



WCTR

INCREASING POTENTIAL OF ROAD PRICING FOR IMPROVED EFFICIENCY OF URBAN TRANSPORTATION

VUKAN R. VUCHIC

University of Pennsylvania
Department of Systems Engineering
Philadelphia, PA 19104-6315, USA

ANTONIO MUSSO

University of Salerno
Department of Civil Engineering
Via Ponte Don Melillo, 84084 Fisciano (Sa), ITALY

Abstract

There are a number of factors which contribute to the continuous pressure for driving in different cities. However most serious, but often overlooked is the problem that the structure of costs of driving stimulates excessive car use. This paper presents the structure of driving costs and classifies them into user, social and environmental costs. The incidence of all these costs is discussed. The importance of using road pricing for a more effective control of the demand for car travel is shown. The paper reviews objectives of road pricing and actions for their implementation and concludes that the need for road pricing and opportunities for its applications will greatly increase in the foreseeable future.

INTRODUCTION

Road pricing, covering an extremely broad range of methods and strategies for pricing the use of roads by vehicles, has been receiving a very strong attention by academic researchers, as well as by political leaders and decision-makers. In contrast to this interest and scientific activities, there is a very limited application of road pricing anywhere in the world, except for the conventional toll roads where the purpose of user charges is primarily to finance or depreciate the investment in infrastructure and to pay for highway maintenance and operation. Is this an area where academics are divorced from reality and have found a theoretically attractive but unrealistic set of problems, or is it a coming concept that is difficult to introduce, but badly needed to prevent further decrease of transportation system efficiency and deterioration of cities?

This paper presents a systematic review of objectives and actions for restricting car use in urban areas. This is followed by an analysis of the structure of costs of driving, with their classification into users, social and environmental costs. The incidence of these costs is also discussed. The increasing need and opportunities for its implementation clearly indicate that road pricing is a real world problem and its applications should be expected in the foreseeable future.

THE NEED, RATIONALE AND OBSTACLES TO IMPLEMENTATION

Most cities and their suburbs in developing and developed countries suffer from chronic road traffic congestion. With increasing car ownership, the problem is steadily growing. Construction of new roads is in many cases not acceptable any more not only because of limited space and negative environmental impacts, but also because it generates increased driving, which eventually brings the situation back to congestion, but at an even greater scale. Country after country are reaching the conclusion that there are limits to highway construction and it is not possible to “build an area out of congestion”, i.e., to solve the transportation problems merely by building more roads and parking facilities.

The core of the transportation problems in metropolitan areas caused by large volumes of automobile traffic is the inherent conflict between the individual convenience and system efficiency and impacts. While the sharpening problems caused by this conflict call for road pricing as an effective solution, its acceptability is a major problem because of widely accepted belief that driving one's own car is an unalienable right of citizens. In many areas similar conflicts between individuals and social interests have been faced and largely resolved. For example, trash disposal, behavior of people in public areas and even vehicle driving rules have required introduction of rules and certain restrictions. However, limitations or charges for use of vehicles are still not understood by large segments of population as necessary measures to increase efficiency and reduce negative impacts.

This conflict of the increasing problem of so-called “collision between cities and cars” and misinterpreted “freedoms”, generates extensive discussions and introduction of new regulatory measures in most countries. This paper presents a systematic overview of the basic aspects of road pricing and discusses its likely development in the immediate future.

In addition to the lack of understanding of this complex problem, which is still found even in highly developed countries, there have been **two major obstacles to a broader introduction of road user charges, or road pricing**. They are:

- First, **physical difficulty of collecting the charges**, particularly if they are variable and

have to be collected at many locations. It appeared unrealistic to place toll booths on many streets in the city and stop cars to collect payments; and

- Second, **political opposition to such charges** by the public, often supported by special interest lobbies which want to retain the present maximum use of cars regardless of its total costs.

While the first problem, physical collection, is rapidly disappearing with changing state-of-the-art of electronic methods for payment collection, the second, political acceptance, remains a major obstacle. To overcome it, extensive professional discussions and explanations to the decision-makers and the general public are needed.

OBJECTIVES AND ACTIONS FOR ROAD PRICING AND OTHER CAR USE DISINCENTIVES

Road pricing represents an element in the major set of policies and measures aimed at automobile use disincentives, or limitations to the unrestrained use of private automobiles. For a comprehensive overview, nine **objectives of road pricing and other car use disincentives** are defined here.

- a. **Collection of revenues for financing construction and/or maintenance of a road or specific facility**, such as a bridge or tunnel. The most common form is a conventional road toll, which is used in many countries and well understood by the public.
- b. **Reduction of peak period congestion**: road pricing for this purpose is aimed at achieving a greater efficiency of operations. These congestion charges are more complicated than conventional tolls because they usually vary with time.
- c. **Reduction of congestion in certain areas in general**, i.e. at all times, rather than peak periods only. Pricing (or entry restrictions) for this objective is found in large cities (Singapore) or in high density areas, such as centers of many European cities.
- d. **Achievement of changes in modal split**; typically, this purpose would be used to induce people to switch from cars to transit. In North America, this would include influencing a shift from single-occupancy vehicles (SOV) to high-occupancy vehicles (HOV), i.e., increasing efficiency within the car/highway mode.
- e. **Generation of funds for financing of transit, bicycles and other alternatives to the private car**.
- f. **Protection of sensitive areas** from heavy vehicular traffic by entry charges. Similar to reduction of congestion, this objective is common either in centers of large cities or historic, tourist and other towns with unique assets and character.
- g. **Compensation for costs and externalities** normally not paid by car users, such as environmental damage, noise, accidents, etc. This may be used as a rationale for introduction of some road user charges which would otherwise face strong opposition.
- h. **Reduction of vehicle-kilometers traveled - VKT**. This may be considered basically as a punitive charge, and it often has a broader, national purpose, rather than one used in a specific urban area. Its primary effect is, however, to reduce discretionary trips, i.e., those which can be consolidated or avoided without major inconvenience to travelers.
- i. **Reduction of auto ownership**. This is the broadest policy for reduction of VKT and externalities

which auto use causes. Some countries impose high sales tax (Norway, Denmark) or high registration fees (Germany) to discourage auto ownership.

Table 1 shows major actions for car use disincentives and their relationship with these objectives. The actions include an array from direct user charges, such as fuel tax, road tolls and parking charges, to traffic limitations which can be non-monetary. The most indirect measures are taxes and fees which discourage ownership of cars, but not their use by the owners. Road pricing, placed in the central column, obviously has a potential to achieve most of the objectives. Several cases of different actions are placed in the relevant boxes.

It should be noted that except for the first objective, a, most other objectives usually overlap to various extent in individual applications. For example, the Singapore Area Licensing System ALS charge combines b and d as its objectives, although most other objectives are also included. The restrictions of entry to the center city of Rome primarily incorporates objectives c and f, but also includes b, d and h. Implicitly, most road pricing schemes, except a, encompass the objective h, reduction of VKT, as an ultimate goal, in addition to other, often dominant objectives.

THE STRUCTURE AND DISTRIBUTION OF URBAN TRANSPORT COSTS

A review of urban transportation cost components and their characteristics is presented in Table 2. The costs include user (traveler) costs, system costs, which are divided into fixed and variable, as well as externalities. The characteristics given for each cost component are: direct or indirect; internal (paid by the user) and external (borne by others); fixed (independent of individual trips) and variable (dependent on the trip); and, paid by some party, or "not paid", i.e., borne indirectly by other travelers, community, or society at large.

Analysis of numerical costs of travel by different modes and in different conditions is always extremely complex because of many influencing factors, variability of costs with location, time, problems of quantification of qualitative elements, etc. When different countries are considered, complexity increases even more. The following comparisons and analysis of relative values presented for the discussion of concepts. For the purpose of clarifying the fundamental concepts, the analysis is intentionally general, rather than extremely detailed.

Figure 1 is a bar diagram of direct monetary costs of transportation by different modes, computed from statistical data for a number of Italian cities. They are given in Italian Lire and in US \$ per passenger-km, using the ratio of 1700 Lire = \$1. The diagram shows that costs of travel by car are about two times higher than the costs of travel by bus, and that bicycle and pedestrian monetary travel costs are negligibly low. On the diagram in Figure 2, fixed, time and external costs of travel are added for each mode.

Figure 3 presents a diagram of costs most relevant for modal split in urban areas. The values are based on a model of 20-km long round trip by car, by urban and by regional transit, assuming typical values for a U.S. city [for further details on the assumptions, see Vuchic, *et al.* (1998)]. Travel by car is given for two cases: one includes the cost of a toll and parking, while the second bar shows the same costs in the case when the user enjoys "free" (i.e., subsidized) parking. The diagram shows that, considering direct costs only, transit can compete with the car only if the driver pays for parking.

Table 1 - Types of actions for car use disincentives and their objectives

Actions Objectives	Fuel tax	Road tolls	Parking charge	Road pricing	Traffic limitations	Car sales tax	Registration fee
a. Road financing		French, Japanese, US motorways		Oslo, Bergen			
b. Reduced peak – Period congestion				Singapore			
c. Reduced congestion in general			Boston, Hamburg		Italian cities		
d. Intermodal shift		New York City		Singapore		Hong Kong	
e. Funds for transit	Germany	San Francisco		Trondheim			
f. Protect sensitive areas					Italian cities		
g. Compensation of externalities							
h. Reduced VKT							
i. Reduced auto ownership						Norway, Singapore	Germany

Table 2 - Characteristics of transport cost components by different modes

Costs/charges	Direct/Indirect	Internal/External	Fixed/ Variable	Paid/ Not paid
Car registration	I	I	F	P
Operating costs	D	I	V	P
Public subsidies	I	I/E	F	P
Cost of time	D	I	V	P
Accidents/insurance	I	I/E	V	P/N
Residential parking	D	I	F	P
"Free"(unpaid) parking	I	E	F	N
Congestion	I	E	V	N
Land consumption	I	E	V	N
Air pollution	I	E	V	N
Noise pollution	I	E	V	N
Water pollution	I	E	V	N
Energy consumption	I	E	V	N
Hazardous materials transport	I	E	V	N

Figure 1 – Operating (out of pocket) Costs for Different Urban Transport Modes

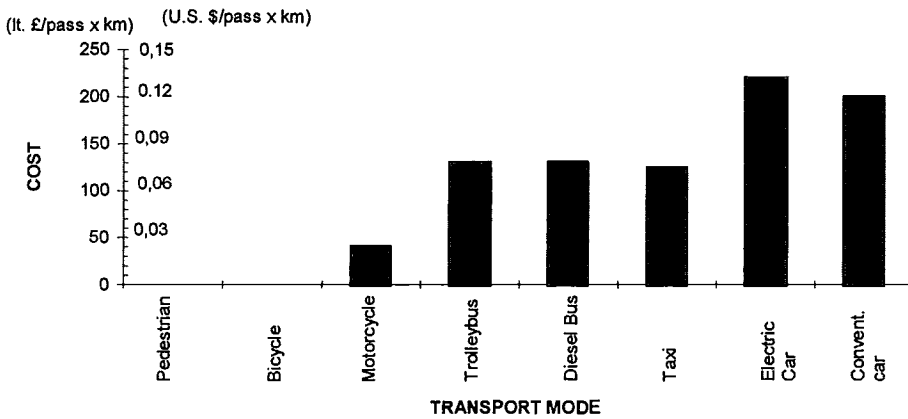
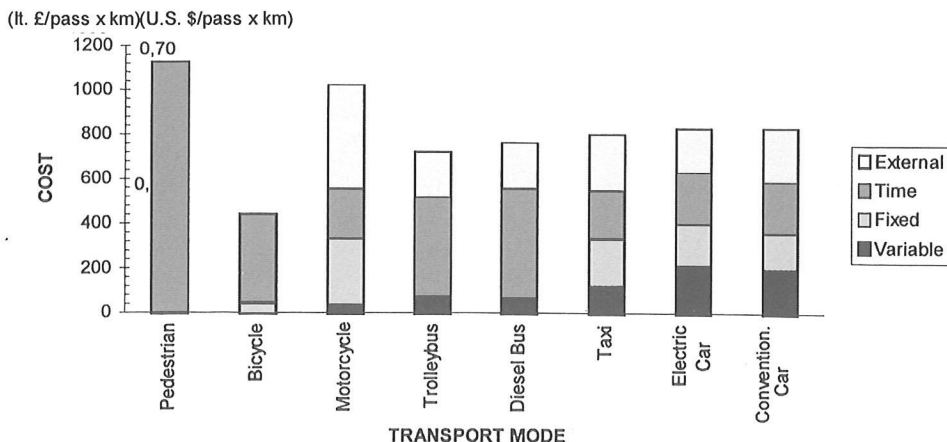


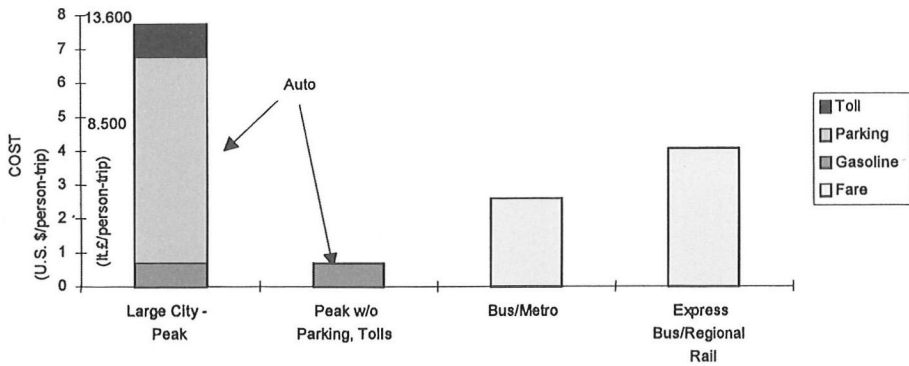
Figure 2 - Components of Costs for Different Urban Transport Modes



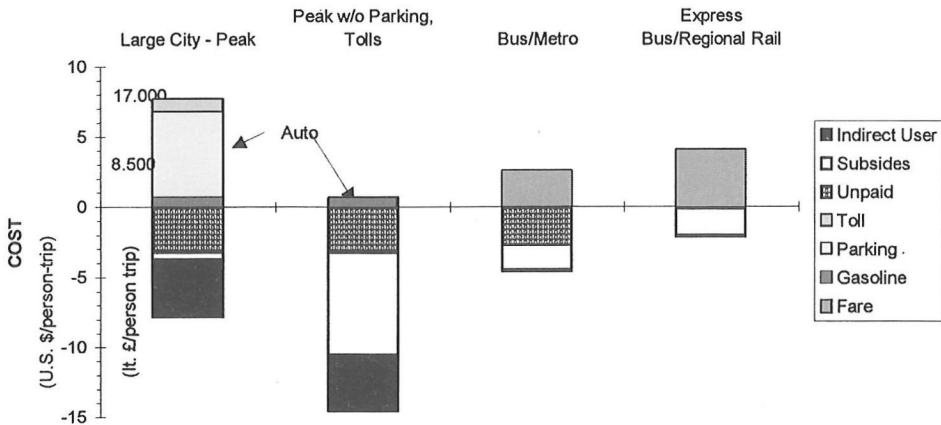
The bar charts in diagram b) of Figure 3 are very important for understanding of intermodal relations in urban transportation. They show full costs of travel divided into two categories. The direct or out-of-pocket costs paid by the traveler (the same as in diagram a) are shown above the horizontal line. Below the line are costs which travelers do not pay directly, or not at all. They include fixed user costs (car depreciation, insurance, etc.), subsidies for roads and transit as well as «unpaid costs», or externalities absorbed by non-user or by the society at large.

This diagram, in Figure 3b, shows the major reason for the imbalance with respect to car travel created by the difference in cost structures among modes: car travel has extremely low direct, operating cost. In the United States this problem is extremely serious: when parking is subsidized, car operating costs amount to only about 4 cents/km, or less than 14 percent of the total travel user costs of 30 cents/km. This strongly favors car travel when users consider direct costs only, which is the case with many travelers in selecting their mode of travel. «Free» or subsidized parking particularly aggravate this situation. The problem is that the car travel carries with it very large other costs, plotted under the horizontal line in Figure 3b diagram, which is not considered by most travelers. Thus, travelers tend to decide on their modal choice on the basis of a fraction of their costs, and thus impose very large externalities on the urban society and environment. This situation shows that it is useful and necessary to increase the direct cost of driving in urban areas. Even if there were no need for collection of additional revenues, the case for increases of operating costs, such as parking charges, gasoline taxes and, particularly, various forms of road pricing, is very strong. In many cases, road pricing may be most effective, because it can be targeted to certain types of travel where it would achieve additional objectives, as discussed in the previous section.

Figure 3 - Costs of Urban Travel by Different Modes



a) Direct Out-of Pocket Costs



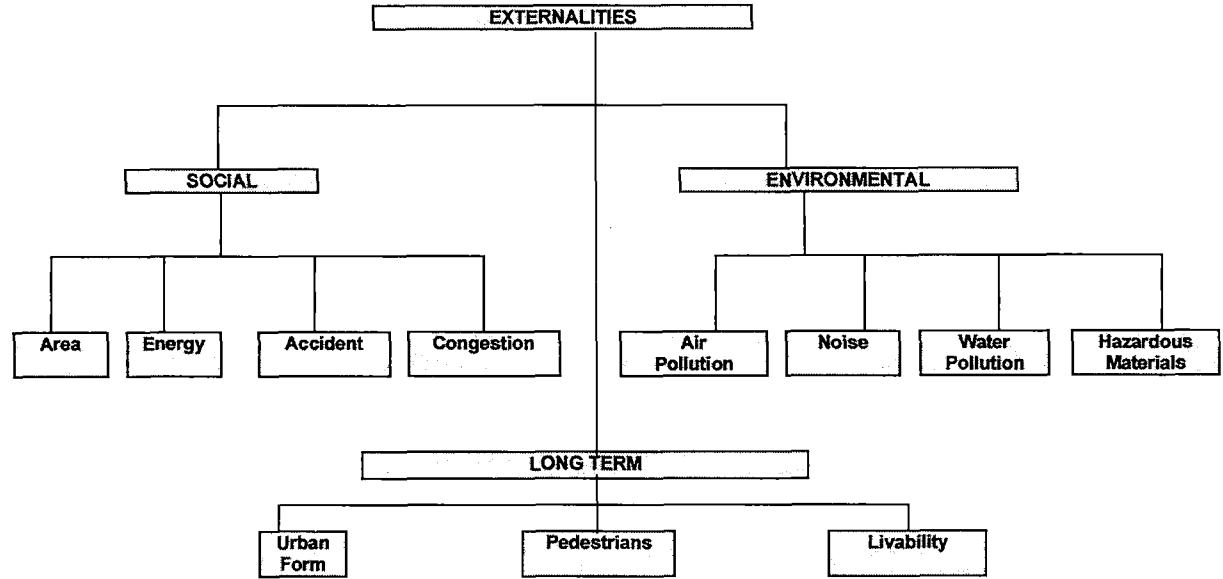
b) Direct and Indirect Costs

ANALYSIS AND EVALUATION OF EXTERNALITIES

Externalities of urban vehicular travel comprise three groups, as shown in Figure 4. Social costs include such items as area occupancy, energy consumption, costs of accidents, and, most important one, congestion. The last one is in large cities particularly strong, because it affects large areas and many people, so that its economic and social aspects are very serious problems. Environmental impacts include air and water pollution, noise and hazardous materials.

Often overlooked, but in many cases the most important is the long-term impact of transportation on the form of the city, its social character and its **quality of life** - often referred to as **livability**. Use of different transportation modes directly influences the shape of the city, its social life, aesthetic

Fig. 4 - Main Categories of External Costs of Transportation



attractiveness, etc. For example, cities which have developed integrated multimodal transportation systems and emphasized pedestrian convenience, such as Munich, Melbourne and Toronto, are very different in their character from the cities heavily oriented to car traffic, with little concern for pedestrians, which are exemplified by Houston and Bangkok.

PRESENT APPLICATIONS AND FUTURE POTENTIAL FOR ROAD PRICING

As mentioned before, the problem of physical collection of road user charges has been a major obstacle to their introduction in most situations, except on toll roads. With few collection locations and rather simple charges, toll collection is feasible, but it involves stopping of vehicles and thus creates a bottleneck in road capacity. Large plazas which solve this problem take very large space, which is a particularly serious problem in urban areas.

In recent years, however, a number of new, more efficient methods for collection of charges have been invented and applied. Singapore introduced in 1975 ALS with prepayments and display of passes, which obviated the stopping of vehicles. This has been followed by the uses of scanners, smart cards and other devices which practically eliminate one of the two obstacles to greater use of road pricing, the problem of physical collection of payments. Specifically, the modern methods of collection of charges have the following major advantages:

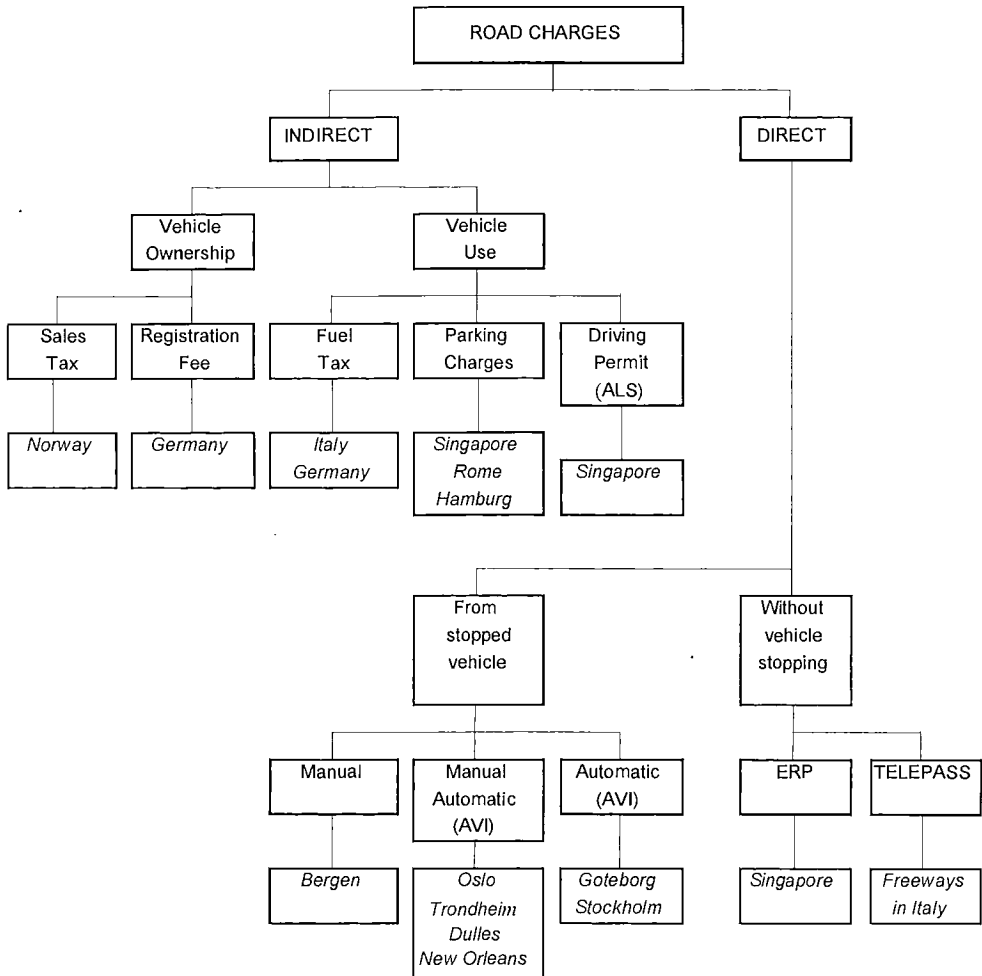
- The need for large toll plaza is eliminated, so that collection can be performed at many locations, along cordon lines, in high-density areas, etc.
- Amounts of charges can be easily varied by location and time, allowing more sophisticated scales which may influence car use by road, area, time of day or type of user. Thus, congestion pricing, peak hour pricing and other policy objectives can be implemented.
- Rates can be easily changed and adjusted to achieve variations according to the objectives. Even more importantly, rate adjustments can be used for adjustments which make the charges more acceptable to the users.
- Easy availability of statistical data facilitates sophisticated analysis and planning of rate changes or adjustments.

These characteristics make implementation of road pricing considerably more realistic. With the increasing pressures of road congestion in urban areas, technical and operational innovations in road pricing systems have thus considerably increased the potential of its broader applications in cities and metropolitan areas.

Figure 5 shows classification of types of collections of road use charges by their characteristics. Indirect charges have never been difficult to collect, but the direct ones are those which have greatly benefited from the recent innovations and electronic devices. The figure also shows examples of cities in which respective collection methods have been applied.

These innovations have a great significance for the future applications of road pricing. With this obstacle removed, the only, albeit extremely serious one, remains the political acceptability and the opposition by the lobbies which launch populist-type campaigns against any constraint to car driving in metropolitan areas, even if they would lead to an increase of overall efficiency of traffic flow, such as road pricing.

Fig. 5 - Classification of Methods for Collection of Road Use Charges



ALS - Area Licensing Scheme

AVI - Automatic Vehicle Identification

ERP - Electronic Road Pricing

As automobile ownership, VKT and resulting road and street congestion increase in most cities around the world, authorities are looking for prevention of further deteriorations of not only traffic conditions, but economic efficiency, environmental quality and livability of cities. Road pricing is gaining recognition as the only fundamental change which can set urban transportation conditions on a stable and permanent base. Academic interest in this topic is now paralleled by such leading public media as daily press (Wall Street Journal) and weeklies (The Economist). Developments indicate that the time for a broader implementation of road pricing is coming.

REFERENCES

- Armani, F. (1993) Gli autotrasporti italiani nel 1992. **Ingegneria Ferroviaria**.
- Gomez-Ibanez, J.A. and Small, K. (1994) Road Pricing for Congestion Management: a Survey of International Practice, **NCHRP Synthesis of Highway Practice 210**. Washington, D.C.
- Hau, T.D. (1992) An Evaluation of Current Practices in Congestion Pricing. **71° TRB Annual Meeting**.
- Johnson, Elmer W. (1993) **Avoiding the Collision of Cities and Cars**, American Academy of Arts and Sciences.
- Lewis, Nigel C. (1993) **Road Pricing: Theory and Practice**. Thomas Telford, London.
- Litman, T. (1994) **Transportation Cost Analysis**. Transport Policy Institute, Victoria.
- Morrison, S.A. (1986) A Survey of Road Pricing. **Transportation Research Vol. 20A**.
- Shoup, Donald C. (1997) The High Cost of free Parking. **The Access No. 10**, University of California Transportation Center, Berkeley, CA, pp. 2-9,
- Vuchic, V.R. (1993) Cheap Gasoline: An American Addiction. **The Urban Transportation Monitor**.
- Vuchic, V.R., *et al.* (1998), Travel Costs and Intermodal Distribution in Urban Transportation. **TRB Record**