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Urban transport in Germany: providing feasible alternatives to the car†

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With the second highest level of car ownership in the world, and the third highest population density in Europe, Germany has adopted a range of policies to balance the many private benefits of car use with its serious social and environmental problems. In order to 'tame' the car, most German cities have implemented a twofold strategy of expanding and improving pedestrian, bicycling and public transport alternatives simultaneously with restricting car use and making it more expensive. That has increased political acceptability since the car-restrictive measures are not perceived as mere punishment of car drivers. The results of this coordinated urban transport strategy have been impressive. Germany, as a whole, has managed to increase public transport use and to stabilize the car share of modal split. Some cities, of course, have been more successful than others, and this paper examines three of the most successful cities: Münster, Freiburg and Munich. In each of the cities, the percentage of travel by bicycling, walking and public transport has been raised over the past 20 years, while the car's share of modal split has fallen. This article documents the range of policies used to restrict car use, both in Germany as a whole, and in the three case-study cities in particular. The key to success is found to be mutually reinforcing transport and land-use policies. It is the combination of a whole set of coordinated policies that explains the dramatic success in changing travel behavior.

1. Introduction

Germany is one of the most highly motorized countries in the world. With 494 cars per 1000 inhabitants, Germany's level of car ownership is second only to the United States. It is surprising, perhaps, that Germany's car ownership rate exceeds that in much larger and less densely settled countries, such as Canada and Australia, which have more sprawled, polycentric urban development, less focused travel patterns and longer trip distances. Corresponding to its high level of car ownership, Germany also has one of the highest rates of car use (6228 car kilometers per capita per year). Although that is much lower than American car use, it is higher than in

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any other European countries, except Sweden, Norway and Finland, where long trip distances in extensive rural areas raise nationwide averages.

In Germany, as in the rest of the world, the private car is an extraordinarily popular mode of transport, providing levels of comfort, convenience, speed and flexibility that usually exceed those offered by public transport. Thus, as incomes in Germany have risen over the past decades, car ownership and use have also risen. Moreover, the private car has crucial symbolic value in Germany, representing individual freedom and socio-economic status. That psychological attraction has further enhanced the car's lure. A striking indication of the car's popularity in Germany is that car ownership doubled in the formerly socialist East Germany within only five years after reunification with West Germany in 1990.

Unfortunately, the immense private benefits derived from the private car are accompanied by social and environmental costs such as pollution, noise, accidents and traffic congestion. Those external costs of car use are especially significant in urban areas, where the density of car use is the highest, the concentration of negative impacts is the greatest and the most people are harmed. In general, therefore, the higher the density, the more problematic car use becomes.

With 229 people per square kilometer, Germany is one of the most densely populated countries in Europe, exceeded only by Belgium and The Netherlands. Not only is Germany as a whole densely populated, but German cities are quite compact, with four times the average population density of the largest American cities (Newman and Kenworthy 1989). The high level of car traffic in such a small, densely populated area has forced German cities to undertake a range of measures to mitigate the adverse social and environmental impacts of car use. Given the popularity of the private car, public policies have not even attempted to restrict car ownership. Instead, their aim has been to restrict car use in those areas where it does the most damage, namely in cities.

In their efforts to balance off the private benefits of car use with its social and environmental costs, German cities have shown that it is possible to maintain overall mobility levels while limiting car use in central areas and residential neighborhoods. The key to German transport policy has been expanding and improving pedestrian, bicycling and public transport alternatives simultaneously with restricting car use. That has increased political acceptability since the restrictive measures are not viewed as mere punishment of car drivers.

For many years, metropolitan-wide public transport systems have provided high-quality, well-integrated services, and large subsidies have enabled them to offer regular riders inexpensive monthly tickets. Virtually every German city has extensive car-free pedestrian zones, traffic-calmed residential areas and a network of bikeways that encourage walking and bicycling, generally complementing public transport use. Having improved these transport alternatives, German policies have also greatly restricted car use in cities and increased its cost. Lower speed limits, shared rights of way, lane restrictions, limited parking supply, car-free districts and preferential traffic signals for public transport have all made car use more difficult in inner city areas. High motor vehicle fees, license fees, petrol taxes and parking fees make car ownership and use quite expensive in Germany. Only such a twofold strategy can really change travel behavior: restricting car use and increasing its cost, while facilitating walking, bicycling and public transport use.

These urban transport policies have been complemented by stringent land-use policies and building codes, which — together with high land costs — make low-

density, sprawled suburbanization almost impossible. The more compact and less extensive suburban development around German cities has produced an overall land-use pattern much friendlier to public transport than in the USA.

The purpose of this paper is to examine specifically how German cities have implemented their coordinated transport and land-use policies, and to what extent they have actually been successful in limiting car use. First, aggregate data are analyzed to portray the overall situation in Germany. That aggregate analysis is then followed by detailed information on three case-study cities that have been particularly successful at 'taming' the private car and improving public transport, walking and bicycling, and thus lowering the car's share of modal split. By examining in depth the situations in Münster (north-west Germany), Freiburg (south-west Germany) and Munich (south-east Germany), the study provides a detailed texture to the analysis not possible by looking only at nationwide aggregates. The focus is on the integrated and carefully coordinated package of car-restrictive, public-transport-supportive and anti-sprawl policies that have not only increased public transport use over the past 20 years, but even reduced the private car's percentage of urban travel in the three cities. As a contrast, the most car-oriented metropolitan conurbation in Germany (Rhine–Ruhr) is examined briefly to isolate the impacts of generous roadway supply on public transport use.

2. Aggregate trends in travel behavior and land use

We begin our analysis with some basic information on trends in travel behavior and land use for Germany as a whole. This establishes the overall context for the individual case-study cities. Moreover, the aggregate trends demonstrate that the three case-study cities, while models of balanced transportation and sustainable development, are not extreme exceptions to policies in other German cities. In almost all German cities, car ownership and use have increased dramatically since 1945, but this has not come at the cost of reduced public transport use, in sharp contrast to both the United States and Britain. Likewise, suburbanization of residences and employment can be found in virtually every German city, but the extent of suburbanization is much less, and its density is much higher than in the USA.

2.1. *Aggregate travel trends*

Car ownership and use have increased dramatically in Germany over the past four decades (see table 1). In 1950, West Germany had one of the Western World's lowest rates of car ownership: only 12 cars per 1000 population. Between 1950 and 1992, however, car ownership skyrocketed to 492 cars per 1000 population, a 41-fold increase, giving West Germany the second highest rate of car ownership in the world (Heidemann *et al.* 1993; German Ministry of Transport 1993a). As shown in table 1, the motorization rate of the unified Germany in 1992 was somewhat lower than the rate for West Germany alone (470 versus 492 cars per 1000 population). Although car ownership in East Germany had doubled in the three years after the fall of Communism, it was still about 10% lower than the West German rate in 1992, thus bringing down the average for Germany as a whole. Between 1992 and 1995, car ownership in both Eastern and Western Germany continued to grow and, by 1995, the unified Germany again had the second highest rate of car ownership in the world (at 494 cars per 1000 population).

As car ownership has increased, so have vehicle kilometers of car use. The data series for car kilometers in West Germany starts in 1952. In the 40 years from then until 1992, car use rose from 18·2 billion km to 409·8 billion km, a 23-fold increase. Of course, the extremely rapid growth in car ownership and use far exceeded population growth, which was only 36% for the entire 42-year period from 1950 to 1992 (excluding the increase due to the reunification with East Germany). The first consolidated statistics for the unified Germany were collected in 1992, and in table 1 it is shown that vehicle kilometers of car use have continued to increase (by 44 billion vehicle km or about 3% per year).

Corresponding to the trends toward ever greater car ownership and use, the number of passenger kilometers traveled by car also increased greatly between 1950 and 1995, and the percentage of motorized travel by car has continually risen. As shown in table 2, passenger km by car in West Germany rose from only 31 billion in 1950 to 613 billion in 1992, roughly a 20-fold increase in total car travel, and a 14-

Table 1. Trends in German population, car ownership and use, 1950 to 1995.

	1950 (a)	1960 (a)	1970 (a)	1980 (a)	1990 (a)	1992 (a)	1992 (b)	1995 (b)
Population (c)	47 696	55 958	60 651	61 556	63 726	65 100	80 800	81 817
Cars (c)	570	4 490	13 941	23 192	30 685	32 007	37 947	40 404
Cars per 1000 population	12	80	230	377	482	492	470	494
Car km traveled (d)	18·2 (e)	73·2	201·1	297·4	401·6	409·8	470·9	514·4

Notes: (*a*) Includes only West Germany; (*b*) both West and East Germany; (*c*) thousands of units; (*d*) billions of units; (*e*) for 1952.

Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

Table 2. Trends in German car travel and public transport use, 1950 to 1995.

	1950 (a)	1960 (a)	1970 (a)	1980 (a)	1990 (a)	1992 (a)	1992 (b)	1995 (b)
Passenger km by car (c)	31·1	155·2	352·3	472·5	596·3	612·6	717·2	741·5
(% of total motorized travel)	35·5	64·9	78·5	80·4	84.4	84·1	83·6	84·0
Passenger km by public transport (c)	56·5	83·8	96·5	115·1	109·8	116·2	140·5	140·9
(% of total motorized travel)	64·5	35·1	21·5	19·6	15·6	15·9	16·4	16·0
Urban public transport trips (d)	5144	6603	7015	7652	6873	7296	9148	9314
Urban public transport trips per capita	108	118	116	124	108	112	113	114

Notes: (*a*) Includes only West Germany; *(b)* both West and East Germany; (*c*) billions of units; (*d*) millions of trips.

Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

fold increase in car kilometers of travel per capita. From 1992 to 1995, car travel continued to grow in the unified Germany, to 742 billion passenger km.

During the same period, public transport use in West Germany was also growing, but much slower than car use (see table 2). Total passenger km by public transport doubled (104% increase), and passenger km per capita increased by 49%, compared to the 1348% increase in car travel per capita. As a consequence, public transport's proportion of total motorized ground transport in West Germany fell from 65% to 16%, while the car's share rose from 36% to 84%. Even after reunification, the car's share of total passenger kilometers traveled remained roughly the same, since by 1995 car ownership and use had increased so dramatically in East Germany compared to socialist, pre-unification levels there. Indeed, there is almost no difference in overall modal split between the Western part of Germany in 1992 and the entire reunified Germany in 1995 (see table 2).

Although the focus of this paper is on urban transport, it is interesting to note that long-distance rail passenger transport in Germany has hardly declined over the past 45 years. Within West Germany, the number of long-distance rail passengers fell only very slightly, from 120 million in 1950 to 117 million in 1992. Thanks to the addition of East Germany, the number of passengers increased to 139 million by 1995. What a contrast to the USA, where the number of intercity rail passengers fell by a staggering 93% between 1945 and 1993! (Pucher *et al.* 1993; US Department of Commerce 1975, p. 729, and 1996, p. 616.)

The preceding aggregate statistics do not separate out travel trends exclusively for urban areas, and in Germany, as elsewhere, further disagregation of data by urban, interurban and rural travel is more difficult. Nevertheless, various urban travel statistics are available, even if less comprehensive than the overall national averages.

For example, the total number of *urban* public transport trips in West Germany increased between 1950 and 1980 (+49%), then decreased from 1980 to 1990 (−10%) and rebounded from 1990 to 1992 (+6%). Much of the change in public transport ridership was evidently due to overall population trends, since on a per capita basis, public transport usage in 1992 was only slightly different than in 1950 (112 versus 108 trips per year). The total passenger level increased substantially with the addition of East Germany, but on a per capita basis there was only a slight increase between West Germany in 1992 and the unified Germany in 1995 (from 112 to 114 trips per capita per year).

As in the case of long-distance rail passenger trends, the very stability of urban public transport passenger levels in Germany over the past 45 years forms an impressive contrast to the plummeting of public transport use in the USA over the same period. From 1945 to 1995, American urban public transport systems lost almost 70% of their passengers (American Public Transit Association 1970 and 1996).

Two aspects of urban travel have remained virtually unchanged since 1972 in both West and East Germany: frequency of travel, and time spent traveling. As shown in table 3, both West and East Germans made about three trips per day over the entire period, and spent about an hour each day making those trips, with only a very slight increase in both indices. By contrast, average trip distance roughly doubled. Thus, the almost universally constant travel time budget appears to hold for Germany: increased travel speeds over the years almost exactly offset increased trip distances, thus yielding only slight changes in overall amount of time per day spent traveling.

Similar to most countries, the modal-split share of urban public transport in Germany has fallen in recent decades, just as the modal-split share of car travel has risen. The changes, however, have been smaller than in most other countries. In particular, there has been only a small decline in public transport's share of urban travel.

Table 4 shows modal-split trends for all urban travel in West Germany. The figures were derived from a representative sample survey conducted for the German Ministry of Transport, which still conducts separate surveys for the Eastern and Western parts of the country. As a percentage of travel by all modes (including non-motorized travel), the car's share rose from 31% in 1972 to 49% in 1995. Public transport's share fell slightly from 17% to 16%. As in most European countries – and in sharp contrast to North America – bicycling and walking are important urban travel modes. Nevertheless, their relative significance has also fallen as urban areas in West Germany have begun to spread out and trip distances have increased. The combined modal-split share of bicycling and walking declined from 49% in 1972 to 34% in 1995.

The direction of trends in East Germany has been similar but with different timing. The car became relatively more important in urban transport over the entire period from 1972 to 1995 for which detailed surveys are available (see table 5). The rise in car modal split was gradual, however, until reunification. It increased from 11% to 25% in the 15-year period from 1972 to 1987 and then from 25% to 44% in

Table 3. Mobility trends in Germany: travel time, trip frequency and travel distance, 1972–1995: contrasting East and West Germany.

Index/region	1972	1977	1982	1987	1992	1995
Trips per day per capita						
East Germany	2·8	2·9	3·1	3·1	3·0	3·0
West Germany	2·9	2·9	2·9	3·0	3·0	3·0
Average trip distance (km)						
East Germany	10	11	12	13	17	19
West Germany	11	13	15	17	19	19
Total travel time (min/day)						
East Germany	56	57	59	58	65	63
West Germany	57	58	57	56	59	60

Source: Brög (1996), p. 4.

Table 4. Modal-split trends for urban travel in West Germany, 1972–1995 (percentage of total urban trips by each mode).

	Car					
Year	Driver	Passenger	Motorcycle or moped	Public transport	Bicycle	Walking
1972	20	11	3	17	8	41
1977	27	13	2	17	7	34
1982	31	11	1	17	10	30
1987	36	10	1	15	12	26
1992	38	10	1	16	12	23
1995	39	10	1	16	12	22

Source: Brög (1996), p. 3.

Table 5. Modal-split trends for urban travel in East Germany, 1972–1991 (percentage of total urban trips by each mode).

Year	Car		Motorcycle or moped	Public transport	Bicycle	Walking
	Driver	Passenger				
1972	6	5	5	23	10	51
1977	9	6	4	25	8	48
1982	12	7	3	24	9	45
1987	16	9	2	24	9	40
1992	33	11	1	15	8	32
1995	37	11	1	14	8	29

Source: Brög (1996), p. 3.

the five years from 1987 to 1992. Public transport, by comparison, fell from 24% to 15% of total urban travel, and bicycling and walking combined fell from 49% to 40%. In the next period, from 1992 to 1995, these trends continued, with the car's share up to 48%, public transport down to 14% and walking and bicycling down to 37%. Thus, in only a few years, the eastern portion of the new re-unified Germany has become as car-oriented as the western portion (48% versus 49% of travel by auto). Corresponding to that increase in car modal split in the eastern part of Germany, car ownership doubled between 1988 and 1992, and public transport ridership fell by 56%. Since 1992, however, public transport ridership has stabilized somewhat, declining by a relatively modest 6%. Thus, the level of public transport use there is currently less than half what it was before reunification. It is truly amazing how quickly the much more public-transport-oriented system in socialist East Germany was replaced by the more car-oriented system of West Germany. In less than a decade, travel behavior has been completely transformed.

2.2. *Aggregate land-use trends*

With 229 persons per square kilometer, Germany is one of the most densely populated countries of Europe, surpassed only by Belgium and The Netherlands. The contrast is even greater with the USA, whose population density is less than one-eighth the German level (28 versus 229 persons per sq. km). In addition, Germany is a highly urbanized country, and its cities and urban agglomerations are quite compact and densely populated. The largest German cities are not more densely populated than other large European cities, but they are much denser than the largest American cities. In their comparative study of 32 world cities, Newman and Kenworthy (1989) found that population and employment densities for central business districts, inner residential areas and suburbs were about the same for German and non-German cities in Europe, but roughly four times as high as for American cities. For example, the overall population density of German cities was 54 persons per hectare, compared to only 14 persons per hectare in the 10 largest American cities. Overall employment density in German cities was 32 jobs per hectare in 1980, compared to only 7 jobs per hectare in American cities.

Not only are urban areas in Germany denser than in the USA, but the extent of suburbanization is much less. Newman and Kenworthy found an average of 31% of all metropolitan population living in German central cities (compared to 26% in the US) and 51% of all metropolitan employment in German central cities (compared to

only 36% in the US). Moreover, the German suburbs are much denser than American suburbs – about four times as dense – with 47 persons residing per hectare (versus 11 in US suburbs) and 20 jobs per hectare (versus only 5 in the US).

In a partial update to that earlier study, Kenworthy *et al.* (1997) essentially confirm the 1980 results, but find that the differences between Germany and the USA have narrowed somewhat. For example, inner city population density in German cities in 1990 is found to be only about two-and-a-half times that in American cities (85 versus 36 persons per hectare), and suburban population densities are slightly less than four times higher in Germany than in the USA (40 versus 12 persons per hectare). Although German cities and suburbs remain much denser and more compact than their American counterparts, they appear to be decentralizing and becoming less dense over time.

Thus, the trend toward decentralization throughout Europe and North America can also be found in Germany (Heidemann *et al.* 1993, Jansen 1993). Increasingly, one finds shopping centers and office complexes near the edges of cities, rather than in the center, and German suburbs are generally growing faster than their central city counterparts. The 1993 OECD study of urban travel and land-use trends from 1970 to 1990 included seven German cities: Düsseldorf, Freiburg, Heidelberg, Berlin, Lübeck, Weimar and Schwerin. All the German cities reported an increasing proportion of their metropolitan area population living in the suburbs and a declining proportion of metropolitan area jobs located in the central business district (Sharman and Dasgupta 1993).

The increased decentralization of German cities makes the provision of public transport more difficult. As German cities begin to spread out into the surrounding areas, trip lengths increase and radial traffic focused on the city center becomes relatively less important. Cross-commuting is increasing, especially within some of the large urban agglomerations such as the Rhine–Ruhr region, Frankfurt, Munich and Hamburg (Heidemann *et al.* 1993, Jansen 1993). The relative advantage of car travel is greatest precisely for those sorts of trip from one non-central location to another. That is probably one explanation for the rapid growth in car use.

East German cities have a rather different structure. Suburbanization under socialism was driven not by the market, but by the decisions of ministry bureaucrats and planners who located almost all new residential construction at the outermost periphery of the city, where land was most available. Thus, in the former East Germany, as in Poland, Hungary, the former Czechoslovakia and the former Soviet Union, massive, high-density apartment complexes ring virtually every city. Because there was almost no coordination between housing and industrial location, the journey to work was quite long and time-consuming. Moreover, the peripheral apartment complexes were never adequately supplied with recreational, educational, medical and shopping facilities, so that long trips into the city center were necessary for those purposes as well. The current trend in East Germany is toward ever more commercial facilities on the fringe to service the population that lives there. That will probably reduce trips to the central city and greatly increase the amount of cross-commuting between the suburbs. Both developments are likely to encourage more car use and less reliance on public transport.

3. Case studies of developments in selected cities

In order to get a better feel for what is actually going on at the local level, we examine a few individual cities in more detail. Three of the cities have been chosen

precisely because they are generally considered to be among the most progressive cities in their transport and land-use planning: Münster (Westfalen) in north-west Germany; Freiburg (Breisgau) in south-west Germany; and Munich (Bavaria) in south-east Germany. Although these three cities have been particularly successful at increasing public transport use, bicycling and walking, they are not so unusual as to be atypical. On the contrary, virtually every German city has implemented similar transport and land-use policy measures, and some have been equally successful. Most cities, however, have not gone quite as far in promoting public transport and bicycling or restricting car use.

As a contrast to the three model case studies, we also examine briefly a more car-oriented metropolitan area in Germany, the Rhine–Ruhr region, which is really a metropolitan conurbation rather than a single urban area. Because it is also the region best served by autobahns, it may provide some lessons about the impacts of limited access highways in those rare instances in Germany where they do provide important commutation routes within metropolitan areas.

3.1. *General information on the cities*

The three model cities chosen cover quite a population range. Freiburg has about 180 000 inhabitants and serves as the economic, cultural and political center of the Black Forest region of south-west Germany, which has a population of about half a million. Its economy is based on tourism, university teaching and research, government and church administration, and a broad range of services provided to the surrounding region. The development of Freiburg has been favored by its ideal climate – sunnier and warmer than any other major city in Germany – and by its key location at the gateway to the Black Forest and less than an hour's travel from Switzerland and France.

Münster has about 270 000 inhabitants and has long been the administrative capital of Westfalen, just north of the Ruhr region, in the north-eastern part of the state of Nordrhein-Westfalen. It has the third largest university in Germany, with over 45 000 students. Similar to Freiburg, its economy is based on services, government administration, education and finance. It is much less focused on tourism than Freiburg. Although considered one of Germany's most beautiful cities, its climate is so unpleasant that it is often referred to as the 'rain hole' (*Regenloch*) of Germany, and the surrounding countryside is almost completely flat, in contrast to the mountains surrounding Freiburg on all sides.

Munich is the world-renowned capital of Bavaria, with about 1 245 000 residents in the city itself and a total metropolitan area population of 2 418 000, making it Germany's third largest city after Berlin and Hamburg. Munich is probably most famous for its beer and BMW cars, but its economy is very diverse, including government administration, education, research, light industry and a wide range of services. Munich is even more important than Freiburg as a center of tourism, and is included on virtually every foreign tourist's itinerary through Germany.

All three cities have long histories, having been founded over a thousand years ago. Their central cities thus reflect centuries of existence as compact, walled cities during the Middle Ages. Even with technological advances, population growth and the demolition of city walls, the cities remained dense settlements through the early twentieth century, partly due to the overall scarcity of land in Germany.

The three cities share one other sad historical event. Their central areas were almost completely destroyed in Allied bombing raids during the Second World War

and had to be rebuilt. Although it was impossible to rebuild the three cities exactly as they had been prior to the war, they managed to resurrect much of the old urban form instead of adopting a modern, car-oriented structure. Freiburg and Münster, in particular, deliberately chose to preserve their historic layouts of narrow, winding streets, pedestrian passageways and monumental squares in their old towns, thus ensuring the continued feasibility of walking and bicycling in their central districts. Partly because of its sheer size, there was more modernization in Munich. But there, as well as in Freiburg and Münster, impressive efforts were made in the 1970s and 1980s to establish extensive car-free pedestrian zones that greatly enhanced the attractiveness and safety of walking, thus improving pedestrian facilities over their prewar condition.

The decision in all three of these cities to rebuild many destroyed structures and retain historic street patterns was probably the most important land-use policy they undertook and is certainly one reason for the success of public transport, bicycling and walking in the succeeding decades. As mentioned later, many other land-use and development policies have reinforced this basic land-use decision.

The Rhine–Ruhr region is about 150 km south-west of Münster; the grouping of cities in the region is best known for mining and heavy industry, severe air and water pollution, rather unattractive cities and large working-class populations. Indeed, the Ruhr has always been the most important industrial center in Germany, since the beginnings of the Industrial Revolution in the early nineteenth century. The south-western part of the Rhine–Ruhr region is the area around Düsseldorf, the capital of Nordrhein-Westfalen and an important European fashion center. Although it also contains much industry, its economy is far more diverse than the Ruhr cities to the north and east. Including that portion of the Rhineland around Düsseldorf, the Rhine–Ruhr is the most populous urban agglomeration in Germany, with 7·5 million residents. The region includes 24 separate cities, the most important being Essen, Dortmund, Duisburg, Bochum, Wuppertal and Düsseldorf. The exact boundaries of the region are highly debatable, but for the purposes of this paper, we set them equal to the service area of the Verkehrsverbund Rhine–Ruhr, the metropolitan-wide public transport system that serves the entire region, encompassing 5026 sq. km.

In contrast to Freiburg, Münster and Munich, the Rhine–Ruhr region is distinctly polycentric, generating dispersed travel patterns that are not focused on any single city center. Moreover, the region is criss-crossed with numerous autobahns and other major national highways, some of which pass directly through or near the various city centers. Most cities of the Rhine–Ruhr region, which were also destroyed during the Second World War, were more extensively modernized and adapted to the car during their reconstruction, partly because they were less historically interesting and less scenic even before the war. Nevertheless, even cities in the Rhine–Ruhr region have undertaken massive efforts to expand and improve public transport services, and their fully integrated public transport system (Verkehrsverbund Rhine–Ruhr) offers the most attractive fare structure in Germany.

3.2. *Travel trends in the selected cities*

Corresponding to the strong trends toward increased car ownership and use in all of Germany, car ownership and use have also risen dramatically in each of the case-study cities. Precise figures are not available for all the cities, especially for vehicle

Table 6. Public transport passenger trends in Munich, Münster, Freiburg and Rhine–Ruhr (millions of passenger trips per year).

Year	Munich (*a*)	Münster (*b*)	Freiburg (*c*)	Rhine–Ruhr (*d*)
1975	405			
1980	451	20	28	643
1985	485	19	34 (57)	692
1990	507	19	45 (64)	1045
1995	529	32	66 (92)	1077

Notes: (*a*) All figures for Munich are for the Münchner Verkehrsverbund, the regional public transport system created in 1972 to serve the entire region. (*b*) Münster does not have a Verkehrsverbund, but a slightly less integrated regional form of cooperation, a Verkehrsgemeinschaft. These passenger figures include only the central Münster bus system and none of the suburban firms. (*c*) The figures in parentheses are passenger totals that include all regional services — i.e. suburban rail and bus, as well as city rail and bus services. (*d*) The Verkehrsverbund Rhein–Ruhr, a regional public transport organization, provides integrated services throughout the area, including bus, tram, metro and suburban rail.

Sources: Public transport systems in each individual city.

Table 7. Modal-split trends for Freiburg, 1976–1994 (percentage of total trips by each mode).

Year	Car	Public transport	Bicycle	Walking
1976	39	14	12	35
1989	37	20	21	22
1994	36	21	22	21

Source: Stadtwerke Freiburg (1996).

and passenger kilometers of car travel in individual cities. All interviews, however, confirmed the impression of rapid increases in the amount of car travel, and a few cities provide specific figures on increases in car ownership. In Freiburg, for example, car ownership grew from 248 cars per 1000 residents in 1970 to 422 cars per 1000 residents in 1990 (Pucher and Clorer 1992). In Munich the rate of car ownership rose from 286 cars per 1000 residents in 1972 to 529 per 1000 residents in 1995 (Münchner Verkehrs-und Tarifverbund 1996). In Münster the rate increased from 290 cars per 1000 residents in 1975 to 521 cars per 1000 residents in 1991 (Stadt Münster 1994). Thus, the rate of car ownership has roughly doubled in each of the case-study cities over the past 20 years.

In light of the rapid increases in car ownership, it is all the more impressive that public transport use has been increasing in all three of the case-study cities, and also in the Rhine–Ruhr region with its dense network of autobahns. As shown in table 6, the number of passenger trips on public transport (including suburban rail) rose from 1980 to 1995 by 17% in Munich, by 55% in Münster, by 136% in Freiburg and by 67% in the Rhine–Ruhr region.

Tables 7–10 provide detailed modal-split breakdowns for each of the four case-study regions over the past 20 years, indicating how the percentage of total travel by each transport mode has changed over time. Perhaps the most striking trend is the increase in public transport's share of modal split in all three of the

model case studies. Even in the autobahn-intensive Rhine–Ruhr conurbation, the percentage of travel by public transport has remained quite high, falling from 15% in 1976 to 11% in 1990 but rebounding back to 15% in 1994 and 1996 (see table 10). Perhaps most impressive is the trend in Munich, where public transport's share of all travel rose steadily from 19% in 1976 to 25% in 1995 (see table 9). Equally impressive, the percentage of travel by bicycling more than doubled (from 6% to 14%), reflecting the enormous investment in bike lanes and bikeways throughout Munich. By contrast, the car's share of travel fell from 42% to 40%.

The modal split distributions for Freiburg and Münster reflect their smaller size, shorter trip distances and, thus, greater relative importance of bicycling and walking (see tables 7 and 8). That is most striking in the case of Münster, where over half of all trips are by walking (22%) or bicycling (32%). Münster, in fact, is the most bicycle-oriented city in all Germany, with 40% of all non-pedestrian trips by bicycle. The modal-split share of public transport rose considerably in Münster between 1990 and 1994 (from 7% to 10%), mainly due to the introduction of sharply discounted semester tickets for university students. The shift of some students from bicycle to public transport caused bicycle modal split to fall from 34% to 32% of all trips. The net result, however, was favorable, as the car's share of modal split fell between 1982 and 1994 from 39% to 37%. The car's share of total travel fell in Freiburg as well, from 39% of all trips in 1976 to 36% in 1994. Increases in bicycling and public transport use were more striking in Freiburg than in Münster. Indeed, bicycling almost doubled, rising from 12% to 22% of all trips. Public transport modal split rose by 50%, from 14% to 21%.

Table 8. Modal-split trends for Münster, 1976–1994 (percentage of total trips by each mode).

Year	Car	Public transport	Bicycle	Walking
1976	39	7	29	25
1989	38	7	34	21
1994	37	10	32	22

Source: Stadtplanungsamt Münster (1995).

Table 9. Modal-split trends for Munich, 1976–1995 (percentage of total trips by each mode).

	Car					
Year	Driver	Passenger	Motorcycle and mopeds	Public transport	Bicycle	Walking
1976	29	13	2	19	6	31
1982	30	8	1	22	10	29
1989	31	9	0	24	12	24
1992	29	7	0	25	15	24
1995	30	8	0	25	14	23

Source: Socialdata (1996).

Table 10. Modal-split trends for Rhine–Ruhr metro area, 1976–1996 (percentage of total trips by each mode).

Year	Car		Motorcycle and mopeds	Public transport	Bicycle	Walking
	Driver	Passenger				
1976	28	12	1	15	5	38
1982	33	11	1	13	8	34
1990	41	11	1	11	7	29
1992	40	12	1	13	6	28
1994	39	12	1	15	8	25
1996	39	13	1	15	7	25

Source: Socialdata (1996).

The modal shifts in Münster, Freiburg and Munich have gone against the general trend toward increased car use. As described below in section 4 on policy, the move toward lesser reliance on the car has been brought about by a range of public policies deliberately aimed at greater use of public transport, bicycling and walking. Without those policies, car modal split almost certainly would have risen, as elsewhere.

3.3. *Land-use trends in the selected cities*

There is very little statistical information available on the extent of suburbanization and the compactness of urban and suburban development in the individual case-study cities. Nevertheless, interviews with city officials and planners clearly indicated substantial increases in suburban development in recent years. That development often takes the form of rapid growth in independent towns and villages at the urban fringe which are captured in the outward spreading commutation radius of the main urban center.

As suggested by the suburban density statistics reported earlier for Germany in aggregate, suburban development is a much higher density than in American cities. Thus, although metropolitan areas are indeed spreading out into the countryside, development remains relatively compact, and the monocentric orientation towards the main city center continues to dominate (with Rhine–Ruhr being an obvious exception).

Suburban developments are more difficult to serve with public transport than central cities. Public transport managers and urban planners in all the case-study cities lamented the problems caused by increasing suburbanization. Whereas they rejoiced in the success of their central city transport networks, they acknowledged the sharp limitations they face in the growing fringe settlements. The extensive surburban rail systems in Germany provide ever better radial linkages between the suburbs and the central city, but there is almost no cross-suburban service. Thus, almost all motorized travel within and between suburbs is by car, just as in the USA. Since most growth in travel demand is precisely for such suburban-oriented trips, the future promises to be challenging for public transport.

4. Urban transport policies

Whereas car use and car modal split have been rising in most of the world's cities, our three case-study cities have at least succeeded in reducing car modal split.

Moreover, Germany as a whole has managed to keep public transport use quite stable and has avoided the sharp increase in car modal split observed in many other countries. The trends in travel behavior and land use in Germany in aggregate, and the case-study cities in particular, have resulted largely from deliberate public policies that have limited car use, and made it more expensive, while promoting public transport, bicycling and walking. We examine in this section the range of transport policies, which together have been so successful at controlling car use. It is the coordination of these transport policies with one another and with land-use and housing policies that has been key to overall success. In the sections that follow, we present an overview of German policies in general, as well as policies in the case-study cities in particular.

4.1. *Improvement of public transport*

One of the crucial aspects of German transport policy over the past two decades has been the steady improvement in public transport. Both the quantity and quality of services has increased. Moreover, the various types of public transport services have been better integrated than ever before, with improved coordination of routes, station stops, timetables and ticketing.

The largest German cities rely on rail lines as the backbone of their route network, and that has been the focus of their efforts to improve the public transport system overall. Smaller cities generally have bus-only systems, but even they benefit substantially from short-distance regional rail services of the German Railroad.

4.1.1. *Metro, advanced light rail and tramway systems*

German cities have a range of rail modes available to them, in addition to the very extensive suburban rail services throughout the country. Only the largest cities have their own full-scale heavy rail metro systems: Berlin, Hamburg, Munich and Nuremberg. Due to their high construction costs, no new heavy rail metro systems are currently planned, but the existing systems have been extended considerably over the past 20 years, and plans foresee further expansions in the future. The most significant expansions are in Berlin and Munich. In Berlin the focus is on providing the key additional links to integrate the two formerly separate U-Bahn systems in West Berlin and East Berlin, but some suburban extensions are also planned. Munich has completed its inner U-Bahn network (at 71 km) and is now extending its radial lines farther out into the suburbs.

Almost all large German cities, and many medium-sized cities, have been building new light rail lines or upgrading old tram (streetcar) lines to grade-separated light rail standards. The advanced LRT systems are usually designated as Stadtbahns or Schnellbahns; they usually have their own rights of way and sometimes are hardly distinguishable from full-scale U-Bahns, especially since many run underground in the city center. In the Rhine–Ruhr region, for example, the Stadtbahn network already covers 227 km of routes, and it is still being expanded (Pucher and Kurth 1995). Freiburg expanded its LRT Stadtbahn from 16 km in 1985 to 23 km in 1995, and further extensions are being built (Stadtwerke Freiburg 1996). In addition, about 50 cities have retained their old tram (streetcar) lines, with shared rights of way, frequent stops and, thus, much slower average speeds than the advanced light rail systems. But even on traditional tram lines, services have improved due to modernization of tracks and other infrastructure, new vehicles and a variety of traffic-priority measures that speed up tram travel in mixed traffic.

Munich has 85 km of tram routes, and Rhine–Ruhr has over 600 km of tram routes.

4.1.2. *Suburban train (commuter rail)*

Regional railroad services are far more important in Germany than in the USA. Indeed, virtually every German city benefits from such services, which were originally operated and financed by the German Federal Railways, but are now being devolved to the states and metropolitan areas. The extent of devolution, regionalization and integration into the rest of the urban transport network varies from city to city. In the largest cities, however, regional rail routes have been integrated more and more into the central city U-Bahn and S-Bahn networks. Munich has the best integrated suburban rail services. Designated as the S-Bahn, they are almost identical in concept and design to the R.E.R. (Réseau Express Régional) suburban rail services in Paris, with many stops shared with underground metro lines (U-Bahn) in the central city, thus making transfers quite convenient. Munich has 510 km of S-Bahn routes fanning out into its suburbs. With over 1600 km of routes, the Rhine–Ruhr public transport system has far more regional rail service than Munich, which is not surprising given the large size of the region and the many cities, towns and villages in the district that need such connections. Freiburg and Münster also are at the center of extensive suburban rail networks serving their entire hinterlands, but in both cases, access to the system is mainly at the central train station, with very few additional stops. At least in Freiburg, as in Munich and the Rhine–Ruhr, the ticketing and scheduling between suburban rail and other public transport modes are fully integrated. In Münster the systems have remained separate because the German Railroad and local public transport system have not yet been able to reach agreement on joint financing.

Overall, however, suburban rail services in Germany have improved considerably over the past 10 years, primarily due to new vehicles, more regularly scheduled services (i.e. every 10 or 20 minutes at the same time after every hour), better service integration and uniform ticketing, which allows travelers to use the same ticket for all public transport modes.

4.1.3. *Park-and-ride and bike-and-ride*

Virtually every rail system in Germany has been expanding its park-and-ride facilities to attract those riders living in low-density areas outside of walking distance or convenient bus service from suburban rail, metro or LRT stations. As suburban areas expand, the construction of additional park-and-ride facilities is viewed as crucial to retain those customers moving to the suburbs. For example, Munich has increased the number of parking spaces at its outlying U-Bahn and S-Bahn stations from only 3000 in 1972 to 26 400 in 1995. Many systems are also catering to the other end of the market by providing bike-and-ride facilities and improving pedestrian access to bus-stops and rail stations. In Munich, for example, the number of bicycle-racks at stations now exceeds 28 000 and is steadily increasing. In Freiburg over 1500 bike-racks are available at LRT stops, and bicycle parking at the main train station can handle 850 bikes. In Münster, the problem of bicycle parking at the main railroad station is so severe that an underground parking garage is now being built to handle 3000 bikes (Stadt Münster 1996). In short, much has been done to facilitate access to rail services.

4.1.4. *Bus services*

Although hardly as dramatic as new rail systems, bus services have also been improved in most German cities. The bus fleet has been completely modernized, featuring mostly low-floor vehicles (for easy boarding) with large windows and comfortable seating. Moreover, virtually all cities have introduced a variety of measures to give buses priority in traffic. Separate bus lanes, bus turnouts and loading bays, access ramps and bus-activated traffic signals (giving buses the green light) have both speeded up bus travel and reduced operating costs. These *Beschleunigungsmassnahmen* ('speed enhancement measures') have been quite successful, which accounts for their rapid spread. Finally, transfers among as well as between bus lines and rail services have been greatly facilitated by special transfer stations, which make transferring simpler than previously. Better coordination of schedules has also reduced the time for transferring. Every city relies heavily on buses, so that these improvements in bus travel are crucial. Most small cities have only bus services, and even the largest cities depend on buses to serve low-density areas and to bring passengers to rail routes.

Of course, the same holds for Freiburg, Münster, Munich and the cities in Rhine–Ruhr. The improvements were especially important for Münster, which has a bus-only system (except for suburban rail). From 1985 to 1995, the route network in Münster was only slightly expanded, but the network configuration, bus scheduling and bus speeds were so much improved that the overall impact was considerable, attracting 58% more passengers with almost no increase in subsidy.

4.1.5. *Overall service supply*

Different cities provide different indices of total public transport service supply thus making intercity comparisons and aggregate summations difficult. Nevertheless, the available supply indices clearly indicate considerable overall service expansion in all the case-study cities. Munich, Rhine–Ruhr and Freiburg, for example, report total place kilometers of service, a measure which takes into account the larger capacity of rail vehicles and different sizes of buses, and reflects both seating and standing room. From 1980 to 1995, place kilometers of service increased from 16·0 billion to 23·8 billion in Munich (+49%), from 32·6 billion to 36·3 billion in Rhine–Ruhr (+11%) and from 565 million to 858 million in Freiburg (+52%). Large service expansion in Munich appears to have offset the fare increases there. In Münster service supply is measured by bus kilometers, which increased from 5·9 million in 1980 to 7·1 million in 1995 (+20%).

4.1.6. *Public transport fare structure*

One important reason for ridership increases over the past 10–15 years is the introduction of innovative, highly attractive fare structures on most German public transport systems. Whereas regular one-trip fares can be quite high (3·30 DM in Munich), weekly, monthly, semester and annual tickets for regular riders are generally inexpensive, thus permitting very low per trip fares for most public transport riders in Germany. Indeed, precisely because the monthly, semester and annual tickets are a bargain, users of such tickets account for the great majority of riders on public transport systems.

We provide just a few examples of fare levels in the case-study cities. The standard monthly ticket in Rhine–Ruhr, the so-called 'Ticket 2000', costs only 65 DM (German Marks), or about $40, for an entire month of unlimited travel

within the first fare zone. For 130 DM (about $81), the monthly ticket permits unlimited travel across all three fare zones and, thus, throughout the entire 5026 sq. km region. The tickets are good on all modes, including suburban rail. If the monthly tickets are purchased for the entire year, an additional 20% discount if offered, leading to an even more attractive price of 54 DM ($34) for the inner zone and 109 DM ($68) for the entire region. The Ticket 2000 is transferable to anyone, so the ticket can be shared by several persons taking trips at different times. Moreover, at off-peak times (evenings and weekend), a single ticket suffices to transport the holder, up to three children, a bicycle and a dog at no additional cost.

As if the Ticket 2000 were not attractive enough, other discounts are also available. Students pay only 85 DM ($53) per semester for unlimited travel within the region, which represents a monthly cost of only 20 DM ($13), a great bargain. Many firms subsidize the monthly tickets of their employees, enabling them to purchase the Ticket 2000 for less than half its already low price: 24 DM ($15) for the first zone pass and 50 DM ($31) for unlimited travel in the entire region.

Rhine–Ruhr is exceptional in the extremely low prices of monthly, semester and annual tickets, but all of the other case-study systems also offer attractive fare structures, at least for regular riders. In Münster the regular monthly ticket costs 66 DM ($39) for the extensive inner zone, which includes both the city and innermost suburbs. If purchased for the entire year, the monthly ticket costs 58 DM ($34). University students pay only 63 DM ($37) per semester for unlimited travel in the same large inner zone. As in most German university towns, the cost of the monthly ticket is included as a regular part of compulsory student fees and is thus paid whether the students use public transport or not. In effect, the marginal price of public transport is zero, offering a very strong incentive for students to use public transport.

In Freiburg, the monthly ticket costs 64 DM ($38) and allows unlimited travel in the large region surrounding Freiburg, extending far into the Black Forest to the east and toward France in the west. Students and apprentices pay only 47 DM ($28) for the same ticket.

The fare structure in Munich is so complicated that it is almost impossible to summarize with any sample figures. It has 9 inner fare zones, 20 outer fare zones and 134 different fare zone combinations, each requiring a different fare. Moreover, Munich offers 24 different kinds of ticket, varying by age-group, type of education and training, degree of handicap and time of day. Although it certainly offers a wide variety of choice, Munich's fare structure seems overly complicated and its average fare per passenger trip (taking into account various discounts) is 36% higher than for Rhine–Ruhr: 1·21 DM versus 0·89 DM (Pucher and Kurth 1995).

In many German cities, the deeply discounted monthly tickets are designated as environmental tickets, emphasizing the pollution, noise and congestion reduction derived from public transport use. Freiburg, in fact, was the first city to introduce the environmental ticket (*Umweltkarte*) in 1984. It was so successful at attracting more riders that many other cities adopted the same approach of marketing public transport as an environmentally friendly mode. For the customer, the monthly environmental ticket combines the advantages of a low fare with the satisfying feeling that one is helping to improve the environment.

4.1.7. *Regional transport organizations*

Germany has been at the forefront of regional coordination of public transport services in urban areas (Pucher and Kurth 1995). Starting with Hamburg in 1967, an

increasing number of German cities have established various organizational forms of regional cooperation and integration (German Ministry of Transport 1988d). By 1990, virtually all West German cities had integrated their public transport systems. The two most important organizational forms are the Verkehrsverbund and the Verkehrsgemeinschaft. Both types of public transport agency enable fully integrated route networks, timetables and fare structures. From the perspective of the passenger, it is as if only one firm were providing all public transport services within each German metropolitan area. The same ticket or monthly pass can be used for any mode of public transport in any part of the region. Route maps, timetables and service standards are uniform. Transfers among modes and routes are easier, both due to physical coordination of services (spatially and temporally) and to the zone-based unification of the regionwide fare structure, which allows passengers free choice of modes and routes (including suburban rail services).

In Freiburg, Munich and Rhine–Ruhr, all public transport services are organized, coordinated and financed by large Verkehrsverbund systems covering extensive service areas that encompass even distant suburbs and related towns. Both services and fares are fully integrated over expansive regions, including some rural areas. Münster's system is a Verkehrsgemeinschaft, with a lesser degree of integration but still substantial coordination, except for suburban rail services, which remain completely separate in Münster, in contrast to the other three cities.

Regional coordination of public transport services has greatly enhanced the quality of public transport in Germany. In most cities, coordination has achieved ridership growth or at least a slowdown in ridership loss. Nevertheless, it has not succeeded in reducing costs or subsidy needs (German Ministry of Transport 1988d). Indeed, the total operating subsidy for urban public transport in Germany grew especially fast during the late 1960s and the 1970s, when most regional transport agencies were formed. Some of that subsidy increase was due to service expansion and fare discounts; it is unlikely that regional coordination in itself caused deficit growth.

4.1.8. *Financing public transport*

Throughout Europe, it has required substantial subsidy growth to finance the range of service improvements and fare reductions necessary to increase public transport ridership. That has become a considerable problem in recent years, with increasing strains on government finances at every level and in every country, including Germany.

In general, operating subsidies in Germany are financed by local government and city-owned public utilities; special fare reductions are financed by state (provincial) government; and capital subsidies are financed mainly by the federal government, with state and local contributions. Until 1995, all subsidies for suburban rail services were paid by the federal government; since devolution, however, states and metropolitan regions are now responsible for covering these costs. As part of the devolution deal, the federal government agreed to provide the states with additional funds each year to cover the suburban rail subsidy (e.g. 12 billion DM, or $7·5 billion, in 1997). Overall, 54% of the subsidy burden is borne by the federal government, 22% by the states and 24% by local governments (German Parliament 1997).

The exact details of public transport finance in Germany are rather complicated, but the total burden of subsidy finance is substantial, amounting to 32·4 billion DM ($20·3 billion) in 1993, the latest year for which the German government has

calculated complete subsidy statistics (German Parliament 1997). Indeed, the German subsidy level exceeds the subsidy to public transport in the USA ($17·5 billion), a country many times larger. Thus, the public transport subsidy per capita is four times larger in Germany than in the USA ($248 versus $67 per year). Moreover, the combined operating and capital subsidy per passenger trip averages 3·48 DM ($2·17), with passenger fares covering only 40·3% of operating costs. Not only are public transport subsidies in Germany large, they have been growing at an average annual rate of 5·9%, roughly twice the rate of inflation.

In short, Germany has indeed succeeded in improving public transport services and offering attractive fares, but at considerable taxpayer cost. Currently, the federal and state governments in Germany are struggling with serious budget crises. The federal government, in particular, must reduce its budget deficits in order for Germany to qualify for European monetary union in 1999. It seems questionable, therefore, whether the German public sector will be able to afford to be so generous to public transport in the future.

4.2. *Improvement of pedestrian and bicyclist facilities*

With 30–40% of urban travel in Europe by walking or bicycling, facilitating these two important non-motorized modes of transport has been crucial. Together with The Netherlands and Denmark, Germany has been at the forefront of efforts to improve the convenience, speed and safety of walking and bicycling.

4.2.1. *Car-free pedestrian zones*

In virtually all German cities, as well as many smaller towns and villages, there is an interlocking system of streets in the old town center and main shopping district that is almost completely off-limits to private cars (Hajdu 1989, Hass-Klau 1992, 1993). Most of those zones enhance pedestrian and bicycle access to the heart of the city while keeping cars at a distance, forcing them to park in fringe lots and garages. By contrast, public transport is allowed direct access to this central zone, although buses and trams are usually required to travel at reduced speeds to ensure the safety of pedestrians and bicyclists. Freiburg, for example, has 8·5 km of streets off-limits to private cars in its central district. Münster has 5·5 km of pedestrian streets in the city center and another 11 km of streets with partially restricted car use. Likewise, many important shopping streets, squares and plazas in Munich restrict access by private cars.

4.2.2. *Traffic calming*

Especially since 1980, most West German cities have reduced speed limits in urban residential areas to 30 km per hour (19 m.p.h.) and have further discouraged car traffic by narrowing streets, increasing the number of curves and installing speed bumps, posts (bollards), concrete planters, wider pavements (sidewalks) and bicycle lanes. Such traffic-calming measures are aimed at reducing car use or, at least, making it less dangerous for pedestrians and bicyclists. Speed limits and other traffic regulations within cities are strictly enforced not only directly by police officers, but also by remote cameras that monitor traffic and automatically photograph cars speeding, failing to stop or to yield right-of-way, or violating various other regulations.

In Freiburg, all residential neighborhoods have been traffic-calmed, with pedestrians, bicyclists and cars having equal rights to use roads in their full breadth,

with cars required to limit their speeds to no more than 30 k.p.h. (19 m.p.h.) and to avoid endangering pedestrians and bicyclists using the roadway. Münster and Munich have been increasing the number and extent of traffic-calmed neighborhoods, but they remain somewhat behind the pathbreaking policies in Freiburg.

4.2.3. *Bikeways, bike lanes and bicycle parking*

Münster has been the unchallenged leader in policies promoting bicycle use in Germany. It has not been satisfied with resting on its past record of having the highest level of bicycle use in Germany. On the contrary, Münster has vigorously built on its past successes by expanding its system of bikeways and steadily introducing new innovations to promote more bicycle use. For example, its network of integrated bicycle paths was expanded from 145 km in 1975 to 252 km in 1995, with most paths separated from car and pedestrian traffic. Münster even has a major bicycle expressway that encircles the city center along the route of the old city wall. In addition, bicyclists benefit from over 300 km of bike paths over lightly traveled roads restricted to local traffic, mostly used by farm vehicles. (Agricultural fields not only surround Münster, but also occupy a substantial part of the city area itself). Moreover, most local residential streets in Münster can be safely used by bicyclists, thanks to traffic-calming measures that give bicyclists and pedestrians right-of-way priority and restrict car speeds to 30 km per hour (19 m.p.h.). Other innovations in Münster include *Fahrradstrassen*, or special bicycle streets, which permit car traffic but give bikes right of way; *falsche Einbahnstrassen*, streets that are one-way for cars but two-way for bicyclists; street networks with artificial dead ends and circuitous routing for cars but direct, fast routing for bicyclists; bus lanes that can be used by bicyclists but not by cars; freedom for bicyclists to make left and right turns where prohibited for cars; and a variety of measures giving bicyclists preferential treatment at intersections, generally intended to speed up bike travel and make it safer.

The success of bicycle policies in Münster has promoted their spread to many other German cities. There is a regular exchange program among cities to share knowledge and experiences with bicycle policies, and Münster is generally seen as the model to follow. Freiburg, for example, has adopted many of the innovations pioneered in Münster: *falsche Einbahnstrassen*, *Fahrradstrassen* and special traffic-priority measures for bicyclists at intersections. Moreover, Freiburg has also invested considerably in its bikeway network, which currently includes 145 km of completely separate bikeways and bike lanes, supplemented by 120 km of bike paths through woods and agricultural areas and 130 km of bike routes on local streets with minimal traffic. As mentioned previously, all residential neighborhoods in Freiburg have been traffic-calmed, which also enhances bicycle use. Similar to Münster and Freiburg, Munich has doubled the extent of its bikeway network since 1980 and currently offers 456 km of grade-separated bikeways along streets, 51 km of bike lanes on streets and 137 km of bikeways through parks, woods and nature reserves.

Virtually all German cities have been expanding bike-parking facilities. In Freiburg, for example, the number of bike-racks in the city center increased from 2200 in 1987 to 4000 in 1996. Since there are more bicycles than residents in Münster, it would not be practical to provide bike-racks in the city center for all bicyclists, and most bikes are simply parked any way possible. Nevertheless, the city already has 6226 bike-racks in the city center and is currently building an underground bicycle-parking facility at the main train station that will handle 3000 additional bikes.

Münster has also been introducing innovations in bike parking, including special rack designs, rack roofing and bicycle lockers at key transport nodes. Bike repair and rental services are provided at some large parking facilities.

4.3. *Policies toward car use*

At the same time as German cities have greatly improved public transport, bicycling and walking, they have restricted car use and made it increasingly expensive. That has provided a double incentive to use the so-called 'environmental modes'. We have already mentioned a variety of measures that have directly restricted car use by favoring bicyclists, pedestrians and public transport users: bus lanes, bike lanes, car-free pedestrian zones, traffic-calming, right-of-way priority and signal priority for non-car modes. Each of those measures either removes roadway space from cars or restricts their speed and right of way. German cities have also been implementing various other policies that yet further discourage car use, especially in the inner city.

4.3.1. *Car-parking policies*

Parking in German cities has become more difficult and much more expensive since 1980 (Topp 1993). In most cities, the price of on-street metered parking increases considerably with proximity to the city center. The largest cities now charge 5 DM per hour for car parking in the center, roughly equal to the price of a round trip by bus, tram or metro. In Freiburg, a medium-sized city, metered parking costs 4 DM per hour in the historic core, 3 DM per hour in the zone just outside the core and 1 DM per hour in the outlying districts. Most free, non-metered on-street parking has been eliminated, except for residential areas, where such parking is generally restricted to residents who purchase car decals entitling them to park in their own neighborhood. Moreover, special parking meters have been installed to prevent long-term parking by commuters in residential neighborhoods. In Münster, all free on-street parking in the city core has been eliminated, and the total number of car-parking places has been reduced. Additional parking facilities have been built outside the city center, thus encouraging drivers to park their cars outside the center and walk or take public transport for the trip to the center. Similar parking policies have been adopted in most German cities. The overall impact has been to make parking a car more expensive and more difficult, at least in the city center.

4.3.2. *Taxes on car ownership and use*

Local policies making car use more expensive have been complemented by national policies that make owning and driving a car increasingly expensive. Germany imposes considerable taxes on car ownership and use. Even in 1989, before various tax increases, total roadway user taxes by all government levels in Germany were more than double the total public expenditures on roadway construction, maintenance and administration (International Road Federation 1991). Since 1990, taxes on car use have been raised considerably. Most recently, the petrol tax was raised by 0·16 DM (about $0·10) per liter on 1 January 1994, bringing the total tax to 0·98 DM per liter (about $3 per gallon). That tax rate is roughly average for Western Europe but six times as high as in the USA.

The result of high petrol taxes is obviously high petrol prices. As shown in table 11, petrol prices were 3·4 times higher in Germany than in the USA in 1995, and

almost all the difference is due to the high taxes in Germany, which account for 78% of the final retail price of petrol.

There is also an annual motor vehicle excise tax, ranging from 13·20 DM to 45·50 DM per cc engine size. The total tax depends on the size of the motor, whether it is petrol- or diesel-powered, and whether its emissions are high or low.

4.3.3. *Slowdown in roadway expansion*

As shown in table 12, urban roadway capacity has grown considerably over the past four decades. The fastest growth was from 1960 to 1970 (+19%), with successive slowdowns from 1970 to 1980 (+14%) and 1980 to 1990 (+6%). The slowdown in roadway construction reflects the new philosophy of limiting and channeling car use rather than accommodating it. Moreover, fiscal constraints and opposition from environmental and community groups have also limited roadway expansion.

In all of our case-study cities, considerable improvements have been made to the urban roadway network over the past two decades. The rapid growth of Munich has

Table 11. Comparison of petrol prices and taxes in Germany and the USA.

	Germany		Ratio of petrol prices, Germany/USA	USA	
Year	US dollars per liter	Tax as % of price		US dollars per liter	Tax as % of price
1978	0·462	58	2·6	0·177	19
1981	0·628	46	1·7	0·380	11
1983	0·538	50	1·5	0·362	21
1985	0·490	49	1·5	0·318	23
1989	0·583	64	2·2	0·270	29
1991	0·767	68	2·5	0·301	33
1993	0·812	74	2·8	0·293	31
1995	1·047	78	3·4	0·304	33

Source: Energy Prices and Taxes, International Energy Agency, OECD, Paris, quarterly from 1988 to 1996 (IEA 1988–1996).

Table 12. Supply of roadways in Germany, 1951–1996 (thousands of kilometers).

	Interurban roadways		
	Autobahns	Total	Urban roads
1951 (a)	2·1	127·6	217
1960 (a)	2·5	135·3	227
1970 (a)	4·1	162·3	270
1980 (a)	7·3	171·5	308
1990 (a)	8·8	173·9	325
1993 (a)	9·1	174·1	331
1993 (b)	11·0	215·8	413
1996 (b)	11·2	217·7	N/A

Notes: (a) Only West Germany; (b) both East and West Germany.
Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

made this an absolute necessity; all its successes in raising the modal-split shares of bicycling and public transport have not reduced auto use overall. Freiburg and its surrounding area have also been experiencing considerable population growth and increases in travel volumes. Even slow-growing Münster has had to deal with traffic growth.

The three cities have adopted essentially the same approach to the problem: increasing capacity on key arteries outside the city center and residential neighborhoods, while reducing capacity within the city center and residential neighborhoods. Thus, all cities have widened many of the most important thoroughfares, bypasses and intersections, and improved them in various other ways as well, to increase their vehicle-carrying capacity. By contrast, they have introduced traffic-calming measures in almost all residential neighborhoods, often narrowing streets, creating dead ends, reducing speeds, installing traffic bumps and forcing circuitous routing. Extensive car-free pedestrian zones in the heart of each city exclude private car traffic altogether. The intent, of course, is to divert car traffic away from the city center and residential neighborhoods, while avoiding undesirable congestion on key arterial routes.

Another important factor is the limited supply of high-speed motorways in German cities. Although the German autobahn system is the oldest and second most extensive limited access highway system in the world, it is not primarily used for urban travel. By contrast, in the USA, 61% of total vehicle mileage on Interstate Highways is in urban areas (US Department of Commerce 1996, p. 616). Autobahns often provide bypasses or beltways around German cities; they very rarely pass through the city center. Instead, they primarily serve long-distance intercity travel needs.

In conclusion, one can hardly say that Germany in general, or German cities in particular, are poorly supplied with roadways. On the contrary, the German roadway system is not only extensive, but its quality is at least as high as that in the USA, where many roads are pockmarked by dangerous potholes. The difference is that German cities and their transport systems have been less adversely affected by the disruption of high-capacity limited access highways than in the USA. Autobahns primarily offer interurban and interstate connections and are far less used for daily urban commuting than in the USA. City cores in Germany have far less high-speed roadway capacity (including key arterials) than American cities, and this appears to be a deliberate policy, namely to restrict car use in the center and instead to encourage walking, bicycling and public transport use.

5. Land-use policies

One important factor influencing land-use policies in Germany is that much of the total land area is taken up by urban uses, leaving less land for agriculture, forests and wilderness areas than in larger, less densely settled countries. That scarcity of land has led to a strict overall land-use policy in Germany, which also carries over to urban land-use planning. For example, state and local governments sharply restrict new residential development at the urban fringe. Much privately owned land around cities is zoned exclusively for agriculture, forests, nature reserves or simply open space. Those restrictions greatly limit the supply of land available for urban development, driving up the price of land, and thus encouraging quite dense development. The compactness of urban development, even in the suburbs, obviously facilitates public transport, which relies on high-volume, focused travel corridors.

Thanks to strict zoning over many years, for example, both Freiburg and Münster contain extensive woods, agricultural fields, forest preserves, wildlife sanctuaries and undeveloped open space directly within their city limits, as well as surrounding their built-up area. Within minutes from central Freiburg, pedestrians and bicyclists can reach vineyards, fruit orchards and dense forests. Bicyclists in Münster use paths through the extensive wheat, rye, corn and oat fields in and around Münster. Hundreds of dairy farms surround Münster. The direct proximity of these rural land uses within or near the city obviously makes their potential for commercial development high. Yet government authorities, presumably in agreement with the majority of the population, have chosen to pursue long-term environmental and social goals instead of short-term economic objectives. They have resisted the encroachment of private industrial and residential development into the protected areas. By raising the overall density of development, such land-use policies have also promoted public transport, bicycling and walking.

6. Conclusions

Urban transport policies in Germany show that it is possible to 'tame' the private car by limiting its use in central cities and providing travelers with an attractive choice of alternative transport modes. By offering cheaper and better public transport services, extensive bikeway systems, large car-free zones, and priority rights of way and traffic signalization for bicycles, buses and trams, Freiburg, Münster and Munich have reduced the percentage of travel by car. That is quite an accomplishment at a time when the car's modal-split share has been increasing almost everywhere else in the world. Although car ownership rates in Germany continue to rise, the social and environmental problems caused by car use are being brought under control.

The key to success in Freiburg, Münster and Munich has been their coordinated, multifaceted approach. In each city, advocates of 'taming' the car carefully garnered the necessary political support for restricting car use and expanding alternative transport modes. Indeed, urban transport has been an important issue in local elections. Thanks to strong support from students, environmentalists, community activists, bicyclists and other opponents of excessive car use, the Social Democrats and Greens have controlled local government in all three cities in recent years. With political support in hand, it was possible to implement a truly coordinated, mutually reinforcing set of policies and programs. Rather than simply punishing car users, the three cities provided a rich, attractive set of alternatives simultaneously with the imposition of restrictions on car use. Another crucial element in the policy shift in each city was an extensive public relations campaign undertaken to explain the reasons for the shift in policy and to provide easily understandable, readily available information on the use of alternative modes. That public information campaign continues unabated, thus consolidating and expanding public support.

References

ALTSHULER, A., 1979, *The Urban Transportation System: Politics and Policy Innovation* (Cambridge, MA: MIT Press).

AMERICAN PUBLIC TRANSIT ASSOCIATION, 1970 and 1996, *Transit Fact Book* (Washington, DC: American Public Transit Association).

BRÖG, W., 1996, European transport policy: between Scylla and Charybdis. Paper No. 5. presented at Special Round Table on European Transport Policy, Organization for Economic Cooperation and Development, European Conference of Ministers of Transport, Paris, France, 15 May 1996.

BRÜHNING, E., 1993, Traffic safety in Eastern and Western Europe at the beginning of the nineties. *Transport Reviews*, **13**(3), 265–276.

FÖRSCHNER, G., and SCHOEPPE, E., 1992, Erste Ergebnisse des erweiterten Systems repräsentativer Verkehrsbefragungen SrV-Plus 1991. *Strassenverkehrstechnik*, **2**, No. 2, 84–91.

FROMM, G., 1992, Mehr Geld für mehr Projekte: das neue Gesetz zur Verkehrsfinanzierung in den Städten. *Der Städtetag*, no. 5, 342–347.

GERMAN MINISTRY OF TRANSPORT (a), 1982–93, *Verkehr in Zahlen* (Bonn, Germany: Bundesverkehrsministerium); annually.

GERMAN MINISTRY OF TRANSPORT (b), 1980–94, *Finanzielle Leistungen des Bundes, der Länder und der Kommunen für den Öffentlichen Personennahverkehr* (Bonn, Germany: Bundesverkehrsministerium); annually.

GERMAN MINISTRY OF TRANSPORT (c), 1992, *Finanzierung des ÖPNV in den neuen Bundesländern* (Bonn: Bundesverkehrsministerium).

GERMAN MINISTRY OF TRANSPORT (d), 1988, *Kooperation im ÖPNV*, Forschung Stadtverkehr, Heft A-5 (Bonn: Bundesminister für Verkehr).

GERMAN MINISTRY OF TRANSPORT (e), 1997, *Bundesfernstrassen in Deutschland, Stand: 1, Januar 1997* (Bonn: Bundesverkehrsministerium).

GERMAN MINISTRY OF TRANSPORT (f), 1993, *Bundesverkehrswegeplan* (Bonn, Germany: Bundesverkehrsministerium).

GERMAN PARLIAMENT, 1997, *Bericht der Bundesregierung 1996 über die Entwicklung der Kostenunterdeckung im öffentlichen Personennahverkehr (ÖPNV)* Drucksache 13/7552, 22 April 1997 (Bonn, Germany: Deutscher Bundestag).

GERMAN PRESS AND INFORMATION SERVICE, 1992, *Tatsachen über Deutschland* (Frankfurt am Main: Societaetsverlag).

GERMAN PRESS AND INFORMATION SERVICE, 1995, *Tatsachen über Deutschland* (Frankfurt am Main: Societaetsverlag).

HAJDU, J. G., 1989, Pedestrian malls in West Germany: perceptions of their role and stages in their development. *Journal of the American Planning Association*, **54**(3), 325–335.

HASS-KLAU, C., 1992, *Civilized Streets – A Guide to Traffic Calming* (Brighton, UK: Environmental Transport and Planning Press).

HASS-KLAU, C., 1993, Impact of pedestrianization and traffic calming on retailing: a review of the evidence from Germany and the UK. *Transport Policy*, **1**(1), October, 21–31.

HEIDEMANN, C., KUNERT, U., and ZUMKELLER, D., 1993, Germany: a review at the verge of a new era. In: *A Billion Trips a Day*, edited by J. Salomon *et al.* (Amsterdam, The Netherlands: Kluwer Academic Publishers), pp. 257–274.

IEA (International Energy Agency), 1988–1996, *Energy Prices and Taxes* (Paris: Organisation for Economic Cooperation and Development), quarterly.

INTERNATIONAL ROAD FEDERATION, 1991, *World Road Statistics* (Geneva: International Road Federation).

JANSEN, G., 1993, Commuting: home sprawl, job sprawl, traffic jams. In: *A Billion Trips a Day*, edited by I. Salomon *et al.* (Amsterdam, The Netherlands: Kluwer Academic Publishers), pp. 101–127.

KENWORTHY, J., LAUBE, F., NEWMAN, P., and BARTER, P., 1997, *Indicators of Transport Efficiency in 37 Global Cities* (Washington, DC: The World Bank).

KUNERT, U., 1988, National policy towards cars in the Federal Republic of Germany. *Transport Reviews*, **8**(1), 59–74.

KUNERT, U., 1990, Past trends and future scenarios for passenger travel demand in regions of West Germany. *Transport Reviews*, **10**(3), 245–267.

MÜNCHNER VERKEHRS- und TARIFVERBUND, 1996, *Geschäftsbericht 1995* (Munich: Münchner Verkehrs- und Tarifverbund).

NEWMAN, P., and KENWORTHY, J., 1989, *Cities and the Automobile Dependence: An International Sourcebook* (Aldershot, UK: Gower).

PUCHER, J., 1994, Modal shift in Eastern Germany: transportation impacts of political change. *Transportation*, **21**(1), 1–22.

PUCHER, J., 1995, Urban passenger transport in the United States and Europe: a comparative analysis of public policies. *Transport Reviews*, **15**(2), 89–107, and **15**(3), 261–277.

PUCHER, J., and CLORER, S., 1992, Taming the automobile in Germany. *Transportation Quarterly*, **46**(3), July, 383–395.

PUCHER, J., and KURTH, S., 1995, Verkehrsverbund: the success of regional public transport in Germany, Switzerland, and Austria. *Transport Policy*, **2**(4), 279–291.

PUCHER, J., and LEFEVRE, C., 1996, *The Urban Transport Crisis in Europe and North America* (London, UK: Macmillan).

PUCHER, J., and WIECHERS, M., 1985, Subventionen im ÖPNV der Vereinigten Staaten und der Bundesrepublik Deutschland. *Zeitschrift für Verkehrswissenschaft*, **56**(3), 143–180.

PUCHER, J., IOANNIDES, D., and HIRSCHMAN, I., 1993, Passenger transport in the United States and Europe. In: *Transport in a Unified Europe*, edited by D. Bannister and J. Berechman (Amsterdam, The Netherlands: Elsevier Press), pp. 369–416.

SHARMAN, K., and DASGUPTA, M., 1993, *Urban Travel and Sustainable Development: An OECD/ECMT Study of 132 Cities* (Crowthorne, UK: Transport Research Laboratory, UK Department of Transport).

SOCIALDATA, 1996, *Verkehrsmittelwahl für Verschiedene Deutsche Städte* (Munich, Germany: Socialdata, Inc.).

STADT MÜNSTER, 1994, *Verkehrsbericht Münster 1993* (Münster, Germany: Stadt Münster).

STADT MÜNSTER, 1996, *Programm Fahrradfreundliche Stadt Münster* (Münster: Stadt Münster).

STADTPLANUNGSAMT MÜNSTER, 1995, *Verkehrsmittelwahl Münster, 1982-1994* (Münster, Germany: City of Münster, Abteilung Verkehrsplanung).

STADTWERKE FREIBURG, 1996, *Geschäftsbericht 1995* (Freiburg: Stadtwerke Freiburg).

TOPP, H., 1993, Parking policies to reduce car traffic in German cities. *Transport Reviews*, **13**(1), 83–95.

UMWELT, 1992, *Luftreinhaltung: Schadstoffminderung bei Kraftfahrzeugen*, Nr. 9, pp. 342–344.

UMWELT, 1993, *Zehn Jahre Katalysator: Deutschland gab entscheidende Impulse für die Luftreinhaltung in ganz Europa*, Nr. 10, pp. 402–403.

US DEPARTMENT OF COMMERCE, 1975, *Historical Statistics of the United States: Colonial Times to 1970* (Washington, DC: US Bureau of the Census).

US DEPARTMENT OF COMMERCE, 1996, *Statistical Abstract of the United States, 1996* (Washington, DC: US Bureau of the Census, Economics and Statistics Administration).

VERBAND DEUTSCHER VERKEHRSUNTERNEHMEN, 1992, *ÖPNV-Finanzierungskonzept vor dem Hintergrund von Bahnreform und Regionalisierung* (Cologne, Germany: Verband deutscher Verkehrsunternehmen).

VERBAND DEUTSCHER VERKEHRSUNTERNEHMEN, 1991, *VDK-Statistik 1990* (Cologne, Germany: Verband deutscher Verkehrsunternehmen).