

# What's that garage for? Private parking and on-street parking in a high-density urban residential neighbourhood

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Published paper: Scheiner, Joachim / Faust, Nico / Helmer, Johannes / Straub, Michael / Holz-Rau, Christian (2020): What's that garage for? Private parking and on-street parking in a high-density urban residential neighbourhood. In: Journal of Transport Geography 85, 102714.

Please reference this paper as shown above.

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**Abstract:** High-density inner-city residential neighbourhoods are often characterised by serious parking pressure and illegal parking. We study parking choices in a historical neighbourhood in Dortmund, Germany, using a household survey. Specifically, we look at the availability of and distance to private parking, the use of available private and on-street parking, and cruise duration. Additionally, we look at simple measures of satisfaction with parking and with the neighbourhood in general. Our results show that available private parking is not necessarily used where there is little control of illegal on-street parking. Furthermore, cruise durations and distance to cars parked on-street suggest that parking pressure is lower than commonly perceived in the neighbourhood. Private parking is under-utilised to the extent that we estimate that illegal parking can be reduced by 28 to 49 percent if private parking were consistently used by those who have it available. Even more substantial reductions in illegal parking can be achieved by deviating from standard sizes for public parking spaces. From our results we draw conclusions for urban parking policy. These include introducing parking fees, coupled with paid parking permits for residents and, perhaps, employees; defining short-stay parking zones; providing parking spaces of different sizes; and increasing the level of enforcement.

**Keywords:** Parking, garage use, parking management, residential parking

## 1 Introduction

Despite recent evidence about the stagnation and, perhaps, decline in driving, car ownership continues to grow around the world. This is particularly pronounced in growing economies such as China, but also in 'saturated' countries with high levels of car ownership (Dargay et al., 2007). Additionally, cars have become bigger over time. Both trends lead to substantial challenges caused by parking vehicles, especially in inner-city areas that serve as destinations for

commuting, shopping and leisure trips but also include residential neighbourhoods with high densities of land-use and population.

These neighbourhoods are often historical developments in which it is hardly possible to extend the number of parking spaces, be it on-road or off-road. These neighbourhoods are frequently characterised by low levels of car ownership and driving (Manville and Shoup, 2005; Ding et al., 2017; Yin and Sun, 2018; Tian et al., 2018) and, thus, less demand for parking per household. At the same time, somewhat ironically, the scarcity of parking space is most challenging here (Topp, 1991; Bates, 2014; Antolin et al., 2018; Liu et al., 2018) and cruising for parking is most common (van Ommeren et al., 2012). However, much previous research has found a positive relationship between the provision of public parking and household car ownership and use (Guo, 2013a; Guo, 2013b; Tyrinopoulos and Antoniou, 2013; Chatman, 2013), and between the availability of private parking – supported by setting minimum parking requirements – and household car ownership and use (Shoup, 2005; Weinberger, 2012; Chatman, 2013; Christiansen et al., 2017b), which is in line with general findings in transport studies about the relationship between transport supply and demand. Hence, a way forward to achieve more sustainable transport may be policies that regulate and/or restrict parking. Such policies, however, are contested. For instance, Burchell et al. (2019) study the perspectives of UK local policy makers on the effectiveness and acceptability of various transport policies to reduce congestion. They find that the policy makers view parking policies as the least effective option, except for in London, and at the same time as unacceptable.

This paper looks at the parking situation and parking choices in a historical inner-city residential neighbourhood in Dortmund, where parking is very challenging. There is also much illegal parking, including follow-up problems such as reduced traffic flow, limited space left for pedestrians and cyclists, restricted visibility when crossing the road (especially for children and smaller adults), the lack of a thoroughfare for emergency services and those using a zimmer frame or wheelchair, and more. The paper uses household survey data to ask (1) how many households have private parking available (open air, car port, or garage), (2) how these parking spaces are utilised and where the households leave their cars, if not in the private spaces, (3) how long drivers search for on-street parking at home, and (4) how satisfied respondents are with parking and with living in the neighbourhood in general. We use our results to draw policy conclusions. There is very little research on the actual use of available private parking spaces or garages. A recent study by Taylor (2020) in Melbourne found that 75 percent of regular residential on-street parking users had off-street parking available at their dwelling. In London, a reduction in the use of garages over the past two decades has been observed (Leibling, 2014). This has been attributed to a number of reasons that are likely to hold for Dortmund: garages have been converted into storage for other things (and even into living spaces); modern cars are larger and thus do not fit into the garages (Figure 2, Pictures 5 and 9); modern cars have better corrosion protection and theft protection and are more likely to be parked in the open; and the growth in multi-car households implies that their extra cars cannot be parked in the garages (Leibling, 2014, p. 268). An additional reason for parking on-street despite owning a private parking space may be that it is more convenient when multiple car tours are made in one day. This idea is supported by Guo (2013c) who found that among people who have access to both a garage and street parking, those who park on-street tend to make more car tours than those who do not.

In the following subsection we briefly summarise the literature on parking with a broad approach, as we pick up a range of related issues in our survey and/or conclusions. Subsection 1.2 introduces parking policies in Germany and elsewhere. Section 2 presents the study site, the data and methods. Section 3 presents the findings, and in Section 4 we draw conclusions for urban parking policies.

## **1.1 Research about parking**

Problems caused by parking have been on the agenda of transportation research for decades, including topics such as land allocation for parking, cruising for parking, scarcity of parking space, illegal parking, the pricing of parking, and more. For instance, parking has been found to cover about 25 percent of land in some US cities, and around 40 percent of land in city centres (McCahill and Garrick, 2014; Manville and Shoup, 2005; see also Shoup, 2005; Davis et al., 2010; Chester et al., 2015, for land consumed by parking).

Cruising has attracted considerable attention, as it creates extra costs for vehicle occupants in terms of search time and cost, and for others in terms of reduced speeds and local congestion, air pollution and noise emissions (Shoup, 2006; Alemi et al., 2018). Recent research (Millard-Ball et al., 2020) conceptually distinguishes between cruising and searching for parking. It assumes that drivers begin to look for available on-street parking earlier in areas where on-street parking is scarce, thus accepting longer walks to their destination. This means that they search but do not necessarily cruise, i.e. they do not cause additional vehicle traffic. Generally, however, there is a robust finding that drivers are not prepared to walk long distances from their parking spaces to their destinations which may contribute to cruising (Inci 2015, p. 54). Lenz (2018) undertook a Master thesis in the Cologne Severinsviertel similar to the one presented in this paper but in an area with paid residential parking permits. He inquired into the length of time it took to find a parking space the last time a car was parked near the residence, and the time of day concerned. From this data we take a mean search duration of 10 minutes between 8 a.m. and 4 p.m. (n=35), 11 minutes from 4 to 5 p.m. (n=29), and as much as 17 minutes from 5 to 6 p.m. (n=37) and after 6 p.m. (n=29), suggesting an increase by about 50 percent in the late afternoon (see Millard-Ball et al., 2020, for more discussion of parking search and cruising).

Shortage of parking space not only increases searching but also increases illegal parking, which in turn reduces the speed of traffic. In a simulation study Kladeftiras and Antoniou (2013) found that speed can be increased by about 10-15 percent by reducing double parking through better enforcement, or 44 percent by completely eliminating double parking.

The recent academic literature devotes much attention to technical issues such as automatic parking lot detection, smart parking and automated parking. However, while these concepts may help reduce search duration and cruising, they do not create additional parking spaces. Concepts of shared parking (Zhang and Mu, 2018; Zhang et al., 2018) could reduce scarcity, but only in cases where the demands of different user groups do not temporally overlap. However, in dense inner-city neighbourhoods with mixed land-use and little private parking there is typically much overlap. Residents tend to demand parking from the early evening to the morning hours, while customers and employees of restaurants, pubs and shops demand parking until the late evening hours.

Another literature strand is concerned with a more behaviourally oriented topic, i.e. parking choice modelling (Antolin et al., 2018; Ibeas et al., 2014). This literature mostly looks at alternatives of public or commercial parking (e.g. on-street, commercial car park, parking deck) but hardly at the choice between on-street and private home parking (Antolin et al., 2018; Ibeas et al., 2014). It seems to be taken for granted that people who have private home parking available use it, although from a theoretical perspective there is reason to assume that this cannot be taken as a given. In low-density areas – e.g., suburban single-family detached housing – with an oversupply of on-street parking, kerbside parking may save the time needed to open the garage door, or allow the garage to be used for other purposes (e.g., storage), or households may have more cars than garages. In dense, inner-city areas with a shortage of public parking, private parking

facilities are often located at a distance from the destination (i.e. the home), thus motivating drivers to prefer front-door kerbside parking if available at the time of arrival.

At the same time, scarcity of parking has been found to contribute to low levels of residential satisfaction (James et al., 2009) and to trigger residential relocation from inner-city areas to suburbs (Scheiner, 2006, p. 73; Kim and Yang, 2017). This may well correspond with strong, perhaps exaggerated perceptions of the lack of parking space and long duration of cruising (to the best of our knowledge, there have been no studies on biased perceptions in this respect).

Generally, home parking seems to be underresearched (Christiansen et al., 2017a, Guo, 2013a; see Taylor, 2020, for a recent study on residential parking in Melbourne), and some go as far as to say that private parking spaces "have been relatively ignored" in research and policy (Enoch, 2014, p. 37). This is in line with urban parking concepts that are typically based on inventories of public but not private parking (e.g., Vieten et al., 2014 for Dortmund).

## **1.2 Parking policies**

Parking policy is a major topic for local and regional transport and urban planning administrations who have sought to manage parking problems for decades. Parking policy can be defined as being related "to the management of the price, supply, duration and location of parking" (Young and Miles, 2015, p. 23). One may roughly distinguish between the domains of supply, regulation, information, and pricing, all of which virtually exclusively target private automobiles.

Concepts vary widely (see Enoch, 2014, and Litman, 2016, for categorising overviews). They include broadly defined approaches such as parking management and smart parking, as well as more specific measures like pricing, time-limited parking, residential (and workplace and visitors') parking permits, and minimum (or maximum) parking requirements for new developments or land-use changes in existing developments (Enoch, 2014; Young and Miles, 2015; Litman, 2016; Taylor, 2020). The latter are defined by jurisdictions, typically on superior policy levels such as federal governments or, in Germany, state governments. The German federal state of North Rhine-Westphalia now intends to transfer this responsibility to municipalities.

In practice, parking policies often have an opportunistic character. In low-density areas with detached housing, parking policies may have little effect due to the abundance of parking facilities, while in high-density neighbourhoods the conflicts of interests between car owners and non-owners about scarce public land are such that urban policy makers may have little motivation to intervene (see study site description in the next section for an example; see also Taylor, 2014, for conflicts arising around scarce parking space when it comes to infill developments). What is more, parking policies typically do not follow a concept for an urban region as a whole (Young and Miles, 2015, for Australia). As a consequence, suburban municipalities in the region that are the origins of commuter flows to the urban core have little motivation to shift commuting to other modes.

In Germany, the road traffic act and the road traffic regulations provide the legal framework on the federal level (see Kirschner and Lanzendorf, 2019, for more detail). Minimum off-street parking requirements were introduced in the 1930s for newly erected buildings (but do not take effect in historical neighbourhoods such as that studied in this paper). The states (Bundesländer) have their own road acts and building codes based on the national framework. Parking is generally prohibited at road junctions (5 m distance), on cycle lanes and on pavements, except in dedicated parking spaces. Double parking is not allowed. On-street parking is allowed within built-up areas if 3 m of road width remain for thoroughfare in cases where there is no explicit regulation. In practice, this mainly refers to villages, small towns and the periphery of cities, as in the denser, more central urban districts there is usually explicit signposting, or dedicated curbside

parking spaces are available. Still it should be noted that the 3 m rule may be inefficient as it is left to the driver to guess whether or not the thoroughfare is warranted. It is important to note that many state building codes (including North Rhine-Westphalia, where our study area is located) define that private garages must not be misused for purposes other than parking motor vehicles (which may be somewhat inappropriate, given that some modern vehicles do not fit in the garages, see below).

Municipalities again have their own parking regulations that provide details of minimum or maximum parking requirements (only relevant for new developments or reuse). They also make decisions on whether or not to introduce paid residential parking permits. This is only allowed in neighbourhoods with a substantial lack of parking spaces, and up to a maximum of 75 percent of available parking spaces by night and at weekends (50 percent on workdays at daytime). Residential parking permits do not guarantee available parking spaces, they are only a privilege in comparison to non-residents in terms of pricing and/or parking duration. The maximum cost that can be charged is no more than €30.70 per year, as defined by the federal schedule of fees.

In her Master thesis, Koch (2018) made an unusual attempt to relieve the parking situation in the study area researched in this paper (Figure 1) which is a high-density inner-city neighbourhood characterised by much illegal parking. In a road re-design exercise, she reconfigured the parking spaces so as to ensure pavement widths of at least 2 m, and included some parking spaces suitable only for smaller cars. This is based on the observation that in denser areas people typically drive smaller cars (Cao et al., 2006), although there is no evidence on this for Germany, let alone for the area under study. The car types were selected to make sure that they represent typical cars in their segment. This resulted in reduced parking space lengths for cross parking and diagonal parking. A range of variants were calculated, but all retained between 45 and 55 percent of standard-size parking spaces (corresponding to the shares of vehicles in the German fleet that require this size), while the remainder were reduced in size, mostly in line with the 'moderately small' VW Polo (length 4.05 m). The variants resulted in 21 to 32 percent increases in legal parking spaces.

## **2 Data and method**

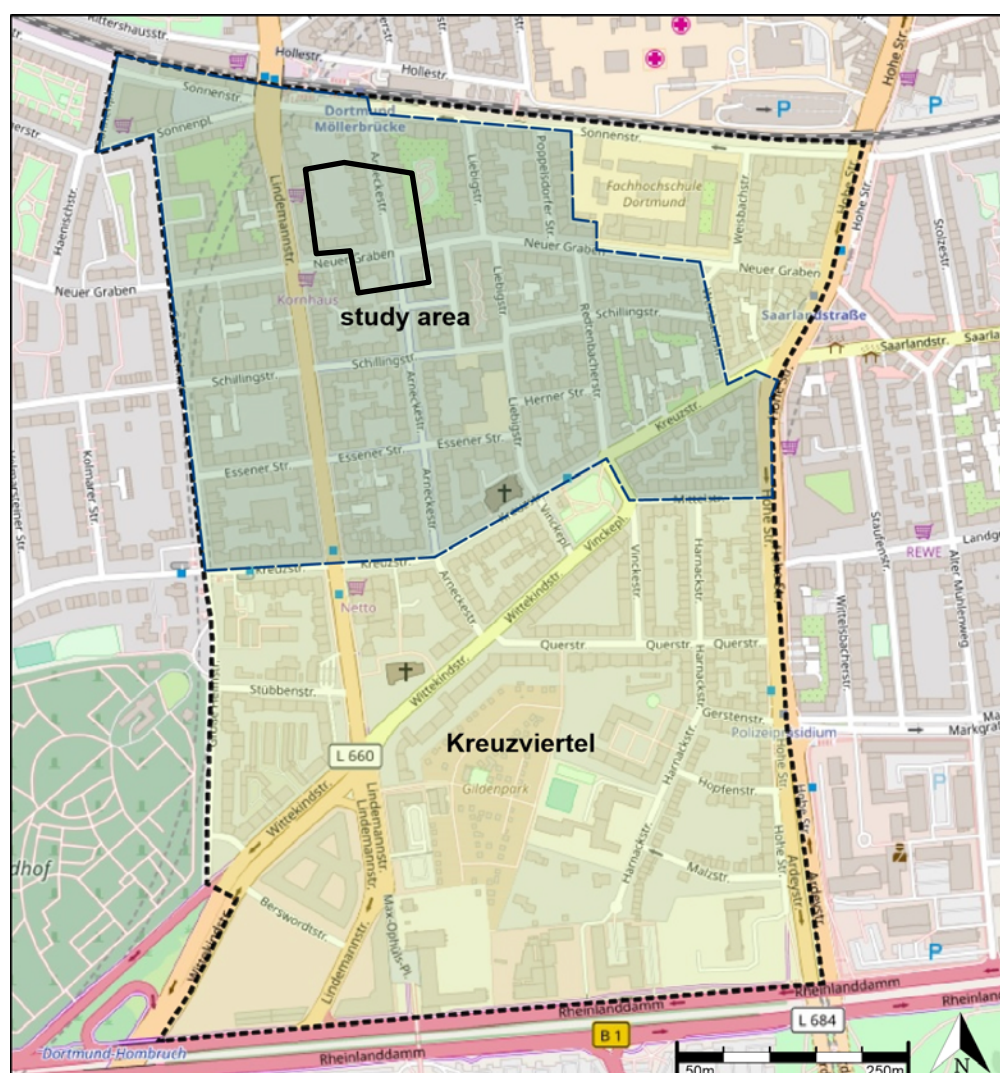
### **2.1 Study site**

We chose the Kreuzviertel in the city of Dortmund, Germany, as our study site. This decision is based on the understanding that the Kreuzviertel is probably the most challenging neighbourhood of Dortmund in terms of parking, and to date no parking management has been implemented there, except for the provision of dedicated parking spaces in many streets and the general tolerance of kerbside parking in most other streets. It is a historical inner-city neighbourhood developed in the late Wilhelminian era (around 1900, 'Jugendstil') with mixed land-use dominated by residential use, but with lots of restaurants, pubs, shops and household services. The northernmost part of the area hosts the applied university for mechanical engineering, and much of the southern part is covered by the university's school of design and some larger hotels. While some of the university staff may use private off-street parking, students who drive leave their cars on-street.

The building structure survived WWII with relatively little destruction (Figure 2, Pictures 4 and 7), which makes it aesthetically very attractive, given Dortmund standards. The neighbourhood has much appeal for young people coming to Dortmund but there is little accommodation available. The term Kreuzviertel does not denote exact boundaries, but the Dortmund city administration parking concept can be used (Vieten et al., 2014, p. 2-3). Due to capacity constraints, we had to limit the survey to the northern part of the neighbourhood, which is commonly perceived as the

core Kreuzviertel due to the university and hotel complex in the south (see Figure 1). Our study area covers just under 50 percent of the neighbourhood.

**Figure 1: Study area**



Source: Authors' concept based on Open Street Map.  
Black frame: study area for Koch's (2018) work on re-designing parking spaces

About 8,500 inhabitants live in the Kreuzviertel, with an estimated number of 5,470 households, which results in a density of just under 13,000 inh/sq-km (area size: 0.662 sq-km). We contacted 3,566 (65 percent). The population composition is characterised by below average proportions of children and the elderly, a strong share of one-person households, and a distinct turnover of population with much inflow and outflow (Stadt Dortmund, 2015).

In terms of transport, the Kreuzviertel is very well connected to downtown Dortmund by the underground and buses, as well as to some of the more remote areas by S-Bahn. Walking and cycling play an important role within the neighbourhood as well as between the neighbourhood and the city centre. With 420 cars per 1,000 inhabitants in 2013 the car ownership rate was somewhat lower than in Dortmund as a whole, though not extremely low (Vieten et al., 2014, p. 3; Dortmund: 461 in 2015, MBWSV NRW 2016, p. 69). The detailed figures provided by Vieten et al. (2014, Annex 4) reveal a lower level of car ownership for the building blocks most centrally located in the neighbourhood (370 cars per 1,000 inhabitants).

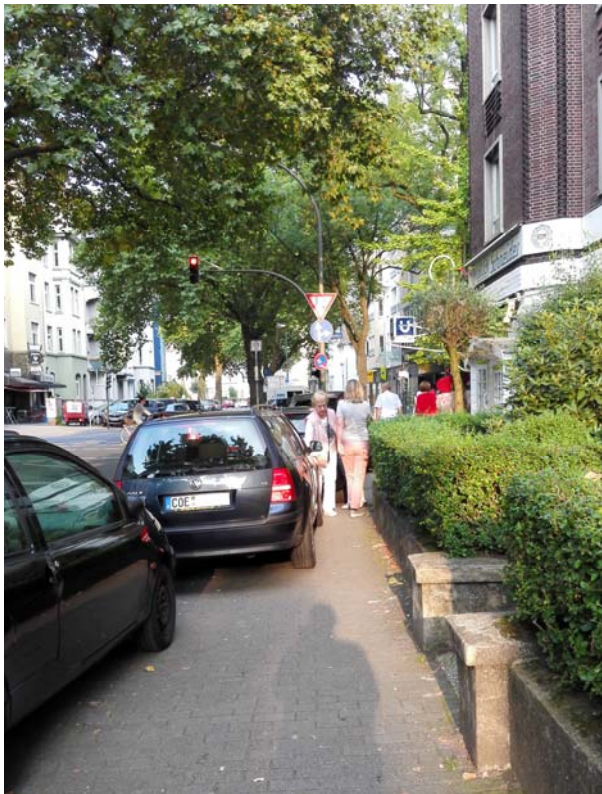
Figure 2: Pictures of the study area



01 Double parking



02 Parking cars blocking road crossing



03 Parking cars leave no space for pedestrians



04 Parking all over the pavement



05 Basement parking. The car does not fit



06 Self-organised front-door garden parking



08 Shared parking for grocery customers in the daytime, for others in the nighttime



07 Typical residential road in the neighbourhood    09 Basement parking converted into storage  
Photographs: Faust, Scheiner.

Most roads crossing the neighbourhood are relatively narrow, and speeds are limited to 30 km/h except for the three main roads of Lindemannstraße, Wittekindstraße and Hohe Straße.

## **2.2 Parking in the study site**

Due to the high population density and the density and diversity of other facilities, parking is a well-known challenge in the neighbourhood. Parking demand comes from the residential population, gastronomy and retail customers and employees working in the neighbourhood or in the nearby city. Prices for private garages are about 70-80 euros per month, but there are hardly any available. For instance, an Immoscout search (23 Jan 2019) revealed zero entries (an earlier search on 24 Oct 2018 showed just one garage available for rent – 120 euros per month -, and none for purchase; Immoscout (<https://www.immobilienscout24.de/>) is an online platform for the marketing of land and buildings). On the other hand, there is a noticeable number of private parking spaces in the backyards or on former front gardens, and some houses have their basements converted into garages (Figure 2, Pictures 5, 6 and 9).

On-street parking is available in all roads on both sides. High parking pressure results in much illegal parking, often at the expense of easy thoroughfare (Figure 2, Picture 7). What is more, many traffic signs and road markings are in such poor condition that it can be hard to recognise legal parking.

Vieten et al. (2014) recorded 2,808 parked vehicles between 10 and 11 p.m., and almost an equal number between 5 and 6 a.m., which equates to 21 percent illegal parking (2,317 legal parking spaces) (Pictures 1-4, 7). In the central parts of the neighbourhood these figures may be much higher. Koch (2018) counted parked vehicles in the area marked in black (Figure 1) in her Master thesis on a Wednesday between 10 a.m. and 1 p.m. This revealed 174 legally and 123 illegally parked vehicles. Legal parking included 160 (92%) vehicles parked partly or fully on the pavement.

Urban policy does little to enforce legal parking. There is a common perception among residents and visitors that parking their car needs excessive cruising, similar to other cities (Millard-Ball et al., 2020). Subjective estimations about typical cruising duration are very likely strongly exaggerated, and may refer to days when the Dortmund football team plays a home match in the nearby stadium and many spectators park their cars in the Kreuzviertel (qualitative evidence in Straub, 2019).

The Dortmund city administration commissioned a parking concept for the Kreuzviertel in 2013 (Vieten et al., 2014) with the aim of providing information on parking capacity and utilisation, and developing a concept. The report identified 2,317 public parking spaces in the area, and 3,566 registered vehicles. The consultant did not recommend introducing residential parking permits.



This was based on the observation that the utilisation of parking capacity was more than 90 percent in the morning and evening hours (survey from 5 a.m. to 11 p.m.) and, hence, was interpreted to be predominantly due to the residential population. This may or may not be true, as a large proportion (29 percent) of parked vehicles were not registered in Dortmund, and the survey of parking duration ended at 11 p.m. so that a portion of the vehicles parked at that time could still be owned by customers of the pubs and restaurants.

In 2016 the urban administration started to introduce residential parking permits in an adjacent neighbourhood called Markgrafenstraße. The design was similar to the concept realised in nearby neighbourhoods. It involves reserving about 50 percent of on-street parking spaces (typically one side of a street) for residents while the other 50 percent are either free of charge, or serve for time-limited, paid parking. Residents of the area are eligible to use the reserved spaces after buying a parking permit (about 30 euros/year, corresponding to the maximum defined by the German federal schedule of fees). Special permits for craftsmen, tradesmen and the like are available for 120 euros/year.

At an open council with residents and shop owners that was organised to present and discuss the concept, a member of the Kreuzviertel association of commerce heatedly claimed that the concept would make it impossible for her employees to access their workplace in the neighbourhood. The city administration consequently postponed the extension of the residential parking zones to the Kreuzviertel. The Kreuzviertel is now part of the third (i.e. second to last) stage with explicit reference to the conflicting character of the concept. This means that realisation will probably be postponed until about 2022 or later.

### **2.3 Survey method and questionnaire**

This paper uses data collected in two Masters (Faust, 2018, Straub, 2019) and a Bachelor thesis (Helmer, 2018). The three theses used the same questionnaire and survey method. The surveys were realised face-to-face at the households' addresses. For a subsample, the questionnaire was left in the households' letterboxes with prepaid mail-back envelopes after two contact attempts. This response channel was not extended to all households or to the third thesis due to a very low response rate.

Two of the three students realised their part of the survey in April and May 2018, the third in October and November 2018. The survey time of day was between 4 and 7 p.m. on workdays which is important for the interpretation of results, as cruising becomes more of an issue in the late afternoon and evening hours.

The questionnaire included questions about household car ownership, private parking availability and use, parking choices, and satisfaction with parking and with living in the neighbourhood in general. It is important to note how the information was collected to estimate search times and distance to parking. Generalised guesses are likely to result in excessive estimates. Hence, we decided to ask about the last time the car was parked near the residence using the following formulation: "When you last parked your car in the vicinity of your residence on a public parking space, how long did you search for a parking space?" Although this formulation should minimise recall error, the responses may still be somewhat biased. We asked the respondents to mark on a neighbourhood map the place where the car was parked at the time of the survey. In case of multiple household cars, all locations should be marked. If one or more of the cars were in use (or the respondent did not know where they were at the time of the survey) we asked for the location on the map where the car(s) were parked last time by the respondent. After this exercise, we asked how long the respondent had searched to find a parking space the last time (s)he had used a public parking space in the neighbourhood. A more detailed measurement of parking search time is direct field measurement (Alemi et al., 2018). This could not be realised in this

study. We are confident, however, that inquiring about one specific parking event yields valid results.

We further asked about the possession or availability of private parking in terms of a garage, a parking space in an underground garage, a car port, or another parking space. We inquired whether or not the parking space(s) were for exclusive use or shared with neighbours or others. Again we asked the respondents to mark the space(s) on the map. Note that we asked all households about parking spaces and garages, as it was possible that some households (notably those with long duration of residence) had parking spaces but no cars.

To determine the use of parking spaces, we asked how often the respondent had used their private parking space for home parking in the weeks prior to the survey (always, mostly, sometimes, rarely, never). In case the answer was not 'always' we inquired into the reasons. We then asked about other uses of private parking spaces (for bicycles, as a hobby room, for storage...).

We then asked whether the respondent would seek private parking and how much (s)he would be prepared to pay. Finally we recorded the household type, duration of residence, whether or not the household owned one or more cars when they moved into the house (or flat), new car purchases or disposals since then, and, if applicable, reasons for this. Finally we used a six-point scale (in line with German school grades) to ask about general neighbourhood satisfaction and satisfaction with parking. Note that no sociodemographic information was collected other than household type. This was, firstly, because we did not want to overtax respondents' patience and our goal was not to model parking choices. Secondly, the most important additional information would have been household income which strongly affects car ownership and the resources available for private parking. This is exactly the information for which we had to expect the least responsiveness. The full questionnaire is available from the authors upon request.

**Table 1: Sampling and response rate**

	Number	Percent
Approached households	3,566	100.0
Noone home	2,374	66.6
Written questionnaire left for mail-back	107	
Written questionnaire responses	12	11.2
Personally met	1,192	33.4
Participated (percent of those met)	828	69.5
Refused (percent of those met)	364	30.5
Participated (percent of those met or for whom questionnaire was left)	840	64.7

Source: own survey.

It may appear worrying that in 67 percent of the households contacted nobody was home despite two attempts at different times of day (Table 1). We had little chance to check whether this affects the sample composition, as there are no official statistics available at the neighbourhood level on, e.g., household types (except for one-person households) or household car ownership levels. We took average household sizes for various household types from *Mobilität in Deutschland 2017* (figures for the metropolitan cities) to estimate a number of 1,722 individuals living in our surveyed households. Taking the 720 cars owned by the households resulted in a car ownership rate of 418 cars per 1,000 inhabitants, which perfectly matches the figure given above. What is more, the distribution of household types and car ownership levels by household type reflected to a reasonable extent the results of another survey in the neighbourhood, undertaken in 2011 (see Table 2). In our survey we found a somewhat higher share of zero car households, which

suggested that there was no bias towards people with a strong motivation to complain about lack of parking (those without a car would perhaps rather complain about the negative consequences of pavement parking). In terms of household types our survey covered a smaller share of one-person households. According to the figures from the City of Dortmund for the statistical area that includes the Kreuzviertel, one-person households were underrepresented in both surveys (Stadt Dortmund, 2015), probably because of the lower likelihood of finding someone at home.

On the other hand, 69 percent of those found at home agreed to participate in the survey, which appears to reflect the urgency of the topic among the local population.

**Table 2: Household types and car ownership in the study area – comparison of two surveys**

	Couple with child(ren)	Couple w/o child(ren)	Single parent	Single household	Shared flat	Total
<b>Car ownership</b>						
ILS survey (2011)						
No car	2.8	13.6	12.5	31.8	66.7	23.6
1 car	55.6	66.4	75.0	66.5	26.7	63.9
2 cars	41.7	19.2	12.5	1.7	6.7	12.2
3+ cars	0.0	0.8	0.0	0.0	0.0	0.3
Our survey (2018)						
No car	4.8	14.1	29.7	48.5	47.5	28.5
1 car	59.2	59.2	62.2	50.0	36.3	53.7
2 cars	35.2	26.8	8.1	1.1	13.8	17.2
3+ cars	0.8	0.0	0.0	0.4	2.5	0.6
<b>% household types</b>						
	Couple with child(ren)	Couple w/o child(ren)	Single parent	Single household	Shared flat	Total
ILS survey	10.0	34.7	2.2	48.9	4.2	100.0
Our survey	15.7	35.6	4.6	33.6	10.0	100.0

Source: own survey (lower half, n=797) and ILS survey 2011 (upper half, n=360, by Research Institute for Regional and Urban Development (ILS), analysis provided by Frank Osterhage).

## 2.4 Analysis

This paper does not aim to model parking choices, but to give an overview of the quantities of parking availability and choices in a highly challenging high-density neighbourhood. Thus, we provide univariate and bivariate descriptive statistics. We start our results presentation with car availability, followed by the availability and use of private parking. We then look at cost of private parking and willingness to pay, and at distance to parked cars and search duration. Finally we present some findings on satisfaction with the neighbourhood in general and with parking specifically. From our results we make an effort to estimate the possible effect on illegal parking if under-used private parking were more effectively utilised.

## 3 Results

### 3.1 Car availability

From Table 2 it can be seen that just over half of the households (54%) have one car. Twenty-eight percent have no car, while 18 percent have multiple cars. This represents a higher level of car ownership than the average of large German cities, where 38 percent of households have no car and 12 percent have multiple cars (infas, 2018, 19), reflecting the higher car ownership level of Dortmund compared to other cities of similar size – especially when the central location and high density of the neighbourhood is taken into account.

The share of zero-car households is almost 50 percent among single households and those living in shared flats (predominantly young adults). Thirty percent of lone parents have no car, while this is only true for 5 percent of couples with children. Conversely, having more than one car is overproportionately associated with couple households, especially those with children, in line with Oakil et al. (2016) who find for the Netherlands that family households adapt less to the environment in terms of car ownership than couples without children.

### 3.2 Availability of private parking

Just under one in five households (18.6%) in our sample reported having a private garage or parking space. A few of these (2.5%) even have two garages or parking spaces. Half of them have garages, the others have parking lots in underground car parks or other parking lots. The latter are often located in backyards or in front of the houses (Table 3).

**Table 3: Availability of private parking**

	Frequency	Percent	Percent of car- owning households
No private parking space, no garage	652	81.4	75.3
Garage	75	9.4	12.6
Shared underground parking	18	2.2	2.8
Other private parking space	36	4.5	6.0
Two garages	7	0.9	1.2
One garage and another parking space	13	1.6	2.1
Households with garages or parking spaces	149		
Number of garages and parking spaces	169		
Of these...			
...with exclusive use		60.1	61.3
...shared use		39.9	35.8
...own property		18.4	15.6
...rented		81.6	84.3
n	801	100.0	100.0

About 60 percent of the parking spaces are used exclusively by the respondent households, while 40 percent are shared, e.g. between renters or owner parties in a house. Eighty-two percent are rented, 18 percent are the respondents' property. The latter are likely to be associated with ownership of housing, while rented garages may be common among homeowners and renters alike. There is no close relationship between garages and other parking lots in terms of ownership status or exclusive use.

We manually measured the network distances of private parking lots and garages from the residential address based on the maps provided by the respondents (Table 4). For 13 respondents the map used did not cover the garage location, which meant that the distance was greater than ca. 500 m. In these cases we assumed a distance of 600 m. This results in a mean distance of 158 m. While more than a third of the households had their garage in the immediate environment (0-25 m), and another 16 percent reported locations at distances of 25-50 m, 21 percent reported locations at distances of 200-500 m, and 8 percent even further away.

### 3.3 Use of private parking spaces

To assess pressure on kerbside parking it is of key importance whether and to what extent available private parking is used (Table 4). Only 37 percent of our respondents who have private parking available, stated that they always use it. Almost one in two (47%) said they use their parking space 'mostly'. Ten percent (16 respondents) never use it.

Despite the small numbers it is clear that the use of private parking is associated with distance from the place of residence – the closer the parking lot, the more frequently it is used. There is a counter-intuitive association only in the smallest distance band. Although we cannot rule out that this is due to the small sample, there may also be a more substantive interpretation. Some of those with private parking at their place of residence may not have made a conscious decision to rent or purchase it, but merely have received it as a welcome feature with their dwelling. These households may not need the parking facilities as urgently as those who acquired them at a certain distance from their place of residence who may be more dependent on them, e.g. because of a larger car or because of getting home late in the evening.

**Table 4: Distance to private parking and use of private parking**

Distance to private parking	% of respondents in distance band	Use of private parking						all	n
		always	mostly	some-times	rarely	never			
0-25m	36.6	36.2	48.3	1.7	1.7	12.1	100.0	58	
>25-50m	15.9	57.7	38.5	3.8	0.0	0.0	100.0	26	
>50-100m	7.3	58.3	41.7	0.0	0.0	0.0	100.0	12	
>100-200m	11.0	33.3	55.6	5.6	0.0	5.6	100.0	18	
>200m	21.3	25.7	48.6	8.6	5.7	11.4	100.0	35	
>500m	7.9	15.4	46.2	7.7	0.0	30.8	100.0	13	
All	100.0	37.0	46.9	4.3	1.9	9.9	100.0	162	
n	162	60	76	7	3	16	162		

Chi Square test not significant (p=0.05).

We used an open question format to inquire why available private parking was not (always) used, and received 95 answers from 86 respondents. The most frequent reason (22 times) was that loading or unloading things (or children) at the front door was more convenient. Time saving, especially in cases when a vacant kerbside parking lot is available, was stated 14 times, and convenience was stated eight times. These three reasons were often given together.

The second-most stated reason (after (un)loading the car) was that kerbside parking was used for occasional short-term parking (16 times). Fifteen respondents stated that their private parking was too far away, and two more stated that they used their private parking only in an 'emergency' (which probably means when the Dortmund football team has a home match), which may refer to distant parking spaces as well.

Eleven respondents said they use the garage for other purposes, e.g. for motorcycles, bicycles, storage, or waste bins. Seven respondents stated they used kerbside parking when they had visitors so as to leave their garage or private parking free for their guests. For nine respondents their garage was too difficult or even impossible to access. This includes responses such as 'inconvenient rolling shutter gate', 'complicated gate opening', 'steep gateway' (perhaps to basement garage), 'car is too large', 'don't want to drive into backyard to avoid noise'.

Four respondents said their parking space or garage was blocked by other illegally parked cars, and only two said they did not have exclusive access as they shared their parking space with other house dwellers.

The purposes for which private parking is used are shown in Table 5. They are evenly spread across bicycles, motorcycles and storage. A smaller number refer to other purposes or nothing.

**Table 5: Use of private parking**

	n	Percent of uses	Percent of cases
Nothing	7	3.7%	4.9%
Car	130	68.4%	90.3%
Bicycle(s)	16	8.4%	11.1%
Storage	16	8.4%	11.1%
Motorcycle(s)	16	8.4%	11.1%
Other use	5	2.6%	3.5%
	190	100.0%	131.9%

Additional information can be taken from the Cologne study where public parking in the neighbourhood studied is limited to two hours for visitors and 24 hours for residents. Parking is not free. In the study (Lenz, 2018) it was observed that more residents have access to private parking (45 percent of car-owning households, compared to 25 percent in the Kreuzviertel), and many more of them regularly use it (90 percent always, six percent mostly; Kreuzviertel: 37/47 percent, respectively).

### **3.4 Cost of private parking and willingness to pay**

The previous section reveals that many residents of the Kreuzviertel who have private parking available leave their cars on-street anyway at times. This favours the idea that there is less parking pressure than commonly perceived. This notion is supported by the widespread low willingness to pay.

We only asked renters of parking spaces about the monthly costs of private parking, as we expected it to be difficult for owners to estimate these costs. A total of 122 responses resulted in an average of €55.40 per month. Twenty percent pay more than €70, the maximum is €110. While the average price for garages is €60.50, other (typically open air) parking spaces cost €35.90 on average.

From Table 6 it can be seen that those who have no, or at least insufficient, private parking available (more cars than parking places), rarely look for private parking facilities. Only 24 percent report searching for a parking space, mostly to rent. This may either reflect low pressure, or a low willingness to pay, or both.

**Table 6: Search for private parking (respondents with no or insufficient private parking available)**

	n	%
No	347	76.1
Yes, to buy	2	0.4
Yes, to rent	95	20.8
Yes, to buy or rent	12	2.6
Total	456	100.0

Among those who were searching for private parking facilities the average price they were willing to pay is €69 (median: €60, maximum: €200, minimum: €20, Table 7). Judging by the prices paid

by people already renting parking spaces, this average appears a realistic estimate of market prices but, as outlined above, there is no private parking available on the market. Under the – somewhat exaggerated – assumption that the willingness to pay of those who are not searching for private parking equals zero, and that these households would rather rent parking facilities than purchase them, the mean willingness to pay is only €16.

The few respondents who look to purchase a parking space are on average willing to pay €17,300 (median: €12,500, minimum €8,000, maximum €35,000).

**Table 7: Willingness to pay for private parking**

Willingness to pay for...	n	mean	median	mean incl non-searchers (willingness to pay = zero)
Ownership	10	17,300	12,500	
Rent per month	107	69	60	16

### 3.5 Distance to cars and search duration

The mean distance to the car is just over 90 m (median: 50 m), and mean search duration is 5.3 minutes (median: 2 minutes). This includes few extreme values (search time  $\geq 60$  minutes) that may be due to either exaggerated estimates or days with football matches.

It is a common observation in the study area that kerbside parking is more difficult in the evening hours than in the daytime. We have no information on time of day of parking, but from the aforementioned Master thesis undertaken in Cologne (Lenz, 2018) we take an increase in search duration from 10-11 minutes to 17 minutes after 5 p.m. (with perhaps somewhat overestimated durations, but probably a valid relative increase). The increase is likely to be less pronounced in the Kreuzviertel, as parking pressure in the Cologne neighbourhood is generally higher, as suggested by longer search time and more ownership of private parking (see below).

**Table 8: Distance to parked car by availability of private parking**

	0-25m	>25- 50m	>50- 100m	>100- 200m	>200m	Total	n
No private parking	37.7	10.4	22.8	19.0	10.2	100.0	506
Private non-exclusive parking	17.7	25.8	12.9	17.7	25.8	100.0	63
Private exclusive parking	39.6	13.5	12.5	24.0	10.4	100.0	100
All	36.1	12.3	20.3	19.6	11.7	100.0	669

Distance to car differs significantly by availability of private parking (Chi Square test,  $p=0.05$ ).

**Table 9: Search duration by availability of private parking**

	zero	1-5 min	6-10 min	11-15 min	16-20 min	>20 min	Total	n
No private parking	33.4	38.0	15.2	6.9	2.8	3.7	100.0	434
Private non-exclusive parking	41.9	34.9	16.3	0.0	4.7	2.3	100.0	43
Private exclusive parking	44.4	35.6	13.3	4.4	2.2	0.0	100.0	45
All	35.1	37.5	15.1	6.1	2.9	3.3	100.0	522

Chi Square test not significant ( $p=0.05$ ).

We categorise distance to parking and search duration by availability of private parking (Table 8, Table 9). Those who have exclusive private parking available show higher proportions of zero searching and very short distances to parking (44% and 40% respectively, compared to 33% and 36% among those without private parking). Still it should be noted that the majority, even of those with private parking, search for on-street parking rather than using their parking spaces

immediately. See Section 3.4 for reasons why people with private parking may park on the street. The accepted search times of those who have private parking are not strikingly different to those of people with no private parking.

The idea that this may have to do with available, if perhaps illegal, kerbside parking is supported by an analysis of the difference between the distance to the private parking lot (if available) and the distance to the parked car (Table 10). A note of caution is warranted, as we cannot clarify the differences in distance for households with two parking sites and/or two cars. We therefore limit the analysis to the first car and first parking site given by the respondent. For 72 percent the difference in these distances is zero. These people are essentially those who park on their own site or park at the kerbside by their front-door and who have parking facilities at home. Among the others, almost nine in ten left their car closer to their residence than where their parking site is located, while only one in ten left it farther away (25% versus 3%).

**Table 10: Distance to parked car versus to private parking**

Distance to private parking minus distance to car	%
>400m	4.5
>300-400m	6.8
>200-300m	4.5
>100-200m	2.3
0-100m	6.8
Zero	72.2
Negative (car further away than parking space)	3.0

### **3.6 Satisfaction with the neighbourhood and with parking**

Our data do not permit us to perform a proper modelling of residential satisfaction. Here we merely aim to demonstrate to the reader the considerable difference between satisfaction with parking and neighbourhood satisfaction in general.

We inquired into satisfaction levels by asking 'How do you rate living in this neighbourhood?' and subsequently, 'How do you rate the parking situation at your residence?' We used the word 'Stellplatzsituation' when asking about parking, which encourages people to think of the ease of parking their car, rather than thinking of being harassed by too many parked cars.

The results (Table 11) show that living in the neighbourhood is rated very positively. Note that we asked people to give German school grades where one is best and six is worst. This is irrespective of having a car or not, and of having private parking available or not. On the other hand, the parking situation is rated extremely negatively, and this is again true for those with and those without cars. Note therefore that even those without cars are dissatisfied with parking. For those with cars, the availability of private parking increases the satisfaction level by 0.3 to 0.4 grades, but certainly not to a satisfactory level, which is reasonable as even those people who have private parking are well aware of the shortage of public parking options. Hence, the parking shortage seems to be a strong matter of concern among local residents.

The high level of neighbourhood satisfaction does not necessarily mean that the parking situation does not affect the satisfaction of residents with the area. Actually there is a weak but significant positive correlation ( $r=0.125$ ) between the two. Yet we conclude from the findings that residing in the neighbourhood is highly valued among the local population despite the tense parking



situation. Apparently the latter is accepted in favour of other amenities, such as vibrant urban life, short trips to various facilities, and high-quality housing.

**Table 11: Satisfaction with parking and with the neighbourhood in general by household car ownership**

Household car ownership	Private parking	Neighbourhood satisfaction	Satisfaction with parking	n (neighbourhood/parking)
No car	-	1.7	4.8	225/210
One car	no	1.6	4.8*	328/326
	yes	1.6	4.4*	99/95
	all	1.6	4.8	427/421
2+ cars	no	1.6	4.8*	101/101
	yes	1.5	4.5*	40/40
	all	1.6	4.7	141/141
All	no	1.6	4.8*	649/632
	yes	1.5	4.5*	144/140
	all	1.6	4.8	793/772

\* Difference between those with and those without private parking significant (one-tailed t-tests,  $p=0.05$ ). Satisfaction levels measured according to German school grades (1=very good, 6=insufficient). The level that is required to pass an exam is 4.

### 3.7 Utilisation of under-used private parking – what's the effect?

We make an attempt here to estimate the amount of additional on-street parking that would be achieved if those with private parking fully used it. This requires the quantification of statements on the frequency of use of private parking. We distinguish between Variant 1 which we consider 'realistic' and Variant 2 which is more 'conservative'. Variant 1 assumes that 'mostly' using available private parking refers to 80 percent of parking events, 'sometimes' to 50 percent, 'rarely' to 20 percent, and 'never' to never (zero). The conservative estimate (Variant 2) assumes that 'mostly' means practically always (100 percent), 'sometimes' means 60 percent, 'rarely' relates to 20 percent, and 'never' is 0 percent.

**Table 12: Reduction of illegal public parking if private parking is fully utilised**

	Variant 1	Variant 2
Private parking (no., sample)	169	169
Unused private parking (no., sample)	37.1	21.2
Unused private parking (percent, sample)	22.0%	12.5%
Households (no., sample)	840	840
Households (total in Kreuzviertel)	5,470	5,470
Private parking (total in Kreuzviertel)	1,100	1,100
Unused private parking (total in Kreuzviertel)	242	138
Legal public parking in Kreuzviertel	2,317	2,317
Cars parked by night in Kreuzviertel*	2,808	2,808
Illegal public parking in Kreuzviertel*	491	491
Reduction of illegal public parking if private parking is utilised	49%	28%

\* Vieten et al. (2014)

Variant 1 results in 37.1 private parking spaces that are unused on average (Variant 2: 21.2) (Table 12). This implies 22 percent (Variant 1) or 12.5 percent (Variant 2) free parking spaces out

of the 169 surveyed private parking spaces. Extrapolating the existing private parking to the neighbourhood as a whole results in 1,100 private parking spaces ( $169 \cdot 5470 / 840$  households). These spaces increase the capacity of the neighbourhood (2,317 legal public parking spaces) by 47 percent, i.e. almost by factor 1.5. For the whole area we estimate 242 unused private parking spaces in Variant 1 ( $37,1 \cdot 5,470 / 840$  households), or 138 in Variant 2.

Following the counts made by Vieten et al. (2014) of 2,317 legal parking spaces, but 2,808 parked vehicles between 10 and 11 p.m., this means that illegal public parking (491 vehicles) could be relieved by almost 50 percent (Variant 1) or 28 percent (Variant 2) if private parking was effectively utilised. Although this is clearly not sufficient to solve the parking problems in the neighbourhood, it implies a substantial reduction in illegal parking.

#### **4 Conclusions for parking policies**

This paper studied parking in a Dortmund inner-city neighbourhood. This area is characterised by a severe shortage of parking from the residents' perspective, although at the same time illegal parking is generally tolerated by the city administration and, hence, parking pressure is actually limited. This leads to a situation where even many people who have private parking available often prefer kerbside parking, further reducing available public parking for those who have no private parking. This is despite the state building code that does not permit garages to be used for purposes other than parking motor vehicles. At the same time, the willingness to pay for parking is very low. The residents' satisfaction level with parking is very low, but this hardly inhibits satisfaction with living in the neighbourhood as a whole.

Two primary policy conclusions can be drawn. Firstly, it should be pointed out that the performance of any parking policy depends crucially on the level of enforcement (Inci 2015, p. 61). This not only ensures that any attempt to introduce parking pricing has the effect intended, but also that the number of perceived (legal and illegal) parking spaces is limited to legal options. The reason why there is such a striking lack of control is beyond the scope of this research. However, we can offer some speculation. One of the authors participated in a workshop on children's trips to school in Dortmund in 2019, in which two representatives of the responsible urban regulatory authority took part. They were heavily criticised for the lack of parking control, and responded that they do not have the staffing capacity needed. This response in turn was perceived by some attendees including the author as a 'blackmail policy' to achieve more personnel.

Secondly, the situation could be resolved to some extent by introducing parking fees. Residential parking permits have been criticised by transport economics as causing a welfare loss, as long as the prices do not meet the actual land prices in an area (van Ommeren et al., 2014; Groote et al., 2016). However, given the practical situation in an area that has never seen a price being put on public parking, and in which the provision of public land for parking is viewed as simply normal by local residents, paid parking permits may well be considered a start, even if their cost level is below the market price. Suffice to say that the welfare loss induced by free parking on scarce land is even larger. In this sense there is a gap between research that seeks to find price optimums for (public) land and research that seeks to contribute to practical solutions.

Paid residential parking permits would motivate those who have private parking available to use it, and perhaps encourage land owners with private parking but no cars to let or sell their parking spaces. This could be increased by the short-term marketing of private parking when owners do not need it, e.g. via apps (Ding et al., 2018).

Due to the mixed land-use character of the neighbourhood, paid parking permits may not be limited to residents, but may rather include in-commuting employees. Efficiency gains could also

be realised in terms of shared parking utilised by residents at night, and by customers or the workforce in the daytime (Figure 2, Picture 8; this is probably the only case in the study area of parking shared between customers and residents). Revenues emerging for the owner of the facility would be liable for taxation, but Picture 8 shows a case where residential parking is free at night. Short-stay parking in the public realm for customers could still be provided by defining short-stay parking zones (that should perhaps additionally be open for use by residents or employees with a permit). Such a concept has to be carefully designed, especially in spatial terms, to make sure that there is no displacement of illegal parking to adjacent areas.

Although the full use of private parking would substantially reduce pressure on public parking, it would not eliminate it. Another option to increase the number of legal parking spaces is to deviate from the standard sizes for public parking. In an as yet unpublished report, the Dortmund municipal advisory board for 'Nahmobilität' (the term is opaque and refers to something between 'non-motorised travel' and 'short trips') suggests considering reduced-size parking spaces in this and other neighbourhoods in an effort to re-gain the pavements for their original purposes – walking, chatting and other human activities. As reported in Section 1.2, research for a Master thesis in Dortmund (Koch, 2018) found that the number of legal parking spaces could be increased by 21 to 32 percent if 45 to 55 percent of standard-size parking spaces were reduced in size to cater for smaller vehicles such as VW Polo or Renault Twingo. This would also guarantee that pavements of varying widths (but at least 2 m) were free of parked vehicles – assuming that restrictions were enforced or barriers erected. Over and above the reduction of illegal parking, reducing the size of some parking lots in a neighbourhood could support preferences for smaller, more fuel-efficient cars that are more compatible with inner-city neighbourhoods.

A more rigid concept could be to limit car access to the neighbourhood (except for through roads) to residents when pressure on parking is strongest, i.e. when the famous Dortmund football team plays home matches. This approach has been implemented by the City of Munich in some residential neighbourhoods since 2018. Three hours before kickoff the city administration positions mobile traffic signs limiting access to residents and shop owners/renters, and erects physical barriers (Stadt München, 2018). The acceptability of such restrictive parking policies (Burchell et al., 2019) could be extended by strong and convincing communication of the benefits of the policies in terms of the livelihood and safety of the neighbourhood.

The focus of this paper was on a case study in Dortmund. Practically all large cities in Germany and in many other countries have high-density, mixed land-use, vibrant inner-city neighbourhoods of the same type. Our results therefore may be applied to similar neighbourhoods elsewhere, where private parking is underused or where there is reason to restrict non-residential parking. Our observations strongly indicate that public space is to a large extent covered by parked vehicles, an unfair distribution considering that about a quarter of households (and a majority of the population) do not own cars. Parking regulations should therefore generally be framed in a way that makes car owners rather than the public responsible for parking facilities at home. This would contribute to relative benefits in terms of housing costs for those with fewer (or without) cars. To make a perhaps rough analogy: no one would claim public space should accommodate other private belongings such as furniture, or family members. The price of public parking (e.g., in historical neighbourhoods where some households have no opportunity to privately organise parking spaces) should be increased piecemeal until the costs meet actual land prices.

In the UK local authorities are permitted to charge employers for the parking they provide for their employees, and the revenue can be hypothecated to improve local transport (Burchell et al, 2019). Though only one city (Nottingham) has picked up this concept to date, this may be another

way forward to increase revenues and improve transport infrastructure (e.g., parking signage) and services (e.g., public transport).

Previous research has found a positive relationship between the provision of public transport and household car ownership (Chatman, 2013; Loder and Axhausen, 2018). Hence, more attractive public transport may be an option to reduce the demand for parking by residents, customers and employees. In our case study this would suggest, however, that the public transport system on the urban and regional scale needs to be taken into account, as public transport provision in the study neighbourhood itself is excellent, and any lack of quality is likely to refer to the 'higher' levels.

Beyond urban parking policies, our outline of the regulatory framework for parking in Germany suggests that some parking laws may be ineffective. This refers, firstly, to the minimum carriageway width of three metres which is left up to drivers to judge and, hence, may not work in practice. Secondly, restricting the use of garages to motor vehicles seems somewhat inappropriate given that modern cars are too large for the garages. Hence, critically revisiting the legal framework is another strand that deserves future consideration.

Last, but not least, it should be reiterated that the performance of any parking policy depends crucially on the level of enforcement. Tolerating illegal parking could well contribute to future growth in car ownership (and car size), and further damage the vibrancy of the neighbourhood.

Acknowledgement. This paper has benefited considerably from comments made by three anonymous reviewers.

## 5 References

- Alemi, F., Rodier, C., Drake, C., 2018. Cruising and on-street parking pricing: A difference-in-difference analysis of measured parking search time and distance in San Francisco. *Transp. Res. A* 111, 187-198.
- Antolín, G., Ibeas, Á., Alonso, B., dell'Olio, L., 2018. Modelling parking behaviour considering users heterogeneities. *Transp.Pol.* 67, 23-30.
- Bates, J., 2014. Parking demand. In: Ison, S., Mulley, C. (eds.) *Parking Issues and Policies. Transport and Sustainability* 5, Emerald, Bradford, 57-86.
- Burchell, J., Ison, S., Enoch, M., Budd, L. 2019. Implementation of the workplace parking levy as a transport policy instrument. *Journal of Transport Geography* 80, 102543.
- Cao, X., Mokhtarian, P.L., Handy, S.L., 2006. Neighborhood design and vehicle type choice: Evidence from Northern California. *Transp. Res. D* 11, 133-145.
- Chatman, D.G., 2013. Does TOD Need the T? In: *J. Amer. Plann. Assoc.* 79(1), 17-31.
- Chester, M., Fraser, A., Matute, J., Flower, C., Pendyala, R., 2015. Parking infrastructure: a constraint on or opportunity for urban redevelopment? A study of Los Angeles county parking supply and growth. *J. Amer. Plann. Assoc.* 81(4), 268-286.
- Christiansen, P., Engebretsen, Ø., Fearnley, N., Usterud Hanssen, J., 2017a. Parking facilities and the built environment: Impacts on travel behaviour. *Transp. Res. A* 95, 198-206.
- Christiansen, P., Fearnley, N., Hanssen, J.U., Skollerud, K., 2017b. Household parking facilities: Relationship to travel behaviour and car ownership. *Transp. Res. Proc.* 25, 4189-4199.

- Dargay, J., Gately, D., Sommer, M., 2007. Vehicle ownership and income growth, worldwide: 1960-2030. *Energy J.* 28(4), 143-170.
- Davis, A.Y., Pijanowski, B.C., Robinson, K., Engel, B., 2010. The environmental and economic costs of sprawling parking lots in the United States. *Land Use Policy* 27(2), 255-261.
- Ding, C., Wang, D., Liu, C., Zhang, Y., Yang, J., 2017. Exploring the influence of built environment on travel mode choice considering the mediating effects of car ownership and travel distance. *Transp. Res. A* 100, 65-80.
- Ding, T., Wang, B., Zheng, L., Xi, J., Wang, S., Xu, S., 2018. Research on parking choice model based on shared private parking space. Paper presented at the 7th International Conference on Green Intelligent Transportation System and Safety, 2016; Nanjing; China; 1-4 July 2016. *Lecture Notes in Electrical Engineering* 419, 935-948.
- Enoch, M.P., 2014. Categorising car parking spaces and policies. *Traffic Engineer. Control* 55(1), 37-39.
- Faust, N., 2018. Private Stellplätze in innerstadtnahen Altbauquartieren. Master thesis, Faculty of Spatial Planning, TU Dortmund.
- Groote, J.D., Ommeren, J.V., Koster, H.R.A., 2016. Car ownership and residential parking subsidies: Evidence from Amsterdam. *Econ. Transp.* 6, 25-37.
- Guo, Z., 2013a. Does residential parking supply affect household car ownership? The case of New York City. *J. Transp. Geogr.* 26, 18-28.
- Guo, Z., 2013b. Residential street parking and car ownership. *J.Amer. Plann. Assoc.* 79(1), 32-48.
- Guo, Z., 2013c. Home parking convenience, household car usage, and implications to residential parking policies. *Transp. Pol.* 29, 97-106.
- Helmer, J., 2018. Verfügbarkeit und Nutzung von privaten Stellplätzen in einem hochverdichteten, innerstädtischen Quartier. Bachelor thesis, Faculty of Spatial Planning, TU Dortmund.
- Ibeas, A., Dell'Olio, L., Bordagaray, M., Ortúzar, J.D.D., 2014. Modelling parking choices considering user heterogeneity. *Transp. Res. A* 70, 41-49.
- Inci, E., 2015. A review of the economics of parking. *Econ. Transp.* 4(1-2), 50-63.
- infas Institut für angewandte Sozialwissenschaft, 2018. *Mobilität in Deutschland. Tabellarische Grundausswertung*, BMVI, Berlin.
- James III, R.N., Sweaney, A.T., Sweaney, A.L., 2009. Sources of discontent: Residential satisfaction of tenants from an internet ratings site. *Environ. Behav.* 41(1), 43-59.
- Kim, H.-J., Yang, M.-R., 2017. A comparative study on residential satisfaction in relation to spatial characteristics of the residential-commercial area in urban Seoul focused on the analysis of Seorae Village of Banpo 4-dong and the Garosu-gil area of Sinsa-dong. *J. Asian Arch. Build. Engineer.* 16(2), 295-302.
- Kirschner, F., Lanzendorf, M. 2019. Parking management for promoting sustainable transport in urban neighbourhoods. A review of existing policies and challenges from a German perspective. *Transport Reviews*, in print, DOI: 10.1080/01441647.2019.1666929
- Klodeftiras, M., Antoniou, C., 2013. Simulation-based assessment of double-parking impacts on traffic and environmental conditions. *Transp. Res. Rec.* 2390, 121-130.

- Koch, A., 2018. Parken im Dortmunder Kreuzviertel. Master thesis, Faculty of Spatial Planning, TU Dortmund.
- Leibling, D., 2014. Parking supply and demand in London. In: Ison, S., Mulley, C. (eds.) Parking Issues and Policies. Transport and Sustainability 5, Emerald, Bradford, 259-289.
- Lenz, M., 2018. Stellplatzsituation in innenstadtnahen Altbauquartieren. Master thesis, Faculty of Spatial Planning, TU Dortmund.
- Litman, T., 2016. Parking Management: Strategies, Evaluation and Planning. Victoria Transport Policy Institute, Victoria.
- Liu, Q., Chen, P., Author, Sun, F., 2018. Parking Policies in China's Metropolises: Rationales, Consequences, and Implications. Urb. Pol. Res. 36(2), 186-200.
- Loder, A., Axhausen, K., 2018. Mobility tools and use: Accessibility's role in Switzerland. J Transp Land Use 11(1), 367-385.
- Manville, M., Shoup, D., 2005. Parking, people, and cities. J. Urb. Plann. Develop. 131(4), 233-245.
- MBWSV NRW (Ministerium für Bauen, Wohnen, Stadtentwicklung und Verkehr des Landes Nordrhein-Westfalen), 2016. Mobilität in Nordrhein-Westfalen. Daten und Fakten 2015/2016, MBWSV, Düsseldorf.
- McCahill, C., Garrick, N., 2014. Parking supply and urban impacts. In: Ison, S., Mulley, C. (eds) Parking: Issues and Policies, Emerald, Bradford, 33-56.
- Millard-Ball, A., Hampshire, R.C., Weinberger, R., 2020. Parking behaviour: The curious lack of cruising for parking in San Francisco. Land Use Policy 91, 103918.
- Scheiner, J., 2006. Standortbewertungen und Wohnmobilität. In: Beckmann, K.J. et al. (eds) StadtLeben – Wohnen, Mobilität und Lebensstil. Neue Perspektiven für Raum- und Verkehrsentwicklung, VS, Wiesbaden, 67-78.
- Shoup, D.C., 2005. The High Cost of Free Parking. American Planning Association, Chicago.
- Shoup, D.C., 2006. Cruising for parking. Transp. Pol. 13, 479-486.
- Stadt Dortmund, 2015. Dortmunder Stadtteile. Statistikatlas. Stadt Dortmund.
- Stadt München, 2018. Zufahrtsregeln für Wohngebiete bei der Allianz-Arena an Spieltagen. Rathaus Umschau 125/2018, 4.7.2018. <https://ru.muenchen.de/2018/125>, Accessed 23.1.2019.
- Straub, M., 2019. Verfügbarkeit und Nutzung von privaten Stellplätzen in städtischen Quartieren am Beispiel des Dortmunder Kreuzviertels. Master thesis, Faculty of Spatial Planning, TU Dortmund.
- Taylor, E., 2014. "Fight the towers! Or kiss your car park goodbye": How often do residents assert car parking rights in Melbourne planning appeals? Plann Theory Practice 15(3), 328-348.
- Taylor, E.J., 2020. Parking policy: The politics and uneven use of residential parking space in Melbourne. Land Use Policy 91, 103706.
- Tian, G., Park, K., Ewing, R., 2018. Trip and parking generation rates for different housing types: Effects of compact development. Urban Stud (in print, DOI: 10.1177/0042098018770075)
- Topp, H.H., 1991. Parking policies in large cities in Germany. Transportation 18(1), 3-21.
- Tyrinopoulos, Y., Antoniou, C., 2013. Factors affecting modal choice in urban mobility. Europ. Transp. Res. 5(1), 27-39.

- Van Ommeren, J., de Groot, J., Mingardo, G., 2014. Residential parking permits and parking supply. *Reg. Sci. Urb. Econ.* 45(1), 33-44.
- Van Ommeren, J.N., Wentink, D., Rietveld, P., 2012. Empirical evidence on cruising for parking. *Transp. Res. A* 46(1), 123-130.
- Vieten, M., Borsbach, K., Bakenecker-Serné, J., Schmidt, S., 2014. Bewohnerparkkonzept Kreuzviertel Dortmund (L155/13 Ergebnisbericht). Im Auftrag der Stadt Dortmund. Neuss.
- Weinberger, R., 2012. Death by a thousand curb-cuts: evidence on the effect of minimum parking requirements on the choice to drive. *Transp. Pol.* 20, 93-102.
- Yin, C., Sun, B., 2018. Disentangling the effects of the built environment on car ownership: A multi-level analysis of Chinese cities. *Cities* (in print, DOI: 10.1016/j.cities.2017.12.002)
- Young, W., Miles, C.F., 2015. A spatial study of parking policy and usage in Melbourne, Australia. *Case Studies on Transp. Pol.* 3(1), 23-32.
- Zhang, C., Chen, J., Li, Z., Wu, Y., 2018. Predicting Owners' Willingness to Share Private Residential Parking Spots. *Transp. Res. Rec.* (in print, DOI 10.1177/0361198118772947)
- Zhang, L., Mu, Y., 2018. Parking Space Allocation with Uncertain Demand and Supply Consideration. Paper presented at the 15th International Conference on Service Systems and Service Management, ICSSSM, Hangzhou; China; 21-22 July 2018.