of agreements, always questionable. However, this information, under reasonable observation, is valid.

PRICES FOR ROAD UTILIZATION

The particular characteristics of road networks must be considered in relation to financing (18,19), especially the tem-

poral variability of the concept of roads as public goods. When traffic volumes are lower than the highway capacity, the assumptions of nonrivalry and nonexclusion are valid regarding road space consumption among the users and the financing can continue to be done under the concept of road use tax or indirect toll. These roads with very low volume to capacity ratios are noncompensatory.

But, in spite of the fact that even congested roads are quasi-public goods, when roads approach their capacities, producing congestion, these assumptions need to be discussed. Crowding out among users appears and it's possible to establish a proposal for fixing road prices by means of direct tolls, whether open or closed, to ration efficiently the scanty factor road and oblige the transit to internalize all the negative externalities associated with traffic congestion. In this case, the revenues will exceed agency direct costs.

All that conforms to a public service system in which it is of prime importance for the private costs of use of the different vehicle users on the different road categories to be as similar as possible to the costs society has to afford—through road agencies budgets—to provide each of them with a road infrastructure service.

It's fundamental to perceive this optimum allocation—ideal but valid as an objective to aim at—because the private costs of operating the various vehicle users are the ones that developed the role of prices for road using. Consequently, the correct assessment of the costs ensures an approximation to an efficient allocation of the resource road equally available among the users.

In this sense, the operating costs of the four types of vehicles on the three road categories are analyzed according to usual methodologies (20). Because the average operation speed is the fundamental variable to determine the vehicle costs, it was necessary to assume average values observed in Argentina's roads. The results are presented in Table 3.

With the operating speeds defined for each vehicle-road situation, estimated road taxes were broken up, starting from the total operation costs, to compare this revenue with the variable costs B ; such charges were identified as taxes on gasoline, oil, and tires, which were added to the taxes on the ownership of vehicles such as for license plates and on buying and selling. Such components of the user cost were assumed as road price or indirect tariff because of road use, having the values presented in Table 4 as a result.

TABLE 2 ESTIMATE OF VARIABLE COST B OF ROAD AGENCIES (US\$ 1989/km-year-ADT)

Type of Vehicle	Cost (US\$) by Road Category		
	Pavement	Gravel	Natural Soil
Car	1.25	4.15	10.00
Bus	7.19	14.53	18.58
Light truck	55.48	22.83	19.80
Heavy truck	93.83	39.43	24.20

NOTE: The ADT is decomposed in each road category using PCEs and ESALs. These equivalencies were obtained with the assumption of different mix of both criteria for the three road categories on the basis of average operation condition, which may vary significantly for the four given vehicle types.

TABLE 3 AVERAGE OPERATING SPEED ON ARGENTINE ROAD NETWORK

Type of vehicle	Speed (km/hr) by Road Category		
	Pavement	Gravel	Natural Soil
Car	105	85	60
Bus	90	75	50
Light truck	85	65	40
Heavy truck	70	55	40

NOTE: The research needs speed to find user revenue contributions because some of the costs subject to user taxes—fuel consumption, tires, and oil do vary with operating speed to the same degree. All the vehicle variable operating costs are some function of speed.

TABLE 4 USER REVENUE CONTRIBUTIONS

Type of Vehicle	Contribution (US\$ 1989/km-year-ADT) by Road Category		
	Pavement	Gravel	Natural Soil
Car	7.22	8.01	9.14
Bus	11.74	13.83	15.62
Light truck	17.62	21.32	28.99
Heavy truck	26.44	37.73	44.71

NOTE: These user revenue contributions were obtained from the user taxes and the assumptions of equivalencies.

HYPOTHESIS ON VEHICLE COMPOSITION AND TRAFFIC DISTRIBUTION IN ARGENTINA'S ROAD NETWORKS

In order to start with the comparative study of the present financing situation of low-volume rural roads with gravel or natural soil surfaces in contrast with paved roadways in the country—treatment made through the cross-subsidization theories—it is necessary to determine the scope in which the model is developed.

Although it makes up more than 600 000 km of roads (22,23), the vast country road network was not taken into account in the analysis mainly because of the little existing information regarding the type and characteristics of the surfaces and the volume of transits.

The study was carried out on the arterial or primary road network (paved) and secondary systems (generally non-paved), road infrastructure that includes as a whole the distribution according to road category as presented in Table 5.

Various vehicle composition and ADT values were assumed on this network in each case, according to measurements and correlations. The ADT values assumed for each road category are the product of the measurements (24) and are in accordance with the range of transits found in the analysis of costs of Argentina's road agencies, as presented in Table 6.

Table 4 and indirect tolls indicate that, for all kinds of vehicles, charges always increase from paved roads to natural

soil roads. This is in accordance with marginal costs, which also increase (Table 2) because of automobiles and buses.

The marginal costs of light and heavy trucks increase more radically as these vehicles use lower-grade roads. Comparing user revenue contributions (Table 4), user revenue for cars increases 26 percent for vehicle use of soil roads compared with paved roads. Light trucks increase 64 percent and heavy trucks increase 69 percent. Since gravel roads and natural soil roads are the first stage of transport of Argentine rural production, it is important to correct or reduce this failure in the present criterion of road fund taxes on fuels or gasolines, oils, and tires, that impacts the space farm—paved roadway.

SOME RESULTS

In a balanced road-financing system (25,26), such deficiencies because of positive gaps between revenues and marginal costs are necessarily compensated by revenues lower than marginal costs on other types of users, through the mechanisms developed in the cross-subsidization theories.

Although strict comparisons between the marginal costs of road agencies—broken up according to vehicle and road type—and the corresponding indirect tolls, also classified according to user and road category, would provide important data for analyzing responsibilities in investments and assumed tariffs, the variety of taxes in road transport in Argentina and their permanent and sharp relative variations make it necessary to pay close attention to the measurements in order to obtain information that in any event will generally have a short period of validity.

From the marginal costs of road agencies (Table 2) and the indirect tolls detected (Table 4), under the hypothesis of utilization assumed in the system of analyzed roads, it can be inferred that if the whole of the specific resources that conform to the revenues of road agencies are taken into account, they would overpass by about +147 percent their present needs.

But, because less than 20 percent of the specific impositions go to road funds, that strong surplus changes into road revenues that are only enough to cover 53 percent of the long-term marginal costs, thus causing the present state of damage of the Argentine road network.

As a consequence, the research work was developed under the assumption of a balanced road budget that allows carrying out a detailed analysis of each type of vehicle and road category, determining their percentage shares both in the expenditures and in the revenues of the road system by means of a

TABLE 5 ANALYZED ARGENTINE ROAD NETWORK

Road Category	Length (km)	Percentage
Pavement	55 000	26
Gravel	40 000	19
Natural soil	115 000	55
Total	210 000	100

TABLE 6 PERCENTAGE OF VEHICLE COMPOSITION

Type of Vehicle	Road Category		
	Pavement (ADT = 500 vpd)	Gravel (ADT = 120 vpd)	Natural Soil (ADT = 30 vpd)
Car	60	70	75
Bus	5	7	10
Light truck	15	13	10
Heavy truck	20	10	5
Total	100	100	100

TABLE 7 ARGENTINE ROAD COMPOSITION EXPENDITURES (1), REVENUES (2), AND COVERAGE OR EQUITY RATIOS (3)

Type of Vehicle	Road Category			
	Pavement	Gravel	Natural Soil	Total
Car	(1) 2.37%	1.60%	3.04%	7.01%
	(2) 25.84%	5.83%	5.24%	36.91%
	(3) 10.90	3.64	1.72	5.27
Bus	(1) 1.14%	0.53%	0.74%	2.41%
	(2) 3.50%	0.96%	1.17%	5.63%
	(3) 3.07	1.81	1.58	2.34
Light truck	(1) 26.30%	1.68%	0.79%	28.77%
	(2) 15.75%	2.96%	2.17%	20.88%
	(3) 0.60	1.76	2.75	0.73
Heavy truck	(1) 59.32%	2.18%	0.31%	61.81%
	(2) 31.54%	3.93%	1.11%	36.58%
	(3) 0.53	1.80	3.58	0.59
Total	(1) 89.13%	5.99%	4.88%	100.00%
	(2) 76.63%	13.68%	9.69%	100.00%
	(3) 0.86	2.28	1.99	1.00

NOTE: When the direct road system marginal cost recovery or equity ratio (3) is <1, it indicates underpayment of revenue relative to marginal cost responsibility.

coverage ratio, as presented in Table 7. An analysis of both vehicle type and road category follows.

Analysis According to Vehicle Type

Automobiles and Pickups

This type of vehicle on paved roads is heavily taxed; its contributions surpass the costs they cause to road agencies approximately 990 percent. On rural gravel roadways and dusty country roads, the situation is similar, and the contributions surpass the expenditures 260 and 70 percent, respectively. On the whole, the taxes of this category of vehicle surpass its costs more than 400 percent, and the equity ratio shows that overall passenger cars pay 5.27 times their marginal cost responsibility.

Buses

This type of vehicle also covers its costs, surpassing them 200, 80, and 58 percent on pavements, gravel, and dust roads, respectively. On the whole, its contributions surpass 130 percent of the expenditures caused to road organizations.

Light Trucks

On pavements, this type of vehicle only covers 60 percent of its expenditures, whereas on gravel and natural soil roads its contributions exceed the costs by 76 and 175 percent, respectively. In general, its contributions reach 73 percent of expenditures.

Heavy Trucks

In this case, the subsidy on pavements becomes more acute, the revenues are only 53 percent of its costs, whereas on gravel and dust roads, the contribution surpasses the expenditures

by 80 and 258 percent, respectively. In view of the strong incidence of its high traffic volumes on paved roads, it covers on the whole only 59 percent of the costs produced to the agencies.

Analysis According to Road Category

Pavements

Taking into account the conditions of system length, vehicle composition, and assumed traffic, for this type of road, with 26 percent of the network under study, 24.5 million vehicle-km circulate daily (77 percent of total traffic), and in spite of the relevant surplus obtained from automobiles and buses, the existing subsidies for trucks cause the revenues only to reach 86 percent of the investment in this road type.

Rural Gravel Roads

In this system, which accounts for 19 percent of the total analyzed network with a circulation of about 5 million vehicle-km daily (13 percent of the total traffic), the users, in all vehicle categories, contribute +128 percent of the expenditures of the agencies in this road category.

Country Dust Roads

Three and one-half million vehicle-km daily (10 percent of total traffic) circulate in these 115 000 km, 55 percent of the model network; and the taxes on the users of this system surpass about 100 percent of the costs of the work done by road organizations in this road category.

CONCLUSIONS

Every vehicle type covers its costs at present, except for the case of trucks, both light and heavy, on paved roads; in these

cases the subsidy is of such magnitude that it cannot be compensated either by the positive gaps of all the other types of vehicles on paved roads, or by the trucks themselves in the other road categories.

This situation would cause a clear handicap to the users of low-volume rural and country roads—usually gravel and dust roadways—who, in every vehicle category, easily cover the costs, in contrast to the sector of users of high-volume paved roads that are strongly subsidized.

Such a situation can be described in economic terms indicating that, at present, low-volume rural and country road users contribute 23.37 percent (13.68 and 9.69 percent, respectively) of road revenues and are responsible for 10.87 percent (5.99 and 4.88 percent, respectively) of the total costs of the road system. On the other hand, paved road users contribute the remaining 76.63 percent of the revenues but cause 89.13 percent of road expenditures.

Consequently, under the protection of a distorted policy of road charges, in Argentina at present there are two cross-subsidy effects in operation: (a) from light to heavy road transport and (b) from rural and country low-volume road transit to arterial roads of the main network.

In order to correct simultaneously these important detected subsidies, the possibility of establishing an effective control of vehicle weights and loads on all roads in an interconnective network and applying a toll to trucks circulating on the main paved roads should be considered in the short term.

Such a toll, which should be a function of the destructive effect trucks cause to pavements (6), would be assigned to the reactivation of an agricultural roads plan, an interesting experience for rural low-volume roads done in Argentina 15 years ago, with a new financing mechanism, no longer through taxes on agriculture exports, but through tolls for heavy transit on paved roads, as a way of making up for, or at least reducing, the detected subsidy.

It is fundamental to understand that to aim at an optimum utilization of a given road network, it is necessary that each and every user assume the resulting costs of their consumption of roads.

Allocating user fees on the relationships between user costs and consumption of roads is known as marginal cost pricing. Considering other factors such as developmental road programs, subsidy programs, and specific taxes based on nonefficiency does not alter these marginal cost relationships.

It may be necessary for political reasons to allocate resources on a noneconomic efficiency basis. This is because political equity is not the same as the economic Pareto optimality that would be achieved through the perfect actions of a *laissez faire* economy.

In this sense, it is considered that the recent Enactment Plan of Road Reconversion and the State Reform and Economic Emergency laws, with their required enactments, assume the critical situation of the sector with a criterion of realism, equality, and efficiency.

These tools, simultaneously with the reorganization of the "Direccion Nacional de Vialidad," decentralizing and offering

greater participation to provincial road agencies, provide genuine mechanisms to balance, through the initiatives of participation of the private sector in a competitive context, the historical road deficit in Argentina.

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