Sustainable Transport in a Compact City

Peter Nijkamp
Sytze A. Rienstra
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Sytze A. Rienstra

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free University amsterdam
Dpt. of Spatial Economics
Abstract
Transport policies in many countries seek to achieve a modal shift from the private car to public transport, in order to reduce environmental externalities like (local) air pollution, stench and visual annoyance, congestion etc. At the same time, the relationship between the spatial organisation and transportation is widely acknowledged, because the spatial organisation determines which transport relations occur and how voluminous these are. The volume of the transport flows is again an important success factor for public transport.

In this paper we will analyze whether and under what conditions a large scale 'collectivisation' of urban transport is possible by adopting the compact city concept. These conditions may be found in e.g. the institutional, economic and socio-psychological field. Furthermore, some empirical results of a survey among Dutch transport experts on a more compact city and the resulting impact on urban transport will be presented. The conclusion is that the compact city is a necessary condition for a large scale collectivisation of transport, but that also many other factors are decisive for the question whether this policy be successful.
1 Introduction

A general phenomenon experienced by almost all cities in the world is the emergence of green and diffuse suburbs around the city centres. As a result, the population density in cities has decreased to a large extent. Particularly the private car has brought low-density living within reach of large groups of upper and lower middle-class families. In fact, suburbanisation of living was a consequence of various broad changes in society, such as income increase, smaller households, more leisure time and changing housing preferences. Suburbanisation is usually also associated with negative socio-economic and environmental impacts, such as longer working and shopping trips, more energy consumption, pollution, accidents, and problems of public transport provision in low density areas (Masser et al., 1992).

The suburbanisation of living was followed by a second wave of suburbanisation of employment in subsequent years. Thus, dwellings as well as jobs tended to disperse further from urban centres into a broader metropolitan area, a process which may be called extended suburbanisation or counter-urbanisation (Breheny, 1995).

The development of decentralised cities as well as other trends in the economy and society have caused an enormous increase in car use, also in urban areas. At the same time, the length of commuting trips has largely increased. As a result, the external costs of transport have drastically risen, according to recent calculations these may account for some 3% of GNP (Verhoef, 1994).

Most large cities in the Western world seem to follow the development towards a more diffuse spatial pattern. When spatial planning comes into play however, a contrasting concept is recently gaining much popularity. A common concept in this respect is the 'compact' city, where housing is provided in a relatively high density and where jobs are concentrated in the central city and in a limited number of subcentres. The compact city has become a leading principle in Dutch physical planning in the past years, and is currently adopted in Europe as a guideline for urban planning (Breheny, 1995).

Such a compact urban spatial organisation may have a drastic impact on the future of transport (mobility level, modal split). Current transport policies in
many countries (especially North-Western Europe) focus on stimulating public transport, and on reducing car use and the mobility level, so as to reduce in this way environmental externalities and congestion. The compact city may be an important success factor for collective modes and for reducing the mobility levels in cities. At the same time however, it should be noticed that the compact city concept has some intrinsic limitations in terms of quality of life, land use and prices, as well as congestion, while also many other success factors (level of well-being, telecommunications) have a drastic impact on the future of transport and the introduction of new transport technologies.

In this contribution we will analyze in how far a compact city may contribute to the achievement of more environmentally sustainable transport by so-called collectivisation of the transport system. Another advantage of the compact city may be the reduction of travel distances (OECD, 1995); we will however, not discuss here this possibility explicitly.

The structure of the paper is as follows. First, we will analyze to what extent collectivisation of transport may contribute to a reduction in externalities. Next, the theoretical relationship between transport and urban form will be discussed. We will mention next other strategic success factors for collectivisation of urban transport. We will turn to some empirical research on the compact city in a subsequent section, by presenting some empirical results of a survey questionnaire among Dutch transportation experts on the feasibility of new transport systems. In the last section we will draw some conclusions.

2 Collectivisation of Transport and Sustainability

As discussed above, transport policy in many countries is focusing on reducing the external costs of transport by stimulating a modal shift from the private car to public transport (see e.g., ECMT/OECD, 1995). It seems to be a legitimate question in how far collective modes are more sustainable. One of the main advantages of public modes is that they are more energy efficient than the private car, which results in lower emissions of harmful gases like \( \text{CO}_2 \), but also of gases which cause smog (see Table 1).
Most collective transport modes are powered by electricity. For future emission reductions therefore, the way electricity is produced in the next decades is important. For example, when coals are used, the CO$_2$ emissions may not be reduced to a large extent, but when one uses solar or wind energy, biofuels or nuclear generation the emissions may be reduced much further (the latter has of course again other impacts on the environment).

But there are also other advantages of a modal shift (Vleugel, 1995):

* the use of space is lower (or the capacity of the infrastructure is larger), which may especially be important in a compact city in which there is little space;
* collective modes produce a less solid waste, also because of the long life time of vehicles;
* collective modes are safer to travel and cause much less social costs;
* there is less noise and stench annoyance, because of the use of electricity instead of fossil fuels; this advantage is especially important in urban areas.

It may be concluded that collectivisation of transport may offer an important contribution to the achievement of sustainability goals. However, this policy option is fraught with a variety of problems, which may emerge in several fields. We will therefore, first discuss the relationship between urban form and transport, and next we will turn to critical success factors in other fields.

3 Transport and Urban Form

Existing locations (residences, industries, public services, recreational areas etc.) determine the transport needs in the short run. Consequently, land use planning, territorial planning or physical planning are important policy interven-
tion measures in coping with transportation issues. There are some fundamental principles related to land use (Owens, 1992).

First, the **quantity of space** and land is limited. The use of land can to some extent be intensified by using the 'third dimension' - the air and subterranean space - and this option may especially be important for the compact city concept.

Secondly, various types of land use are **not compatible** with one another at short distances from each other, because of negative external effects and a possibly high market price for certain specific categories of land, which excludes land use with a low rate of return on investment.

And thirdly, land use is significantly influenced by **institutional measures** imposed in spatial planning. In this respect European countries have different traditions. For example, the Netherlands and the United Kingdom have a relatively well-developed planning system on various spatial scales, whereas for example Italy and Greece have systems that enable many 'degrees of freedom'.

Regarding objectives of spatial planning for a reduction of transport needs and collectivisation of transport, much research has focused on the relationship between urban form and passenger transport. Urban form in this context means size and density, i.e. where the interdependent working places and dwellings are located within the metropolitan area (Banister and Watson, 1994; ECMT/OECD, 1995; Wegener, 1995). One of the major conclusions so far is that various higher density cities are associated with a **high use of public transport** and with a low gasoline consumption (Newman and Kenworthy, 1989), although it should be noted that these findings cannot easily be generalized. It should be noted that the environmental and energy benefits of compact cities depend largely on the size and structure of incoming and outgoing commuting flows, as well as on the location of work places. From an economic perspective, also the changes in land prices ought to be considered, so that an unambiguous answer is often problematic.

A powerful spatial barrier to adopting a new transport technology appears to be the **spatial inertia** of the built environment and of infrastructure networks. Artifacts following from land use, such as housing blocks, industrial estates and transport infrastructure, have a long life cycle related to the capital investment involved. As a result, various types of land use are fixed for a number of
decades. So, once the infrastructure is built, it will be there for a long period (especially in historical city areas). As a consequence, technologies which imply step by step (incremental) or small change may have a better chance for adoption in the urban territory than technologies implying radical change of infrastructure and land use.

4 Other Factors Influencing Urban Transport

Although the intricate relationship between transport and the spatial organisation is widely recognized, also other driving factors may be distinguished that are critical for the future of the urban transport system (Rienstra et al., 1995). In this section we will concisely discuss such factors.

Economic and institutional factors

In recent years a marked shift in emphasis on economic principles for a combined transportation, environment and spatial policy can be observed. In spatial planning a trend towards abolishment of planning systems is found, because intervention of the government is less accepted in society and less effective (Fokkema and Nijkamp, 1994). It may be questionable however, whether the compact city may come into existence without a strict planning policy of the government, because of the trends discussed in Section 1.

In transport policy various user charge principles in transport are increasingly being discussed and implemented, such as road pricing, toll principles, parking fees and perhaps in the long run even tradeable permits. These measures mainly affect car transport and may stimulate the use of public transport.

However, there is also the trend to abolish unjustified and unnecessary protectionist or privileged regulations in order to increase the efficiency of transport operations. In this respect there is an increased attention towards efficiency and the profitability of e.g. public urban transport companies (Nijkamp and Rienstra, 1995). For example, in many cities the UK public bus companies have largely been privatised, which has had an enormous impact on the way the bus network is being operated. In this way the profitability of links and the total
network - and as a result spatial threshold factors - of public transport modes have become more important. These factors are concerned with the minimum volume of passengers between given points, necessary for a collective transport mode to be in operation and to make it feasible from an economic perspective. In this respect, barriers to adoption arise when spatial threshold (minimum) levels of demand for collective modes are not reached, for example, due to a low population density. Spatial upper level factors are different, in that they are associated with a particular type of vehicle and the maximum distance it can bridge. Barriers may arise when the transport distance needed exceeds the critical upper level of the spatial range of the transport mode in question.

A main problem of public transport in urban areas is the waiting time. Because of the short distances involved, the travelling time is largely dependent on waiting times. The poor competitive position of public transport vis-à-vis the private car may be shown for example by figures in the Netherlands: 40% of all car trips are on distances below 5 kilometres, while this figure is only 16% for all public transport trips (calculations based on CBS, 1994). As a result, the frequency (and reliability) of vehicles is very important to make the system competitive with the car, but in this respect again a high level of demand is necessary for the profitability.

Another aspect in which collective systems may be distinguished from individual ones concerns the dependence on supplementary transport systems. Travelling by collective modes is intermodal by nature, while individual modes offer door-to-door transport. This makes the functioning of collective modes dependent on the connectivity with other transport systems (including walking and cycling) that offer transport to and from the nodes. Coordination problems between different modes may be an important failure factor in this case.

It may be clear that the compact city - in which voluminous transport flows occur between the compact city centre and its subcentres - may therefore be an important success factor for public transport modes. However, also socio-psychological factors may play an important role, as will be indicated hereafter.

Socio-psychological factors

The private car appears to be psychologically very important, because
factors like pleasure, privacy, personal control and representativeness largely contribute to the preference for the private car (Vlek and Michon, 1992). The same may hold for the diffuse life pattern of individuals, since the living conditions in compact urban areas may considered to be worse than in more diffuse cities.

Another problem for collectivisation of transport may be that the behaviour of individuals is hard to change, because the perceived cons of other transport options appear to be low, while the acceptance of the construction of large-scale infrastructure in cities with little space may cause resistance in society. Subterranean construction may be an (expensive) solution in this case. The same may hold when large-scale measures are taken to reduce car traffic in cities.

In this respect it should be added that in democratic countries governments will not introduce measures which largely contrast the public opinion (Rietveld, 1995). Therefore first a change in the attitude would have to occur before the above discussed policies may successfully be introduced.

It may be concluded that a more compact city may be preferable for the collectivisation of urban transport, but that it is questionable whether such a policy may succeed, because of other success and failure factors. Therefore, it is interesting to analyze how transportation experts view the future of the urban spatial organisation and the transport system. This will be the subject of the next section.

5 Expert Opinions on The Compact City and the Future of Urban Transport

In the previous sections the relation between transport and urban form has been discussed from a general point of view. In the present section we will present opinions of Dutch experts.

To investigate the future of (urban) transport a postal questionnaire survey has been sent to Dutch transportation experts. For a detailed description and accounting of the questionnaire used we refer to Nijkamp et al. (1996); here we only note that the response rate was 36% (n = 271), and that the response gave a representative picture of the sample. One of the main objects of the survey was
the future of urban transport in relation to the spatial organisation. In the questionnaire it was asked to indicate both expected and desired future developments of transport in order to analyze also the discrepancy between reality and wish and to give a descriptive and normative opinion on future developments.

In the next subsections we will present some results of the above mentioned questionnaire which deal with the compact city concept and the future of urban transport.

5.1 Expected and desired spatial developments level and modal split

The expected spatial developments at the urban scale level

At the urban level it is expected by 44 per cent of the respondents that there will be a moderate compact urban development, so that the policy to achieve more compact cities will largely succeed (see Figure 1). As a result, the trend towards 'green suburbs' will largely stop. Striking is that only 14 per cent expects a more diffuse spatial organisation, a share which is smaller than what might be expected beforehand because of past trends.

Figure 1 about here

Next, it is interesting to assess how the expected spatial developments are related to the modal split. Most respondents expect the modal split to change in favour of the private car, while about one third thinks that the modal split may change in favour of public transport or that no increase in car use will occur.

When a cross-table analysis is carried out, it appears that only the segment which expects a development towards a compact city also thinks a shift of the modal share may occur in favour of collective modes. However, the majority expects the modal split to change in favour of the private car.

Desired developments at the urban scale

When the desired developments are analyzed, a majority of the experts is in favour of a compact urban structure, while a large minority wishes a moderately
compact organisation. Only a small group thinks that a (moderate) diffuse spatial organisation is to be desired.

When the resulting changes in the modal split are analyzed, it appears that 94 per cent wishes a shift towards public transport. Many respondents are also favouring a growth in car mobility, but a large group wishes no mobility growth or only public transport to grow.

From a cross-table analysis it appears, that in general the same trend as found for the expected developments can be identified.

5.2 The resulting transport system

Also questions have been asked to give expected and desired scores on a 1 to 10 scale (which is most common in the Netherlands) to policy measures, existing modes and the potential of new transport modes. The results on these questions will be presented next.

Expected and desired policy measures

The results for the expert views on future urban transport are depicted in Figure 2.

Figure 2 about here

The highest score for expected policy measures is found for an increase in parking levies which may make the use of private cars less attractive. The second highest score is given to reducing the number of parking places, which is expected to be introduced to a smaller extent than an increase in parking levies. Road pricing (or in cities maybe cordon pricing) is not expected to be introduced at a large scale, given the score far below 5.

The scores for the desired measures are all higher than for the expected ones, although for the parking levies this score is just a little higher. It is still the highest score however, with a reduction of the number of parking places on the
second place.

The new technology of road pricing gets also a much higher score, viz. above 6, so it may be concluded that also this option is desired to be introduced at a reasonable scale. As expected, the standard deviation of this measure is the highest, so that the experts disagree most on this measure.

Other policy measures which are mentioned by the set of respondents are: changing the spatial organisation, park and ride systems and car sharing ('call a car').

*Expected and desired use of conventional modes*

The scores by the experts on the *expected* use of conventional modes fluctuate all (except for the train) around 6. The highest score is assigned to metro and light rail systems, which are expected to be introduced at a larger scale than is the case now. This is a quite likely situation, since for example in several Dutch cities (Amsterdam, Rotterdam) new links are under construction. For the remainder, the car and slow modes (cycling, walking) are given the next highest scores, while the bus and tram get somewhat lower scores. It seems plausible that the score for the train is somewhat lower, since this mode is not in the first place meant for urban transport, although the train is sometimes also used as a mass transit system.

When the *desired scores* are analyzed, it appears that all modes are getting higher scores, except the private car, which is plausible because of the high external effects of this mode. Especially the slow modes and the metro/light rail get now very high scores of above 8, implying that the modal split in urban traffic should change in favour of these modes. Also the tram and bus get relatively high scores, while the score of the private car is here even below 4, so that a much lower modal share is regarded as desirable for the conventional car.

*Expected and desired use of new modes and technologies*

Respondents were also asked to assign scores for several new technologies and modes which might be introduced until the year 2030. The highest *expected* score is found for electric cars, although this score is only about 6, so that an intermediate large scale introduction is not expected. The second highest score is
found for new fuels (e.g., liquid hydrogen), which means again an improvement of the position of the private car. The people mover is getting a rather low score, while subterranean transport is expected to be introduced at only a small scale. So especially improvements of the private car are likely to be introduced, while the other developments are having far less chances in the opinion of experts.

The desired scores are all higher than the expected scores. Thus, it is desired that more of the new modes and technologies should be introduced than is at present expected. The electric car is again getting the highest score, followed by the people mover. Also somewhat higher, but still low scores are given to the introduction of new fuels and subterranean transport by car and train. Other modes mentioned by the experts are passenger transport by water, improved human powered vehicles and the electric bicycle.

Conclusions

From the above discussed results, it may be concluded that the private car and its improved versions are expected to dominate the urban transport system also in future, although various policy measures will be introduced to make the car less attractive. It appears that these developments are expected to occur although the urban spatial organisation is expected to become moderate compact.

In the desired situation however, there is more emphasis on collective modes, while also more and severe measures should be introduced to make the car less attractive as the dominant mode. These developments should be favoured in a situation where the organisation of urban space becomes more compact.

6 Conclusions

In theory there is a clear positive relationship between a concentrated spatial development and a collectivisation of the transport system. In practice however, problems may occur both in achieving a more compact spatial urban pattern and a modal shift towards collective modes. For both possibilities, it is
clear that current trends - like the abolishment of spatial planning and the
deregulation and privatisation of the public transport sector - will have to change
drastically. Also socio-psychological factors may have to change, since otherwise
policies may not be expected to be introduced successfully due to lack of support
from the public.

In this respect it is interesting that most Dutch transportation experts expect
the compact city policy to become rather successful. Apparently they think the
trade-off between preferable environmental conditions and living conditions will
be in favour of the first. However, at the same time it is not expected that a
modal shift in the urban transport system will largely occur. Only metro/light rail
systems may be introduced to some extent, while the only new technology may
be the electric car. When these expectations become reality, congestion in urban
areas may largely increase while most externalities will not be reduced.

In the desirable world of the Dutch transportation experts however, the
compact city should be introduced, accomplished by a large scale modal shift
towards collective modes and new transport technologies. It may be clear
however, that in this situation many current trends should be modified and
turned into a more environmentally sustainable direction.

It may be clear that a clear and consistent policy package is a sine qua non
for collectivising urban transport. Such a package may consist of a strict land use
and development control policy, an increase of fuel prices, introduction of
telematics, stimulating integrated commuting strategies by employers, large scale
investments in public transport, improving the efficiency and attractiveness of
public transport and stimulating walking and cycling (see also ECMT/OECD,
1995). Such a policy however, may cause a lot of resistance in society and will
therefore likely not be introduced in a consistent way.

It may be concluded that a policy aiming at achieving a compact city
together with a collectivisation of transport - which may lead to the fulfilment of
sustainability criteria - is possible and may even be desirable. Such a policy
however, will be facing severe difficulties in many fields.
References


Table 1  Modal comparison of CO₂ emissions in grams/pass.km. (index)

<table>
<thead>
<tr>
<th></th>
<th>Pass. train</th>
<th>Car</th>
<th>Tram/metro</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>71</td>
<td>201</td>
<td>100</td>
<td>159</td>
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Note: These figures should be used with care, as the uncertainty margin may be up to 25% or more, depending on the assumptions regarding seat occupancy, technology used, vehicle use etc.

Source: Netherlands Railways (NS)

Figure 1  The expected and desired urban spatial organisation and the resulting change in the modal split

Note:  n = 271
Figure 2 The average scores on measures and modes in the urban transport system

Note
1) Score 1 - 10; 1 is lowest, 10 is highest
2) n = 254-266