TOPIC 1
TRANSPORT AND
LAND USE (SIG)

COMMUTER POOLING AND ENERGY CONSUMPTION

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Abstract

The paper reports on a recent study in which the theoretical pooling potential of work trips was investigated for the metropolitan region of Dortmund in Germany. A microsimulation model linked with a geographical information system calculates all possible pooling constellations, selects the most reasonable matches and calculates potential energy savings.

INTRODUCTION

Modern urban development has led to settlement patterns in which residences and workplaces are spatially separated with the consequence of increasing work trip lengths. In most cities residences are more dispersed than workplaces. However, jobs are no longer concentrated in the core but are undergoing a deconcentration process, too. Work trips from the suburbs are therefore no longer exclusively oriented towards the city centre but are more and more redirected towards suburban locations. Traditional public transport with buses, trams, metros and local trains is poorly suited for this new spatial pattern. For most residents the use of the car is the only acceptable way to commute. This leads to congestion on the main radials and increasingly also on suburban roads and is wasteful in terms of energy consumption.

There exists a wide range of potential measures to reduce automobile commuter traffic. However, the joint use of vehicles such as cars, vans and minibuses, group taxis or other, more flexible forms of public transport, is only occasionally considered as a solution (eg Reinke 1985). In order to explore the potential of these forms of collective travel, one would have to know the microscopic, small-scale location of residences and workplaces and the resulting spatially disaggregate transport demand in the metropolitan region. This information is, however, not available. So, there is no clear information about the theoretical potential for energy conservation through vehicle sharing.

The paper reports on a recent study in which the theoretical pooling potential of work trips was investigated for the metropolitan region of Dortmund in Germany (Spiekermann and Wegener 1992a; 1993a). For this purpose a microsimulation model of travel demand was linked with a geographical information system. The first step of the study was to generate a disaggregate spatial data base from aggregate census data for more than 210,000 work trips in the region. The model calculates, on the basis of origins and destinations, all possible pooling constellations of work trips and selects the most reasonable matches using criteria such as minimum detour of commuters or maximum passengers. The paper introduces the methodology of the study and presents its main results.

RESEARCH METHOD

The metropolitan region of Dortmund, Germany, is the case study region and empirical data base of the study. It consists of the city of Dortmund and 19 surrounding communities. The Dortmund region has a population of about 2.3 million, of which more than 600,000 live in Dortmund. The region has about 900,000 jobs, of which 260,000 are located in Dortmund. For analytical purposes the Dortmund region was subdivided into four subregions:

- *Central Business District (CBD):* a high concentration of service employment in a small area.
- *Inner City:* the urbanised ring around the CBD containing high-density housing and many work places.
- *Inner Suburbs:* suburban high- and low-density housing areas, subcentres, shopping malls and industrial estates. Because of the large area of Dortmund, the spatial structure of this subregion is mainly suburban.
- *Outer Suburbs:* less urbanised municipalities of Dortmund's hinterland and some urbanised cities of the polycentric Ruhr region.

In the study only those work trips were analysed that have their origin and/or destination within Dortmund, ie only internal commuters and incommuters and outcommuters of Dortmund are considered, but not commuters within the Outer Suburbs. The initial data base was compiled from 1987 census data. There is a total of 212,945 commuters, 169,060 of them are internal commuters, 28,052 are incommuters, 15,833 are outcommuters. These origin-destination data were classified by three modes: walk and bicycle, public transport and car. The data for each transport mode were stored in a 189x189 matrix. The 189 zones are the 170 statistical districts in the city of Dortmund and the 19 surrounding communities. Each cell of each matrix contains the number of work trips for a specific mode between two zones.

For the study a microsimulation model of travel decisions linked with a geographical information system was developed. The first step of the study was to generate a disaggregate spatial data base from aggregate census data for more than 210,000 work trips in the region. The model calculates, on the basis of origins and destinations, all possible pooling constellations of work trips and selects the most reasonable matchings using criteria such as minimum detour, waiting time of commuters or group size of the pool.

Spatial and temporal disaggregation of work trips

Although the above data base is rather disaggregate, a still greater spatial resolution was necessary for the analysis, ie it was necessary to know the exact location of residences and work places and the resulting transport demand in the metropolitan region. Therefore the commuting data were further disaggregated using a geographical information system (GIS) and microsimulation techniques according to the following steps (Spiekermann and Wegener 1993b).

The map of actual land uses of the Dortmund region was digitised. For the whole region more than 4,000 areas were recorded as polygons. Then the land use data were converted to a raster with a width of 100 m, ie a cell size of one hectare. Each cell had two attributes, the land use category and the zone number of its centroid. These cells represented the *addresses* of work trip origins and destinations for the following disaggregation steps. The next step merged the land use and work trip data. First, two weighting factors, one for residences and one for jobs, were assigned to each land use category. Using a random number generator, for each work trip one cell of the origin district and one cell of the destination district were selected as origin and destination addresses. Again using the random number generator, also a starting time was assigned to the work trip. The assumption was that starting times are equally distributed between six and nine o'clock in the morning because of the increasing flexibilisation of work times. The result of this disaggregation procedure was a data set of 212,945 records containing for each work trip its origin and destination addresses (in raster cell units), the starting time and the transport mode actually used.

Identification of pooling possibilities

The criterion for whether two or more commuters can be pooled is whether they live in the same neighbourhood and/or work in the same area of the region and travel at approximately the same time. If these conditions are satisfied, they can share a vehicle for their journey to work. Two kinds of pooling of work trips are distinguished:

- *Pooling on the whole trip.* Work trips can be pooled on the whole trip if origin, destination and departure time are similar. In this case all commuters of a pool stay together over the whole distance.
- *Pooling on parts of the trip.* Work trips can be pooled on parts of the trip if either origins *or* destinations and the departure times are similar and the shorter trips begin or end along the route of the longest one.

In order to operationalise this, some assumptions on what is spatial and temporal similarity are necessary. The assumptions are that commuters are willing to adjust their departure time by a certain time interval Δt (15 or 30 min) and accept a maximum walking distance Δd (500 or 1,000 m) in order to join a car pool. If a work trip has a total length below Δd, it will not be pooled; the commuter is expected to walk to and from the job.

All work trips are analysed using these criteria. This means that each work trip has to be compared with all other work trips with respect to spatial and temporal similarity. Each commuter is considered a potential driver and all other commuters meeting the criteria are recorded as potential passengers. Each commuter is also regarded a potential passenger and all other commuters meeting the criteria are registered as his potential drivers. Depending on the combination of criteria, between three and 22 million pairings of commuters are possible. For instance, if Δd = 1,000 m and Δt = 30 min, every potential passenger can choose between more than 100 drivers on average.

Assignment to commuter pools

Obviously, a commuter can be a passenger of one driver only. But which of the available pools should he or she join? In order to model the choice decision of passengers, two different criteria are used:

- If the passenger acts rational, he or she chooses the pool causing the shortest detour.
- If the passenger acts altruistic, he or she chooses the pool with the largest group size and so helps to achieve the largest energy saving.

For both decision rules the pooling potential was calculated. In combination with the criteria of similarity described above, a four-by-four tableau of sixteen scenarios emerges (Table 1).

Table 1 Sixteen scenarios of pooling work trips

	Maximum walking distance	500 m		1,000 m	
	Maximum departure time adjustment	15 min	30 min	15 min	30 min
Total trips only	Minimum detour	1a	2a	3a	4a
	Maximum passengers	1b	2b	3b	4b
Also parts of trips	Minimum detour	1c	2c	3c	4c
	Maximum passengers	1d	2d	3d	4d

For each of the above sixteen scenarios the number of commuters that can be pooled was calculated. The assignment algorithm used is approximate because the order in which the commuters are processed influences the results. However, experimental variations in the order of processing showed that no significant changes in the results occurred.

ACTUAL COMMUTING PATTERN

Before analysing the pooling potential, this section presents the actual commuting pattern in the Dortmund region in terms of origin and destination region, mode, distance and commuting corridors. Table 2 shows origins and destinations of the work trips:

Table 2 Commuting pattern in the Dortmund region

To / From	CBD	Inner City	Inner Suburbs	Outer Suburbs	Total
CBD	1,469	1,091	713	58	3,331
	0.7%	0.5%	0.3%	0.0%	1.6%
Inner City	11,171	21,175	12,187	2,750	47,283
	5.2%	9.9%	5.7%	1.3%	22.2%
Inner Suburbs	23,749	41,273	56,232	13,025	134,279
	11.2%	19.4%	26.4%	6.1%	63.1%
Outer Suburbs	8,800	11,782	7,470	-	28,052
	4.1%	5.5%	3.5%	-	13.2%
Total	45,189	75,321	76,602	15,833	212,945
	21.2%	35.4%	36.0%	7.4%	100.0%

Note:
Percentages: Percent of all work trips

- Only few workers live in the CBD, more than twenty percent live in the Inner City, but two thirds live in the Inner Suburbs. Incommuters from the Outer Suburbs account for thirteen percent of all commuters.
- The work places in the region are still rather centralised. More than twenty percent of the jobs are located in the CBD, another 35 percent in the Inner City. One third of the work trips is directed to the Inner Suburbs. The number of outcommuters from Dortmund to the Outer Suburbs is insignificant.
- Work trips with origins in the Inner Suburbs account for almost two thirds of all work trips. Only a small portion of them is directed to the CBD and the Inner City. More than forty percent of the commuters with residence in the Inner Suburbs also work in the Inner Suburbs. In total, one fourth of all work trips commutes within the Inner Suburbs.

The average work trip length is 6.5 km. The shortest trip lengths can be found within the CBD and the Inner City. The average length in the Inner City is about 2 km. The shortest trips outside the Inner City are trips in the Inner Suburbs (4.5 km). This is due to the polycentric structure of the region. The longest trips are from or to the Outer Suburbs. The difference in average length between public transport and car trips is rather small. The average trip length of pedestrians and cyclists is only slightly less than that of cars.

Figure 1 shows the commuting pattern of Table 2 by modal share:

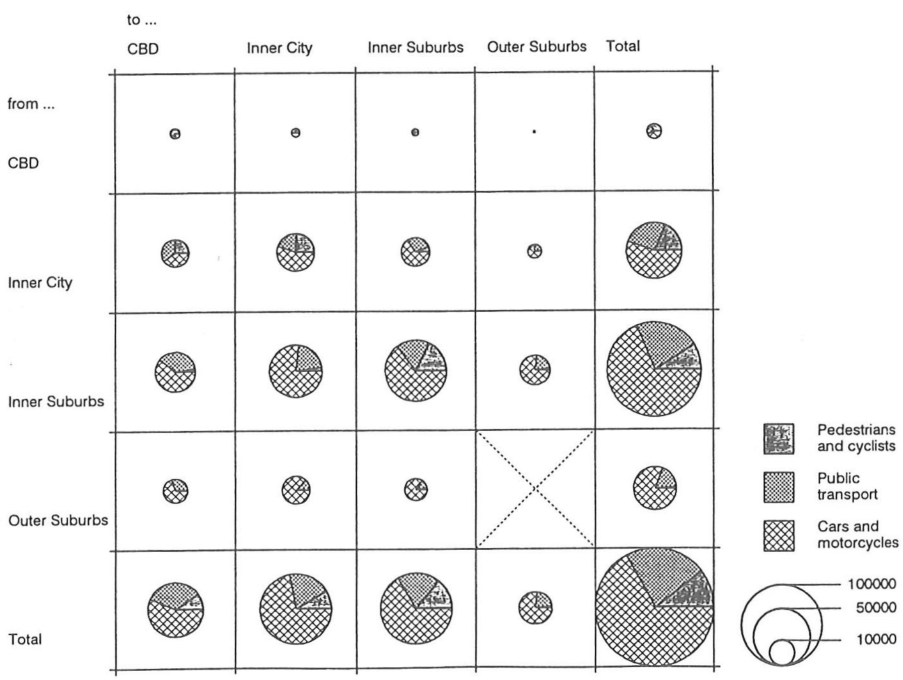


Figure 1 Commuting in the Dortmund region by modal shares

- Little more than ten percent of all commuters walk or cycle to work. The portion is much higher for commuters living and working in the same subregion or commuting between the CBD and the Inner City. Even within the Inner Suburbs pedestrians and cyclist account for nearly eighteen percent of all trips. Nearly fifty percent of all pedestrians live in the Inner

Suburbs. This underlines the polycentric settlement structure of Dortmund, in which suburban subcentres developed around old village cores.

- Public transport is used only by one fifth of all commuters on their journey to work. The highest proportion is on trips to the CBD. However, only every third commuter to the CBD travels by public transport. In the suburban subregions the share of public transport is even lower.
- Two out of three commuters use the car for their work trip. The highest proportion of cars can be found in the suburbs. One out of every two work trips towards the CBD is done by car, the proportion is even higher for trips to the Inner City. Due to the dispersion of residences, most car users live in the Inner Suburbs. One out of four car users commutes within the Inner Suburbs, the same number commutes from the Inner Suburbs to the Inner City.

The analysis indicates that commuting by car is independent of the level of service of public transport. Even on relations that have excellent public transport, the share of public transport is less than one third. There is no single cell in the matrix of Figure 1 in which the share of public transport is higher than that of car.

Figures 2 and 3 visualise work trips based on the disaggregate data base at the 100x100 m raster cell level. The 3D plots show the spatial distribution of commuter trips in Dortmund by mode. The upper part of Figure 2 shows all work trips within Dortmund. They are bundled in several corridors towards the CBD and the Inner City, where traffic clearly has its peak. Some minor peaks can be found at suburban centres. The lower part of Figure 2 shows car trips. Automobile commuting seems to be widespread over the urban area, but most corridors have a clear orientation towards the CBD and the Inner City. Figure 3 shows work trips by public transport users (top) and pedestrians and cyclists (bottom). Non-motorised routes can be found more often in high-density areas. Public transport is most clearly directed towards the CBD; the radial network of the tram and underground system is visible. The differences in magnitude between the transport modes are obvious; differences are less pronounced if one looks at the spatial structure of trips.

POOLING POTENTIAL OF WORK TRIPS

This section presents the results of the analysis with respect to the pooling potential. After the allocation procedure described previously, there is in each of the sixteen scenarios for each commuter a record containing:

- address of residence (in 100 m raster cell units)
- address of job (in 100 m raster cell units)
- transport mode actually used
- pooling characteristic (driver of a pool, passenger, single driver or pedestrian)
- driver (only if passenger).

This information is the basis of the results presented below.

Table 3 presents the work trips that can be pooled for the sixteen scenarios. There is a wide range of pooling rates: between 33 (Scenarios 1a and 1b) and 90 percent (Scenarios 4c and 4d). The pooling potential is less if only pooling of total trips is permitted (upper part); but even in the less restrictive scenarios with maximum accepted walking distance and departure time adjustment (4a and 4b) three out of four commuters can be pooled. If pooling is permitted for parts of a trip (lower part), even the restrictive scenarios (1c and 1d) have pooling rates of about 85 percent. The decision criterion 'minimum detour' versus 'maximum passengers' does not affect the total number of pooled work trips but has an impact on the size of the pools. An additional percentage of work trips cannot be pooled because the work trip length is below the maximum walking distance. These commuters are expected to walk. This accounts for 2.4 percent of all commuters for a maximum walking distance of 500 m and 7.7 percent for 1,000 m.

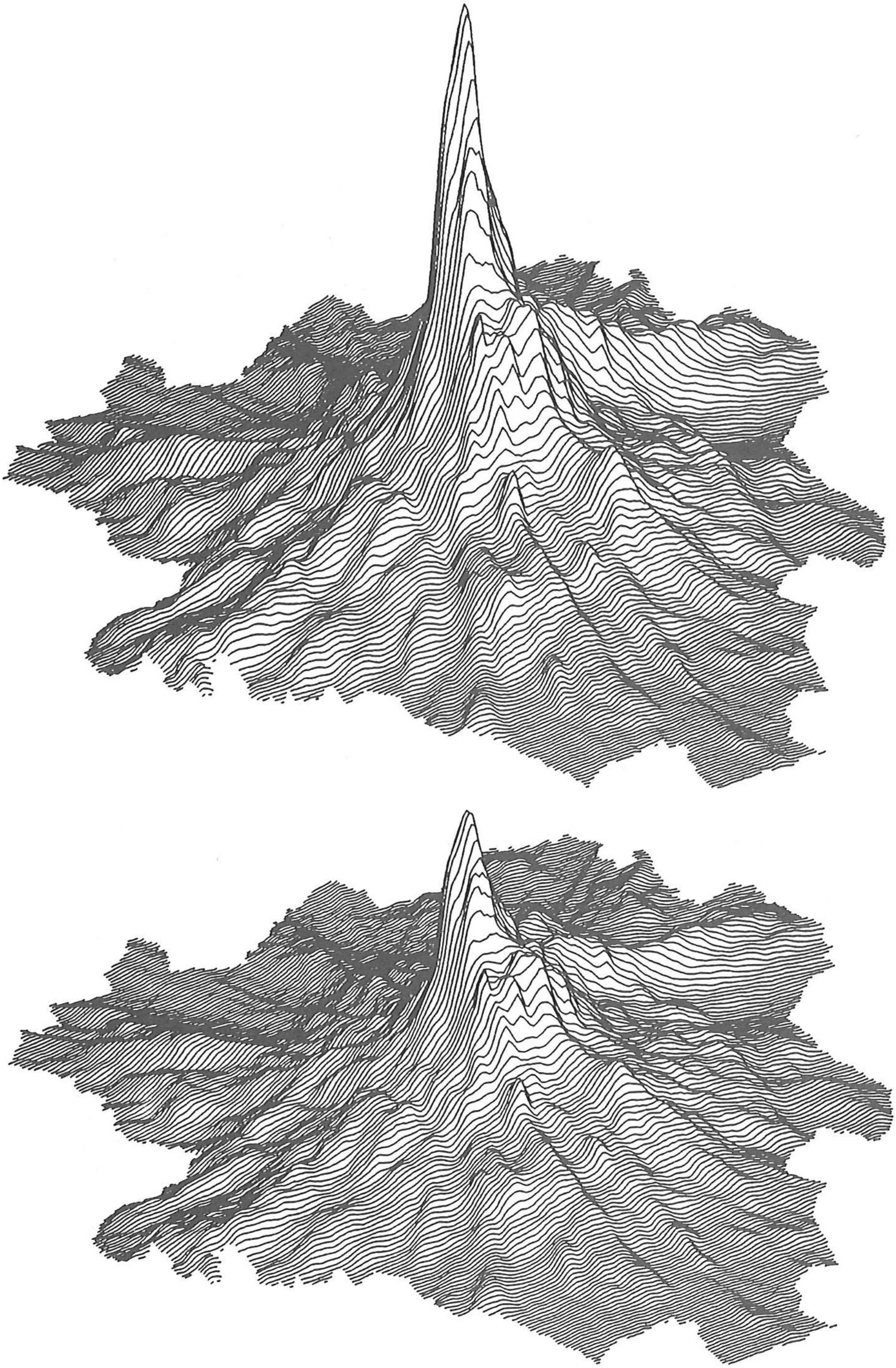


Figure 2 **Work trips in Dortmund: all (top), car (bottom)**

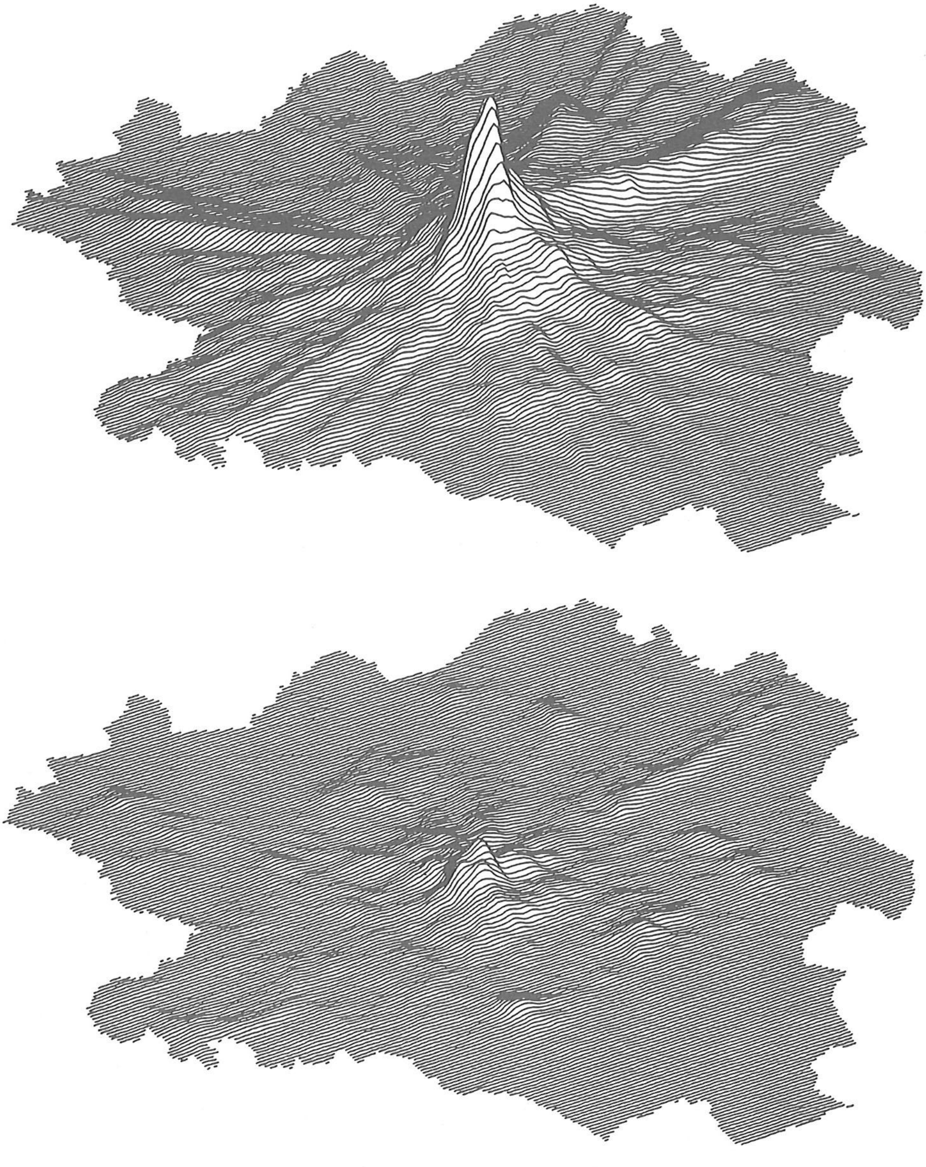


Figure 3 Work trips in Dortmund: public transport (top), pedestrians and cyclists (bottom)

Table 3 Total pooling potential of work trips by scenario

	Maximum walking distance	500 m		1,000 m	
	Maximum departure time adjustment	15 min	30 min	15 min	30 min
Total trips only	Minimum detour	71,151 33.4%	91,773 43.1%	137,889 64.8%	154,767 72.7%
	Maximum passengers	70,531 33.1%	90,848 42.7%	136,602 64.1%	153,400 72.0%
Also parts of trips	Minimum detour	182,188 85.6%	191,691 90%	190,224 89.3%	193,043 90.7%
	Maximum passengers	178,345 83.8%	188,106 88.3%	188,560 88.5%	191,828 90.1%

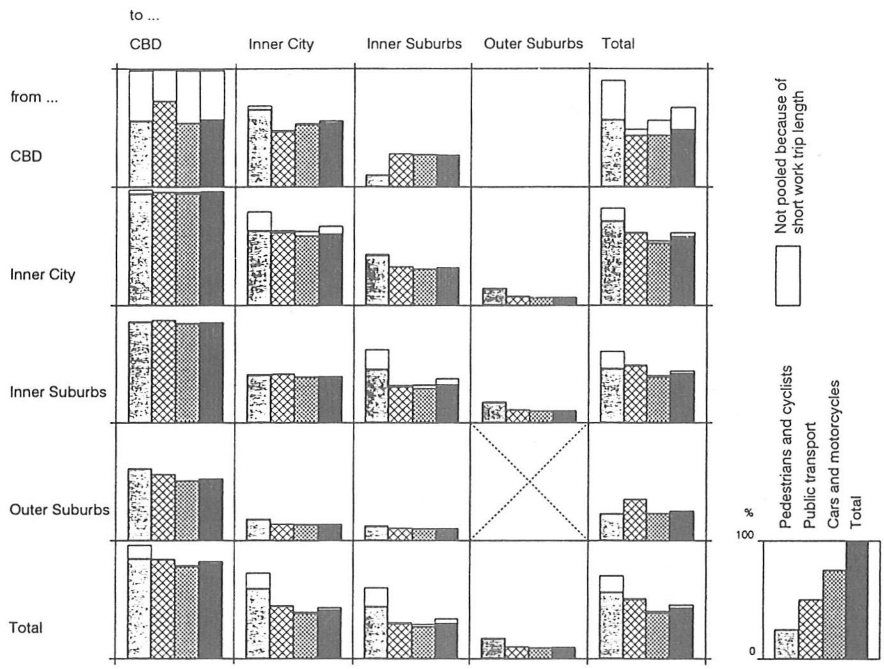
Note:
Percentages: Percent of all work trips.

The following parts of the analysis discuss Scenarios 2a and 4a in more detail. Both scenarios have in common: a maximum accepted departure time adjustment of 30 minutes, pooling only for the whole trip, and choice of minimum detour. They differ in that the maximum accepted walking distance in Scenario 2a is 500 m and 1,000 m in Scenario 4a. This single difference has strong impacts on the total pooling potential and on the group size of the commuter pools:

- For Scenario 2a, about 43 percent of the work trips can be pooled, ie a group size of at least two commuters, but only about five percent can be pooled in groups of more than five. The pooling capability of long distance commuters is less than average.
- For Scenario 4a, the percentage of work trips that can be pooled is about 73 percent and much higher than in Scenario 2a. Also much more work trips can be pooled in larger groups: 25 percent of the commuters can be pooled in groups of more than five, about ten percent even in groups of more than ten commuters. The highest pooling potential is found in the middle-range distance classes, and again the pooling capability of long distance commuters is less than average. But also short distance commuters can be pooled less because many of them have a work trip distance below the maximum accepted walking distance and are therefore expected to walk.

If one classifies the pooling potential by origin and destination and mode, a more detailed picture emerges. Figure 4 illustrates this for the two scenarios:

- In Scenario 2a, a spatial division of the pooling potential is visible. Due to the high concentration of jobs in the CBD and the Inner City, trips from outer to central locations can be pooled much more easily than outward trips. Almost all commuters which live *and* work in the CBD or the Inner City can be pooled or might walk. If the jobs are located at the urban fringe, the pooling potential decreases. There is no real distinction between the pooling potential of commuters who today use different transport modes. On average 80 percent of the work trips by car to the CBD might be pooled. The pooling potential of car users declines with growing distance from the core. In total, 38.7 percent of the work trips by car can be pooled, which is equivalent to 55,253 or one out of four commuters.
- If the maximum walking distance is changed from 500 m to 1,000 m (Scenario 4a) another picture emerges. Within Dortmund nearly all commuters can be pooled or can walk. Even most commuters living in Dortmund and working in the Inner Suburbs and most work trips from the Outer Suburbs to the CBD can be pooled. However, other work trips from or to the Outer Suburbs can be less easily pooled. The figure also shows that many trips shorter than 1,000 m are made by car. Most of the remaining work trips by car within Dortmund and from the Outer Suburbs to the CBD can be pooled. In total, 103,892 work trips by car can be pooled, which is one half of all work trips or 72 percent of car trips.



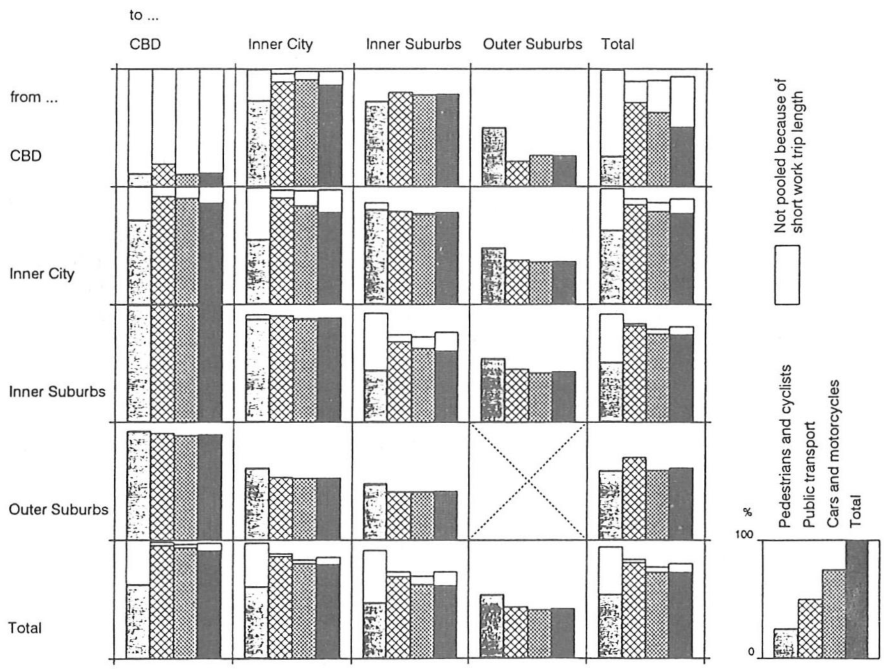


Figure 4 **Pooling potential of commuters by origin and destination and mode actually used: Scenario 2a (top), Scenario 4a (bottom)**

POTENTIAL ECOLOGICAL BENEFITS OF COMMUTER POOLING

Commuter pooling is, of course, no end in itself. This chapter demonstrates the ecological benefits that could result if the theoretical pooling potential were actually achieved. It will be shown that traffic and so energy consumption of commuter traffic could be substantially reduced by pooling of work trips.

Table 4 shows the reduction of vehicle kilometres, ie of traffic and pollution. The reduction potential is the difference between total vehicle kilometres *without* and *with* pooling. Distances are airline distances between origin and destination; trip lengths on networks might be longer by approximately one third. In the restrictive scenarios about fifteen percent of vehicle-kilometres can be saved; if one assumes acceptance of longer walking distances and extended departure time adjustments nearly 80 percent of vehicle kilometres can be avoided. Even the less restrictive scenarios for pooling of total trips cut the energy consumption in half. Admittedly these reduction potentials do not take into account that twenty percent of the work trips in the Dortmund region are already pooled, ie are by public transport. However, as the car is the dominant mode and every commuter has many choices to join a pool, the reduction potential in relative terms is probably the same if one looks at work trips by car only.

Table 4 Reduction potential of vehicle-km by scenario

	Maximum walking distance	500 m		1,000 m	
	Maximum departure time adjustment	15 min	30 min	15 min	30 min
Total trips only	Minimum detour	199,210	274,271	530,642	636,304
		14.4%	19.8%	38.5%	46.1%
	Maximum passengers	200,586	277,898	556,353	677,063
		14.5%	20.0%	40.3%	49.1%
Also parts of trips	Minimum detour	590,186	676,575	784,896	836,223
		42.5%	48.8%	56.9%	60.6%
	Maximum passengers	677,049	795,547	995,562	1,087,478
		48.8%	57.3%	72.2%	78.8%

Note:
Percentages: Percent of energy consumption of all work trips without pooling.

This is done in Figure 5 which shows the spatial distribution of saved work trips by car, ie trips that are not made because of pooling. The figure shows the potential reduction of car traffic if car users joined a pool. Compare this with Figure 2 (bottom) which displays the current distribution of work trips by car in Dortmund. The saving is displayed for the two selected scenarios, Scenario 2a (Figure 5, top) and Scenario 4a (Figure 5, bottom). As the actual commuting pattem, the potential reduction of traffic is unequally distributed in the urban region. The CBD and the Inner City benefit most. There will also be a clear reduction of traffic in the main corridors to the CBD. The less restrictive Scenario 4a will lead to additional car traffic savings everywhere in Dortmund, but now also the Inner Suburbs benefit. The two scenarios selected for illustration are those in which only pooling of total trips is possible, but even despite that restriction substantial reductions in traffic are possible.

Finally the outcome of the study will be discussed in terms of potential energy savings. For this assessment figures for average energy consumption of different modes (MJ per passenger kilometre and MJ per vehicle kilometre) were taken from Banister (1992). The reference base of the following results is the current energy consumption by commuters in the Dortmund region. Today, Dortmund commuters consume 32,584,768 MJ per day of which 94 percent are consumed by car commuters and six percent by commuters using public transport.

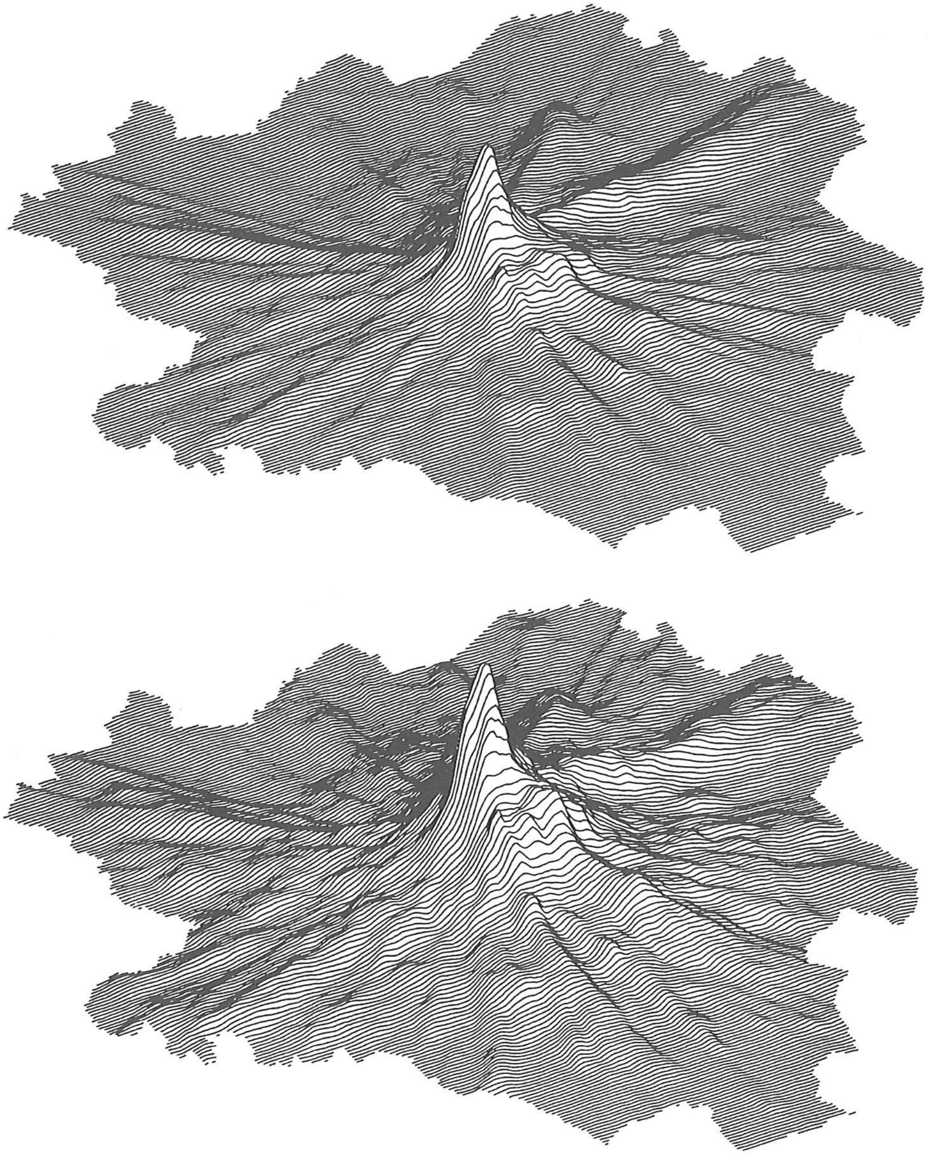


Figure 5 Reductions in car traffic: Scenario 2a (top), Scenario 4a (bottom)

Table 5 presents the potential of energy savings for the sixteen scenarios. It is assumed that a pool of up to 5 people uses a car, a group of between 6 and 12 people uses a van, groups of more than 13 people are assumed to use a bus, while the size of the bus, ie its energy consumption, depends on the size of the group. As expected, there is a large diversity of energy savings between the sixteen scenarios. Four of the restrictive scenarios will even lead to an increase in energy consumption. The explanation for this is that in these scenarios commuters which today use public transport are considered to join a car pool or even use a car as single drivers; this means that they increase their energy consumption. All other scenarios will lead to energy savings between 20 and 55 percent.

Table 5 Energy consumption (in MJ per day) by scenario

	Maximum walking distance	500 m		1,000 m	
	Maximum departure time adjustment	15 min	30 min	15 min	30 min
Total trips only	Minimum detour	35,678,712 109.5%	33,476,812 102.7%	26,083,432 80.0%	23,131,396 71.0%
	Maximum passengers	35,668,212 109.5%	33,455,404 102.7%	25,774,662 79.1%	22,545,922 69.2%
Also parts of trips	Minimum detour	24,977,484 76.7%	22,880,018 70.2%	19,661,590 60.3%	18,418,024 56.5%
	Maximum passengers	24,691,626 75.8%	22,207,092 68.2%	17,613,534 54.1%	15,129,739 46.4%

Note:
Percent of energy consumption of all work trips without pooling.

CONCLUSIONS

The paper attempted to contribute to the debate on possible strategies to reduce the energy consumption of urban transport. It presented the results of a study in which the potential effects of one specific measure, the pooling of work trips, was investigated. The research question was whether increasingly dispersed settlement structures permit the joint use of vehicles for work trips and thus energy savings. Therefore the criteria for pooling of work trips used were spatial and temporal similarity.

The method developed combines a geographical information system (GIS) with microsimulation techniques. The combination of microsimulation and GIS will also form the basis of a larger study aimed at comparing different urban structures under the conflicting objectives of efficiency, equity and environmental sustainability (Spiekermann and Wegener 1992b; Wegener and Spiekermann 1995).

The analysis of actual commuting patterns confirms that today car is the dominant transport mode in urban transport. Even between origins and destinations that have excellent public transport links an overwhelming part of the commuters use the car for their journey to work. However, this expression of a car-oriented society is also the point of departure for strategies that try to reduce energy consumption and CO_2 emissions of urban transport.

The assessment of the pooling potential of work trips based on spatial and temporal similarity suggests the following observations:

- Depending on the scenario, up to eighty percent of all vehicle-km might be reduced by pooling without a major loss of convenience. This might lead to a significant cost reduction for the pooled commuters and to an important reduction of energy consumption and pollution.
- There is no significant difference between the spatial distribution of all work trips and of work trips that can be pooled.

- There is no visible correlation between the pooling capability of a work trip and the transport mode actually used.
- The share of the pooling potential of work trips decreases from the CBD and the Inner City to the Outer Suburbs.
- Work trips from the suburbs to central places can be more easily pooled than work trips from central to less central locations.
- The potential energy savings by work trip pooling are substantial: more than 50 percent of today's energy consumption for commuting might be saved.

In the light of these results, one might ask why only few commuters join a car, van or bus pool or why new, more flexible forms of public transport with less capacity than traditional vehicles are not implemented. The answer to this question has many aspects. The most important of them are:

- Sharing vehicles requires coordination and adjustment and the loss of individual autonomy over start and end of a joumey. One of the most important advantages of the private car is that its use requires no planning in advance. On the other hand, commuter pools need planning and regularity. However, in more and more jobs regular working hours are becoming an exception, less and less people are able to predict in the morning at what time their work will end. In addition, an increasing number of people works part-time with changing work hours. They depend on mobility that can be quickly realised.
- For many people the work trip is no longer *commuting* between residence and work place, but a segment in a complex and often changing trip chain. Shopping, transport of goods, carrying children to or from kindergarten, school or sports, visiting people or attending other leisure activities are inherent features of today's mobile life. Pools based on regularity do not fit into this lifestyle.
- In more and more jobs the firm location is only one of several locations of work. Salesmen or construction workers, architects or service technicians use their car for the work trip *and* for trips between the firm and the frequently changing locations of work. These people depend on their car as a work tool and are seldom in a position to join a pool.
- For most households it is normal to have a car. Yet compared with its true social and ecological costs the use of cars is *too cheap*. Due to low car taxes and cheap fuel there is no real incentive to reconsider individual spatial mobility and to join a pool.

In the light of these aspects the results of this study are too optimistic. A pooling potential based only on spatial and temporal similarity of work trips produces a too favourable picture. Several accompanying policies are necessary. The easiest and probably most powerful measure might be to increase car operating costs. Such an increase will lead to a significant reduction of vehicle kilometres. Part of this reduction might be achieved through pooling of work trips. In the same direction aim traffic regulations which favour high-occupancy vehicles. American cities have achieved significant results with such measures. More innovative are policies that try to overcome the most important deficiency of car sharing schemes, the lack of information between demand and supply. The introduction of group taxis or demand-guided bus systems are possible strategies. Central to this kind of measures is an information system that brings demand and supply together.

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