MARGINAL SOCIAL COST PRICING AS A BASIS FOR TRANSPORT POLICIES IN EUROPE

Rémy Prud'homme
(University Paris XII)
<prudhomme@univ-paris12.fr>

November 22, 2002

Abstract — The European Union proposes to make marginal social cost pricing (MSCP) the basis of transport policy in Europe. This paper shows that MSCP is only one pricing principle amongst several competing ones, and not necessarily the best one. It then examines the four major so-called transport externalities (accidents, congestion, air pollution, and CO2) and concludes that internalization of their marginal costs is neither feasible nor the most efficient instrument available to deal with these serious social issues.

"Abundan los sistemas increibles, pero de architectura agradable o de tipo sensacional"[1]
Jorge Luis Borges
Ficciones (Tlon, etc. II)

I - Introduction

Policies —and transport policies are no exception— are defined as a set of related objectives and

instruments. The instruments utilized must be such that they will make it possible to reach the objectives. One must have the instruments of one's objectives, or the objectives of one's instruments. But, in practice, instruments count more than objectives. Objectives without instruments have little or no impact. But instruments without objectives can be very influential. It is therefore legitimate to focus on instruments in the analysis of policies, or planned policies.

There are four types of instruments, the four "I"s: interdictions, investments, incentives, and information. Interdictions or prohibitions, and also prescriptions (you are not allowed to do this, or, more rarely, you must do that), are a common policy instrument. Investments, and more generally, production of goods and services by a government entity or agency is also a common policy instrument. Incentives, that modify prices, either by taxes (to lower the demand for the taxed goods) or by subsidies (to increase the demand for the subsidized goods) are a third instrument, much liked by economists. Information, such as plans and programs, or dissemination of facts and ideas, that can also modify behaviors, are a final type of instruments. These four instruments are

[1] "Many are the systems which are unbelievable, but of a pleasant architecture or of a sensational type"

widely utilized in transportation policy, by all levels of governments.

The EU (European Union) has been active in the area of interdictions, in trying to eliminate monopolistic behaviors, and barriers to competition, and in effectively pushing auto-related emission norms. But subsidiarity puts a limit to the amount of interdictions that can be set by Brussels. The EU has not been very active in the area of investments. It has contributed to the financing of some transportation infrastructure, particularly in the less developed parts of the Union. But the size of the budget of the EU limits its use of this instrument. The EU is not very well equipped to play a significant role in the production and dissemination of transportation information, and does not make much use of this instrument. There remain incentives. The EU cannot impose taxes and provide substantial subsidies. But it can, and it does, provide national governments with ideas about taxes and subsidies, with guidelines and principles on pricing policies. Such principles constitute the backbone of EU policies in transportation.

The key idea put forward by the EU is the need to introduce marginal social cost pricing. In theory, the principle applies to all transport modes and is neutral relative to transport modes. In practice, because nobody

knows what marginal social cost pricing in rail transportation could be, the EU proposal amounts to introducing marginal social cost pricing for road transportation. It can be argued that marginal social cost pricing is not an efficiency principle leading to an economically determined reduction of auto usage, but that a politically (or ideologically) determined reduction of auto usage leads to marginal social cost pricing, as an instrument to achieve that goal, together with other instruments such as massive subsidies to rail usage. This paper does not enter into this argument, and takes marginal social cost pricing for what it pretends to be. "Marginal" means that each additional (marginal) vehicle should pay the costs that it imposes to society. "Social" means that all costs, including the so-called external costs, should be paid. This is the same thing as saying that road transport externalities should be "internalized".

The concept is attractive. But a closer examination suggests that it is also questionable, and that its implementation is full of pitfalls and complexities. This note will first discuss the merits of marginal social cost pricing, and then examine the problems associated with the internalization of the major alleged road transport externalities: accidents, congestion, air pollution, CO2.

II - Theory: MSCP is only one pricing principle

It is important to realize that MSCP (marginal social cost pricing) is only one pricing principle, amongst several other, and not necessarily the best one. The competitors are: average cost pricing, Ramsey-Boiteux pricing, redistributive pricing and specific pricing. Each of these principles serves one desirable policy objective, as indicated in Table 1.

Table 1 - Policy Objectives and Associated Pricing Principles

Policy Objective	Pricing Principle
Ensure neutrality between goods and self-financing	Average cost pricing
Minimize welfare losses associated with taxes	Ramsey-Boiteux pricing
Promote income redistribution	Redistributive pricing, discriminatory pricing
Achieve specific aims	Specific pricing
Facilitate efficient use of existing infrastructure	Marginal cost pricing

The policy objective chosen might be to ensure *neutrality* between goods and services. One might consider that the choices of consumers between transport modes, and indeed between transport and other goods, should not be distorted by taxes and subsidies (or rather should be similarly distorted by the same taxes and subsidies). This objective will be achieved by *average cost pricing*. The consumers of each mode will pay the total costs that their

consumption entails, and only these costs. This will not distort choices between modes, nor indeed between transportation and other goods. Average cost pricing has the additional advantage of making production self-financing. With average cost pricing, total costs are equal to total revenues, and the private sector is interested to step in. Avoiding distortions and subsidies seems to be a primary concern of EU policies in most areas —outside transportation.

A second, equally desirable, policy objective might be to *minimize welfare losses* associated with taxation and pricing. Taxes are necessary, to finance useful public expenditures. Unfortunately, taxes (with few exceptions[1]) adversely impact the incentive structure and result in reduced output, also called welfare losses. Not all taxes, however, for a given yield, lead to the same welfare loss. What are the taxes that minimize these welfare losses? The answer to that question was given by Ramsey, in the case of goods taxation, before WW II: the lower the price elasticity of demand for a good, the higher the taxes that should be applied to that good. A similar answer was arrived at by Boiteux, after the war, in the case of a monopoly trying to combine marginal cost pricing with a budget constraint. The prices of the various goods

[1] such as taxes on externalities

produced by the monopoly should include an element inversely proportional to the price elasticity of the demand for these goods. This sort of pricing is called *Ramsey-Boiteux pricing*. Most ministers of Finance (including those who have never heard of Ramsey or Boiteux) practice it. The high (300%) tax rate of fuel taxation to be found in most European countries is a good example of Ramsey-Boiteux pricing. Because the demand for fuel is highly price-inelastic, a high tax rate does not decrease fuel consumption as much as it would for other goods, and does not distort too much consumption patterns.

A third goal is to *redistribute income* from rich to poor. This is a social, not an economic, objective, but it is one which is widely shared. Two pricing principles can contribute to it (in addition to progressive income taxation). One can tax more heavily the goods that are consumed mostly by the rich. This is called *redistributive pricing*. One can also, at least in theory, charge the rich more than the poor for a given good. This is known as *discriminatory pricing*.

Fourth, pricing can be utilized to achieve *specific objectives*, in regional policy, or in defense policy, or in industrial policy, or in environmental policies, for instance. The market-produced structure of relative prices will not be allowed to prevail if and when it is in

contradiction with these objectives. Taxes and subsidies will be created to alter it in the desired directions. This is called *specific pricing*.

Finally, a legitimate goal of policy might be *to ensure the efficient usage of infrastructure*. Certain goods and services, such as transportation, are provided by means of infrastructure. Users of infrastructure, however, inflict costs upon society: they deteriorate the road they use, they slow down the speed at which other users travel, or they reject pollutants that might create environmental damages. They should pay for these costs, and only for these costs. This is achieved by *marginal social cost pricing*. This will ensure the optimal usage of the infrastructure. If they pay less, then there will be at the margin some users who inflict costs greater than the benefits they derive from usage —which is not optimal. If they pay more, then there will be some people also at the margin who are excluded from usage, although the benefits they would have derived from it are greater then the costs they would have created —which is not optimal either.

Four points can be made about MSCP (marginal social cost pricing).

First, as appears from the small trip just made in the theory of pricing, MSCP is just one of the pricing principles available, not the only one. It serves one goal, a legitimate and important goal, but not the only possible or desirable goal. It is just one tool in the toolbox of the economist. This should be clearly realized, to better resist a sort of intellectual terrorism that presents as necessary what is only contingent

Second, MSCP may be —and often is— in contradiction with other pricing principles. All of the policy objectives mentioned —and the pricing principles that can help achieve them— are legitimate and desirable. Unfortunately, they are often contradictory. Ramsey-Boiteux pricing and redistributive pricing, for instance, do not necessarily go hand in hand. The goods with a low price elasticity of demand are not always the goods mostly consumed by the rich. MSCP is in contradiction with average cost pricing. In particular, there is no reason to expect the revenues produced by MSCP to balance expenditures. MSCP is therefore likely to lead to surpluses, or, more likely, to deficits. This, by the way, is clearly in contradiction with the stated EU policy goal of favoring private participation in the area of transportation. Private enterprises want a pricing system that balances costs and benefits, and do not enter

businesses that do not. MSCP is also in contradiction with redistributing pricing. It ignores completely income redistribution objectives. As we shall see, in certain cases, it might even redistribute income in favor of the rich. MSCP is also in contradiction with Ramsey-Boiteux pricing in the sense that it ignores the price-elasticity of demand for road services. Again, all these objectives are important and must be considered jointly. The search for just one pricing principle that would be superior to others, or that would eliminate the need to consider other principles, is bound to be unsuccessful.

Third, and always from a theoretical viewpoint, MSCP is rather limited in scope as a transport policy principle. It is mute about transport investments. It is only concerned with the optimal usage of existing investments. It assumes implicitly that these investments are optimal. But what if they are not? Consider two links, A and B, with a similar transport demand. For A, a very generous highway has been built, and this highway is never congested. MSCP implies that there will be no congestion charges on link A. For B, by contrast, not much has been done, and there is only a two-lane road. Congestion is heavy, and MSCP implies high congestion charges. Overinvestment will lead to low prices and underinvestment to high prices. Not only is this in contradiction with

many of the other transport policy objectives, but it creates a perverse incentive against transport investment. Underinvestment "pays". Why invest, then? Ministers of Finance would be quick to learn that lesson.

The traditional answer to this issue is to say that investment decisions and usage decisions are and should be completely separated. Sound cost-benefit analysis should determine investments. MSCP should determine their usage. This made sense when both investments and charges were both the business of government. If charges were greater than investment needs, fine; if not, the general budget would pick up the deficit. But now that everybody, including the EU, wants to bring in the private sector, that reasoning is no longer possible. In addition, who could claim that all investment projects that pass the test of "sound cost-benefit analysis" are effectively undertaken? The least that can be said is that MSCP only provides a limited answer to transport policy issues. It refers to a world in which no new transport investments are considered. It does not provide any guidance to what many people would consider the most important issue: what transport investments should be done?

Fourth, and this is probably the most important point, MSCP is very difficult to implement. Its theoretical merits (real, although limited) have to be

compared with its practical drawbacks. Saying that "external costs" should be "internalized" is one thing. Figuring out which costs are external, to whom, what their amount is, and how they could be internalized is another story. At a sufficiently high theoretical level, every economist agrees with the idea that "external costs should be internalized". But when it comes to the identification of these external costs, to their estimation, and to the mechanisms by which they should be internalized, the consensus stops. The rest of this paper discusses some of these difficulties on the case of the four main types of road-related externalities: accidents, congestion, air pollution, and CO2.

III — Accidents: Internalization is Not the Answer

Every year, some 50,000 people are killed in car accidents in Europe. There is no doubt that this tragedy raises a serious public health issue, and that strong policies should be conducted to reduce, if not to eliminate, car accidents. The question is: what is gained by calling this an externality, by estimating the costs of this so-called externality, and by internalizing it?

On the externality dimension of car accidents

An externality is an "unpriced effect", a cost inflicted by A upon B and for which A does not compensate B (in the case of a negative externality; a benefit conferred by A upon B and for which A is not compensated by B in the case of a positive externality). Let us assume that A is the cause of a car accident. Two cases may arise. In the first case, A only creates damage to himself, in particular if he is killed in the accident. In this case, the damage is fully internalized, and A pays a price for his/her action, indeed an infinite price, and there is no externality involved. In the second case, A also causes damage to somebody else, and harms or even kills B. In all European countries, the law is such that B (or his family) can sue A, and obtain a damage compensation from the courts. In practice A is insured, and it is his/her insurance company that will actually pay B. In most European countries, automobile insurance is compulsory, precisely to ensure that B will effectively be compensated. In this second case, there is no externality either. One can consider that the courts do not evaluate damages at their "real value"; but this is a completely different debate.

To find externalities in car accidents, one has to look for costs inflicted upon public health systems, or to the economy, or to society at large.

In our societies, it is argued, medical care is largely socialized, and the medical expenditures for A and/or B associated with a car accident will be in whole or in part borne by public health systems, not by A or B. Is this not an externality? Yes, it is, but one which is already internalized in several countries. In France, these costs have been estimated (to about 1 billion euros per year), and a tax of about three times that amount is paid by insurance companies on the basis of automobile insurance premium, and handed over to the public health system. It is therefore borne by auto users.

The other argument used to show the existence of externalities in car accidents is even more far-fetched. When A kills himself or kills B, he/she inflicts a cost upon society because he/she deprives society of what A or B would have produced in the rest of their lives. This notion of output forgone is not very convincing.

First, it ignores consumption; if A and B had lived, they would have produced, but they would also have consumed; why ignore consumption?

Second, according to this approach, the value of the life of a retired person, who no longer produces, is equal to zero. In this line of reasoning, why not go one step further, and consider the disappearance of someone who no longer produces but continues to consume as a net benefit for society? The death of a retired person would thus produce a positive externality! The absurdity of such conclusions casts a doubt on the validity of the premices.

Third, if we believe that one person less is a cost to society, then we must believe that one person more is a benefit to society. Immigration therefore produces considerable positive externalities. The per year number of immigrants in Europe is about 30 times as large as the number of car accident casualties. If we accept the EU estimates of negative accident externalities of about 2% of GDP, then positive immigration externalities amount to about 60% of GDP.

It appears therefore that this "human capital" approach to the value of human life —which has been dominant for years— is not very creditworthy. It is more and more often replaced by a "contingent analysis" approach. Representative samples of people are asked how much they are willing to pay to see one life (or 100, or 1000 lives) saved. The value attached by society to one human life is derived from their answers.

This approach is more promising. At present, however, it not very operational, because the answers given depend very much upon the survey procedures utilized, and diverge wildly from study to study.

In addition, when one considers the total number of car accident casualties and allocates it to road usage, one implicitly compares the present situation to a zero road usage situation. It is true that if there were no cars (and no roads), there would not be car accidents. But there would not be easy access to doctors and to hospitals, not to mention economic development. Cars kill people, but cars also save people. In the Dayak country, in Borneo, there areno roads, no cars, and no car accidents, but there are high mortality rates. If we count car accident fatalities as a negative externality, then we must count car saved lives as a positive externality.

This does not mean that we should passively accept car accident casualties —the opposite is true— but it means that we do not gain much by calling them negative externalities. Suicide, which claims more human lives than car accidents, is not treated as an externality. When someone hangs himself with a rope, it is a tragedy, not an externality of the rope industry. When someone drown herself (intentionally or not), it is not described as an

externality of water usage[1], but as an unfortunate event that should be prevented by all possible means.

On the internalization of car accidents damages

Whether car accident damages are an externality or not, one thing is sure: *internalization is not an effective answer to this drama*. The rationale of internalization (and its justification) is to make economic agents aware of the costs they inflict upon society, and to induce them to modify their behavior accordingly. The probabilistic nature of car accidents will prevent this from happening.

Suppose car accidents damages are an externality, and suppose this externality is internalized. In practice, it will mean that a tax on car usage, most probably a tax on fuels, is imposed. Whether it should be a tax on top of what is already imposed (without the pretext of externalities), or instead of what is already imposed, remains to be decided. That tax will be equal to the total amount of car accident externalities divided by car usage or fuel consumption. Note, by the way, that there is nothing marginal in that. The tax will result in a

[1] This reminds the author of a survey about "a chemical compound, produced and distributed in large quantities by multinational corporations, widely used in food and beverage industries, absorbed in great quantities by human beings, and associated with thousands of deaths every year in both developed anhd devbeloping countries". The

moderate increase in the cost of auto usage. What will be the impact of the tax upon drivers?

Will this tax modify the behavior of drivers? Will it make them drive more prudently, take a better care of their vehicles, be more sober, respect driving rules and prohibitions, and more generally "avoid accidents"? Obviously not. If anything, the additional money they will spend on fuels will not be spent on improving their vehicles, and this will increase the accident rate.

Will this tax deter some drivers from using their car? Yes, but to a minor extent. The estimates of car accident externalities in France are presently put (in the questionable fashion described above) at some 40 billion francs per year. This is about 5% of total vehicle expenditures in France. Assuming a price elasticity of demand of -0.6, and assuming that this internalizing tax is added to existing taxes, the tax would reduce car usage, and car accidents, by about 3%. This is to be compared with a reduction of about 75% per kilometer driven in the last 20 years.

Clearly, marginal social cost pricing is not the answer to the tragedy of car accidents. Calling externalities the damages associated with car accidents,

---

question was wether it should be banned, controled, or ignored. Only a

and internalizing them in the form of higher prices is not going to have any serious impact upon car accidents. What is needed, has had an impact, and will continue to have an impact, is a series of well-known policy actions aimed at: improving roads, improving vehicles, and improving driving behavior.

IV Congestion: an Externality Internal to Car Users

Road congestion (rail congestion is, at this stage, an empty concept) is, according to many estimates, including EU estimates, the second largest type of the so-called car usage externalities. Yet, it has very little in common with car accident damages. The concept of congestion is vague and ill defined –which may explain its success.

Common mistakes about congestion

The dominant view, and the one that was formulated in earlier EU policy documents, is (i) that congestion costs are the value of the difference between the time it takes to drive at free flow speed and the time it takes to actually drive, (ii) that they are enormous (the figure of 2% of GDP was widely quoted), (iii) that they are an

handful of respondents identified the chemical as water.

externality, and therefore (iv) that they should be internalized, i.e. that road usage costs should be increased by this amount. None of these propositions makes much sense.

Congestion costs cannot be defined as the value of the time "lost" when not driving at free flow speed. The reference situation, the empty road, is not a meaningful alternative. Suppose —and these numbers are not unrealistic— it takes me 15 minutes to drive to my office when I am alone on the road (at 3am for instance), 30 minutes to drive on an average day, 45 minutes to go to the same office by public transport, and 60 minutes by bicycle. Why compare the time it takes me normally with the time it would takes me if I were alone, and conclude I "lose" 15 minutes? Why not compare it with the time it would take me with public transport, and say I "gain" 15 minutes, or even with the time it would take me by bicycle and conclude I "gain" 30 minutes. Or, if the reference situation is indeed the empty road, why not say that every time I take public transport I "lose" 30 minutes?

Calling "externality" the amount of time thus "lost" is equally questionable. Car drivers only impose costs upon themselves. It can be argued that they also slow down buses. This is true in many developing countries. But in most European cities, this is a very limited phenomenon.

In small cities, congestion is usually relatively unimportant. In large cities, the subway is the dominant mode of public transport, and one which is protected from road congestion. In any case, the externality inflicted by cars upon buses is reciprocal, in the sense that buses also slow down cars. Congestion is therefore mostly internal to car users. Non car users have nothing to gain at congestion internalization. Yet, it is mostly championed and promoted by non-car users, such as railroads or public transport organizations.

The Theoretical Case for Road Pricing

This crude and mistaken —but dominant— view of congestion is not the only one available. A more sophisticated view can be presented. One of its outputs is a justification of road pricing, at least in theory.

Let us consider a road. There is a demand for the usage of this road, which is a function of the cost of using it. If the cost, in money and time, is high not many people will want to use this road. If it is low, many more people will want to use it. The cost of using the road is a function of the number of people using it. The more people on the road, the lower the speed of vehicules, the greater the time it takes to drive one kilometer, the higher the cost of using the road. This cost function can

be interpreted as a supply curve (although it is not one in good theory). A *natural equilibrium* will prevail. Beyond a certain number of users, the cost of using the road becomes greater than the benefits of using it for the marginal user, and only those who are ready to pay (in money and time) more will continue to use the road. This natural equilibrium, unfortunately, is not optimal. This is because, at any point, an additional driver entering the road will slow down traffic speed. In so doing, he/she will inflict a cost (in time) upon all his/her fellow drivers. This cost is very small, but it is multiplied by the number of drivers on the road. From the view point of society, or more precisely of all drivers, what should be considered and compared with the marginal benefit (the utility derived by the last driver from using the road) is the marginal social cost, that is the money and time cost paid by the last driver plus the time cost inflicted upon all other drivers. When the two are equal, an *optimal equilibrium* will be reached. Society would be worst off if more people or fewer people were using the road. Several important conclusions emerge from this model.

First, it shows that congestion is a relative phenomenon, not an absolute one. It is a matter of more or less. There is always a certain degree of congestion, and the objective of "eliminating congestion" is meaningless.

What should be aimed at is the optimal level of congestion, or to put it otherwise, an optimal level of road usage. This optimal level of congestion/road usage, for a given road, varies with the demand for the road. The optimal level of congestion/road usage is not the same at the morning peak hour and in the middle of the night.

Second, the model shows that this optimal level of congestion/road usage is not achieved automatically. On the contrary, in the absence of policy intervention, there will be slightly too many cars on the roads (calculation suggests that 10-15% is a good order of magnitude) and therefore an excess of congestion. This makes it possible to define the costs of congestion in a non-arbitrary fashion, by reference to the optimal situation. Congestion costs are what road users pay for not being at the optimum. It is what could be gained by moving from the equilibrium congestion/road usage to the optimal congestion/road usage. It is the difference between the maximal utility that could be produced by the road and the utility, which is "naturally" produced.

Third, the simplest and most efficient way (at least in theory) to reduce road usage/congestion to the optimal level is to introduce a congestion tax. That tax should be equal to the difference between the private cost and the social cost. In other words, it should be equal to the

congestion externality at the optimal road usage/congestion level. This is why it is often called an internalizing tax. The amount of this internalizing tax has not much to do with the value of the time "lost" as the difference between actual transport time and free-flow time.

Practical Difficulties with Congestion Pricing

Congestion is therefore one case in which marginal social cost pricing makes good economic sense. In theory. In practice, however, implementation difficulties are formidable. Five issues can be raised.

A first question to be raised is: is it worth it? What is at stake? Is there much to be gained? Or, to put it in other words, what is the magnitude of the congestion cost that can be saved by road congestion pricing? An attempt was made to estimate it on the case of the Paris agglomeration. Paris is not just any city. It is the largest European agglomeration, with nearly 12 million people. It concentrates most of the French traffic jams (as conventionally defined). The three different studies that were undertaken converge towards congestion costs, economically defined, of about 500 million euros. This is not negligible, but it is only about 0.15% of the Paris agglomeration GDP.

A second issue is: what is the tax that should be imposed to take us to the optimum road usage and eliminate the congestion cost? The answer is that there should be many different taxes. Because congestion on a road varies with the characteristics of the road and with the demand for the road, the appropriate marginal social tax will vary with each road and each hour. The appropriate tax to be imposed on a trunk road is very different from the one to be imposed on an arterial road; the one to be imposed at the morning peak has nothing to do with the one to be imposed at an off-peak hour. This raises a theoretical problem as well as a practical one. If there are just a few (1-3) different taxes, then the tax will in many cases be either too high or too low, and this set of taxes will not be able to achieve the potential gain expected form internalization. But if they are many (more than 20) different taxes, it must be feared that drivers will not be able to memorize and understand these complex price signals and to modify their behavior accordingly, which means that the potential gains expected from internalization will not be fully realized either. It is not easy to find a way between the Charibda of an ineffective single tax and the Scilla of an ununderstandable multiplicity of taxes. Only a fraction of the potential gain will be obtained. In the case of Paris,

this might be something like 300 or 350 million euros instead of 500 million euros.

The next question is of course: how could technically such a complex tax collection system be put in place, and at what cost? The progress of technology is such that the information system required —which does not exist presently— can most probably be developed. Some electronic devices would have to be fixed on each car, and in each road. They would make it possible to send each car owner a "congestion bill" at the end of each month. Visiting cars would probably escape the system (which would further reduce the optimizing potential of the tax). Above all this uncomplete and imperfect system would be installed and operated at an economic cost. This economic cost, for which there are no solid estimates, should be deducted from the economic gain expected from the congestion tax. In the case of Paris, this would further reduce the benefit to perhaps something like 200 or 250 million euros, or 0.07% of the Paris GDP.

A fourth issue is that the amount of tax to be collected is *much* larger than the expected benefit of the tax. In the case of Paris agglomeration, according to our estimates, it would amount to about 5 billion euros per year, 10 times the theoretical benefit of the tax, and 20 times the effective benefit. For a pure theoretician, this

is not a problem. A tax is not a cost, but a transfer, and it could be redistributed to car users. For car users, however, it is indeed a problem. Note that the measure is in principle introduced only in their interest, for them, and does not benefit the rest of society. Car users will overwhelmingly reject the idea that they should pay 10 in order to gain 1 or less. They will never believe that the 10 will be given back to them (and they will probably be right). This amounts to making them happy against their will.

A final problem is the regressivity of the congestion charge. The system will mostly benefit the rich. Every car user will pay the same amount of money, and gain the same amount of time. This is to the benefit of people who have a high value of time, who happens to be mostly, although not only, the rich. The poorer, who will be excluded from the roads, will be worst off than before, by definition. The loss/benefit of the people in-between would depend upon what is done with the proceeds of the tax. But it is clear that the net benefit (which is likely to be a loss in most cases) will be a function of the value of time, that is of income. This pricing principle is therefore clearly regressive.

All of these difficulties appear so serious that they tend to empty the justification of marginal congestion

pricing. As a theoretical construct (when correctly understood), it is a good idea. There must be cases when it should seriously be considered. But in most cases, in practice, it appears as a false good idea.

V - Air Pollution : A Disappearing Externality

Motor vehicles reject gases or particulates that are potentially dangerous for human beings or for the environment. The most important such gases are: CO, NOx, VOC (volatile organic compounds), SO2, particulate matters, and lead. (CO2, which is not dangerous for human beings, is a different matter, to be discussed below).

Automobile emissions of these pollutants are a good case of externalities. Auto users inflict damages upon other auto users and upon non-auto users, and the polluted cannot ask compensation from the polluters. Polluters (auto users) therefore have no incentive to reduce their pollution, either by driving less or by using less polluting vehicles. The resulting situation is therefore sub-optimal. Policies are necessary to redress the situation created by these externalities. Pollution taxes or charges constitute one such policy. If every car user were made to pay exactly for the pollution damages he/she creates, then she/he would integrate this damage in

his/her calculations and decisions, and reduce pollution emissions to the optimal level. This is, in theory, a very elegant and efficient policy. Unfortunately, it is a policy that is extremely difficult to implement, and it turns out that in the past thirty years alternative policies (based on interdictions) have been implemented, and have been extremely successful.

Difficulties of Incentive Policies

Making car users pay for the pollution damages they create is easier said than done. In the spirit of marginal social cost pricing, what is needed is an estimate of the damage done by a particular car at a particular place at a particular moment. Averages will not do, because these marginal damages will vary immensely from car to car, place to place and moment to moment. This is about the only thing that is known about car pollution damages. It means that an average charge would most of the time be either much lower or much higher than the "marginal damage" done. Not only would this be unfair, but above all it would be inefficient. It would miss its objective of reducing pollution at the optimal level — which is the justification of marginal cost pricing of pollution. A minimal knowledge of marginal damages would therefore be necessary. We are very far from having anything like it.

The relationship between car exhausts and damages done is a complex and poorly understood one. First, comes the relationship between car exhausts and ambient air quality. Pollutants emitted by other (non-transport) sources have to be taken into account. Meteorological conditions (sun, wind, rain, etc.) play a key role[1]. From one day to the next, the same car exhausts can and do produce completely different ambient outcomes. Within one single metropolitan area, at any point in time, ambient air concentrations for most pollutants can vary from one location to the next by a factor of 10. This is true not only for CO, which is a very local pollutant (very local means less than 50 meters), but also for SO2, NOx, particulates, ozone, which are supposed to be regional pollutants. Then, comes the relationship between ambient air quality and physical damages. Epidemiological studies have to take into account individual's characteristics (whether they smoke or not, etc.). It is increasingly realized than indoors air quality —which is breathed 10 times more than outdoors air quality— is a key factor. It is not known whether what counts are "background levels" of air pollution or "peak levels". Some medical authorities estimate that the damages associated with car exhaust pollution (measured in years of life lost, for

[1] In Paris, the so-called pollution peaks usually take place in mid August, when car usage is at its lowest level.

instance) are 1,000 times less important than the damages associated with smoking. Finally comes the relationship between physical damages (assuming we know them) and monetary damages, which is equally uncertain. The net result is that nobody can ascertain with any seriousness the marginal damage associated with a particular car on a particular day on a particular road —even with a margin of error of 1 to 10. Even if we could, there would remain the problem of monitoring it, and of collecting the charge.

Marginal social cost pricing in the area of air pollution is therefore unpracticable. It has never been implemented, and will never be. What is proposed, instead, is some form of average social cost pricing. Questionable estimates of automobile-related air pollution damages are produced; the amount of such estimates is then divided by fuel consumption; and the result is a tax per liter of fuel presented as a marginal internalization tax —which it is not.

Success of Interdiction Policies

Fortunately for the environment and for air quality, other policy instruments have been utilized. The air pollution externality has not been ignored. It has been fought by means of emission norms, a form of

"interdictions". It turns out that this instrument has been very successful.

If the motor vehicles of to-day were exhausting as much pollutants as the vehicles of 1970, total emissions of pollutants would have increased at the rate of automobile circulation, that is they would have been multiplied by a factor of 3 or 4 since 1970, and the present air pollution situation would be very serious indeed. But this is not what happened. In all countries, governments intervened, and imposed cleaner cars. The motor vehicles of to-day exhaust 20 to infinitely less (depending on the pollutant and the vehicle) than the vehicles of 1970. In Europe, the lead was taken by the European Union that negotiated with motor vehicles manufacturers a programmed decline of emissions.

Because this was not done overnight, because of a "stock effect" (old polluting cars remain on the roads for a wile, and the average car emissions are therefore much higher than the norms that applies to the newly produced vehicles), and because some vehicles (particularly heavy vehicles and diesel-fueled vehicles) lagged behind, progress was mixed. There was a race between more and more vehicle-kilometers driven and less and less polluting vehicle-kilometers. For some pollutants, like CO, lead, SO2, this race was clearly won by air quality. For other

pollutants, such as N0x or particulates, the issue was for long uncertain.

But in the end, the race was won by air quality for all pollutants. The turning point varies according to country and pollutant, but if we were to give just one date, we could suggest 1990. Since then, total emissions for all pollutants decline everywhere in Europe, and decline very rapidly. In 2001, total emissions (not unit, per car, emissions) represent less than half what they were at the highest point. This decline is bound to continue. It can be forecasted with a great accuracy: it is easy to figure out what the number of car-kilometers will be, and easy to figure out what the average emissions per car-kilometer will be, taking into account the stock effect. These forecasts have been made, by the European Union itself. They show a further decline by more than half in the present decade. In 2010, for all the six air pollutants discussed here, total emissions will be about 20% of what they were in 1990 —not 20% lower, but one fifth of what they were.

Motor vehicles emissions of pollutants provide a fascinating case of false reasoning. One starts with the idea that such emissions are externalities. This is true. One continues by saying that they should therefore be internalized. This is half-true; the correct statement is

that something must be done about it, something that can be, but need not be, internalization. And one concludes that fuel prices should be increased by the amount of the cost of that externality. This is plain wrong, not only because nobody can credibly estimate that cost, but because the logic of internalization implies charging the marginal costs, not the average cost. It does not follow that nothing should be done about vehicle emissions of pollutants, but that other policy instruments should be utilized. This is exactly what happened. Emission norms have been imposed, and have led to a massive reduction of motor vehicles emissions of pollutants. It is doubtful that internalizing taxes, be they equal to marginal costs or to average costs, would have achieved a similar reduction.

VI — Carbon Dioxide: Estimating Its True Marginal Cost

The above discussion of air pollution has left aside CO2 (carbon dioxide) for two reasons. One is that CO2 is not a health-related pollutant. The other is that CO2 emissions have not followed the pattern of air pollutant emissions. This does not mean that automobile-related emissions of CO2 are not a serious problem. The opposite is true. CO2 is a long-lived greenhouse gas. Greenhouse

gases prevent solar heat from being reflected away. They contribute to increase the temperature of the earth. The resulting global warming will bring all sorts of climatic changes in the future. Most of these changes will have a cost for mankind.

Contrary to what is often suggested, motor-vehicles emissions of CO2 are not the only, and not even the main, cause of global warming. Worldwide —and this is the only scale that makes sense— they account for a little more than 10% of anthropogenic (man-related) contributions to the greenhouse effect. This is because CO2 is not the only greenhouse gas, and because motor vehicles are not the only source of CO2 emissions[1]. Anthopogenic contributions are a fraction of total contributions, but they are obviously the only ones on which man can have an action. A contribution of 10% is not massive, but it is not negligible either.

CO2 emissions are a good case of externality, and one that would lend itself well to internalization. It is clearly an externality, in the sense that car users rejecting CO2 impose a cost upon future generations, for which they are not made to pay. If that cost could be

[1] The much higher figures (30-40%) often quoted to estimate the contribution of motor-vehicles to global warming are obtained by considering CO2 as the only greenhouse gas, and by looking only at European data on CO2 emissions by source.

calculated, it would lend itself well to internalization, for two reasons. One is that the contribution to damages is constant, irrespective of where and when the vehicle is driven. The marginal damage is here equal to the average damage. The other is that the damage would be easy to allocate, because it is proportional to fuel consumption. Differences in CO2 emissions by type of fuel are not very large, and are well know. A tax on fuel consumption would therefore approximate very well CO2 (or carbon) emissions. In addition, it would be particularly easy to assess and collect, because of the small number of fuel producers.

Unfortunately, there are hardly any estimates of global warming damages. The reasons are that they are very difficult to produce. First, the damages are global, and concern the entire world; some areas or countries will suffer more than some other; some will even benefit: global warming is not a bad thing for Siberia. Second, they are uncertain. Third, they are complex. Fourth, it is not easy to put monetary value on some of the forecasted changes. Fifth, they will occur in the very long term, in the second half of this century. This raises the issue of a discounting rate. A damage of 1 euro taking place in 2050 is not equal to a damage of 1 euro taking place now. It is worth less, but how much less?

In practice, what is often done, in particular by the European Union, is to use the economic cost of meeting the Kyoto commitments in CO2 reduction. At Kyoto, governments in principle agree to limit their CO2 emissions, relative to their 1990 levels. The EU committed itself to a 5% reduction in 2010. Meeting this commitment has an economic cost, that can be estimated, and related to the quantities of CO2 reduction it implies. One thus produces a figure of 19 euros per ton of CO2. It is therefore proposed to increase motor vehicles fuel prices by the corresponding amount. This is presented as an estimate of the social cost of global warming, to be "internalized".

It is not, by any means. The Kyoto commitments are the output of an intergovernmental diplomatic negotiation. As such they have a political legitimacy. But they have no economic or scientific legitimacy at all. There is no reason why the figure of 19 euro per ton of CO2 they produced would have any relationship with the marginal (or average) cost of global warming generated by one ton of CO2.

An attempt was made to estimate this cost, the marginal cost of the global warming CO2 externality. Scientists tell us that CO2 accumulates, and that damages in a given year are a function of the sum of CO2 emitted until that year. We begin by projecting for every year of

the century annual and cumulated CO2 emissions in the absence of CO2 control. We then take the few available estimates of what the total cost of global warming would be in the future, let us say in 2050, if nothing were done about greenhouse gas emissions. We take 75% of that cost, because CO2 is said to be responsible for about 75% of the greenhouse effect. We then estimate, for every year, the damage cost (with the proportionality rule just mentioned). For every year, we estimate the damage created in that year by 2000 CO2 emissions (always with the proportionality rule). These numbers are discounted with a certain rate of social discount. Their addition gives a number representative of the cost of the damage done by emissions of CO2 in 2000[1]. Dividing this number by the number of tons of CO2 emissions in 2000 gives us the marginal social cost of one ton of CO2.

Estimating the Cost of CO2 Emissions

We have two estimates of the economic costs of the greenhouse effect, in the absence of specific strong policies. One for year 2050, by Munich-Re, for UNEP, puts this cost at US$ 300 billion. The other for year 2100 —and therefore less reliable— puts this cost at 1% of the world GDP; assuming a 3% growth rate of the world GDP, this

[1] Let D=Social cost of damages done by 2000 CO2 emissions, D_t=CO2 damages in year t (for instance 2050); R=CO2 emissions in year 2000; r=rate of growth of CO2 emissions; s=social rate of discount; n is any year between 0 and 100. We have:

$$D = \Sigma((D_t*R*(1+s)^n)/(\Sigma R*(1+r)^t)$$

amounts to US$ 5885 billion. CO2 accounts for an estimated 75% of these costs. In 2000, total world CO2 emissions were about 24.9 billion tons.

Let us assume that, in the absence of CO2 strict controls, CO2 emissions would increase at a rate of 3% per year. One can calculate, for each year of the century, yearly CO2 emissions and cumulated CO2 emissions. In 2050, for instance, yearly COE emissions would be about 109 billion tons, and cumulated CO2 emissions close to 3,000 billion tons. In 2100, these numbers are, respectively, 480 and 15,600.

Damages are known to be a function of cumulated emissions. Let us assume this function to be linear, i.e. that damages are proportional to cumulated emissions. Having an estimate of damage for one year, it is therefore easy to estimate damages for each year of the century. What is the responsability of the CO2 emissions of year 2000 in the damages for each year t? It is the damage for year t multiplied by CO2 emissions of year 2000 (24.9 billion tons) and divided by cumulated emissions in year t.

Once we have the damage caused for each year of the century by the CO2 emissions of 2000, it is easy to discount and to add. The calculation was done with a 8% rate of discount, the rate which is formaly applied in the French public sector. This procedure applied to the Munich-Re estimate produces a cost of US$ 26 billion, which, divided by 24.9 billion tons, means a cost of about 1 US$ per ton. Applied to the 1% of world GDP estimate, our procedure produces a cost of US$ 95 billion, or 3.8 US$ per ton.

The per ton numbers are the marginal costs of the greenhouse effect caused by the CO2 emitted in 2000. Reducing CO2 emissions by one ton reduces damages over the century by 1 (or 3.8) dollar(s). This is many times less than the 17 dollars (19 euros) put forward by the European Commission. With a rate of discount of 5%, the marginal cost are increased to 1.6 dollar with the Munich-Re estimate and to 5.9 dollars with the 1% of GDP estimate.

The most meaningful estimates are those produced on the basis of the Munich-Re —a serious insurance company— estimate for damages in year 2050. They suggest a marginal cost of CO2 emissions of 1.1 to 1.9 euros (depending on the social rate of discount used), 10 to 20 times lower than the EU figure.

VII — Conclusions

This brief review suggests that MSCP (marginal social cost pricing) and internalization of transport-related externalities cannot seriously be proposed as the main instrument of transport policy in Europe. At an abstract and theoretical level —the level of an undergraduate economics course— MSCP has great merit. The market for transport does not function very well because of externalities, and therefore does not lead us to an optimal outcome. Let us internalize these externalities at the margin. Prices will reflect true costs at the margin,

market failures will be eliminated, and the market thus corrected will take us to the beautiful land of optimality. A closer examination of the proposal, however, raises all sorts of major difficulties.

First, it appears that none of the four major so-called transport externalities lends itself well to internalization at the margin, as discussed at some length above. Table 2 summarizes this discussion.

Table 2 - Four Major Transport Related Issues

	Accidents	*Congestion*	*Air pollution*	*CO2*
A serious problem?	Yes	Yes, though exaggerated	No longer	Yes
Scope?	National	Local	Local/regional	Global
Affected people?	Mostly car-users	Car-users	Not only car-users	Everybody
An externality?	No	No/yes	Yes	Yes
Marginal costs known?	No	No	No	No
MSCP feasible?	No	Difficult	No	Yes
MSCP efficient?	No	Doubtful	No	Perhaps
Other instruments tried ?	Yes	Not enough	Yes	No

For various (and different) reasons, marginal social costs are not known with any seriousness. Even if they were, they could not, technically, be internalized, except in the case of CO2. As a result, what is proposed under the name of internalization cannot be expected to solve in any significant manner the very real problems at hand. The

only exception could be CO2, if we really tried to estimate the social cost associated with emissions of CO2.

Second, it is not clear in the proposals made whether marginal social cost pricing should replace the present pricing system, or be added to it. The present pricing system, partly in line with a Ramsey-Boiteux pricing principle, is characterized by a very high taxation of road transport and an equally high subsidization of rail transport. In most European countries, fuels are taxed at a rate of 300 to 400% —higher than any other good, including alcohol and tobacco— whereas rail transportation is subsidized at a rate of about 100% (fare revenues cover about 50% of costs). Adding MSCP to existing taxes is in complete contradiction with the logic of MSCP. That logic is that transport users should pay the marginal social cost of transport usage, but only that cost, to take us to optimality. If road users pay the marginal social cost of their usage in addition to the taxes they already pay, then the effective marginal price they pay will much higher than the marginal social cost they inflict upon society. And this will take us away from optimality. On the other hand, if we replace the present system of taxes and subsidies by a marginal social cost pricing system, two things will occur. One is that road usage price will in most cases probably decline (in view of the

uncertainties about marginal social costs, one has to be prudent here). The other is that rail prices will more than double. This is not al all what Economic Union policy documents aim at.

Third, internalization of marginal costs is not the most efficient way of dealing with the very serious and real issues of accidents, congestion, air pollution, and global warming. Other instruments —fortunately— can be used, and have already been used with success. To reduce car accidents, a mix of safer cars, safer roads and safer driving behavior is required, rather than an increase in road usage costs that would not have much of an impact on car accidents. To deal with congestion, road construction and improvement are likely to be in many cases the most appropriate policy (it is for cost-benefit analysis to tell us), even if, in certain limited cases, road pricing could and should be seriously considered. For air pollution, the remarkable success of emission norms is a clear proof of the potential of "interdiction" types of instruments. For CO2, the internalization of marginal costs —if only these costs could be known— is more promising. But the real solution will come from technical breakthroughs in non-CO2 emission engines or in CO2 traps. The idea that internalization is the only, or even the best, way of dealing with social problems is so simplistic

and erroneous that it is difficult to understand how it came through.

Finally, as discussed in section II above, marginal social cost pricing is only one pricing principle amongst several. Even if it could be implemented in the case of transportation (which is not the case), and if it were an instrument adequate to tackle the serious problems associated with transportation (which is not the case either), marginal social cost pricing would only achieve one of the possible objectives of transportation policies. It would contribute to an efficient usage of existing transport infrastructure. But it would not help select the appropriate transport investments, it would not keep the balance in average costs between different transport modes and between transport and other goods, it would not necessarily contribute to minimize distortions introduced by general revenue-raising, it would not contribute to income redistribution, and it would not serve specific policy objectives in defense, regional or environmental policies. It is true that it is not easy to design pricing system that can serve simultaneously all these worthy objectives. But this difficult task is not made simpler by the dogmatic choice of just one pricing principle, MSCP. A more pragmatic approach is required, that could be based on average social pricing, corrected as appropriate to

incorporate all the policy objectives just mentioned and utilizing all the available policy instruments —including internalization of externalities when feasible and efficient.