# For a systemic approach of transport nuisances in urban areas

Communication to WCTR 2013 – Rio de Janeiro – July 15-18th

Frédéric Héran, associate professor in economics, University of Lille 1, researcher at CLERSE (Centre lillois d'études et de recherches sociologiques et économiques)
UMR 8019 du CNRS (Centre national de la recherche scientifique)
frederic.heran@univ-lille1.fr

***Abstract***

Negative externalities of transports in urban areas are usually regarded as a collection of perfectly distinct nuisances. Each nuisance is identified, then isolated, only the direct impacts are really taken into account and indirect impacts estimated negligible. This results in a separate treatment of each nuisance causing unintended effects. Negative externalities form in fact a system of interdependent nuisances that converge at the level of indirect impacts, with numerous synergies and significant negative spirals. So it is better to prevent the nuisances rather than having to treat them. And that is why the traffic calming is an relevant solution. As for the socio-economic assessment of nuisances, it is no longer simply a sum of individual costs.

**Keywords** speed – effective speed – optimal speed – cost-benefit analysis

***Table of contents***

## *0. Introduction*

The issue of negative externalities of modern transports in urban areas is an old topic that has emerged with the automobile development and the increase of accidents. The environmental impacts – noise and "smokes" – began to be studied in the 50's[1]. Several methods of monetary appraisal were then developed and various technical solutions mobilized: measures for reducing accidents, protection against noise, emissions standards... With global warming, attention is now focused on greenhouse gas emissions and ways to reduce them: electric cars or hybrids, clean engines, alternative transports…

Yet this communication will focus on all the nuisances. Can we actually study separately each of them? For the city dweller, cutting negative externalities by type does not make much sense. For him, living next to a high traffic road or a railway is simply very painful, even unbearable, and he does not try to make subtle distinctions between inconveniences. On reflection, this city dweller is not wrong. It is likely that nuisances are more closely linked than the specialists think it. This overall impact is probably much greater that the sum of the expert assessments. This is the hypothesis we will explore.

If this hypothesis is confirmed, the future of urban mobility does not pass mainly by cleaner cars and some high tech public transports, but also and especially by traffic calming, the only way to reduce substantially all the nuisances.

To explore this topic, we will first return to the usual approach by showing that negative externalities are considered as a collection of isolated nuisances. Then, we will consider these externalities, on the contrary, as a system of interdependent nuisances. Finally we will draw some consequences of this approach about their treatment and their socio-economic assessments.

## *1. The sectoral approach, or negative externalities such as a collection of isolated nuisances*

How the negative externalities of transport are usually considered in urban areas appears singularly restrictive: only a few nuisances are considered important and indirect impacts quickly removed. So that nuisances are considered independent, despite serious problems of consistency in their treatment.

### *1.1. Four nuisances and some others*

In official reports as in the most renowned scientific works, only four negative externalities are considered important: three environmental impacts – local pollution, greenhouse gas and noise – and the road unsafety. Transport economists seem to agree on this point (Bonnafous, 1992; Quinet, 1998; Banister, 2005…). Briefly recalled some nuisances sometimes complement the table: congestion as externality inflicted by motorists to bus passengers, severance

[1] "(…) The penetration of motor vehicles throughout urban areas is bringing its own peculiar penalties of accidents, anxiety, intimidation by large or fast vehicles that are out of scale with the surroundings, noise, fumes, vibration, dirt and visual intrusion on a vast scale." (Buchanan, 1963, p. 55)

effect, space consumption, effects on the landscape, vibrations, odours, heat islands, architectural constraints imposed by garages… (Héran, 2000)

There are still other nuisances that are not specific to urban areas, such as fossil fuel consumption, impact of vehicle production and construction of infrastructure, waste or pollution of water and soil…, or are mainly about countryside as the impact on biodiversity and the use of agricultural land. Transport contribution to the greenhouse effect is not primarily related to urban transport (about 40%). Similarly, accidents do not involve mainly the urban areas (40% of the most seriously injured), but their impact on quality of life is important.

The four main impacts are also the only negative externalities that are roughly estimated by economists. Indeed, the non-monetarized nuisances do not count, despite the recommendations to quantify or qualify them (Boiteux, 2001). For example, the severance effect is often considered negligible because we know to measure the cost of the lost pedestrian time to cross or circumvent the infrastructure, but not the consequences on the neighbourhood relations.

### *1.2. Nuisances deemed independent*

From the outset, each nuisance was considered independent of each other, with specific consequences. Pollution causes lung and cardiovascular diseases, noise causes stress, road accidents cause deaths and injuries, congestion delays users, severance effects complicate local journeys, etc. To study and solve these problems, it is sufficient to find good specialists for each nuisance, to identify each phenomenon and its impacts, to properly assess its cost, and finally to determine the more suitable technical solutions.

It happens that some negative externalities resist and there is no adequately solution at a reasonable cost, as it is the case for CO2 emissions. But the research continues to find alternatives. In any case, it is rarely considered to prevent the nuisance by reducing car traffic or speed, or by not building infrastructure. The solutions are there to contain and mitigate the problem and preserve the traffic.

Some interferences may exist between nuisances, but only by imagining recoveries – the famous double counting – and never the opposite, namely synergy effects. In other words: 2 + 2 can make 3, but never 5. Rightly, the French report *Transports: investment choices and nuisances costs* (Boiteux, 2001) warns the reader ten times against double counting, but it never considers the possibility of synergies. It is right that the independence of each nuisance is a condition for using economic calculation.

Finally, there is no question that solutions could cause adverse effects. In such cases, they should simply be minimized by treating them as well as possible. Anyway, these undesirable impacts are considered *a priori* secondary and cannot challenge an infrastructure project.

This very common sectoral approach permeates all disciplines. It is the result of functionalism that grew during the nineteenth century and the first half of the twentieth century and aimed to segment the different areas of the real world to better know them. The effort was necessary and remains essential. But the lack of integration of the results leads to a partitioned design of the world.

As urban functions, nuisances are segmented, classified and treated, and the method seems perfectly rational. More broadly, this logic is a Cartesian conception of problem solving. It would suffice to apply the second precept of Descartes consisting "to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution" (*Discours de la méthode*, 1637). It would be easier to deal with problems by isolating their components, and then solving them one by one. This common sense idea is now widespread. It would be a simple question of technical rationality.

### *1.3. Adverse effects of sectoral solutions*

The segmented approach of nuisances is source of inconsistencies, because, in the absence of coordination, there is no reason that sectoral solutions are necessarily compatible. If unintended positive consequences can happen, it is much more common to observe both unexpected and opposite consequences, called "perverse effects"[1]. We propose to classify them into five categories: 1/ the problem is not sufficiently reduced, 2/ it is even made worse, 3/ it is simply delayed or 4/ moved, 5/ it is removed, but in generating other nuisances.

1/ Treatments that solve only a part of the problem. Such is the case of double glazing that reduce noise indoor and not outdoor, or particle filters that are unable to retain the ultrafine particles, or posts that prevent illegal parking on the sidewalk for cars but not for motorcycles. Of course, a solution can be more or less partial, but the result is often quite far from the desired compromise, the optimized social cost of the nuisance.

2/ Treatments that exacerbate the problem. These paradoxical cases really exist. If a dangerous pedestrian crossing is replaced by an overpass unusable by persons with reduced mobility, it becomes impossible for them to cross the arterial. In urban areas, cycle paths secure cyclists in link section but increase their risk in junctions and the balance can become negative (Wolf, 1992).

3/ Treatments that only temporarily solve the problem. They can be illustrated, in accident research, by the phenomenon of risk homeostasis (Wilde, 1982). Technical solutions that enhance safety increase the confidence, and the drivers tend to take excessive risks, offsetting the expected benefits of the device. With progress in braking, drivers no longer respect the safety distances, which were reduced by approximately 20% in 30 years (Cohen, 2006). Another example is the infrastructure-induced mobility: the increased road capacity reduces congestion in short term but tends to attract new vehicles until saturate the new road, cancelling the first benefits (ECMT, 1998; Noland, 2002). And we could also cite the autocatalyst or the porous asphalt whose effectiveness decreases gradually.

4/ Treatments that move the problem. This is the case of noise barriers which reflect the sounds in a different direction, or electric cars that return the pollution problems in the energy sector (Morcheoine and Vidalenc, 2009), or bypass roads which postpone the severance effect in periphery (Héran, 2011, Chapter 12). The improvement of passive safety of vehicles protects drivers, but heavier vehicles, with an increased kinetic energy, are an aggravating accident factor.

---

[1] "A perverse effect is an undesirable indirect effect, generally opposed to the initial aim, and unexpected." (CERTU et SETRA, 1998, p. 43) As Phil Goodwin says: "The hope is that the main effects will be approximately right and the omitted effects will be unimportant. This Is not always true." (2003, p. 603 ; see also Goodwin, 1998)

5/ Treatments that exacerbate other nuisances. They are quite common. The speed bumps secure the streets but are noisy and the residents complain. The elevated transport infrastructures free the floor space but degrade the landscape. The deletion of pedestrian crossings in link section or the installation of barriers to channel pedestrian movements reduce conflicts with cars but induce detours. Increasing the junction capacity reduces congestion, but complicates pedestrian journeys. Etc.

Table 1 provides an overview of the main adverse effects of sectoral solutions. It also shows that some of these solutions may have beneficial indirect impacts, but such cases are much rarer. The noise barriers secure the edge of the road. The underground infrastructures can limit at the same time noise, space consumption and the impact on the urban landscape, but their access ramps create obstacles and make the traffic easier, cancelling the long-term benefits. The electric car is also very popular for its ability to reduce both noise and local pollution, but without reducing other nuisances. By contrast, owing to its silence, it increases the accident risk for pedestrians, cyclists and especially blind people. In addition, many impacts are difficult to determine, as many effects combine. What about the impact on noise or pollution by coordinated lights, when the traffic flow is smoother but also higher? Etc. Anyway, such a matrix should be systematically explored by multidisciplinary research teams.

**Table 1. Overview of some beneficial and perverse effects associated with main sectoral solutions**

| Nuisance | Effect on / Solution | Noise | Pollution | Accidents | Congestion | Severance effect | Space consumption | Effect on the landscape |
|---|---|---|---|---|---|---|---|---|
| Noise | Double glazing | • | | | | – | | |
| | Noise barriers | • | | + | | – – | – | – – |
| | Porous asphalt | 0 | | | | | | |
| | Electric vehicles | • | ? | – | | | | |
| Pollution | Autocatalyst | | 0 | | | | | |
| | Electric vehicles | + + | ? | – | | | | |
| Accidents | Speed bumps | – – | – | • | | | | |
| | Better braking and acceleration | – | – – | 0 | | – | | |
| | Passive safety of the vehicle | | – – | ? | | | | |
| | Secured parallel itineraries | | | – | | – – | | |
| Congestion | Coordinated lights | ? | ? | – – | 0 | – | | |
| | Separated junctions | | | ? | 0 | – – | – – | – – |
| | New infrastructures | – – | – – | – – | 0 | – – | – – | – – |
| Severance effects | Pedestrian over/underpasses | | | ? | + | ? | – | – |
| | Elevated infrastructures | – | | | | ? | + | – – |
| | Underground infrastructures | + + | | ? | | ? | + | + |
| Space consumption | Posts, barriers against parking | | | ? | | – | ? | – |
| | Elevated car parks or roads | | | | | – | • | – – |
| | Underground car parks or roads | | | | | – | • | + |
| Effects on landscape | Landscape integration of infrastructures | | | | | | – – | • |

Direct impact: • Durable
0 Zero in long-term
? Unknown effect because many opposite impacts

Indirect impact: Beneficial effect: + + strong impact + low or partial impact
Perverse effect: – – high impact – low or partial impact
? Unknown effect because many opposite impacts

However, these adverse effects are of little importance if the overall effect is largely positive. But such an assessment is rarely achieved: by definition, a perverse effect is unexpected. Thus, the idea that there is an infrastructure-induced mobility is now recognized, but not always taken into account. Today, everyone knows that land use transport interaction models are required, even if they are far from being sufficiently operational. More broadly, with time and feedback, the socio-economic assessments of transport infrastructure improve. The northern bypass road project of Grenoble (a town in south-east of France) was unanimously rejected by the Commission of Inquiry, in March 2010, after an overall analysis which revealed an induced traffic and associated nuisances in sensitive areas, damages to the landscape and to urbanization projects (Pouyet, 2010).

Regarding the severance effects, nobody even imagines that the overall accessibility could be decrease. For example, tens of thousands drivers who pass every day on an expressway are obviously much more numerous than hundreds of pedestrians and cyclists who seek to cross it. Yet this reasoning is based on a methodological error. We cannot compare a concentrated motorized flow, at a dispersed non-motorized flow. The cars go the fastest, when the active modes go the shortest. In addition, because of the difficulty of crossing, a part of non-motorized people renounced to move, or use now motorized modes (Héran, 2011, Chapter 6).

We must face the facts: the traditional approach of the nuisances is inadequate. Obsessed with double counting, the sectoral solutions come to forget essential aspects. Many contradictions appear, without the balance of the proposed solutions. It becomes necessary to systematically explore the relationship between the various nuisances.

## *2. The systemic approach, or negative externalities such as a set of interdependent nuisances*

In the 60-70's, the systemic approach has amply demonstrated that the reductionist precept of Descartes is actually wrong. The decomposition of a problem into its parts can be a first analytical step, however it is absurd to solve each part separately, at the risk of serious contradictions. These parts are necessarily linked together, and form an open system in constant evolution (von Bertalanffy, 1968; Le Moigne, 1977, p. 13-16). Therefore, only an integrated solution, that takes into account of this double systemic and dynamic dimension, has some chance of success.

At least, three types of relationships between the various nuisances can be distinguished: direct links, synergies and negative spirals.

### *2.1. Direct links*

Firstly, each nuisance may be taken in a cumulative process that strengthens it. 1/ To overcome road noise, everyone is obliged to raise his voice, which increases the noise level. 2/ Pollutants combine to produce secondary pollutants that may be harmful, as it is the case of ozone. 3/ Accidents can sometimes generate other accidents, as in the case of pile-up, but can also, it is true, urge caution. Congestion spreads easily in a network close to saturation. 4/ The severance effect caused by big infrastructures tends to deepen, because the neglected surroundings are deteriorating, and then other infrastructures are built there (Héran, 2011, Chapter 5). 6/ A large space used to move rapidly (separate lanes) increases space used to

cross other roads (interchanges) and space for off-street parking. 7/ The degraded landscapes encourage a general carelessness, as shown by the city entrances (Gallety, 1991).

In addition, many nuisances maintain direct links between them. 1/ By perturbing attention, the noise contributes to road unsafety, and by filling the space, it increases the barrier effect, discouraging walking and cycling. 2/ The dust pollution dirties the buildings and degrades the urban landscape. And an oil puddle can cause an accident. 3/ The road unsafety is a powerful factor in generating traffic barrier (Hine & Russell, 1993). An accident can also cause pollution and sometimes leads to congestion. 4/ Beyond time losses, congestion induces many other nuisances: noise, pollution, severance effect, invasion of all spaces (bus lanes, bike lanes, sidewalks) and degradation of the landscape. 5/ The traffic segregation, which is partly the cause of severance effect, also generates a profusion of safety improvements and signing, which saturates the urban visual space. And detours are sources of congestion. 6/ In the 50-70's, reducing the width of sidewalks, removing the cycle paths, and the invasion of public spaces by parking, increased unsafety or active modes. The space consumption by individual motorized vehicles also contributes to increase congestion and degrade the landscape. 7/ The outdoor advertising (which is part of the transport impact on the landscape) is a factor of road unsafety, to the point that it is forbidden in Sweden not to distract drivers. And a degraded environment constitutes an obstacle to walking.

In total, on all possible direct impacts of nuisances, a majority of relationships exist (22/42 in the case of Table 2), even if we lack quantitative data to assess the importance of each of these links. Nevertheless, it is already a first evidence that nuisances make a system.

**Table 2. Direct links between main nuisances**

| Nuisance | Noise | Pollu-tion | Acci-dents | Con-gestion | Severance effect | Space con-sumption | Land-scape |
|---|---|---|---|---|---|---|---|
| Noise | O | | X | | X | | |
| Pollution | / | O | / | | | | X |
| Accidents | / | / | O | X | X | | |
| Congestion | X | X | X | O | / | X | X |
| Severance effect | | | X | / | O | | X |
| Space consumption | | | X | X | | O | X |
| Effects on landscape | | | X | | X | | O |

Reading: noise can contribute to accidents.
Legend: O Cumulative process X Durable or important impact / Not durable or weak impact

### *2.2. Synergy*

There is synergy (or "cocktail effect") between multiple nuisances when their impact is greater (or sometimes lower) than the sum of the impacts of each nuisance. Because of interferences with other nuisances, the resulting impact can be much greater: accelerations, crossing of thresholds, and irreversibilities may occur. "The whole is greater than the sum of the parts" Aristotle already stated in his Metaphysics, around 350 BC, famous quote regularly referred by the proponents of the systemic approach.

To highlight such phenomena, it is necessary to venture further into the analysis of impacts, pondering on the consequences of the nuisance accumulation, firstly on used transport modes and on the type of journey, secondly on man and his environment. It turns out that all nuisances converge towards four main indirect impacts: 1/ disaffection for active modes, 2/ reduction of neighbourly relations, 3/ deterioration of human health and 4/ degradation of

the living environment. Of course, none of these four indirect impacts are attributable solely to transport nuisances, as it is also the case for any nuisance. Table 3 summarizes how all nuisances – six of them have been used here to simplify reading – generate these indirect impacts.

**Table 3. The four main indirect impacts common to all nuisance**

| Indirect impact / Direct impact | Disaffection for active modes | Reduction of neighbourly relations | Deterioration of human health | Degradation of the living environment |
|---|---|---|---|---|
| Air pollution | Discomfort during the effort | Unpleasant exchanges in a polluted environment | Lung diseases, cancers… | Dirty buildings Fumes, odors |
| Noise | Unpleasant journeys in a noisy environment | Unpleasant exchanges in a noisy environment | Anxiety and sleep disturbance | Calm places too scarce |
| Road unsafety | Fear to cross the arteries on foot or borrow them by bike | Exchanges limited by fear of facing traffic | Physical and psychological traumas | Worrying accident risk |
| Space consumption | Reduced spaces for pedestrians, often lacking for cyclists | Remoteness of living spaces | Stress associated with confined spaces | Few spaces not subject to traffic |
| Severance effect | Deterrent waiting times, detours, and grade separations | Reduced relations on the edge | Overweight linked to lack of physical activity | Broken and discontinuous spaces |
| Effect on landscape | Pedestrians and cyclists less visible in a landscape dominated by the car | Unpleasant exchanges in a degraded landscape | Depression in aggressive and chaotic urban landscape | Public space dominated by traffic |

The disaffection for active modes is largely attributable to transport nuisances. First, road unsafety make their use dangerous. Then, due to the severance effect of transport infrastructures, it may be more difficult to cross the main roads on foot than the city by car. In addition, the space consumption by motorized individual vehicles tends to reduce the space for active modes. Finally, the noise, the pollution generated by traffic, the degraded landscapes by vehicles and infrastructure make unpleasant the journeys by active modes. For the city dweller who wants walking or cycling, this accumulation of difficulties, particularly prevalent in the urban periphery, is strongly deterrent. The result is a necessary accompaniment of vulnerable people and more broadly, a shift towards motorized modes.

The reduction of neighbourly relations is also a consequence of high-traffic streets. In the 70's, the urban designer, D. Appleyard, compared three San Francisco's residential streets with light, moderate and heavy traffic. His research showed that residents of light street had three more friends and twice as many acquaintances as the people on heavy street. He found that families prefer to leave the streets with heavy traffic, for living in the periphery, owing to the high level of nuisances: at the same time noise, pollution, road unsafety, omnipresence of cars… (Appleyard, Gerson & Lintell, 1981).

Concerning the deterioration of human health, almost all the nuisances contribute to it: road unsafety of course, but also pollution through lung diseases and cancers, the noise source of anxiety and sleep disturbance, or depressing degradation of the landscape. Even the excessive space consumption by vehicles contributes to restricting the vital space for pedestrians and

cyclists, source of stress. The severance effect is may be more harmful: reducing active modes journeys, encouraging townspeople to use motorized modes, limiting physical activity and fostering overweight and obesity. And all of these impacts is not without consequences for labour productivity. The car mobility has also positive impacts on health: it facilitates access to health care, healthier food, and better housing. But the public health balance of transport has likely become negative, owing to the rapidly rising of obesity (British Medical Association, 1997; WHO, 2000).

Finally, the degradation of the living environment is also, in part, the result of all transport nuisances, such as noise, pollution, accidents, confined spaces, forced journeys, disfigured landscape. In 60-70's, this phenomenon has encouraged the families exodus in the suburbs. The households desire to better quality of life in a quieter, greener, less polluted and less dangerous environment is the reverse of the degradation of life in urban centres. The rehabilitation of city centres has also allowed a return of some residents. Although, again, motorized transport also facilitate access to amenities, but at a high price: automobile dependence for many people (only a third of the French people have now a modal choice) and increasing nuisances especially in the near periphery (Dupuy, 1999).

These four main indirect impacts, which have been briefly described, are themselves caught in various negative spirals.

### *2.3. Negative spirals*

There is a negative spiral (or "snowball effect"), when a nuisance causes an impact which in turn increases the nuisance: $A_t \Rightarrow B_t \Rightarrow A_{t+1}$ with $A_{t+1} > A_t$. When turning, this spiral causes an accumulation of the nuisance which can finish to block any developments. Then, the relationship becomes circular: the cause is also the consequence of the effect: At => Bt => At. This phenomenon is called "vicious circle", owing to its implacable and perverse nature. However, for the emitters of nuisance that take advantage of the situation, the spiral can, of course, be considered positive ("virtuous circle" or "magic circle") (Dupuy, 1999).

The simplest example is probably the accompaniment of children by car. To prevent to their children the accident risk on foot or bicycle, the parents decide to accompany them by car, helping to increase road unsafety, causing congestion around schools and recreation centres by vehicles stopping anywhere (Héran, 2003). Of course, many other factors are involved, but it is undeniable this spiral helped to fundamentally change the child's journeys[1]. The accompaniment of children by car, which was still the exception in the 60's, has now become the rule, with implications for the children's autonomy development and for the parents' constraints. Each parent is now in a blocked situation, where it is not possible to do otherwise under penalty of endangering the life of his child. Only a heavy collective initiative like "Safe route to school", involving all stakeholders, can break the vicious circle[2].

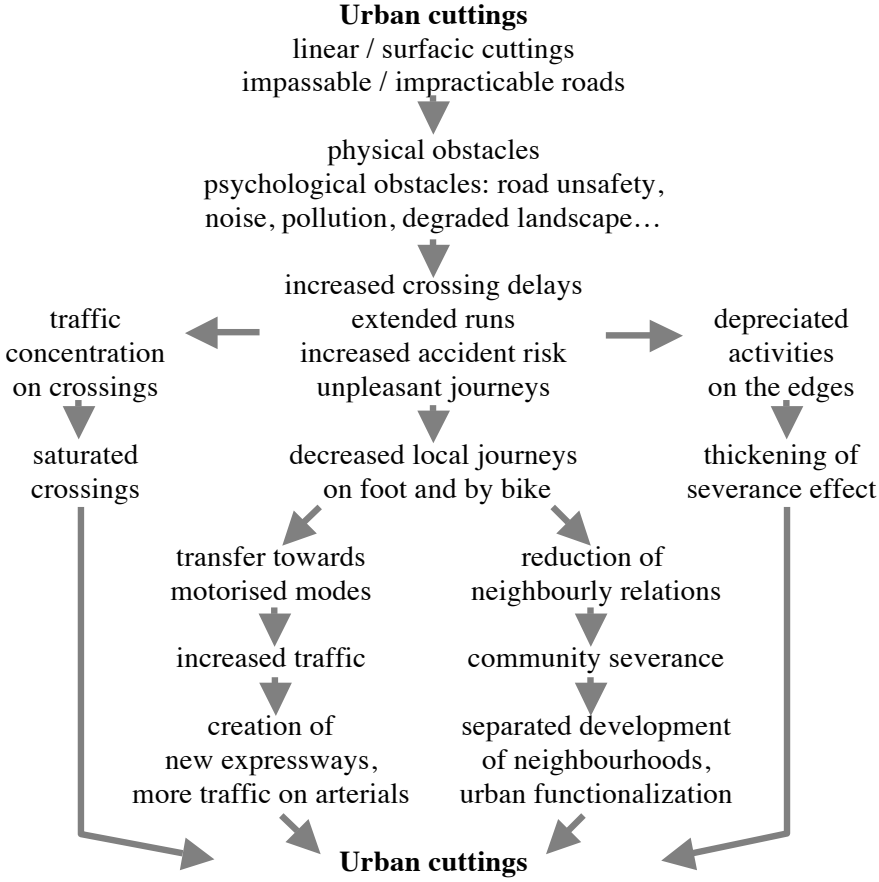
---

[1] Two decades apart, M. Hillman (1973, 1990) asked the same questions in the same schools, and was able to measure the loss of autonomy for children (aged 7-11) in their journeys. Whereas in 1971, 85% of them went alone to the school, in 1990, they was only a third. And the youngers (aged 7-8) are twice less to be allowed to cross the street alone. The main reason cited by parents is the traffic danger (45%) far before the child unreliable (20%), the fear of attacks (20%) and the distance too long (15%).

[2] See http://www.saferoutesinfo.org/.

Usually, the negative spirals are not isolated, but numerous and tangled. In the case of severance effect, we can distinguish four spirals at least (see Figure 1).

**Figure 1. Negative spirals due to severance effect of big infrastructures**




Source : Héran, 2011, Chapter 10.

Finally, each of the four main indirect impacts identified above leads itself on a negative spiral that reinforces it.

1/ The disaffection for active modes is strongly enhanced by two phenomena. Walking and especially cycling are considered much more dangerous than they really are. The practice is not determined by the objective risk that users do not know, but by the subjective risk that they tend to overestimate, because pedestrians and cyclists have no body and feel vulnerable (Prémartin et Faure, 1995). In addition, the accident risk of active modes increases when the number of pedestrians and cyclists decreases and vice versa, a phenomenon called “safety by number” (Jacobsen, 2003).

2/ The reduction of neighbourly relations leads to a fundamental change in social relations: at the limit, there is no question of meeting each other, moving without a car. A chance encounter in the street becomes impossible. This explains the “decline of the neighbourhood” analyses the sociologists Y. Chalas (1997).

3/ Similarly, the deterioration of health related to motorized transport, including the sedentary lifestyle it promotes, tends to reduce using of active modes. However, walking and cycling

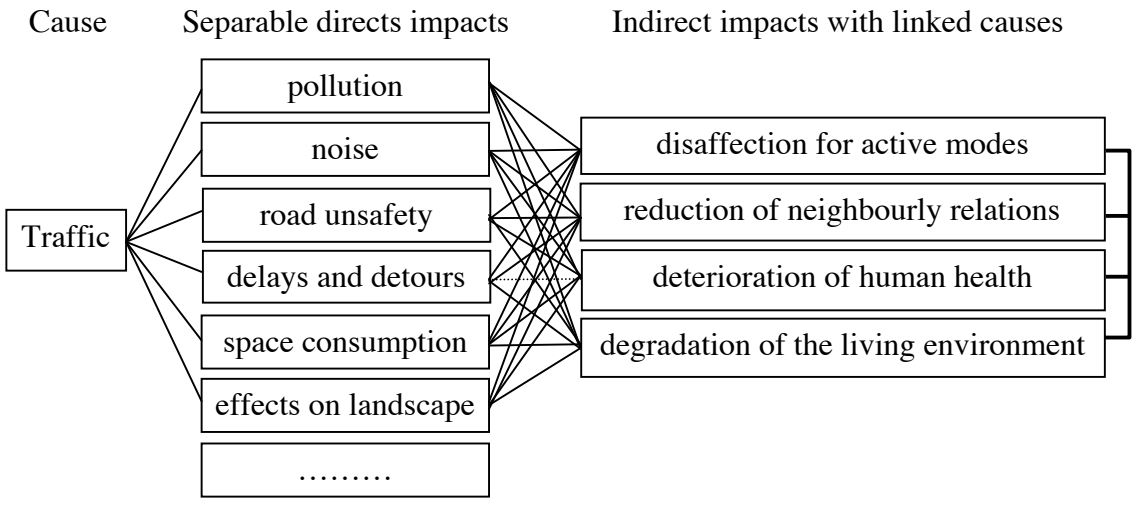
have well-known health benefits, not only to avoid obesity, but also to prevent and even treat many chronic diseases: diabetes, cancer, cardiovascular disease… (INSERM, 2008).

4/ And finally, not only the degradation of the living environment pushes townspeople to live in the periphery, but they are now obliged to move by car, contributing to further increase the nuisances (Emelianoff and Theys, 2001). This well-known phenomenon was denounced as early as the 60-70's (Jacobs, 1961). In Europe, this vicious circle has been halted, thanks to an expensive reconquest of city centres, with traffic calming areas and tramway or underground lines. But the problem is moved to the suburbs that are more than ever under automobile pressure, in France at least.

All these negative spirals lead to blocked situations, which are very difficult to break or with exorbitant costs. We have seen it with the accompaniment of children by car, but it is also the case for cycling very difficult to relaunch as it became confidential (loss of credibility of this mode and loss of skilled technicians). Ditto for the households living in periphery completely dependent on their cars, or for people with health irretrievably affected. About the run-down neighbourhoods, only a complete renovation has a few chances to straighten their picture.

In total, the nuisances related to motorized modes appear strongly interdependent, not only because their blurred borders, but also because they cause together important indirect impacts which lead themselves to formidable negative spirals. All these impacts are neither separate nor hierarchical but are system. They can be quite clearly distinguished at the first level, but are interwoven at the second level, forming an intricate network of causes and effects (see Figure 2).

**Figure 2. The system of transport nuisances in urban areas**



## *3. The consequences of a systemic approach of nuisances*

If nuisances form a system, then their perception, processing and evaluation are deeply transformed.

### *3.1. System disturbances and lifestyles*

Townspeople have an overall perception of nuisances. The nearby residents of an expressway denounce all the suffered inconveniences without slicing them. They do not have an accurate perception so far: asked about the severance effect, they refer mainly to noise, because it is the only nuisance easy to perceive and name (Enel 1998, p. 20). And most importantly, over time, residents are forced to adapt and change their lifestyle.

This is why the residential location choice of households can also be a choice of a lifestyle with more or less nuisances. The most affluent households can afford not only to live in homes away from nuisances, but also in quiet neighbourhoods, where walking and cycling are possible, and neighbourly relations preserved. In contrast, the poorest households are forced to live near high-traffic arterials, in areas only accessible by car, where the friendliness of the street disappeared. The motorized transport strengthens environmental inequalities. Of course, other factors intervene in residential location choice, especially for the middle classes who have a limited ability to arbitrate: they can choose to live in the centre but near a busy thoroughfare.

Anyway, households are not the only ones who understood the nuisances as a system. This is the implicit belief of the proponents of "urban ecology" developed in the early 20th century, as today the proponents of "sustainable city" (Emelianoff, 2005). This current is now seeking to emancipate themselves from too sectoral approaches.

### *3.2. Increased efforts to prevent nuisances*

The only way to limit the perverse, costly and conflicting effects of sectoral solutions is to try to prevent the production of nuisances. Obviously, a treatment to the source the problem is preferable at a containment of his effects. That is why, it is first necessary to recall the physical phenomena that are the origin of each of transport nuisances (see Table 4).

For road unsafety, the key phenomenon is the kinetic energy of vehicles, equal to their mass multiplied by the square of their speed ($E = ½ m v^2$). The classic three explanatory factors – the vehicle, the driver's behaviour and the road – will have no role if the law of the kinetic energy does not exist. This means that reducing the speed limit from 50 to 30 km/h on 80% of the street network, the accident severity is greatly reduced, although the average speed decreases by about 10% (Litman, 1999).

For noise, vibration of the air are caused mainly by the motors below 50 km/h and the rolling beyond 50 km/h. For local pollution, the incomplete combustion of fuel explains pollutant emissions. Again, the driving style and the environment may increase these two phenomena, but vehicles and fuels are mainly involved. Hence the effectiveness of European standards for reducing noise and pollution at the source on new vehicles.

The severance effect, meanwhile, is basically due to the vehicle speed which requires both segregated and hierarchical street networks (Héran, 2011, Chapter 6). The transport modes

cannot coexist with very different speeds without a high accident risk. This is why many technical solutions compartmentalize users: separate lanes, signalized or grade-separated junctions, one-way streets… Similarly, the car drivers accept detours to join expressways or public transport users accept to catch railway or underground lines more direct, but it is impossible to impose such detours for the active modes that are not motorized.

The static space consumption is due to the template of each transport mode for manoeuvring and parking. And the dynamic space consumption is due in addition to the vehicle speed requiring safety distances, side safety spaces (emergency lanes, median, open spaces for clearing the sides), and interchanges. So, an average of 9 m wide, and not 3.50 m, is necessary to drive at 130 km/h in urban periphery (Héran, 2008). Congestion is caused, not only by increased motorization of households, but also by the space consumption of the car much higher than other modes and by its speed that increases covered distances in a given time.

As for the effects on the landscape, they are related to the visual intrusion of infrastructures and vehicles, but also to outdoor adverts and signs installed along the arterials, catching the eye of drivers, passengers or pedestrians.

**Table 4. Origin of the nuisances and direct impacts**

| Nuisance | Origins | Main physical phenomena | Consequences for humans |
|---|---|---|---|
| Greenhouse gas | Fuel combustion | Greenhouse gas production: $CO_2$, $CH_4$… | Climate change |
| Air pollution | Fuel combustion | Pollutant production: $NO_x$, CO, $SO_2$, VOCs, PAH, PM… | Lamb, cardiovascular diseases… |
| Odours | Fuel combustion | Release of aromatic compounds | Olfactory discomfort |
| Noise | Motors, accelerations, rolling | Air vibrations | Stress |
| Accidents | Driver's behaviour, vehicle and road | Kinetic energy (vehicle mass and speed) | Physical and psychological trauma |
| Severance effect | Traffic segregation and road hierarchy | Speed | Reduction of neighbourly relations |
| Space consumption | Vehicle parking and traffic | Static and dynamic space consumption | Reduced mobility |
| Effects on landscape | Visual intrusion related to transport | Saturation of the visual field | Degraded landscapes |

From these investigations, it appears, not surprisingly, that these are the motor vehicles, their presence, their speed and mass, their engines and the fuel they use, the travelled infrastructures, and outdoor adverts and signs that drivers are supposed to look that are basically the source of transport nuisances. This is by agreeing to reduce the number of vehicles, their speed, the infrastructure size and the billboards, that the nuisances reduction will be the strongest, and the perverse effects limited. Here we find the traffic calming policy passing through the generalization of 20 mph zones and home zones in residential areas, including in periphery, and transforming motorways in urban boulevards, to encourage the alternative modes to the car and change the neighbourhood areas to make them more pleasant, with healthier and better life.

This type of solution exists in many cities in Northern and Central Europe: in Amsterdam, Copenhagen, Bremen, or Hamburg, since the 80's, in Berlin, Munich, Bern or Graz, since the 90's… However, is there a danger that the speed limitation reduces territory accessibility? Il would be too long, here, to disassemble this objection. It is sufficient to point out that the most advanced cities in traffic calming are not on the decline. On the contrary, they provide a high quality of urban life which contributes to their attractiveness, especially among managers.

### *3.3. A questioning of the socio-economic assessments of nuisances*

Unless error of reasoning or calculation, the socio-economic assessments of nuisances always underestimate their cost, for multiple reasons.

First, it is impossible to quantify everything: many nuisances still resist to any assessment (as recalled by the Boiteux report, 2001). How to estimate, for example, the reduction of neighbourly relations engendered by severance effect? A comprehensive survey would be required among the residents concerned, then find a method to measure the phenomenon. *A priori*, the contingent valuation method is a possible candidate, but it is unclear what questions to ask residents who have only a vague knowledge of the problem. And most of all, families, who contribute significantly to create social links, have probably already moved from the neighbourhood.

Then, when assessments exist, they are struggling to take full account of indirect or long-term or overall effects. How to assess, for example, the indisputable role of motorized modes in the growth of obesity? Facing these uncertainties, it is customary to take lower values, and often zero, to reduce disputes, waiting for better.

Finally and most of all, assessments ignore the four main indirect impacts resulting from the combination of direct impacts (cf. above). The case of the severance effect is exemplary and deserves to be detailed.

At first glance, there are only a few annoyances imposed by transport infrastructure mainly for pedestrians and cyclists: waiting time to cross the traffic, detours to avoid obstacles, efforts to use over or underpasses. However, since at least the work of D. Appleyard (1972, 1981), the Anglo-Saxons consider that main transport infrastructure cause what they call community severance, i.e. a reduction of neighbourly relations, complicating the access to shops and local services (schools, post…), causing the disintegration of social links and a sense of exclusion, especially among low-income people (James and al, 2005). In fact, it is not only the extra effort required by some obstacles that explain the community severance, but also all the other nuisances of the road or railway: noise, pollution, unsafety, visual intrusion…

Classical objection: these nuisances have already taken into account. Regarding noise, contingent valuation or hedonic pricing methods integrate all discomfort related to noise, including the displeasure to walk in the noisy street near housing. Similarly, road unsafety assessments take into account the danger of crossing or borrowing high-traffic arterials. Also, to avoid double counting, it should ultimately retain only the direct and immediate physical impacts, i.e. not much. In reality, it is the combination of direct nuisances that complicates neighbourly relations and all the socio-economic assessments ignore this aspect.

In short, if the nuisances form a system, then it is necessary to asses their total cost, not as a sum of individual costs, but with an overall approach. There is no question of denying any interest in sectoral assessments – which should continue to be further developed – but only to relativize their reach. We will here sketch avenues of research.

Being able to take into account many characteristics of the environment, the hedonic price method (HPM) is an interesting candidate. It can isolate differences in property values related to the existence, in around the housing, of noise, pollution, a degraded landscape, or a limited access to local services. However, the limitations of this method are numerous. The nuisances are not directly measured, but the discomfort perceived by people which may be either overestimated by those who feel forgotten by the public policy, or more often underestimated by households do not have a full awareness of all nuisances, being often themselves involved in their production. In addition, people more sensitive to nuisances either have moved and are no longer around to complain, or cannot move and try to better adapt to minimize the discomfort (Faburel and al, 2005).

Directly revealing the willingness to pay to reduce nuisances, the contingent valuation method is even more attractive. But, beyond its huge difficulties of implementation, it also suffers from a ambiguous perception of nuisances by residents remaining on site.

The behaviourist approach underlying these two methods assumes that the resident behaviours are based on individual rational choices. It would suffice to observe to reveal them. In fact, households are taken in many contradictions (the negative spirals identified above). In the example of accompaniment of children, each parent takes a rational decision by seeking to protect them from road accidents, yet it itself contributes to increase the danger. Another example: in fleeing the dense city and its nuisances to settle in houses that are only accessible by car, suburban people increase the nuisances. Etc. In short, townspeople can be fully aware of the harmful effects of motorized transport, while they contribute to these problem heavily, not by cynicism or by "nimby effect" (not in my back yard), but because they usually cannot do otherwise.

To assess the overall cost of transport nuisances, a different approach is needed. The ideal would be to compare town models (the more relevant perimeter would probably be the urban employment area) and for each to measure the consequences of choices in urbanism and transport infrastructures on travelled distances and used modes, with their impact on public health and environment. The cities with a certain density and mixed urban functions, traffic calming and good networks for alternative modes to the car, and high quality public spaces, allowing a more favourable modal split, should logically show a much better economic and environmental balance than cities with opposite characteristics. But will we ever make comparisons as ambitious?

In economists' language, instead of separately minimize the social cost of each nuisance – i.e. the sum of protection expenditures and residual damage costs –, it should minimize the social cost of nuisance system, but with a daunting challenge to evaluate the terms of the equation and the corresponding function, then find the right compromise – the social optimum – between motorized mobility and level of nuisances. The limits of economic calculation are clearly reached.

## *4. Conclusion*

The negative externalities related to urban traffic can no longer be regarded as a mere collection of perfectly distinct nuisances, with negligible indirect impacts, and studied separately by various experts. On the contrary, they form a system of interdependent nuisances that converge at the level of indirect impacts, with the emergence of synergies and significant negative spirals. All of that, contributes to the disaffection for active modes, a lower neighbourly relations and the deterioration of human health as the environment, a set of interrelated negative effects that weighs heavily on many cities. As they are currently designed, the socio-economic assessment methods clearly underestimate the problem. This does not mean of course that they should be abandoned, but somewhat relativized and completed as much as possible.

This result should first lead to profoundly change the way of studying nuisances. To understand the diversity of their interactions, it is necessary to bring together researchers from different disciplines (physics, psychology, sociology, economics…) and fields (noise, pollution, accidents…), to conduct the necessary investigations. In addition, the treatment of nuisances must be completely revise. The issue is less to limit these effects, than to tackle these root causes, and more over to prevent them. The aim is to reduce inconsistencies in the solutions usually adopted, and beyond, to bring down the nuisance system. This is why the traffic calming policies appear far more promising. It is they which can at the same time boost active modes, foster social relationships and improve the health of the population while better preserving the environment.

Such a perspective, however, raises many questions beyond the narrow confines of this article: are the benefits higher than the costs, as seem to show the most advanced cities in this field? How to negotiate the transition between cities based on speed and individual motorized vehicles to slower and less motorized cities? How explain that everyone could find a better balance between all these constraints?

## *References*


APPLEYARD Donald, GERSON M. Sue, LINTELL Mark, 1981. *Livable Streets*. Berkeley: University of California Press. 364 p.

APPLEYARD Donald, LINTELL Mark, 1972. The environmental Quality of City Streets, the Residents' Viewpoint. *Journal of the American Institute of Planners*, 35, pp. 84-101.

BANISTER David, 2005. *Unsustainable Transport. City transport in the new century*. Abingdon: Routledge. 292 p.

BERTALANFFY Ludwig von, 1968. *General System Theory: Foundations, Development, Applications*. Harmondsworth: Penguin books, XXII-311 p.

BOITEUX Marcel (dir.), 2001. *Transports : choix des investissements et coût des nuisances*, rapport pour le Commissariat général du Plan, rapporteur Luc BAUMSTARK. Paris : La documentation française. 325 p. (Transports: investment choices and nuisances costs)

BONNAFOUS Alain, 1992. Transports et environnement. Comment valoriser et maîtriser les effets externes ? *Economie et Statistiques*, n° 258-259.

BRITISH MEDICAL ASSOCIATION. 1997. *Road Transport and Health*. London: The Chameleon Press. 94 p.

BUCHANAN Colin D., 1963. *Traffic in Towns*. London: HMSO. 264 p.

CERTU, SETRA, 1998. *Projets routiers urbains. Les études d'environnement dans les projets routiers. Guide méthodologique*. Lyon : CERTU. 191 p.

CHALAS Yves, 1997. Le déclin du quartier. *Urbanisme*, n° 297, pp. 49-53.

COHEN Simon, 2006. Considérations sur les courbes débit-vitesse. In *Séminaire vitesse. Apports récents de la recherche en matière de vitesse*, Actes INRETS n° 105, pp. 57-66.

DUPUY Gabriel, 1999. *La dépendance automobile. Symptômes, analyses, diagnostic, traitements*. Paris : Anthropos, 160 p.

DUPUY Gabriel, 1999. From the "magic circle" to "automobile dependence": measurements and political implications. *Transport Policy*, vol. 6, issue 1, January, pp. 1-17.

ECMCT, 1998. *Infrastructure-induced mobility*. Report of the 105th round table. Paris: ECMT, OECD. 312 p.

EMELIANOFF Cyria, 2005. La ville durable en quête de transversalité. In N. MATHIEU, Y. GUERMOND (dir.), *La ville durable, du politique au scientifique*. Ed Cemagref, INRA, pp. 129-142.

EMELIANOFF Cyria, THEYS Jacques, 2001. Les contradictions de la ville durable. *Le débat*, n° 113, pp. 122-135.

ENEL Françoise, 1998. *Les coupures routières en milieu urbain*. Rapport de synthèse. Paris : Véres consultants, recherche pour le Plan urbain. 92 p.

FABUREL Guillaume, MALEYRE Isabelle, PEIXOTO Frédéric, 2005. *Nuisances sonores routières et ferroviaires en milieu urbain*. Recherche pour le compte de l'ADEME dans le cadre du PREDIT 3, 2 tomes.

GALLETY Jean-Claude, 1991. Le paysage des entrées de ville. *Recherche Transports Sécurité*, n° 32, pp. 127-137.

GOODWIN Phil B., 1998. Unintended effects of transport policies. In BANISTER David (ed.), 1998, *Transport policy and the environment*. London: E & FN Spon, pp. 114-130.

GOODWIN Phil B., 2003. Unintended effects of policies. In HENSHER David A. & BUTTON Kenneth John (ed.), *Handbook of Transport and the Environment*, Elsevier Ltd., chapter 7, pp. 603-613.

HERAN Frédéric (dir.), RAVALET Emmanuel, 2008. *La consommation d'espace-temps des divers modes de déplacement en milieu urbain. Application au cas de l'Ile de France*. Rapport pour le PREDIT 3, lettre de commande 06 MT E012. 189 p.

HERAN Frédéric, 2000. *Transports en milieu urbain : les effets externes négligés. Monétarisation des effets de coupure, des effets sur l'affectation des espaces publics et des effets sur les paysages*. Paris : La documentation française, 118 p. (Transport in urban areas: the negligible external effects. Monetarization of severance effect, space consumption and effects on the landscape)

HERAN Frédéric, 2003. La double spirale de l'insécurité routière à pied et à vélo. Intervention à la 5e journée d'étude de la FUBicy *Villes cyclables, villes plus sûres*, 11 avril 2003, Dijon. 10 p. (The double spiral of road unsafety on foot and by bike)

HERAN Frédéric, 2011. *La ville morcelée. Effets de coupure en milieu urbain*. Paris : Economica. 220 p. (The fragmented city. Severance effect in urban areas)

HILLMAN Mayer, ADAMS John, WHITELEGG John, 1990. *One false move… a study of children's independent mobility*. London: Policy Studies Institute. 187 p.

HILLMAN Mayer, HENDERSON Irwin & WHALLEY Anne, 1973. *Personal mobility and transport policy*. London: Policy Studies Institute. 134 p.

HINE Julian, RUSSELL John, 1993. Traffic Barriers and Pedestrian Crossing Behaviour. *Journal of Transport Geography*, vol. 1 n° 4, pp. 230-239.

INSERM, 2008. *Activité physique. Contextes et effets sur la santé*. Éditions INSERM. 832 p.

JACOBSEN Peter L., 2003. Safety in numbers : more walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, vol. 9, pp. 205-209.

JAMES Emma, MILLINGTON Anya, TOMLINSON Paul. 2005. *Understanding Community Severance I: Views of Practitioners and Communities*. TRL, Department for Transport. 61 p.

LE MOIGNE Jean-Louis, 1977. *La théorie du système général, théorie de la modélisation*. Paris : PUF. 258 p.

LITMAN Todd, 1999. *Traffic Calming. Benefits, Costs and Equity Impacts*. Canada: Victoria Transport Policy Institute. 32 p.

MORCHEOINE Alain, VIDALENC Eric, 2009. Les transports électriques en France : un développement nécessaire sous contraintes. *ADEME & vous*, n° 21. 8 p.

NOLAND Robert B. and LEM Lewison L., 2002, A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the US and the UK. *Transportation Research D*, vol. 7, n° 1, pp. 1-26.

POUYET Jean-Pierre (dir.), 2010. *Conclusions de la Commission d'enquête sur l'enquête préalable à la déclaration d'utilité publique du projet de rocade nord de Grenoble*. 12 p.

PREMARTIN Marie, FAURE Anne, 1995. Sécurité subjective, sécurité objective et comportements : l'apport des opérations "Ville plus sûre, quartiers sans accidents". communication à la *5e conférence internationale sur les comportements de déplacement*, oct. 11 p.

QUINET Emile, 1998. *Principes d'économie des transports*. Paris : Economica. 419 p.

WILDE Gerald J. S., 1982. The theory of risk homeostasis : implications for safety and health. *Risk Analysis*, vol. 2, n° 4, pp. 209-225.

WOLF Gérard, 1992. Les deux-roues légers : sécurité et aménagements. In Thierry BRENAC (dir.), *Sécurité des routes et des rues,* Bagneux : SETRA, CETUR, pp. 167-189.

WORLD HEALTH ORGANIZATION (Regional Office for Europe), 2000. *Transport, environment and health*. Edited by Carlos DORA and Margaret PHILLIPS, WHO Regional Publications, European Series, n° 89. 86 p.