PERGAMON

Transport Policy 6 (1999) 1–17

TRANSPORT POLICY

www.elsevier.com/locate/tranpol

From the “magic circle” to “automobile dependence”: measurements and political implications

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Abstract

“Automobile dependence” is becoming an ever greater obstacle to sustainable transport policies. This dependence is due mainly to the fact that the positive effects for drivers of the growth of the automobile system are greater than the negative effects of traffic congestion. The model described in this paper is a simple one; it is based on an analogy with telecommunications systems and presents these positive effects in terms of accessibility. On the basis of the model, quantitative measurements of the French situation were made. Results show the importance of positive effects, which make it extremely difficult to reduce automobile dependence. Adopting a laisser-faire approach would only lead to very slow changes. Taxing automobiles and automobile use is not enough to offset the above-mentioned effects. Urban densification, beyond its segregative impacts brings little more than local solutions to a problem which is increasingly global. The author suggests the implementation of policies which would have a direct impact, within the automobile system, on the processes which generate these positive effects. The aim of these policies would be to diversify vehicles and their ownership, modify road networks (more, but slower, roads), and limit the capillarity of these networks. The policies proposed in this paper are both effective and realistic, since they aim to reduce automobile dependence, but not the quality of service provided to drivers.

Keywords: Magic circle; Automobile dependence; Driver’s licence; Accessibility; Traffic; Car fleet; Road network; Club effect

1. Automobile system, positive effects and dependence

Some thirty years ago, American oil industry and road engineers discovered the “magic circle” of automobile development[1]. They observed that the increase in automobile traffic led to the expansion of the road network, thus encouraging car owners to drive more, more people to buy cars, an increase in traffic was once again followed by the growth of the network, and so on and on. Obviously, such snowballing was a boon to those in the oil and road business. However, since then, the magic circle has not stopped turning; on the contrary, it has accelerated to such a degree that we now view it with more concern than wonder.

A recent article raises the issue, formulating the question in its title: “Can we overcome automobile dependence?” (Newman, 1995). Given the context of generalized automobile use[2], the expression “automobile dependence” means that as individuals, we cannot live without cars, just as a smoker cannot live without cigarettes and a drug addict without drugs. This is what Ivan Illich denounced two decades ago as the “radical monopoly” of automobiles (Illitch, 1974), a monopoly which has negative effects even on those who do not own a car. According to Newman and Kenworthy, certain cities, Los Angeles for example, shows a collective dependency on cars, whereas others, like Paris, are less automobile-dependent (Newman and Kenworthy, 1991). Finally, from a more global point of view, automobile dependence and the resulting increase in motorization and car traffic cause natural resources – space, oil and fresh air – to become increasingly scarce.

In an effort to overcome this dependence, Newman and his colleagues advocate the rehabilitation of physical planning. In their opinion, a strong redensification of cities would diminish automobile dependence.

This opinion has been widely criticized. Some of Newman’s detractors believe that automobile dependence is simply a reflection of people’s preference for living in less dense areas and travelling faster. Thus, one should take no particular measures and just leave it to the market to reveal such preferences, determine prices and regulate consumption (Gomez-Ibanez, 1991). It is most interesting to note that M. Webber, a well-known former physical planning

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[1] The “magic circle” was presented for instance in *Asphalt Institute Quarterly*, April 1966.

[2] In the fifty years that followed the second world war, the automobile stock and traffic have more than doubled in the United States and were multiplied by ten in Europe. At the world level, the number of automobiles has grown much faster than the population: there were 14.2 people per car in 1980 and only 12 in 1993.

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PII: S0967-070X(98)00028-6

advocate, now shares this point of view (Webber, 1992). However, according to other detractors, though a certain number of adjustments may be necessary, the solution is not in physical planning: if the aim is to reduce motorization and automobile use, one must raise the cost of fuel, increase taxes, set up tolls, etc.

Sensitive government intervention to manage the negative externalities of auto use is increasing all the time. Congestion pricing, parking buy-out, hot lanes, off-site trip generation management are new ways for controlling the trend. But it is always controlling from the periphery, not dealing with the center of the matter.

In 1995, Phil Goodwin published a report on car dependence in the United Kingdom. In the introduction, Goodwin speaks of the necessity of reaching a political consensus in order to reduce automobile-related costs. But "all serious statements", he writes, "now refer to the difficulties such policies face, imposed by "car dependence". In part, this is simply a recognition of the obvious observation that car use is very widespread, and deeply connected with the patterns of everyday life. Improving our understanding of the sources and consequences of the role of the car in modern societies should help us understand which policies will work and which will not, and how to achieve desirable economic and environmental objectives with the minimum of harmful, or destructive side effects" (RACS, 1995).

This corresponds precisely to our point of view on the question. Goodwin's both sensitive and comprehensive approach reveals the possibilities and limits of traditional methodology for the analysis of car dependence. Our aim is thus to present an original explanatory model. Given the controversy raised by Newman's work, it is necessary to carry out measurements and assess the policies (especially as concerns land use planning) proposed to reduce car dependence. We will thus make policy-making suggestions, based on the measurements provided by our model.

In this article, we will first provide a simple model which explains the true nature of automobile dependence and what its actual components are. From there on, we will suggest a few policies, which are more efficient than Newman's, to reduce this dependence.

Our model for the analysis of automobile dependence is built on the measurement of the positive effects produced by the automobile-based system[3]. It is based on the concepts of club and network effects, usually applied to telecommunications but adapted in this case to the automobile sector (Hayashi, 1992; Capello, 1994; Economides, 1996; Curien and Dupuy, 1997). The basic idea is the following: what a person gains by joining a club (or a network[4]) depends on all its present members (those already in the network).

According to our model, access to the automobile system occurs in three stages:

(a) obtaining a driver's licence
(b) acquiring a car
(c) travelling on the road network.

At each stage, there occurs a specific positive effect caused by the presence of other members who have already passed this stage. For stage (a), it is in the full sense of the term a club effect, created by the number of people who already possess a driver's licence. The proportion of drivers in the overall population increases the gap between the maximum speed allowed to those who have a licence and to those who do not. For stage (b), one should rather speak of a fleet effect, linking services for drivers to the size of the automobile fleet. For stage (c), the term network effect is most appropriate, as the effect depends on the distribution of car traffic on the road network.

These three positive effects interact cumulatively, and as a result there is considerable pressure to enter the automobile system. Despite negative effects (congestion) in very dense urban areas, dependence is thus very strong and extremely difficult to overcome.

2. Remarks concerning methodology

In accordance with our definition of the automobile-based system, we will study not only the behaviour of the individual driver, but also the road network he uses and the services offered to him. As to the variations in the automobile-based system, these can only be shown by comparing different periods of time or different countries. This creates several methodological difficulties: in such comparisons, variables external to the automobile system per se, such as demography, income, fuel prices, also differ and must also be taken into account. For this reason, the available data does not allow us to carry out very precise analyses[5]. Nevertheless, the information we have is significant enough to have an impact on actual knowledge in the field[6] as well as on potential policy-making.

[3] For P. Hall, the automobile-based system is based on mass production, service centers for all, high-level performance of automobiles, a set of traffic rules and regulations, a network of roads and highways, a network of facilities which are necessary to road travel (motels, fast food restaurants, etc.) (Hall, 1988).

[4] The authors often use interchangeably the terms of club or network positive effects (or externalities) although in fact they are dealing with stock effects (or externalities). This is owing to the fact that in the telecommunications network, such a distinction is not always necessary, which is not the case for the automobile system. For a more detailed list of works on the subject of these positive effects (or externalities), see the bibliography of (Capello, 1994).

[5] The study carried out by the RAC Foundation for Motoring and Environment does not refer to a strict definition of the automobile system or of car dependence and in this respect it was able to provide relatively precise analyses based on available data, pertaining to specific contexts (RAC, 1955)

[6] The analyses already published in this issue, though often quite informative, have two main drawbacks. In the first place, they are qualitative (Sachs, 1992) and secondly, they do not isolate the specific impact of automobiles in relationship to other changes (Kunstler, 1993). A bibliography of these approaches can be found in (Dupuy, 1995).

We limited our analysis to a calculation of elasticities. These elasticities express the effect of a variation in the composition of the club, fleet or network on the personal benefit to an individual of the automobile system. This limitation was necessary because of the lack of available data. Thus, it was impossible for us to adjust the functions representing the benefits gained for any given composition of the club, fleet or network. But formulating the issue in terms of elasticities nevertheless has one advantage, which is that most analyses explaining motorization and road traffic on the basis of variables such as income, price and existing road infrastructures are usually formulated in terms of elasticities. This has made it possible for us to compare our results with these analyses, as will be seen later.

The model is strictly limited to the benefits provided to the car driver by the automobile sector, in other words to the **positive sectorial effects**. The negative externalities of the automobile system (traffic congestion, pollution) have already been widely studied and are relatively well known as compared to the positive effects and for this reason, these issues[7] will not be dealt with here. Next, the model is only concerned with the positive effects which can be expressed in terms of benefits within the automobile system. Thus, the analysis does not look into the effects which may be important but are of a more sociological nature. For instance, the positive effect that having a driver's licence or owning a car can have on a person's social status are not included in this study. It is true that this played a crucial role in the past, in the popularization of automobiles (Boltanski, 1975). However, this effect is no longer as strong as it used to be, except in countries which are only beginning to become motorized. An interesting review of the literature, covering both sociological and psychological aspects of car dependence can be found in (RACS, 1995). We will come back to this point at the end of the article.

The benefits of the system for the (present or potential) automobile driver are measured in terms of speed or access to services. We will refer to the common notion of accessibility. Accessibility indicates both the possibility of reaching a place or specific service within a given amount of time and the choice of available destinations from a given point within a given travel-time (Taylor, 1996). If d represents the density of available services (number of services per surface unit) and s the speed of travel in the network (number of km which can be travelled within one hour in any direction from a given point), accessibility a is proportional to d and s^2. From then on, the relative variations of a, s, and d are linked by

$$\Delta a/a = 2(\Delta s/s) + \Delta d/d.$$

According to whether the composition of the club, fleet or network affects the individual benefits gained from the automobile system thanks to the density of services only or to speed only, the corresponding variations of accessibility will be measured either from

$$\Delta d/d,$$

or from

$$2\Delta s/s.$$

Accessibility, as studied here, concerns only automobile-related services, in other words, services provided within the automobile sector, a more limited framework than the automobile system. Positive effects also play a role in the supply of services related to the automobile system and provided by other sectors (the business or health sectors, for example). However, it was impossible for us to evaluate all these effects together, because of which we chose to limit our investigation to services provided by the automobile sector itself (sales, repairs, etc.).

For this study we used mainly the French data[8]. To illustrate the results of positive effects, we chose to study them in the context of an "average" French region: the Auvergne region. However, on the whole, the results can be generalized to other French regions and even to other countries.

Now that the framework has been established, we will successively analyse three effects: the club, the fleet and the network, and observe how the three combine in a cumulative process. This will lead us to some measurements (some of them comparable to Phil Godwin's results) and to their political implications, particularly in relationship to Newman's position on the subject.

3. Club effects: the driver's licence

Obtaining a driver's licence is the first step necessary to enter into the automobile system. In France, a driver's licence is often considered the same as an identity card. It is required for certain jobs. Young people consider it a symbol of adulthood. It is a sign that one belongs to a club of licenced drivers, a club which provides benefits to its members. Among these benefits is the right to drive a car according to the highway code, and to drive fast: in France, the speed limits are 90 km/h on an ordinary road and 130 km/h on highways, with small variations according to the type of infrastructure[9].

The benefits of entering the club can be measured by comparing the situation of those who do not have a driver's licence but are allowed, according to French law, to drive small cars

[7] Except when they interact with the positive effects we are trying to measure (see later).

[8] For a synthetic and comparative description of the principal French data concerning automobile use and ownership, see (Orfeuil, 1993).

[9] For instance 50 km/h in very dense urban areas, 110 km/h on some suburban roads, etc.

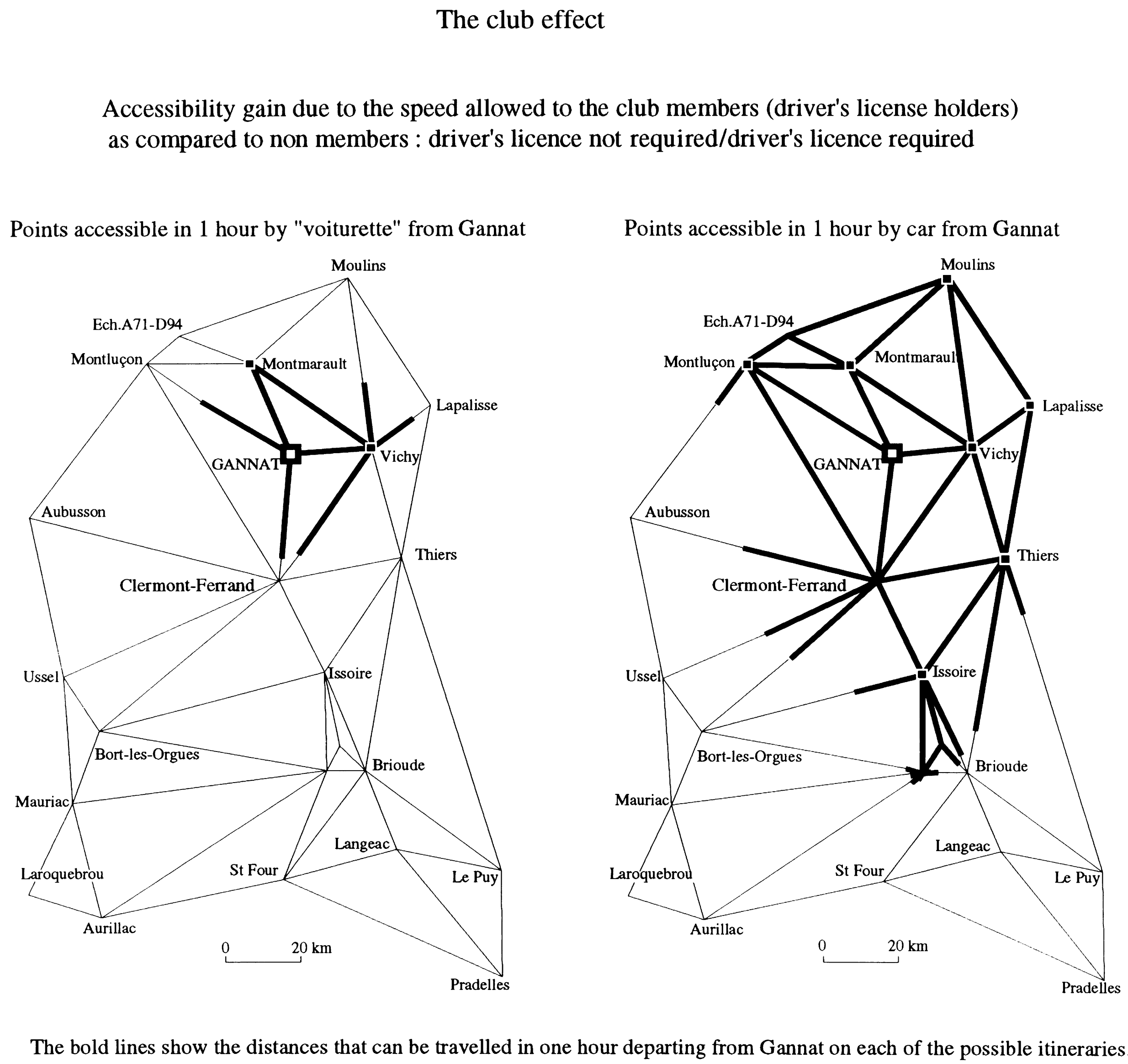

Fig. 1. The club effect. Accessibility gain owing to the speed allowed to the club members (driver's licence holders) as compared to non-members: driver's licence not required/driver's licence required.

("voiturettes") which cannot go faster than 45 km/h[10]. Fig. 1 shows the advantage of having a driver's licence over not having one. Taking a small French town, Gannat[11] we calculated the distances a licenced driver (member of the club) can travel in one hour as compared to those travelled by a non-licenced driver (not a member of the club) using the same road network.

The club effect is modelled as follows. The benefits obtained through being a member of the club are measured by the increase in accessibility as shown in the difference between the maximum speed authorized to licenced drivers and that authorized to non-licenced drivers driving "voiturettes". This advantage supposedly depends on the proportion l of licenced drivers in the population under study. In fact, the history of the automobile (Courty, 1990; Foreman-Peck, 1987) shows that licenced drivers, depending on their proportion in the population, do play a role in the setting of authorized speed limits both for themselves and for those who do

[10] Other comparisons, with public transport users or cyclists, are also possible. The point of comparing with "voiturette" drivers is that they are technologically similar: the voiturette is a small car whose motor has been bridled by the manufacturer to make its speed compatible with legislation. The door-to-door diffference in speed between a regular car and a voiturette corresponds, on an average, to the difference of speed between a car and public transportation. With a voiturette, one can cover longer distances, using less effort, than with a bicycle. Further, with a voiturette, one can carry the shopping home, which is not so easy to do on a bicycle, a motorcycle or using public transportation. Thus, in terms of the Goodwin report, it is more relevant to compare car driving to voiturette driving than to bicycle riding or public transportation.

[11] Gannat has a population of about 6000. It is located in the Auvergne region, in central France.

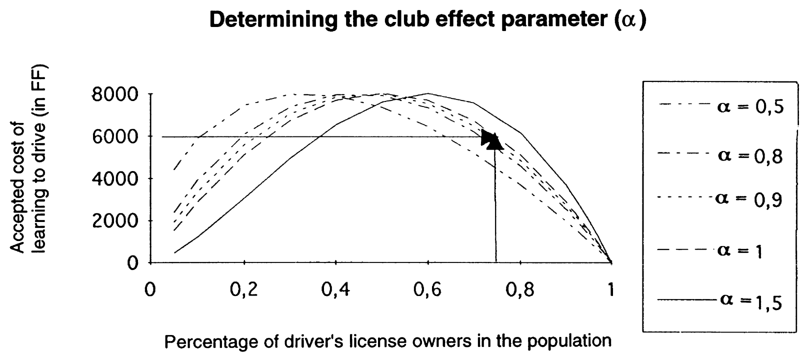

Fig. 2. Determining the club effect parameter (α).

not have a licence[12] and represent a hindrance to traffic on the road network.

Thus, the more members there are in the licenced drivers' club (for a given population), the more the speed differential (and thus the accessibility differential) favors those drivers. One can suppose that individuals preparing to take the driver's licence examination consider that the benefit to be gained in terms of speed surpasses the cost of preparing the licence. This benefit is represented by a function of proportion l of licenced drivers, such as:

$$\theta(s - s_0) = \theta l^{\alpha},$$

where s is the authorized speed for licensed drivers, and s_0 is the authorized speed for non licensed drivers. θ is a parameter distributed evenly over the population and representing a more or less marked interest in speed, in the sense that it increases the accessibility[13]. However, the gain in accessibility enjoyed by a licensed driver is defined here in relationship to the accessibility for non-members. Consequently, the elasticity of accessibility relative to l, E_C, is lower than

$$\Delta a/a/\Delta l/l = 2\Delta s/s/\Delta l/l = 2\alpha.$$

Suppose that what is gained by members of the club in terms of authorized speed equals what is lost by non-members, one can point out that

$$E_C = (1 - s_0/s)\alpha.$$

Given the current speed limitations set by the highway code on French roadways, the elasticity of accessibility in relation to the number of members in the club of licensed drivers would therefore be close to

$$E_C = 0.6\alpha.$$

Given the following French data; that 75% of people of driving age (at least 18) have a driver's licence[14] and that the average cost of learning to drive is approximately 6000 FF, we established a maximum acceptable cost of learning to drive at 8000 FF. The function which links the acceptable cost of obtaining a driver's licence to the proportion l of licenced drivers among the total population reaches a stable point of equilibrium for the aforementioned values when the α parameter has a value of 0.8 (Fig. 2)[15].

The elasticity of accessibility in relation to the number of members in the club of licensed drivers would therefore be:

$$E_C = 0.5.$$

In other words, an increase of 1% in the number of driver's licence owners (in the whole of a given population) leads to a 0.8% relative speed advantage over non owners and an actual accessibility advantage of approximately 0.5%. This data corresponds to the present data in a highly motorized country (France), where the proportion of non-licenced drivers is explained by various cultural or demographic reasons (Madre and Pirotte, 1997) with little or no relation to the club effect. This elasticity was probably even greater in the past. In any case, this result corresponds to what can be observed concerning the driving restrictions progressively imposed on non-licenced drivers and users of two-wheeled vehicle driving.

4. Fleet effect: automobile acquisition

Once in possession of a driver's licence, the second step towards entry into the automobile system consists in acquiring a vehicle that can be driven at the authorized speed and according to the rules fixed by the driving code. The benefit of owning a car increases as the number of cars already on the road (the fleet) increases. In order to measure the advantage because of the fleet effect, we chose to study the services provided to automobile owners by dealers and agents in charge of sales, after-sales services, maintenance and emergency repairs.

[12] The highway code is established by public authorities in close collaboration with the Automobile Clubs, which justifies the term of "club effect" in this particular case.

[13] This functional representation is inspired from models used in the telecommunications sector (cf. Curien and Gensollen, 1987; Curien and Dupuy, 1997).

[14] Data taken from the 1994 INSEE-INRETS survey.

[15] Another model, where α depends on l, gives about the same value for E_c.

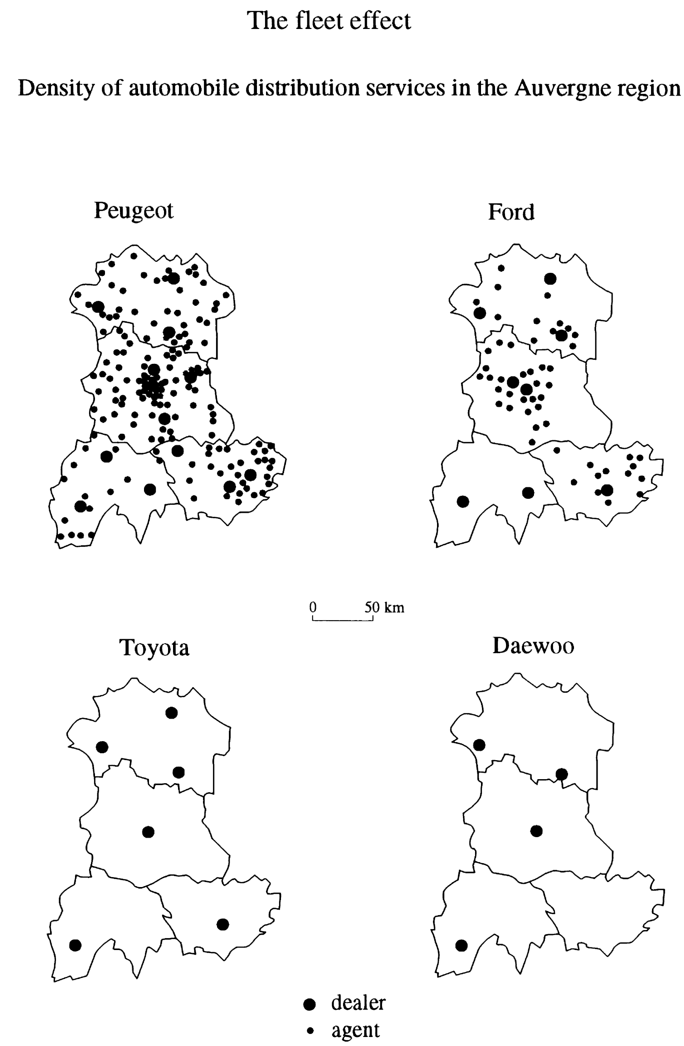

Fig. 3. The fleet effect. Density of automobile distribution services in the Auvergne region.

In France, as a result of both tradition and present legislation, each big automobile manufacturer has its own network of dealers and agents. Thus, the simultaneous observation of the fleets of the various makes of car present in France and the networks of corresponding dealers and agents allow us to measure the positive fleet effect. The acquisition (or at least the use) of a make of car with a large fleet offers the driver more services than would a less well-known make[16]. This difference can be illustrated by maps giving the locations of dealers and agents of more and less well-known makes. In France, Renault has nearly 7000 dealers and agents, Peugeot 4000, Toyota only 250. Fig. 3 shows the differences in the Auvergne region, already chosen as an example in the preceding section. In terms of density of service availability, there is obviously an advantage to owning a well-known make with a large fleet.

The corresponding model is very simple. Statistically, at a given date, there is a proportionality between the number of dealers and agents of a certain make in the country and the number f of registered cars of that make. The elasticity E_p of the services offer (and therefore of accessibility as well) in relation to the fleet is 1. An increase of 1% in the fleet of a given make will therefore correspond to an increase of 1% in the number of dealers and agents in France and thus the accessibility of services provided to the car owner. With a few adjustments, this result can be applied to other regions. Thus, as far as fleet effect is concerned, the Auvergne region would have an elasticity of fleet $E_f = \Delta d/d/\Delta f/f$

$$E_f = 1.$$

We have chosen to limit the analysis to intra-sectorial effects, those internal to the automobile sector. However, in this category we could also take into account road signs, maps (Ribeill, 1991) or gas stations, even if the services provided there belong rather to the network effects studied in the following section, as in many cases more services are provided to the driver than to the car. Shopping

[16] Even if agents of one make can perform certain types of repairs on cars of another make.

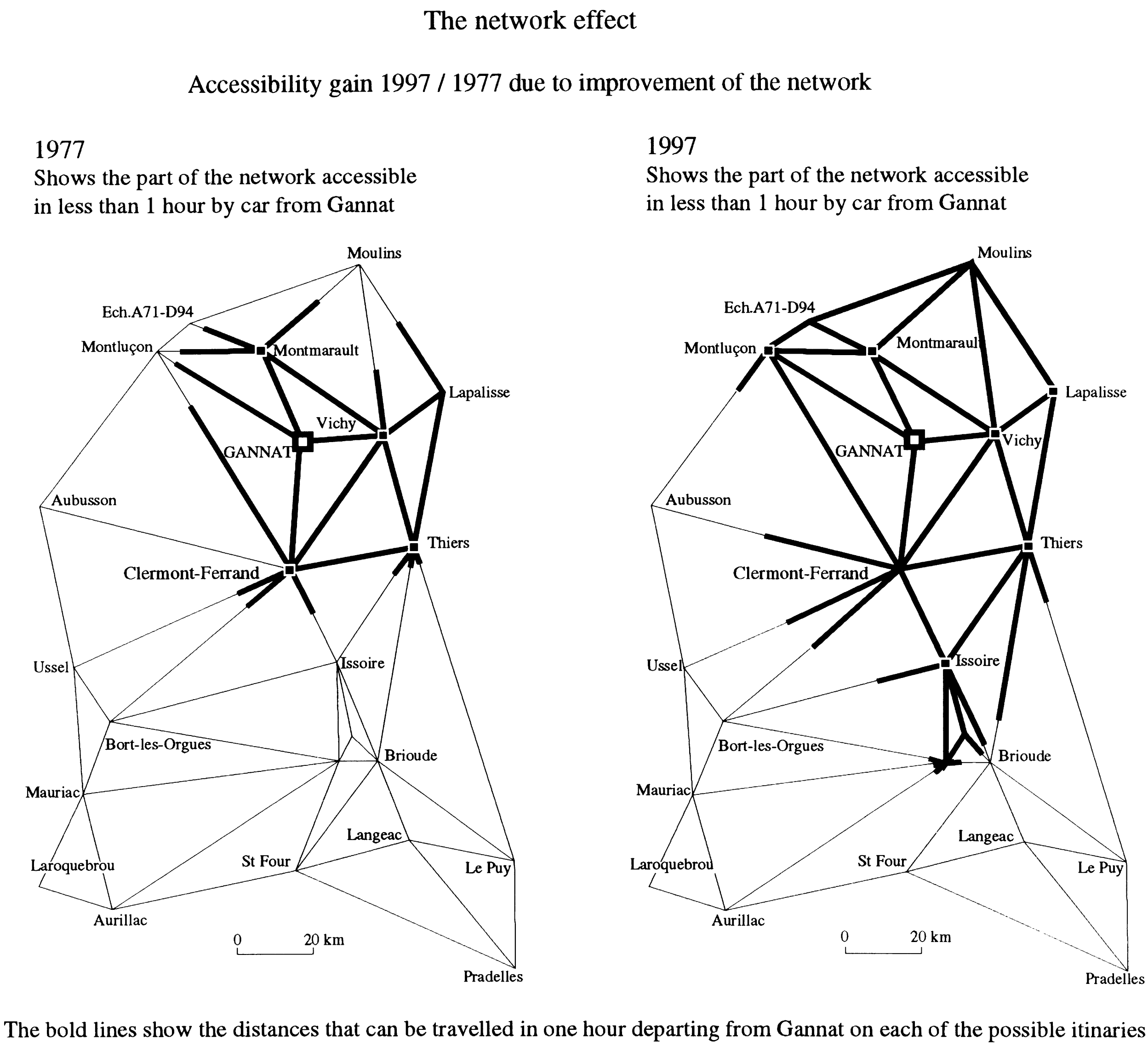

Fig. 4. The network effect. Accessibility gain 1997/1977 owing to improvement of the network.

centers, parks, sportsground and cinema theatres also seem to spring up according to the same principle, except that in the latter case, the effect is because of the whole fleet, all brand names included, and not to the fleet of a single make. Car parks, for instance, which provide an essential service, are built in relation to fleet. In this regard, it should be noted that in France, a car is parked on an average 95% of the time. The parking supply must thus correspond directly to the size of the fleet[17] (and not to the amount of traffic).

Thus, the value of the actual fleet effect seems much greater than that calculated by the method mentioned earlier.

[17] According to geographic distribution nonetheless.

5. Network effect: road traffic

The owner of a driver's licence (member of the club) having acquired a car (belonging to a fleet) will probably want to use the road network. The benefit that the driver will gain on entering this network depends on the number of drivers already using it[18].

This, first calls to mind a negative externality, the result of traffic congestion: the more dense the traffic, the more tieups the new driver will encounter, hence, the slower he will go.

In fact, though this effect exists, it only does so to a limited extent in time and space. It is minor compared to the positive network effect, whose workings can be explained in the following way.

[18] Traffic is usually measured by number of car × kms.

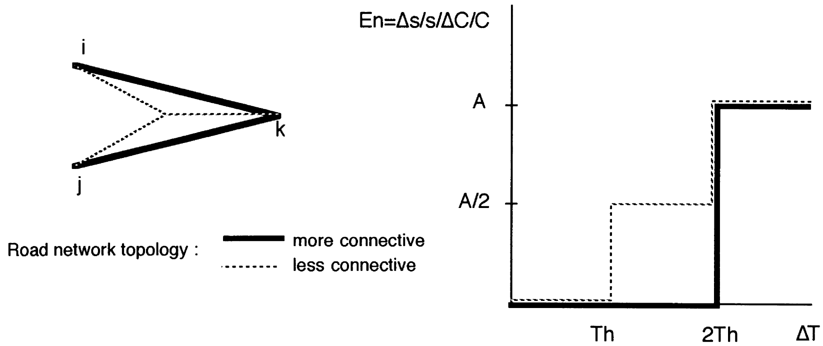

Fig. 5. Speed/traffic elasticity in function of traffic variation and network topology.

The denser the traffic on a road network, the more money is devoted to improving that network. This is the main principle of the Roadworks Investment Fund, which has been in existence for several years now in many countries (Roth, 1996). A special budget for road investment is supplied by the taxes levied on fuel consumption, car oil, etc., the total amount of which is just about proportional to road traffic[19]. Improvements come in the form of an increase in possible speed[20] on certain parts of the network, precisely those with the heaviest traffic.

Contrary to the previous effects, in this case there is no isotropy, because of which we used the term network effect. Heavy or light traffic depends on where the drivers are coming from and where they are going, and on the structure of the existing network. Money for improvements is set aside for one road or the other according to traffic. Improvements may be justified for reasons of capacity, security or environment, but in all cases, improvements make for increased efficiency on the infrastructure in question, particularly as concerns speed[21].

Let us return to the Auvergne region, and journeys made starting from the town of Gannat. Fig. 4 illustrates the effect of this network effect. We compared distances from Gannat in all directions of the road network that could be travelled in one hour in 1977 and in 1997. The map shows the considerable increase in the efficiency of the road network.

Precise modelling is much more complex[22]. It takes into account both the design of the road network and the structure of movements – in transportation engineering terms, the origin-destination matrix[23]. As Steyer and Zimmermann note concerning telecommunications[24] for the user, benefits depend not only on the actual or probable number of other users of the network, “but also on the choices… made by the other users he is in relation with…. In this case, a network is the topology of the users’ intercommunication needs and of the expected benefits ” (Steyer and Zimmermann, 1996).

However, we can show where such an effect comes from by considering the simple example of a road network allowing communication between three points in a region, *i*, *j*, and *k*. Let us look at the effect of a global increase $\Delta C/C$ in traffic on the network. The rule, which the operator will adopt in our hypothesis, is the following: invest in one segment in such a way as to increase speed (by $\Delta s/s$) if the traffic increase ΔT on that segment exceeds the threshold *Th*. Then

$$\Delta s/s = \delta A \Delta T/T,$$

with $\delta = 0$ or 1 according to whether $\Delta T >$ Th or not on the segment considered. *A* is a constant called the adaptation factor of the network. According to the topology adopted for the network[25], if the average increase in speed $\Delta s/s$ is divided by the global increase in traffic $\Delta C/C$, in other words, by a factor of 2, then the elasticity E_{n} varies according to the graph shown in Fig. 5.

From the point of view of accessibility, the increase in speed made possible on the various segments can be interpreted as an increase in the distance that can be travelled in a given amount of time. In the case of the most connective road network topology[26], the area accessible from point *k* is unchanged as long as $\Delta T < 2Th$; and in the case of the least connective road network, the area accessible from point *k* is farther when $\Delta T > Th$. Coming into play here are the global increase $\Delta C/C$ in traffic on the network, the adaptation factor *A* and a topological, matrix factor, which expresses the adequation between the topology of the

[19] Where such a fund does not exist, there is nonetheless a close relationship between the amount of taxes and the amount of road investment.

[20] Possible, but not real speed. Cf footnote 30.

[21] On the contrary, when less used, a road is often not maintained, in which case it deteriorates and is less efficient.

[22] For a telephone network, the non isotropic problem was accurately formulated, but modelling only leads to operative solutions with extremely restrictive hypotheses, which tend back to the case of isotropy.

[23] The origins-destinations matrix represents users’ “desire lines”. In the telecommunications sector, the term “affinities matrix” is used.

[24] In connexion with the spread of fax machines, precisely.

[25] And in certain simplifying hypotheses of traffic symmetry and kilometric equality of trip distances.

[26] The connectivity of such networks can be measured according to the theory of graphs by the index γ (Curien and Dupuy, 1997). Here, the most connective topology corresponds to $\gamma = 2/3$, the least connective to $\gamma = 1/2$.

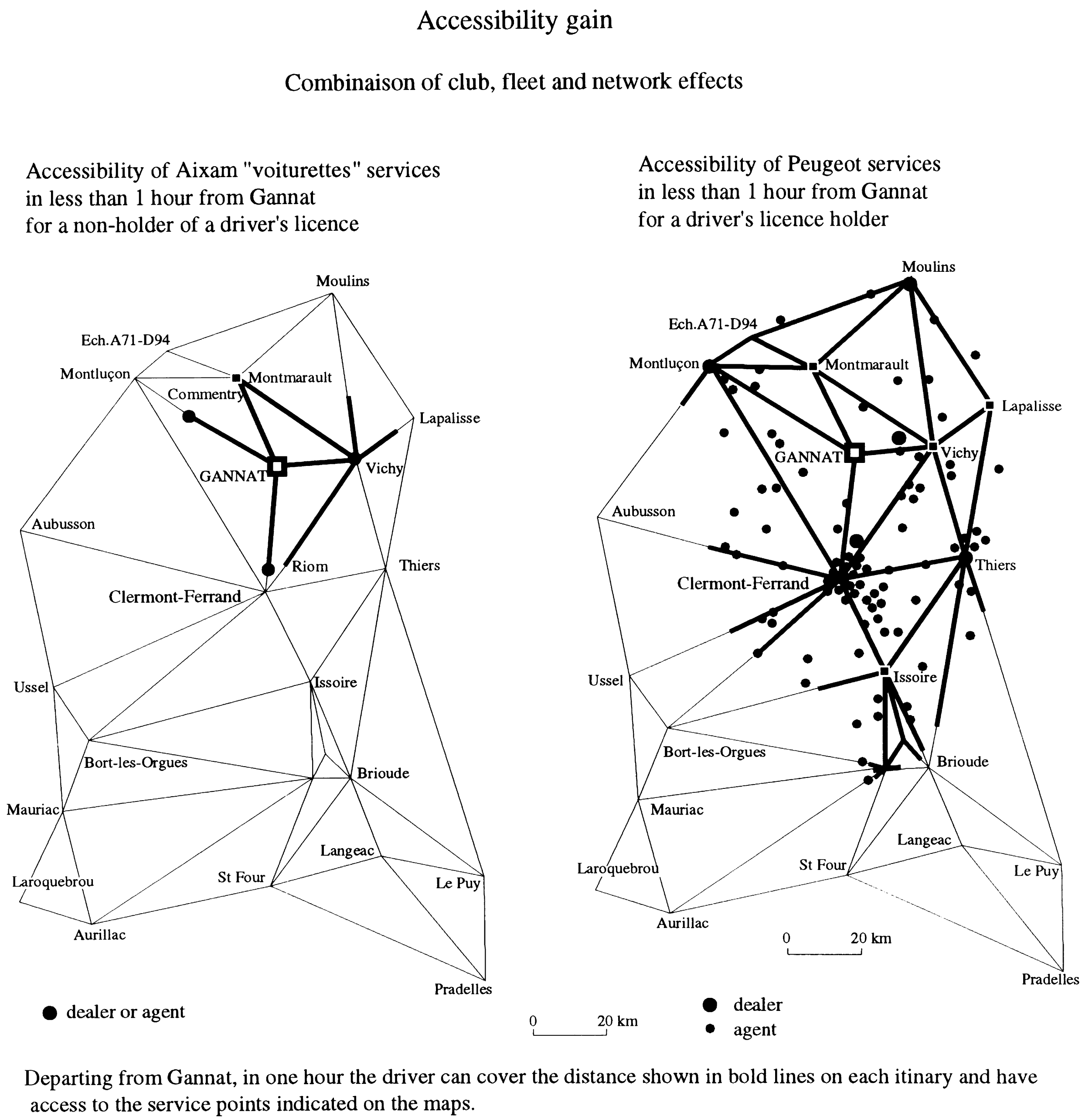

Fig. 6. Combination of club, fleet and network effects.

road network and that of itineraries. As a result of the hierarchy of roads and traffic regroupings, the greater the difference between the road network design and the O/D matrix[27], the greater is the positive impact of traffic on speed[28] and therefore, the greater is the positive effect of the network.

This model shows the importance of the phenomena of anisotropy and polarization, which, by orienting the flow of traffic, favour the building of major trunk roads and motorways which in turn drain the flows.

In Fig. 4, there is a noticeable anisotropy in the north-south direction and around the center constituted by Clermont-Ferrand, the capital of Auvergne.

As we are not in possession of sufficient data to separate the incidence of the topological factor and the adaptation factor, we globalized the two factors by measuring network effect by means of the E_n speed elasticity in relation to traffic on the French

[27] Or, in terms the theory of graphs, the weaker the connectivity.

[28] As can be noted in the least connective topology in Fig. 5.

network[29]. A comparison of network speed on one hand[30] and traffic on the other over an interval of 12 years, gives us an elasticity for the advantage of using a network, and therefore of accessibility, $E_n = \Delta a/a/\Delta C/C = 2\Delta s/s/\Delta C/C$

$E_n = 0.8.$

This same value also holds true for the Auvergne region on the basis of observations made over an interval of 20 years. Here, it is doubtless a matter of a lower estimation of the E_{n} elasticity. In fact, the overall speed increase of approximately 25% registered on French roads in general covers quite different contexts. In city centers, speed remained stable during the period. However, the creation of bypasses and their increasingly frequent use by drivers has increased speed considerably. A study of bypasses put in service about ten years ago shows that they allowed a speed increase of approximately 50%. The rapidity of the journey from Gannat to Saint-Flour (see Fig. 4) increased by almost 60% owing to the building of motorways A71 and A75. These two figures are a good illustration of the model mentioned earlier and lead us to believe that the effect of the topological factor mentioned earlier would bring about network effects measured by E_{n} elasticities significantly higher than 0.8 on the most frequented parts of the network.

6. Combinations of positive effects: chain reactions

We showed that the automobile system affords the user the benefits of club, fleet and network effects and we quantified the latter by calculating the elasticities.

Positive effects go hand in hand and thus accumulate. On obtaining one's driver's licence, one benefits from the size of the club made up by those who already possess theirs. On acquiring a car, one benefits from the size of the pre-existing fleet. Finally, when driving at the maximum speed allowed, one takes full advantage of a road network whose efficiency depends on its being used by other car owners and, in particular, one enjoys the services provided to one's make of car.

Going back to the example of the Gannat area, the benefits gained by the three posive effects together is shown in Fig. 6 by the superimposition of several maps. On the first, we see a non-licenced "voiturette" driver on the road network as it was in 1977, within the one-hour isochron. On the road he finds the service points (few in number) provided by his make of car[31]. On the second map, we see a driver at the wheel of a standard car 20 years later in 1997. He is driving at the speed allowed by his license and by the present state of the network and finds the services provided by Peugeot (second largest French make)[32]. Visually, the difference is considerable.

The fleet effect produces Δd. Δs is the result of club and network effects, or

$$\Delta s = (\Delta s)_C + (\Delta s)_n.$$

By definition of accessibility as given earlier

$$\Delta a/a = E_C \Delta l/l + E_n \Delta C/C + E_f \Delta f/f. \qquad \text{(I)}$$

If all driver's licence owners acquired a car and if all car owners drove the same way on the network, we would have

$$\Delta l/l = \Delta f/f = \Delta C/C = q,$$

from which

$$\Delta a/a = q(E_C + E_n + E_f).$$

Taking into account the previously obtained values ($E_{\mathrm{c}} = 0.5$, $E_{\mathrm{n}} = 0.8$, $E_{\mathrm{f}} = 1$) and taking $q = 1\%$

$$\Delta a/a = 2.3\%.$$

In fact, the hypothesis of equality of the relative variations of l, f, and C cannot be accepted. Data collected in the United States clearly invalidates it. Between 1969 and 1977, the number of driver's licences increased by 24%, the fleet by 13% and total traffic by 40%. Thanks to the analysis of the data from the United Kingdom, we can understand some of the interactions occurring between the three variables (RACS, 1995). In particular, the learning period tends to slow the increase in the total number of kilometers or miles covered, in relationship to the number of licenses delivered. Thus, drivers who have been licensed for less than two years drive an average of 73 miles per week. Those who have been licensed for more than ten years and less than 20 years drive an average of 130 miles per week. The demographic characteristic of the population under consideration makes the issue of learning processes even more complex. However, we can roughly estimate intermediate elasticities necessary to the calculation of the expression (I) using data from French surveys made in 1982 and 1994[33]

$$\Delta l/l/\Delta f/f = 0.8$$

$$\Delta C/C/\Delta f/f = 0.6$$

which leads to a global positive effect measurement in the

[29] Using data from French national surveys, 1981 and 1993. These surveys provide traffic values and average driver speed on the road network. A particular difficulty can be avoided by taking the whole of the French road network: indeed, the discontinuities in accessibility variations resulting from threshhold effects are smoothed out when we consider the whole of the network rather than efficiency on a particular itinerary. In this sense, the elasticity calculation retains its meaning despite local discontinuities owing to threshhold effects.

[30] We refer here to actual driving speed and not to the speed theoretically allowed on the network. The difference is mainly a matter of the amount of time lost slowing down and stopping to respect priorities (André, 1997).

[31] The example we have chosen is that of Aixam, the French leader on the voiturette market with a fleet of approximately 25 000 cars (out of a total voiturette stock of 67 000 cars in France).

[32] Peugeot fleet in France consists of about five million vehicles

[33] INSEE-INRETS surveys

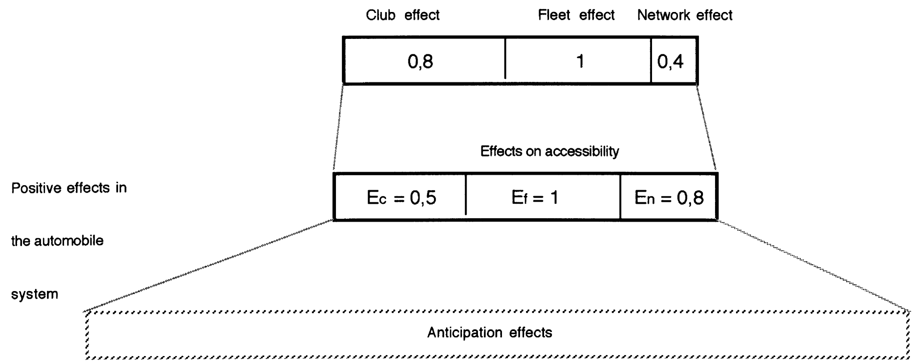

Fig. 7. Combination of positive effects in the automobile system.

automobile system (club + fleet + network):

$$\Delta a/a = 0.8E_C\Delta f/f + 0.6E_n\Delta f/f + E_f\Delta f/f$$

$$\Delta a/a\Delta f/f = (0.8\times 0.5 + 0.6\times 0.8 + 1)\Delta f/f$$

the E_a elasticity (in relation to automobile fleet) of accessibility provided to the user entering the system is thus

$$E_a = \Delta a/a/\Delta f/f = 1.9$$

In other words, all things being equal, in France, *a 1% increase in motorization gives the driver an accessibility gain of close to 1.9%*.

To gain an even more precise idea of the value of these positive effects of the automobile system, a dynamic model taking into account the effects of anticipations could be made. Actually, it is quite probable that fleet and network effects come into play as positive anticipations in the decision to obtain a driver's licence. Also to be taken into account are recent analyses linking the decision to buy a car to the number of kilometers travelled, and therefore to traffic on the road network (De Jong, 1997)[34]. Other effects also come into play that we were unable to consider. The increase in speed resulting from network effect has an impact not only on driving itself and choice of roads, but it probably strengthens the club effect as well (for a given number of driver's licence owners), i.e. the difference between the authorized speed limit for licence owners and that imposed on the others. Finally, the cumulative result of positive effects as described can be represented as shown in Fig. 7.

Despite the methodological limitations explained earlier, the result is significant. The globally positive effect (in terms of accessibility) is considerable such as to bring about strong motivation to join the automobile system (or not to leave it). If the accessibility gain thus proposed were to have an impact on demand with an elasticity of 1, the effect would be much greater than that of factors usually assumed to have direct impact on the increase of automobile use[35] as shown in the table below:

Elasticity of automobile demand[36] in relation to

Price of fuel	− 0.22
Cost of using a car	− 0.30
Household income	+ 0.45
Positive accessibility effects	+ 1.9

The effect would therefore be four times greater than that of income, six times greater than the cost of using a car, and nine times greater than the effect of the price of fuel[37]. Even if we suppose that demand would react to the increase in accessibility no more than it does to the expansion of the road network[38] (in other words, the corresponding elasticity would only be 0.15), according to our calculations, system effect (expressed in terms of the elasticity of automobile demand) would still be almost as great as the direct effect of cost, usually considered an important factor.

Of course, certain constraints do limit demand, but on the whole, not enough[39] to prevent positive effects from playing their role in the explosive growth of the automobile system. Each new driver added to the system contributes to heightening its interest (here, in the form of accessibility) for those about to enter – and so, on and on rolls the same magic circle which was identified in America back in the 1960s and led to today's automobile dependence – the same snowballing effect observed in the expansion of the telecommunications networks.

[34] De Jong's model shows, in fact, using data from the Netherlands, Norway and Israel, that a household's purchase of a second car can be interpreted as an economic choice. The calculation assumes that the fixed cost of an additional car is amortized owing to the number of kilometers travelled.

[35] According to present French data.

[36] In vehicles × km

[37] Using the (short term) elasticity values (RACS, 1995) would hardly have any influence on the extent of the measured effects.

[38] In France, inter-city freeways are usually toll roads.

[39] In particular, so far, scale economies in automobile production have lowered costs (Womack, 1990).

7. The magic circle and automobile dependence

The results of this study lead to a few conclusions and suggestions concerning the point of view upheld by Newman. The use of the term “automobile dependence” shows that Newman and his colleagues see things clearly. Doubtless there is a virtuous (magic!) circle of positive effects spurring the growth of the automobile system, which, in turn, generates negative externalities: traffic congestion, pollution, the irreversible consumption of fossil oils, space, etc. But it must be added that the importance of club, fleet and network effects and the combination of all three has made it increasingly difficult to do without the automobile (dependence). To belong to the system has become essential, and to a large extent it is the fact that many others are in the system[40] that motivates us to enter it (or to remain in it), to use a car, and thus to become dependent on it.

Given the value of the positive effect as described earlier, it would be impossible to adopt a Manichean point of view. It would be no simple matter to stop the magic circle from rolling in order to be rid of its indirect negative consequences[41]. It is important to understand the links between the virtuous circle and automobile dependence.

The increased use of automobile brought about by the magic circle of positive effects creates negative externalities of different sorts. Road congestion is an intra-sectorial negative externality that concerns traffic and parking. As we have said, the network effect means that a global accessibility increase will cause temporary and localized traffic congestion on main roads until they are rebuilt to adapt to the increase in traffic. In city centers, the fleet effect also creates problems because of cars parked on the streets, thus reducing speed and accessibility.

These negative externalities have been implicitly taken into account in our model. Their effect is to reduce elasticity values compared to what they would have been without traffic congestion.

Noise and other disturbances are extra-sectorial negative externalities. As we have said, the model does not take them into account. From our point of view, they cannot be directly linked to the notion of dependence.

Dependence must be seen as a negative externality which is extra-sectorial from the point of view of the automobile sector, but nevertheless closely tied to the automobile system. The dependence externality affects those who cannot enter the automobile system or who are obliged to leave it[42]. For this reason, at a given time, it depends directly on the positive effect that we characterized by the Ea elasticity. As indicated in the RAC Foundation for Motoring and the Environment report: “Car dependence grows rather than simply existing” (RACS, 1991). Dependence is all the greater when a large number of people are concerned and it can become a political issue. The elderly, adolescents, inhabitants of rural areas, ethnic minorities and disadvantaged social classes are in this case (Taylor and Ong, 1995; RACS, 1995; Nutley, 1996)[43].

8. “Can we overcome automobile dependence?”: the role of physical planning

The radical suppression of the automobile would put an end to both the magic circle and dependence. Yet it is hard to imagine how such a policy could be justified, given the fact that for the most part, the automobile system is part and parcel of the market economy. In contrast, because of the positive effect, entry into the automobile system – beyond the benefit to the individual of acquiring a commodity and using it – means a *bonus* of a collective type, one which has a backlash effect on the collectivity if dependence on it becomes too great.

Laisser-faire is not a solution[44]. In the long term, it would surely lead to a lessening of positive effects and perhaps to substitutes that would get round the effects of dependence. But the weight of positive effects is such that laissez-faire can only reduce negative externalities after an extremely intense and prolonged period of growth (Madre and Pirotte, 1997). It is doubtful whether this sort of laissez-faire would guarantee sustainable automobile development.

A more realistic and satisfactory policy would be to reduce the *bonus* owing to positive effects in such a way as to keep dependence within acceptable limits. In short, to slow down the rotation of the magic circle in order to reduce automobile dependence. But how?

Purely economic policies, via prices, do not seem to be enough. First of all, from a theoretical point of view, it is difficult to define an optimum point which would balance out accessibility advantages and dependence drawbacks. Further, as things stand today and considering the importance of certain advantages, it seems impossible to counterbalance the positive effects in this way. If we make car owners pay for the advantages they obtain from the positive effects of the automobile system, we might hope to reduce, if not suppress automobile dependence. In this respect, it is interesting to look at the theory and experience of tariff

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[40] Independent of fashion, not studied here.

[41] All the more so because accessibility increases benefit not only to individuals. Some authors have shown the importance of accessibility for economic activity in general (Prud’homme, 1997).

[42] Dependence concerns those whose age, health, handicap, or economic situation prevent them from acquiring an automobile. It also concerns drivers unable to use their cars because of a serious and prolonged energy or environmental crisis, such as would be the case when there is another oil crisis or a major climatic alarm caused by the greenhouse effect. From the point of view of available space, the Netherlands is now in just such a critical situation.

[43] Even if the members of these social groups partially benefit from the development of the automobile system when they borrow someone else’s car (RACS, 1995).

[44] On the short or medium term, the so-called Mogridge conjecture is often considered as a justification for laisser-faire (Derycke, 1997)

systems in the telecommunications network. Increased prices did, in fact, make it possible to momentarily curb avalanche caused by club effects until supply was able to cope with demand, but the analogy ends there. In the case of telecommunications, it was possible for a single operator to impose a price and, taking positive effects into account, vary it in such a way as to adapt the acceleration of demand to supply until saturation. In the automobile system, faced with a complex combination of several types of positive effects, there is neither a single operator nor a simple tariff system. The price of learning to drive is set on a market composed of numerous driving schools and does not seem to depend directly on the proportion of driver's licence owners. The price of a car only very indirectly reflects the size of the fleet in a given territory. Taxes on vehicles and fuel are based on horsepower and the number of kilometers travelled but not on the topology of traffic on the road network. Only motorway tolls could be seen as corresponding to a form of pricing of positive network effects. The aim of inter-city highway tolls is mainly financing and not dissuasion from dependence. However, in France, a balancing-out policy allocates part of the revenue from tolls to the construction of motorways in less travelled areas. Theoretically, the effect would be to lessen the positive effects of toll roads, yet at present, tolls are hardly imposed with that in mind. Further, there are hardly any toll roads in and around cities (Derycke, 1997), which significantly limits the results that might be expected from such a policy[45].

Newman and his colleagues are thus justified in putting physical planning back into the center of the debate. If we refuse the total banishment of the automobile and discard the idea of laissez-faire, and if we admit that a solely economic policy is insufficient and impracticable, then we can only hope to overcome automobile dependence by actions on the constituent elements and mechanisms of these effects, of which physical planning is one.

From this angle, to what sort of action do our results lead? We can look at the problem from three points of view. The first is limited to the automobile sector, the framework of our analysis. A second point of view would enlarge the approach to include the automobile-based system, and a third would examine in a yet broader manner communications systems other than the automobile system. We will first deal with these communications systems, then with the automobile-based system, and finally, with the automobile sector, which, it would seem, should be the focus of policy measures aiming to restrain automobile dependence.

9. Political implications outside the automobile system

Our analysis leads us to consider other communication systems apart from the automobile system: public transportation and telecommunications networks. These systems have one thing in common with the automobile system in that they too may possess positive club, stock and network effects and therefore, magic circles. To the extent that they may constitute alternatives to automobile transportation, their development can be of interest in the reduction of automobile dependence.

Without getting into analyses beyond the framework of this article, we would like to make two remarks concerning the efficiency of policies in this domain and the role of physical planning.

The efficiency of policies aimed at reducing automobile dependence through public transportation or telecommunications depends both on the extent of the positive effects generated by each of the latter, and on their substitutability. In France, the relative decline in public transportation over a number of years means that extremely deliberate policy-making is necessary to ensure positive effects. As far as telecommunications are concerned, the fact that they generate greater positive effects would increase the efficiency of such policies, at least in countries highly developed in the field of telecommunications (Mitchell, 1995; Drewe, 1997).

There remains the question of substitutability. As far as public transportation is concerned, substitution rates in relation to the automobile are very low (often less than 5%, according to observations made when new tramway or regional railroad lines are put in service). As concerns telecommunications, experts agree on a substitution rate no higher than 15% (Weiner, 1993).

As a result of the low level of substitutability of the automobile by public transportation or telecommunications, these systems' positive effects are not obviously sufficient to overcome automobile dependence. Given the limited efficiency of policies based on these effects, physical planning can thus definitely play an important role. However, in order to be efficient, the positive effects of physical planning must lead to a reduction of automobile dependence. Even a very rapid public transportation system, if it does not ensure service to the desired destination, will not create positive accessibility effects[46]. A telecommunications system can only reduce automobile dependence if communication and transportation facilities are taken into account when planning the relocation of activities (Capello, 1994; Drewe, 1997). Otherwise, the positive effects of the telecommunications networks will not reduce the advantages of physical accessibility, and therefore, of automobile dependence.

In any case, policies in this domain have limited efficiency and are extremely dependent on the context of public transportation and telecommunications systems in each country.

[45] In particular to counterbalance the effect of bypasses, mentioned earlier.

[46] This fact was taken into account in the "ABC" planning system in the Netherlands.

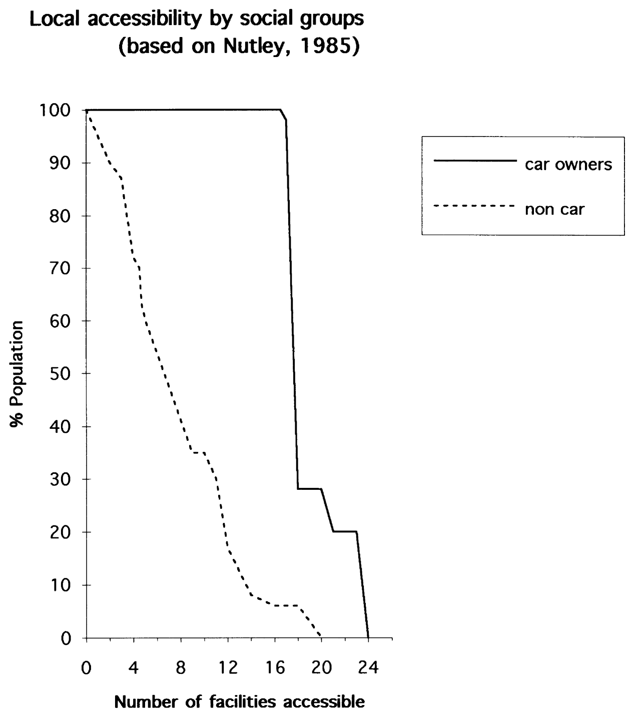

Fig. 8. Local accessibility by social groups (based on Nutley, 1985).

10. Political implications within the automobile system

Our analysis opens out onto two different policy avenues as concern the automobile system: we either discourage those not yet in the automobile system from entering it, or we encourage some of those already in it to leave.

The first would seem to pose no problem. Those not yet in the system are doubtless attracted by it, but in most cases, for reasons of income, age, physical or intellectual capacity, or for cultural reasons[47], they are not yet part of it. They can thus be left outside the automobile system, while remaining assured, locally, of what Newman proposes: density, accessibility to pedestrians, public transportation and convenient service. A good example of this exists in France: Saint-Denis, a suburb north of Paris with a population of 91 000, where 48% of households do not own a car.

This policy, however, has one serious drawback, which is that of segregation. Those who remain outside the automobile system can certainly survive and are less dependent; however, they do not benefit from the same advantages as others do. For example, as far as accessible facilities are concerned, the segregation effect as measured by Nutley is evident (cf. Fig. 8, Nutley, 1985).

As far as job access is concerned, Taylor and Ong's study on outlying metropolitan areas in the United States gives a clear description of the segregating effects of the suburbanization of jobs. Black minorities have less access to jobs not because they live for the most part in the central areas, but to the extent that their access to car ownership is limited, compared to that of white people[48].

However, in order for Newman's densification policy[49] to be efficient, it would have to be enforced in all the zones where it is needed. The accessibility problem in rural zones, which has been raised by several authors in connection with countries such as the United States, Great Britain and France remains unsolved (RACS, 1995; Nutley, 1996; Dupuy, 1997).

The second policy, that of encouraging a certain number of those already in the automobile system to leave it, is a priori more difficult to put in place even if we count on important effects as a consequence of what we have shown earlier. Owing to the effects measured earlier, such a policy' success would reverse the movement of the magic circle. For those not yet in the system, the advantage of entering it would decrease with an elasticity of about 2 in relation to the flow of those leaving it.

This sort of policy would involve a high-quality transformation in the organization and layout of the city, making automobile accessibility almost useless. For routine journeys, highly efficient public transportation would satisfy demand (Deakin, 1991). For certain types of trips, car rental would replace ownership. By combining residential, commercial and other functions and activities in one area, one would also reduce the need for travelling from one place to another. An example of this can be found in large European cities (Paris, for instance, or, more recently, Stockholm) (Cervero, 1990). The compact cities of the Netherlands illustrate such physical planning policies in a context where, because of lack of space, it is absolutely necessary to reduce automobile dependence (Drewe, 1997).

Thanks to a strong historical tradition and to a virtuous circle turning over a longer period of time, choices unfavorable to the automobile along with a lessening of dependence can actually be observed in city zones of this type. However, because of their cost[50] and owing to certain irreversible factors, mentioned by Goodwin (RACS, 1995), in their early stages, transformations of this sort only concern a small part of the population, and carry a risk of segregating effects (Troy, 1992). But unlike the preceding case, it is the wealthier part that would be segregated here, rather than the reverse.

All told, the economic and social difficulty of implementing these policies stems from the need to increase their scope to a exceedingly great extent, because the automobile system has become too vast. As a result, they are of limited

[47] This is particularly the case for women and elderly persons, for whom, even in highly motorized countries, access to the automobile is not a general rule. Cf on this subject the converging conclusions of several authors (Lee-Gosselin and Pas, 1997; Madre and Pirotte, 1997)

[48] The study shows that commuting time for those who depend on public transport is on an average 75% longer than for those who drive to work.

[49] This policy is applied in the framework of the Australian programme Better Cities.

[50] Such transformations must in fact be of extremely high quality (therefore very costly) to match the quality of access provided by the automobile.

efficiency in countries which are already highly motorized. For this reason, we do not believe that "the overall message… cautiously optimistic" of the RAC Foundation for Motoring and the Environment, concerning the possibility of reducing car dependence, is correct as regards the automobile system as a whole. However, we fully agree with its conclusions regarding policy-making in the automobile sector per se.

11. Political implications within the automobile sector

Within the automobile sector, there are three possible ways to reduce automobile dependence:

1. Diminish the club effect by reducing the gap between members and non-members of the club. Achieving this would involve authorizing different categories of drivers to drive different categories of vehicles at different speeds. This would lessen both the attractiveness of a driver's licence and the club effect. Measures favouring two- and three-wheeled vehicles, motorized or non-motorized electric or non-electric mini-cars support this aim and the Japanese example proves the efficiency of such a policy. It is simply a question of adapting legislation and facilitating the use of such vehicles parallel to the use of ordinary cars. Physical planning obviously has a role to play here, by creating bicycle paths, parking facilities for small vehicles, recharging stations for electric cars, etc.[51]
2. Reduce the fleet impact by favouring forms of automobile access generating fewer external effects. Short-term rental and car-sharing cooperatives (as in Switzerland) promote better use of a given fleet and reduce fleet effect. A more limitative public parking policy (as in German city-centers) would also have considerable impact.
3. Increase the connectivity of the road network in such a way as to reduce the effects of heavy traffic and the network effects they generate. This would mean building more, and less rapid, roads in the aim of making the overall design of the road network correspond more closely to the desired lines. With a stable fleet, this sort of design would reduce the number of vehicles × kilometer, thus reducing speed increases caused by the modernization of the network. Such a policy could be enforced by setting up a well-planned tolling system which would discourage heavy traffic on main roads and favour the construction, maintenance and use of slower but more direct roads.
4. Control the capillary spreading of the road network. Roads are often built in anticipation of the future construction of housing or other facilities (in rural areas, for example). By limiting this expansion, one diminishes the importance of speed (club and network effects) in determining accessibility levels, and the positive effect is thus reduced.

It should be noted that as a general rule, the physical planning actions we suggested for implementation within the automobile sector and which are aimed at lessening dependence by reducing positive effects, tend to facilitate travel as far as the individual driver is concerned, rather than the reverse. We are therefore talking about policies which are both efficient and realistic.

12. A few concluding remarks

So far, we have discussed the situation in the developed countries. In the case of developing countries, where automobile use is growing rapidly but remains limited, policy-making aimed at reducing dependence is an easier task (Gakenheimer, 1997): differentiations between types of vehicles and licences (with an effect on accessibility), restrictions linked to the fleet effect (parking in particular), restrictions connected with network efficiency, favouring connexity and connectivity of networks rather than capillary spreading. In areas where the automobile system is still at a moderate stage of development, the wisest course is to lead a policy of density combined with a strong public transportation supply. The telecommunications system can also be mobilized. The cost of such policies can remain within reasonable limits and there is no fear of an increase in segregation. The efficiency of such policies can be illustrated by a number of interesting examples, both present and past. For decades, they were implemented in the Soviet Union. In its own way, China favoured spatial density, combined with an extraordinary increase in the use of bicycles, tricycles and other similar modes of transportation[52]. Some developing countries are already counting on telecommunications systems as a solution to transportation problems.

Thus, in terms of policy, a study of the positive effects of the automobile system leads us to conclude that physical planning is doubtless one of the least inefficient ways of fighting against automobile dependence, especially in countries in the process of becoming motorized. Elsewhere, in the developed countries, its efficiency has likewise been proved, but its advantages must be weighed over and against the risks of its segregating effects.

Three remarks should be made in conclusion to this article. First, that Newman focuses his analysis and recommendations on cities (Newman, 1995, 1996; Newman and Kenworthy, 1998). Goodwin's report on car dependence adopted a much wider perspective (RACS, 1995). Our study shows that the positive effects of the automobile system are felt way beyond the limits of the city: the club, fleet and network effects studied earlier are defined and hold

[51] These conclusions converge with the prospective analyses of automobile market specialists (Nieuwenhuis and Wells, 1997).

[52] However, an evaluation of the political regimes that supported these policies is left to the reader.

true on a regional, national, even on an international scale, and not only on an urban scale[53]. Such a fact must be taken into account when deciding at which level of government the task of making and implementing policies aiming to restrain automobile dependence should be carried out.

Secondly, the automobile system is in the process of becoming a world system, first of all from the production point of view, but also from that of consumption (Lung, 1997). For this reason, countries still at the early stages of motorization are susceptible to the impact of fashion and prestige, a phenomenon generating significant effects, although these have not been discussed in our analysis, they should be reintroduced at this point. Indeed, the demand for cars today in Eastern Europe and in China is most likely to be influenced by these phenomena, a fact which should be taken into account in the definition of policies.

Thirdly, if it is for the purpose of protecting scarce resources such as air, space and oil that Newman proposes densification as a means of reducing automobile dependence, the positive effects at the root of automobile dependence reveal yet another resource to which modern society attaches increasing importance, and that is time. The results of our measurements seem to correspond not to some sort of anarchic behaviour or systematic waste, but to a new rationale of "space–time densification" which reflects the scarcity of time[54]. It may be that the premises of Newman and his colleagues' reasoning are more debatable than their conclusions. Can there be any doubt but that the revolution in modern societies is that of having made time incredibly scarce? Automobile dependence is only a reflection of this, and no policy should remain unaware of it.

Acknowledgements

My thanks to Nicolas Curien, Pierre-Henry Derycke, Paul Drewe, Ralph Gakenheimer and Phil Goodwin, who contributed their suggestions to this article. I also owe a debt of gratitude to Anne-Marie Barthélémy (Department of Geography, University of Paris-Nanterre) for the cartography, and to Laurent Chapelon, Doctoral student at C.E.S.A. (University of Tours) for the accessibility calculations.

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[53] The same thing could not be said when the automobile first came into use. Even if many automobiles then served the purpose of establishing a link between the city and the country, the urban scale lost none of its political pertinence (Mac Shane, 1997). This observation should provide food for thought for developing countries.

[54] As suggested in the research of Y. Zahavi (1976, 1982) and also the "time value", adopted in traffic engineering studies.

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