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Parking violations as an economic gamble for public space

Stefan Gössling [a,b,*], Andreas Humpe [c], Rafael Hologa [d,e], Nils Riach [d,e], Tim Freytag [f]

[a] School of Business and Economics, Linnaeus University, 391 82, Kalmar, Sweden
[b] Western Norway Research Institute, PO Box 163, 6851, Sogndal, Norway
[c] Munich University of Applied Sciences, Schachenmeierstraße 35, 80636, München, Germany
[d] Physical Geography, University of Freiburg, Schreiberstraße 20, 79085, Freiburg, Germany
[e] T3 Transportation Think Tank gGmbh, Clayallee 177, 14195, Berlin, Germany
[f] Human Geography, University of Freiburg, Schreiberstraße 20, 79085, Freiburg, Germany

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ABSTRACT

Parking fees and fines represent contested issues in cities, as they conflict with vehicle owners' opinion over 'rights' to public space. As cities have moved to regulate vehicle density by introducing parking fees, a share of drivers may feel compelled to 'cheat', weighing the price of parking fees against the cost of fines, or to simply park illegally outside designated areas. To better understand these interrelationships, this paper considers negotiations of public space as an economic gamble that can be assessed on the basis of parking violations. The study is situated in Freiburg, Germany, and relies on a mixed-methods approach that investigates the views of the regulatory agency and its enforcement officers, as well as registered parking violations (n = 181,735, in 2019). Time-spatial probabilities of being fined when parking illegally are calculated as risks, defined as detection probability per "hexagon-hour", an indicator integrating space and time. Results confirm that in the inner city, it is economically rational not to pay parking fees during 86.1% of hexagon-hours, and in surrounding areas during 99.9% of the time. Findings confirm that urban space can be negotiated in an equilibrium of fees, fines and controls. To make vehicle ownership and use less attractive, the price of parking needs to be high. Fines need to be high in relation to fees, and control densities need to constitute significant detection risks.

1. Introduction

Cities face a significant deployment cost for parking provisions (Shoup 2006). Roads and parking represent a significant share of urban space, which also determine negative externalities such as congestion and air pollution (Van Ommeren et al., 2012; Zong et al., 2015). Parking availability influences transport choices, urban planning and design, as well as urban sprawl (Topp 1993). The public expectation is for cities to provide parking opportunities, which, specifically in Germany, are often considered 'public rights to space' for private vehicles (Taylor 2014, 2021). Yet, public space has a construction and maintenance cost, as well as a (market) value for alternative uses such as green belts or gastronomy-related seating areas. As parking fees and resident permits are generally underpriced, parking represents a subsidy to vehicle owners and users (Arnott and Inci 2006; Arnott and Rowse 2009). Various transport studies have concluded that it is important for cities to manage parking with a view to reduce traffic densities and congestion that reinforce problems such as cruising for parking (Shoup 2006; Van Ommeren et al., 2011; Yin et al., 2018; Zong et al., 2019). Where parking provisions are mandated, for instance by federal laws, this also prevents alternative urban designs, such as more livable streets with reduced vehicle numbers and higher shares of active transportation.

Germany has complex transport laws that favor the car (Taylor 2021). Federal laws dictate urban traffic rules, including fines for parking violations, or ratios of resident permits to general parking space availability. Parking violations have been identified as a common phenomenon in German cities (Taylor 2021; Topp 1993), even though 38% of households in large German cities do not own cars (Infas 2018). As car numbers grow in Germany, conflicts over public space are bound to become increasingly felt. This raises the question of the role of parking policies in limiting car traffic, as well as the fairness of pricing vehicle space (Creutzig et al., 2020). It is against this background the paper seeks to understand interrelationships of parking fees, fines and controls.

* Corresponding author. School of Business and Economics, Linnaeus University, 391 82, Kalmar, Sweden.
E-mail address: sgo@vestforsk.no (S. Gössling).

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2. Theoretical background

2.1. Interrelationships of parking and space

Car ownership is a source of conflicts related to pollution, injuries, noise, and space, with cities all over the world facing growing individual motorized traffic and congestion (Shoup 2006; Topp 1993; Van Ommeren et al., 2012; Zong et al., 2015). Car density, however, also depends on the space made available for cars - which can vary significantly between countries and cities -, as well as the price charged for parking. For instance, there are claims that in Europe, the area devoted to parking is half the size of Belgium (Inci 2015), while car numbers continue to increase throughout the continent (Eurostat 2020). This forces cities to consider the scale of on- and off-site parking, and its management. As parking space is difficult to multiply in most urban designs, for instance through additional garages, the question is usually addressed from a perspective of pricing (Shoup 2006). Pricing is widely seen as the only strategy to relieve urban congestion (Arnott et al., 2015) and to reduce the cost of housing (Bakis et al., 2019). The effectiveness of pricing strategies has been demonstrated in various studies (Cats et al., 2016; Pierce and Shoup 2013; Yin et al., 2018; Zong et al., 2019), though egress time – the time it takes to walk from parking to the destination – and, to a much lesser degree, cruising time to find parking, also influence demand (Yan et al., 2019).

Given the centrality of pricing, various studies have investigated the importance of fee systems (Cats et al., 2016; Ottosson et al., 2013; Pierce and Shoup 2013). Differentiated systems were originally proposed by Shoup (1999, 2006), who suggested that parking fees should be high enough to reduce on-street parking to below full occupancy at any time of the day. By implication, this would also reduce cruising for parking time (van Ommeren et al., 2021). In light of the significant share of space devoted to road systems and parking (Gössling et al., 2016; Szell 2018), Arnott et al. (2015) concluded that where parking demand is high, on-street parking should be eliminated by forcing drivers to use garages. As curbside parking is preferred by drivers, on-street parking has to be significantly more expensive than garages (Gragera and Albalate 2016).

Cities may be categorized based on five different approaches to parking management, including direct subsidies, indirect subsidies, cost neutrality, market-based, and fair public space (Table 1). "Subsidy" approaches include those that do not adequately reflect on the cost of parking, for instance where parking is free or below deployment cost. "Cost neutrality" is an approach that charges fees in consideration of the direct and indirect parking cost to city and society, i.e. deployment as well as negative externalities. "Market-based" refers to models distributing space to the highest bidder, representing an income optimization model for cities. "Fair public space" treats space as a public good, weighing for instance quality of life or the benefits of active mobility into decision-making.

Depending on organizing principle, parking is widely available or a scarce resource. This includes on-street and off-street spaces, in residential areas, at workplaces, or in city centers (Kirschner and Lanzendorf 2020). For available parking, different price structures apply. Parking may be for free, with or without time restrictions, or charged in relation to the length of the stay. Specific rules may exist for residents with permits, disabled people, employees, in the form of safe parking for women, or at shopping-malls. Exceptions may be made for shop owners, delivery vans, or handymen. Rules may change depending on the day of the week, or the time of the day. National laws may dictate rules, such as minimum parking requirements per dwelling (Brueckner and Franco 2017), the ratio of resident to non-resident parking, or the maximum fines that can be charged (Taylor 2021). Parking cultures also determine availability, for instance when residents prefer to park on-street even though they have access to private parking (Scheiner et al., 2020). Park & ride opportunities may encourage drivers not to enter city centers (Antolín et al., 2018).

2.2. The cost of parking

The cost of parking provisions is significant. For example, the cost of public garage constructions in a sample of US cities averaged US$24,000 per space for aboveground and US$34,000 for underground garages (Shoup 2011). Even on-street parking represents a cost for annual deployment (repairs, maintenance, controls, administration). In many cities, the cost of public parking is not matched by the prices charged. For example, in many German cities, on-street parking is free for residents, who only pay an administrative fee. The capital, Berlin, charges €20.40 for a period of up to two years (April 2021; Service-Portal Berlin 2021).

de Groote et al. (2016) report that in Amsterdam, street parking was, in 2015, €5 per hour or €40 per day, while residential parking permits were €100-€400 per year. De Groote et al. (ibid.) conclude that Amsterdam subsidized permits, as the difference to street parking is €3200 per year, with a concomitant welfare loss of €3.5 million in the city center alone. More recently, Ostermeijer et al. (2019) report that cities in the Netherlands have increased the price of residential parking permits to €1000. Even this does not necessarily represent the market value of the road space, as specific groups in society, businesses, or residents may be willing to pay higher prices for alternative uses. It also ignores that free or low-cost parking leads to an additional social cost in air pollution, noise, or emissions, as it encourages and increases individual motorized transportation. Parking maneuvers entail increased

Table 1
Approaches to parking.

Pricing approach	Characteristics	Outcomes
Direct subsidy	Free on-street parking (for everyone or residents; entirely free or entailing symbolic administrative fee for permits).	Vehicle ownership is subsidized, as all parking entails a cost to a community. This reduction in private car costs makes the car more attractive, and likely leads to higher levels of car-ownership.
Indirect subsidy	Includes annualized deployment cost (construction, maintenance, controls, administration).	Charges drivers with the basic cost of parking at the local level, though there is still a cost to society (noise, air pollution, etc.). Makes car ownership substantially more expensive.
Cost neutrality	Includes annualized deployment cost, the cost of negative externalities (noise, air pollution, climate change, injuries), the cost of transport behaviour (car reliance and car as self-evident mode choice), as well as cost of cruising for parking effects.	The full internalization of car externalities makes vehicle ownership significantly more expensive. This is likely to make the car less attractive, specifically where transport alternatives exist.
Market-based	Based on willingness of others (residents, businesses) to pay for alternative uses of space.	Parking availability is likely reduced in significant ways, making it much more unattractive to own a car. Car sharing is likely to become more popular, as parking is always available in fixed locations.
Fair public space	Space is considered public good. Distribution on the basis of cost considerations, i.e. active transport favored as making positive economic contributions.	The city distributes space to maximize public goods. As vehicles entail costly externalities, while active forms of mobility or green spaces provide benefits related to mental and physical health, car numbers are very significantly reduced. Again, car sharing models profit from this approach.

safety and crash risks (Findley et al., 2020). van Ommeren et al. (2014) conclude that parking is often available at a price below its cost. Even where the cost of parking is high, it may not represent a market-optimum and hence a welfare loss and subsidy forwarded to drivers (Arnott and Inci 2006; Arnott and Rowse 2009, 2013; Shoup 2006; see also Table 1).

Through minimum parking requirements, cities determine the space that has to be reserved by property developers for parking, a policy often perceived as necessary to ensure that there are no spillover effects because of parking pressure (Inci 2015). However, parking requirements increase the cost of residential housing and become an investment in the car. Manville et al. (2013) determined that a ten percent increase in minimum parking requirements in New York led to greater vehicles density per land unit (5%) and vehicle density per person (4%). It also caused population density to fall by 6%. Residential parking influences mobility behaviour, as households with parking have been found to drive more and use public transport less often (Manville and Pinski 2020). Gabbe et al. (2020) argue that residents may prefer to waive car ownership in favor of more affordable housing. The general consensus is thus that in new residential areas, parking requirements should be removed.

To optimize parking, cities have also engaged in comprehensive pricing experiments. The SFpark project in San Francisco increased on-street and decreased garage prices to remove vehicles from streets (Pierce and Shoup 2013). The project achieved 85% garage occupancy rates (from 25%), and a ten percent increase in revenue, despite minimum parking rates falling from US$2.50 to US$1.00. While it is unclear if the new (lower) price structures also attracted more vehicles, Pierce and Shoup (2013) confirm that drivers are willing to pay premiums for on-street parking in comparison to garages. In Amsterdam, resident parking at reduced annual fees (€400) was made available only to those households willing to stay on a waiting list until limited permits became available (de Groote et al., 2016). Households on waiting lists had to pay €3600 per year, representing the standard parking fee, which reduced car ownership levels by 2% per year of waiting. de Groote et al. (2016) conclude, however, that high-income households received the largest parking subsidies under this scheme. There are other complexities. Inci (2015) and Antolín et al. (2018) confirm, for instance, that car drivers find spending time for cruising for parking more acceptable than walking to a destination. Residents, on the other hand, expect to be treated preferentially, showing lower willingness to pay for parking in an apparent understanding of entitlement to public space (Antolín et al., 2018; Taylor 2021). Pressure on parking, which often is perceived higher than it objectively is, may also be significantly reduced by forcing residents to use available private parking (Scheiner et al., 2020).

2.3. Parking violations

There is a general consensus that parking policies should consider local conditions (Inci 2015). The German situation is somewhat unique in this regard, because parking is considered part of traffic (Taylor 2021) and guided by federal, state and municipal laws (Kirschner and Lanzendorf 2020). This limits the opportunities of cities to define their own parking laws, including the public space devoted to cars (Taylor 2021). Taylor (2021) argues that the privilege of ubiquitous parking opportunities generates firmly established notions of entitlement to parking. This is a barrier to the design of more desirable transport systems. Indeed, Kirschner and Lanzendorf (2020) find that conservative political views characterize German cities, with a general reluctance to accept 'parking rights' restrictions. These views have evolved, as is evident from transport cultures that differ between countries (e.g. Barter 2011) as well as cities within Germany (Klinger et al., 2013; Scheiner 2012). Germany is also characterized by a constant increase in vehicle numbers that began to accelerate in the 1960s (Scheiner 2012), and continues today. In recent years, the German Federal Motor Transport Authority (Kraftfahrtbundesamt 2021) registered an annual net growth of more than one million cars in the German fleet, now amounting to 575 cars per 1000 inhabitants.

Parking violations in Germany include a wide range of offenses as listed in Bußgeldkatalog (the federal fee catalogue), a document detailing all relevant parking offenses (Table 2). Federal laws regulate parking availability, ratios of residential to non-residential parking, and the legality of removing on-street parking, for instance to promote car sharing (Taylor 2021). In July 2021, this situation was slightly adjusted, as communities were given the power to make decisions regarding the pricing of residential parking. The *management* of parking is organized by city administrations, usually under a councillor for building and construction, and controlled by municipal regulatory agencies through enforcement officers. Various authors have emphasized that both parking fees and fines are relatively low in Germany (Kirschner and Lanzendorf 2020; Taylor 2021), potentially leading to illegal parking phenomena (Topp 1991). As noted by Kirschner and Lanzendorf (2020: 68), the low cost of fines (€10–35) is "sometimes making it cheaper to pay a fine instead of a parking ticket". Research in the city of Dortmund also shows that residents favor on-street parking over their own private parking, as on-street parking is for free (Scheiner et al., 2020). This adds pressure on available parking.

The evidence suggests that where parking is not controlled, or where it cannot be ticketed, parking violations will increase: A study in New York City found that diplomats accumulated 150,000 unpaid fines in the period 1997–2002. Importantly, this behaviour was learned, as parking violations increased by more than 8% per month of living in the city, and only declined when repeat violations led to the stripping of license plates from vehicles (Fisman and Miguel 2007). As highlighted by Lei et al. (2017), parking fines are usually much higher than the parking fee, leading to opportunistic behaviour in which the likelihood of controls are weighed against the risk of detection:

> Although the drivers may not possess accurate knowledge of the exact patrol schedule, it is not uncommon that they are aware of the approximate patrol frequency […]. Accordingly, when the patrol frequency is low, a knowledgeable driver may incline to be more opportunistic and pay less money for parking […]. (Lei et al., 2017: 376).

While research has addressed a wide range of issues related to parking, including externalities and optimal pricing in the context of parking supply (van Ommeren et al., 2021), less attention has been paid to the question of parking violations and the relevance of controls (Lei et al., 2017). Opportunistic behaviour is determined by attitudes, and depends on the scale of fees in relation to fines and detection likelihoods. So far, papers discussing parking fees and management appear to assume a situation of lawful behaviour, i.e. that drivers do actually pay fees. However, the evidence is that a share of drivers will park illegally

Table 2
Parking violations in Germany (examples).

- parking on foot and cycle paths
- parking on narrow and unclear situations
- parking in sharp curves
- parking on pedestrian crossings and up to 5 m before these
- parking where this is prohibited or restricted
- parking up to 10 m before traffic lights
- parking in narrow sections, also obstructing rescue vehicles
- parking in front of fire access roads
- parking in front of fire access road with actual obstruction of rescue vehicles
- parking on restricted areas
- parking in traffic-calmed areas
- parking in second row
- parking in a bay reserved for cars with trouble
- parking space taken away unauthorized
- parking in an inefficient way
- parking at an expired parking meter
- parking in a handicapped parking spot

Source: Bußgeldkatalog (2021).

(Fisman and Miguel 2017; Lei et al., 2017; Topp 1991).

3. Methodology

Car ownership is a key variable in parking demand. In Germany, 22% of households have no car, 53% one car, and 25% several cars (in 2017; Infas 2018). The share of households without cars is far higher in larger cities (38%) where multiple car-ownership is also less common (12%). There is no data for the share of households with cars in Freiburg, though the city counts 230,000 inhabitants and 93,340 cars (City of Freiburg 2021). This corresponds to 406 cars per 1000 inhabitants and is significantly lower than the German average (575 cars per 1000 inhabitants; Kraftfahrtbundesamt 2021). Differences in car ownership exist between Freiburg's districts, and commuters are known to generate growing traffic into the city (City of Freiburg 2021). The inner city sees the greatest parking pressure for its total of 565 public parking spaces (Garten- und Tiefbauamt 2021, personal communication).

To assess the spatial and temporal distribution of parking violations in the city of Freiburg, Germany, a three-step procedure was developed, combining qualitative and quantitative research. In a first step, open interviews were conducted with five officials from the regulatory agency ("Ordnungsamt Freiburg") in order to understand the general set-up and the conditions of parking management. Anonymity was ensured to all respondents. One interview was conducted in person (Gössling/Freytag; June 2020) and four by phone (Gössling; November 2020); these lasted between 30 min and 1.25 h. The interviews were based on an interview guideline and covered views on the traffic system and its evolution, perspectives on law enforcement, specifics of the parking system management in Freiburg, as well as aspects related to the field of work of the respondents (management, organization, service, legal, economics). An ethnographic approach, field notes, was chosen to note responses, as a digital recording may have made respondents self-conscious and more acutely aware of being 'on record'. Results are presented as themes including organization of controls, procedures of recording violations, views of parking prices and fees, other issues. As the interviews included personal viewpoints reflecting on the traffic situation and specific conflicts, all quotes are associated with respondent numbers (R1-R5), assigned in random order.

In a second step, three law enforcement officers were accompanied during their tours in different city districts in March 2021. This step was considered necessary to gain an understanding of the handling of parking violations, conflicts, and the in-situ control situation. Discussions with enforcement officers generated additional insights; these were also recorded as field notes, and later evaluated in terms of content relevant to this research project. Again, answers were anonymized as R6-R8. Last, a data-set of all registered parking violations was obtained from the regulatory agency in anonymized form. The data consists of 181,735 parking violations registered during 12,397 patrols equivalent to one 2–3 h shift, with 2–3 shifts per working day, between January 1st and December 31st, 2019. Parking violations are recorded with an exact address, date and time, and can thus be georeferenced. Controls are tighter during weekdays including Saturdays, when shops are open. The year 2019 includes 302 work days including Saturdays and 63 Sundays or bank holidays. Violations are recorded only during specific patrol times (Table 3). Parking is generally free outside office hours (19.00-09.00), though residential parking areas can only be used by car owners with residential permits. Violations not related to the payment of parking fees may still be recorded after 19.00 and until the shifts end.

Table 3
Patrol times in Freiburg.

Day	Time
Monday-Friday	08.00–23.25
Saturday	09.00–00.00
Sunday	11.00–17.00

Data was analyzed using different methodologies. To gain an overview of the distribution of parking violations (as registered), street data was translated into maps. This required a conversion of cleaned address data as registered by officers to a common address format. The R package Tidygeocoder (Cambon 2020) was used for this purpose, allowing for the generation of accurate point geometries (latitude/longitude). Registrations of violations that could not be treated in this way were geocoded on a case-by-case basis. Once all violations had been georeferenced, data was transferred into a map showing distributions and hot spots. As registrations of violations are a function of violation number and control frequency, patrol data (day/time of registration) was analyzed to understand when specific city districts are controlled. This was based on the occurrence of actual registrations of violations, with a minimum of one, as evidence that a patrol had occurred in a given location/area. Finally, the likelihood of detection of a violation in a specific part of the city at a specific time was calculated by dividing the city into 250 m × 250 m hexagons (Fig. 1), to correlate these with patrols.

The analysis focused on parking zone 1 and 2, where patrols are frequent. Zone 3 was not considered, as this area is only randomly controlled, for instance when residents report parking violations. For calculations, a hexagon is considered "controlled", if a patrol registered at least one violation within a given "hexagon-hour". Probabilities were then calculated on this basis: For instance, if a control occurred in a specific hexagon between 10.00 and 11.00 during two out of ten days, the probability of being detected in this hexagon at this time is 20%. This approach presupposes that parking violations are ubiquitous in time and space, an assumption confirmed by officers: Any patrol would register violations, as these occurred frequently. Notably, calculations of detection likelihoods are conservative, as they represent an assumption of continuous risks: in reality, once an officer has passed through a given area, the risk falls to zero during the remaining time of the hexagon-hour. Calculations of risks in regard to parking without paying fees are also conservative because officers will grant a 10-min excess parking time before a fine is issued.

Correlations are then translated into city-wide detection risks for weekdays including Saturdays. Risks depend on the frequency of controls, parking fees (€1.30, €2.60, €3.20 per hour, depending on zone), and fines (€10). This is used to calculate "detection risk thresholds", defined as the risk level at which it is "economically rational" to pay a fee, because the fine will exceed the fee saved in relation to control frequency (Table 4). For example, a fine of €10 corresponds to the parking fee paid for 3.1 h (€3.20 per hour) in zone 1. Consequently, it is economically rational to pay a fee where the detection risk is 32% or higher. Calculations were made in April 2021; the federal government introduced a new fee catalogue in July 2021 that increases fines for parking without having paid the fee to €20. This will double risks, i.e. the detection risk threshold will fall to 16% (in zone 1, *ceteris paribus*). The calculated risks for parking fee violations are illustrated by a color scheme for each hexagon-hour (Figs. 3 and 4), with green representing detection risks below the €20 fine threshold, yellow below the €10 threshold, and red "acute" risks. In other words: it is economically rational to always pay parking fees in red hexagons, to pay fees in yellow hexagons from July 2021 onwards, and to never pay fees in green hexagons. This situation will only change if control frequencies increase.

4. Results

4.1. Officials' views on traffic and parking violations

Parking fees in Freiburg generate an income of €3–5 million per year and there is an expectation on the side of the city that specific targets in income from parking are met (R2). Enforcement is organized in shifts, and only a share of traffic can be controlled within the existing system (R6). Apart from fines, close to 500 vehicles are towed away every year (R5). Enforcement officers control a total of 24 districts in Freiburg.

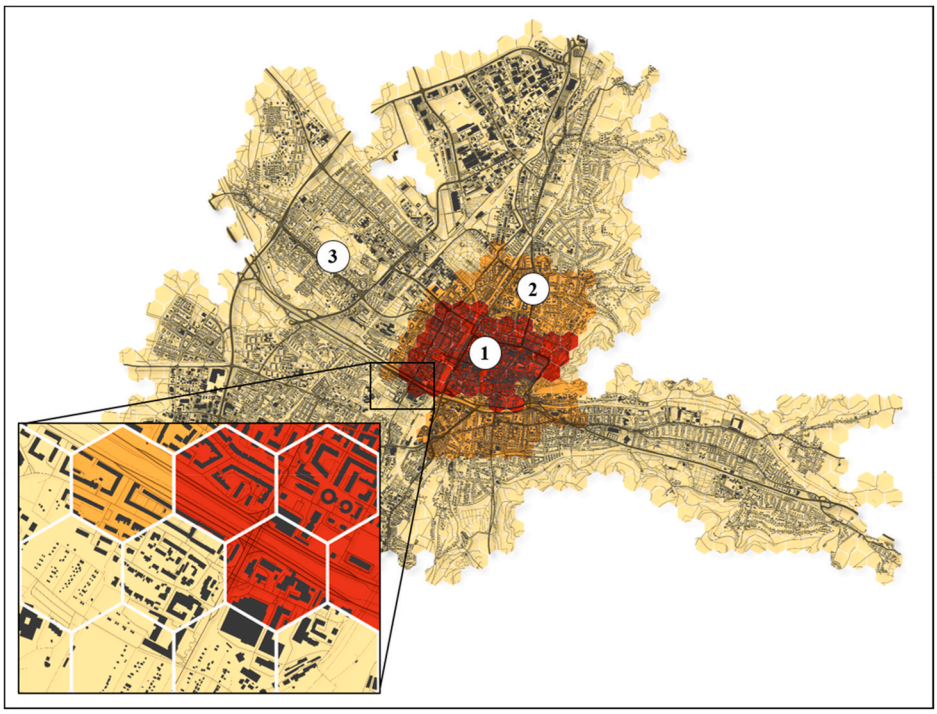

Fig. 1. Freiburg divided into hexagons, with parking zones 1-3.

Table 4
Detection risk thresholds (weekdays & Saturday).

Parking zone fee (per hour)	Detection risk threshold	
	Fine €10 (April 2021)	Fine €20 (July 2021)
Zone 1: €3.20	32%	16%
Zone 2: €2.60	26%	13%
Zone 3: €1.30	13%	7%

They are assigned a specific district each day, but they can independently choose their route within the district (R8). Focus is on the inner city, outskirts are controlled more rarely or when residents report violations. Enforcement officers use an app for registration. When a violation is established, the app is used to print tickets that are stuck under car wipers, while the information is also recorded electronically. Subsequent controls can detect longer-term parking violations that result in additional fines (R6). The general perception of officers is that the price of parking in Freiburg is low, both for resident permits and public parking.

Officials suggest that low fines make it attractive to gamble, i.e. not to pay parking fees or to engage in other parking violations (R2).

Fig. 2. Distribution of registered parking violations in Freiburg, 2019

Parking zone one:

Time slot *t*	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00
Hexagone #	08:59	09:59	10:59	11:59	12:59	13:59	14:59	15:59	16:59	17:59	18:59	19:59	20:59	21:59	22:59
2534	2.0%	7.6%	14.9%	10.6%	8.6%	11.9%	10.9%	12.3%	20.2%	9.6%	6.3%	2.3%	5.0%	11.6%	12.3%
2563	0.7%	0.3%	1.3%	2.0%	0.3%	0.7%	1.3%	2.0%	1.3%	0.7%	0.0%	0.7%	1.0%	2.6%	2.0%
2564	0.3%	2.6%	5.0%	3.0%	5.6%	5.3%	6.0%	7.6%	9.9%	2.6%	1.0%	1.3%	1.0%	3.3%	2.0%
2592	4.3%	8.9%	17.9%	16.2%	13.2%	13.9%	18.2%	19.2%	27.8%	17.2%	5.6%	2.6%	4.0%	11.3%	12.6%
2593	0.7%	2.6%	6.0%	6.6%	4.6%	5.3%	7.0%	8.6%	14.9%	5.0%	2.3%	1.7%	1.0%	2.3%	6.0%
2621	7.3%	22.2%	12.3%	9.3%	16.2%	11.6%	9.9%	8.3%	10.6%	7.3%	10.6%	3.6%	3.6%	12.3%	6.3%
2622	0.0%	2.0%	4.3%	3.3%	1.7%	5.0%	3.0%	3.3%	7.3%	2.6%	2.0%	0.0%	0.0%	0.0%	0.7%
2623	1.0%	3.0%	6.0%	7.3%	1.0%	4.3%	7.6%	8.3%	15.2%	5.0%	2.6%	1.3%	3.3%	3.0%	5.6%
2649	1.3%	9.9%	8.6%	7.0%	11.3%	6.6%	7.3%	7.3%	12.6%	4.6%	6.0%	3.6%	5.0%	9.9%	3.3%
2650	23.2%	27.8%	23.2%	20.5%	23.8%	23.5%	15.9%	16.2%	20.2%	18.2%	14.6%	20.5%	29.5%	30.1%	12.6%
2651	10.6%	9.3%	13.2%	12.9%	6.0%	10.3%	11.3%	9.9%	13.2%	8.9%	4.0%	4.3%	3.0%	2.6%	2.0%
2679	12.9%	29.5%	23.2%	12.9%	24.8%	24.2%	13.6%	7.9%	15.9%	17.9%	15.2%	13.2%	21.5%	30.5%	11.3%
2680	21.2%	48.3%	33.1%	42.4%	35.4%	35.4%	36.4%	28.5%	34.8%	36.8%	31.5%	24.8%	17.2%	20.2%	12.3%
2681	0.0%	5.3%	13.2%	11.6%	7.9%	11.6%	11.3%	12.6%	14.9%	8.6%	3.3%	1.0%	1.0%	2.3%	1.0%
2707	4.0%	39.7%	33.4%	31.8%	40.7%	32.5%	29.8%	27.5%	29.1%	21.9%	24.8%	7.6%	8.6%	19.9%	5.6%
2708	12.6%	14.6%	14.9%	16.2%	11.9%	16.2%	9.9%	8.9%	13.9%	11.3%	9.9%	14.9%	22.2%	20.9%	7.6%
2709	40.7%	55.3%	43.0%	24.2%	50.0%	37.1%	35.4%	28.8%	31.8%	31.5%	34.1%	15.6%	14.6%	15.2%	5.0%
2737	6.0%	37.4%	32.1%	17.9%	34.4%	34.1%	31.1%	19.9%	23.8%	24.8%	20.5%	8.3%	9.9%	12.6%	4.6%
2738	25.5%	61.6%	44.4%	46.7%	53.3%	43.0%	44.4%	39.4%	41.4%	35.8%	32.8%	15.9%	11.9%	12.6%	4.3%
2739	2.0%	33.1%	28.1%	16.2%	20.9%	16.9%	14.9%	13.9%	15.2%	8.3%	7.3%	0.0%	0.3%	0.3%	0.0%
2765	27.5%	53.0%	47.4%	23.5%	49.3%	42.4%	41.1%	38.4%	35.4%	41.1%	32.5%	15.6%	12.9%	22.5%	5.6%
2766	15.6%	14.2%	8.3%	14.9%	10.3%	15.2%	10.9%	7.3%	11.3%	6.3%	4.6%	2.0%	4.6%	7.9%	1.0%
2767	12.3%	42.4%	30.5%	25.8%	36.4%	31.1%	25.8%	21.2%	22.5%	16.9%	18.9%	7.9%	6.6%	6.6%	2.3%
2794	8.9%	26.8%	15.6%	7.0%	21.2%	14.9%	12.3%	13.9%	15.6%	8.9%	7.9%	1.3%	0.3%	1.0%	0.0%
2795	33.4%	60.9%	46.7%	33.1%	55.6%	44.7%	45.0%	37.7%	43.7%	41.7%	37.7%	19.9%	22.5%	33.8%	12.9%
2796	29.1%	33.8%	31.5%	35.1%	34.1%	41.4%	35.1%	29.5%	30.5%	29.5%	28.1%	18.5%	15.6%	16.6%	10.9%
2797	2.3%	29.8%	28.5%	19.9%	19.9%	19.2%	14.2%	14.2%	14.6%	7.9%	5.3%	0.0%	0.0%	0.0%	0.0%
2823	19.5%	43.4%	25.5%	20.2%	37.7%	25.5%	27.5%	22.5%	26.8%	23.2%	20.9%	8.9%	9.9%	13.2%	5.3%
2824	2.6%	4.0%	2.6%	6.0%	3.3%	3.0%	2.6%	2.0%	3.3%	2.3%	0.7%	1.0%	0.3%	1.0%	1.3%
2825	12.9%	33.1%	29.8%	19.5%	35.1%	34.4%	25.5%	24.8%	26.8%	23.5%	20.9%	10.3%	5.6%	5.6%	4.3%
2852	11.3%	27.2%	15.6%	7.0%	13.9%	13.6%	11.3%	14.2%	14.6%	7.3%	3.6%	1.3%	2.3%	8.3%	3.0%
2853	19.9%	21.5%	9.6%	23.8%	16.6%	17.5%	18.9%	14.9%	17.9%	14.2%	12.9%	10.3%	13.2%	20.2%	9.6%
2854	19.9%	55.0%	32.5%	23.5%	47.4%	30.8%	37.1%	31.5%	29.1%	30.1%	26.8%	16.9%	8.6%	10.3%	6.0%
2882	8.3%	8.3%	2.3%	10.3%	10.6%	6.3%	9.6%	4.6%	4.3%	4.6%	3.3%	1.3%	4.3%	3.6%	2.6%
2883	3.0%	48.3%	40.4%	11.3%	30.5%	23.8%	24.8%	22.8%	21.9%	17.5%	15.2%	4.3%	6.3%	10.3%	5.3%
2912	12.3%	47.4%	27.8%	12.6%	40.4%	18.5%	29.1%	23.8%	23.2%	21.2%	20.2%	4.6%	3.6%	7.3%	4.3%

Fig. 3. Control probability in zone 1 (inner city), weekdays and Saturday.

Officials expect that parking violations will decline when fines are raised (R3). However, fees and fines are in an equilibrium, as one enforcement officer points out, observing that "gambler" numbers increased when parking fees were raised in Freiburg: "now people poker for real" (R6). This suggests that drivers compare fees and fines, in what one officer referred to as "parking offender philosophy" (R2). Another officer noted that given low fine levels, frequent controls are important: "if it's cheap, people ponder if they should risk a fine" (R5).

Even though parking garages are cheaper than on-road parking, they are unpopular with drivers (R2), and hence rarely fully occupied (R4). Officials also reported that a share of repeat offenders would violate parking rules over and over again (R3), sometimes collecting 50 fines within a year (R5). Yet, officials affirm a "soft" approach to enforcement: "Our goal is accomplished when people park legally" (R2), with officers highlighting the objective of "educational effects". There is also a sense of understanding for the lack of parking in some districts (Zähringen, Wiehre, Stühlinger), prompting the agency to tolerate some parking violations: "People would have to walk 800 m. That's when we ask: what is a driver supposed to do?" (R2). Officials emphasized that in some districts, parking permits exceed available parking and that specific habits have developed over years of tolerating violations (R2, R4). The new city council has put more pressure on the regulatory agency to enforce existing laws, for instance in regard to parking on pedestrian walks (R5). Yet, there is a view that tighter controls are not meaningful, as parking violations "are constant on a specific level", and because more controls will not cover the cost of additional patrols (R3). Tighter controls are also believed to lead to conflicts; for instance, the strict enforcement of 'no parking on pedestrian walks' is considered impossible (R2, R3).

Officials and enforcement officers share the view that the evaluation of specific situations is a continuous area of conflict, where the opinions and demands of different traffic user groups have to be compared and weighted against each other. There is a shared view that some violations entail fines that are too low to be meaningful and that space demand for vehicles exceeds provisions (R4). "If everyone parked correctly, there wouldn't be enough parking" (R3). Parking pressure increases everywhere, even in semi-urban districts, industrial areas, and park & ride locations. As a result, incoming commuters increasingly push into residential areas. Officials reasoned that the car would have to be displaced at some point, in favor of bicycle and walking or e-scooters (R3). People walking and cyclists increasingly often complain about parking violations: "I used to get five letters per week, today I get 30 emails per day" (R4). There are also growing conflicts over "rights" to parking, with residents asking for all parking to be reserved for residents. This, however, is not possible, as distributions are dictated by the national traffic code (R4). Larger cars, specifically SUVs, enhance the problem: "we acknowledge this as a problem, but that's that. [..] We have to enforce the transition towards fewer cars. That's also what people suggest

Parking zone two:

Time slot / Hexagone ID	08:00 08:59	09:00 09:59	10:00 10:59	11:00 11:59	12:00 12:59	13:00 13:59	14:00 14:59	15:00 15:59	16:00 16:59	17:00 17:59	18:00 18:59	19:00 19:59	20:00 20:59	21:00 21:59	22:00 22:59
2476	0.7%	2.3%	5.3%	4.3%	3.6%	7.6%	3.6%	5.6%	9.3%	6.0%	3.0%	1.3%	2.0%	3.6%	2.6%
2477	0.7%	7.0%	15.6%	14.6%	12.6%	12.6%	11.6%	14.2%	16.9%	6.3%	1.0%	0.0%	1.3%	0.3%	2.3%
2506	1.0%	5.3%	12.3%	12.6%	7.9%	9.9%	8.9%	11.3%	17.5%	5.6%	1.3%	1.3%	1.7%	1.3%	2.0%
2507	2.6%	5.0%	11.3%	10.3%	8.9%	9.9%	7.3%	8.9%	12.9%	6.0%	2.3%	0.3%	1.3%	2.0%	4.6%
2535	0.7%	1.7%	4.3%	5.3%	2.6%	4.6%	4.0%	3.3%	11.6%	5.0%	2.3%	1.3%	1.0%	1.3%	3.6%
2561	0.3%	4.3%	7.9%	5.0%	5.0%	4.6%	5.6%	3.6%	6.0%	5.0%	1.7%	0.7%	1.0%	4.3%	3.6%
2562	0.0%	1.3%	0.7%	0.3%	0.7%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2565	1.0%	5.0%	8.6%	8.6%	8.9%	7.9%	6.3%	10.3%	15.9%	8.6%	2.6%	1.7%	4.6%	7.0%	9.9%
2590	1.0%	2.6%	4.6%	5.0%	1.3%	3.3%	4.0%	3.0%	5.6%	2.3%	1.3%	0.3%	0.3%	2.3%	1.7%
2591	0.7%	1.7%	6.3%	5.0%	3.3%	2.6%	4.0%	4.0%	3.6%	2.3%	0.7%	0.0%	0.3%	1.0%	0.0%
2594	1.7%	3.0%	7.0%	4.0%	1.7%	5.3%	3.0%	7.9%	9.3%	4.3%	1.3%	1.3%	0.7%	3.0%	4.0%
2619	2.0%	5.3%	7.6%	6.3%	2.6%	4.0%	4.6%	4.0%	5.0%	1.3%	1.7%	0.7%	0.3%	2.3%	2.3%
2620	6.0%	7.9%	9.9%	9.3%	6.6%	6.6%	6.6%	7.6%	10.3%	2.0%	3.0%	1.3%	1.3%	2.6%	0.0%
2624	2.0%	7.9%	11.3%	11.6%	8.9%	12.3%	12.6%	12.3%	17.9%	8.3%	0.3%	0.0%	0.0%	0.0%	0.7%
2648	2.3%	5.6%	7.9%	7.3%	3.6%	7.0%	4.0%	4.3%	7.0%	3.0%	0.0%	0.0%	0.0%	1.0%	0.3%
2652	0.3%	3.0%	6.6%	5.3%	3.3%	6.6%	7.3%	7.9%	13.3%	4.0%	0.7%	0.7%	0.0%	0.0%	0.0%
2677	0.7%	3.0%	5.3%	3.6%	2.0%	3.0%	3.0%	3.6%	3.6%	0.7%	0.3%	1.0%	0.0%	0.3%	0.7%
2678	1.0%	4.6%	7.6%	7.3%	3.6%	7.0%	6.3%	6.3%	7.0%	4.6%	0.7%	0.7%	1.3%	2.0%	1.0%
2682	1.0%	0.3%	0.3%	0.3%	0.7%	0.7%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2706	1.3%	7.6%	7.3%	8.6%	6.0%	3.6%	6.6%	6.3%	7.0%	3.3%	1.3%	1.3%	0.0%	1.3%	1.3%
2710	2.0%	10.9%	8.9%	7.0%	7.9%	5.0%	6.0%	8.3%	8.6%	3.3%	1.0%	0.0%	0.0%	0.0%	0.0%
2711	7.6%	4.3%	2.6%	2.0%	1.7%	4.0%	1.0%	0.3%	0.7%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
2735	4.6%	6.3%	10.6%	11.3%	9.3%	8.3%	8.6%	8.3%	10.6%	5.0%	3.3%	1.3%	1.0%	4.0%	3.0%
2736	3.3%	25.2%	19.9%	14.9%	29.8%	19.5%	17.9%	19.9%	19.5%	16.2%	8.9%	1.7%	0.7%	2.3%	1.7%
2740	6.0%	3.6%	3.3%	6.0%	3.3%	3.6%	1.0%	0.3%	0.7%	0.7%	0.0%	0.0%	0.0%	0.3%	0.0%
2764	3.3%	5.0%	6.3%	7.6%	6.3%	6.0%	6.6%	5.0%	5.0%	3.0%	2.0%	0.0%	0.0%	0.3%	0.0%
2768	2.0%	6.3%	6.3%	3.6%	3.3%	3.6%	1.0%	2.0%	3.3%	0.7%	0.0%	0.3%	0.0%	0.0%	0.0%
2769	1.0%	1.3%	1.3%	0.7%	1.0%	1.0%	1.7%	1.0%	2.6%	0.3%	2.0%	1.3%	0.7%	3.6%	0.7%
2793	0.0%	2.6%	6.6%	8.3%	6.6%	7.9%	6.3%	4.6%	5.6%	2.6%	1.3%	0.0%	0.0%	0.0%	0.0%
2798	17.2%	25.8%	16.3%	16.2%	17.2%	14.9%	15.6%	14.2%	17.2%	11.6%	9.6%	0.3%	0.0%	0.3%	0.0%
2822	0.3%	2.3%	3.6%	2.3%	2.0%	4.6%	5.0%	3.0%	4.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
2826	1.7%	11.9%	13.6%	12.6%	10.6%	11.9%	9.9%	9.9%	7.6%	3.3%	1.0%	0.0%	0.0%	0.0%	0.0%
2827	0.7%	0.3%	6.6%	4.3%	2.3%	2.0%	2.6%	2.6%	1.3%	1.0%	1.0%	0.3%	0.0%	1.0%	0.0%
2851	0.0%	0.3%	4.3%	7.0%	4.6%	9.3%	7.9%	3.6%	6.6%	3.3%	1.7%	0.0%	1.0%	1.0%	0.3%
2855	0.3%	13.9%	15.6%	11.3%	14.3%	13.2%	10.3%	9.6%	9.6%	4.6%	2.3%	0.0%	0.0%	0.0%	0.3%
2856	1.3%	7.3%	15.2%	13.9%	10.3%	7.6%	9.9%	10.3%	9.3%	2.3%	2.3%	0.0%	0.0%	0.0%	0.7%
2881	13.6%	17.9%	13.2%	14.2%	12.3%	13.9%	8.6%	13.2%	14.6%	6.0%	5.0%	3.3%	4.6%	13.2%	6.6%
2884	1.0%	8.3%	15.2%	14.6%	10.9%	10.9%	8.3%	9.6%	8.3%	4.3%	1.7%	0.3%	0.0%	0.0%	0.3%
2885	4.3%	7.6%	15.6%	12.9%	12.3%	8.3%	9.3%	7.9%	8.6%	2.6%	2.0%	0.7%	0.3%	0.0%	0.3%
2910	7.9%	8.3%	10.3%	8.6%	5.6%	10.6%	5.6%	7.6%	7.6%	4.6%	3.3%	0.7%	1.7%	7.9%	1.0%
2913	0.3%	4.3%	9.6%	10.9%	7.6%	5.3%	7.0%	7.9%	7.9%	3.0%	1.3%	0.0%	0.0%	0.0%	0.0%
2914	0.0%	4.0%	8.3%	7.9%	5.0%	4.0%	4.6%	5.0%	5.3%	0.7%	2.0%	0.3%	0.0%	0.0%	0.0%
2939	5.0%	6.6%	7.0%	7.3%	9.6%	6.6%	3.3%	5.0%	3.0%	3.0%	3.0%	3.0%	4.3%	16.6%	7.3%
2941	0.3%	7.9%	7.3%	6.3%	8.6%	6.3%	6.0%	6.0%	6.6%	2.3%	0.3%	0.0%	0.3%	0.0%	0.0%
2942	0.7%	2.6%	8.3%	7.9%	6.3%	6.3%	6.3%	4.0%	6.0%	1.7%	1.3%	0.0%	0.0%	0.0%	0.0%
2943	0.0%	7.9%	7.6%	7.3%	7.3%	3.0%	4.0%	7.6%	6.0%	1.7%	2.0%	0.0%	0.3%	0.7%	0.3%
2968	0.3%	2.0%	2.6%	1.7%	0.3%	5.0%	1.7%	3.0%	3.0%	1.0%	0.7%	0.7%	0.0%	2.0%	0.0%
2971	0.7%	1.0%	6.6%	7.9%	4.3%	4.3%	5.6%	3.0%	4.6%	1.3%	0.3%	0.3%	0.0%	0.3%	0.0%
2972	0.3%	1.0%	2.6%	4.3%	2.3%	2.0%	1.3%	1.3%	1.7%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
2997	3.6%	5.6%	6.6%	5.0%	8.6%	4.6%	2.3%	3.3%	1.7%	0.0%	1.0%	0.3%	0.7%	1.7%	2.0%
3000	0.0%	0.0%	3.3%	4.3%	2.0%	1.7%	2.0%	0.7%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%
3001	0.0%	1.0%	2.0%	1.3%	1.0%	0.7%	1.0%	0.3%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3029	0.0%	0.3%	0.7%	0.0%	0.3%	0.0%	0.3%	0.3%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3030	0.3%	1.3%	1.7%	1.0%	1.7%	0.3%	0.0%	0.0%	1.0%	0.3%	0.0%	0.0%	0.3%	0.3%	0.0%

Fig. 4. Control probability in zone 2, weekdays and Saturday.

increasingly often. They [literally] bomb us with photographs saying 'it cannot go on like this'" (R4). Officials "expect the situation to get worse" (R5), though they also caution that it is not realistic to expect rapid change, as some habits, such as parking on pedestrian walks, are firmly established. There is also driver resistance, as evident from some organized events against parking restrictions, as well as resistance that is political, as for example the social democrats do not support a transition (R1). There is a sense that opinion over desirable transport systems is increasingly divided, polarized and radicalized. There are those who see a future with fewer cars, more cycling, walking and public transports; and those who are attached to the car, with statistics showing that car density increases in Freiburg, as do the average distances driven per year (R1).

4.2. Spatial and temporal distribution of parking violations

The analysis of the georeferenced data shows clear parking violation patterns (Fig. 2). Most parking violations are recorded within the inner city, with some concentration in adjacent areas. Individual violation incidents are evident in residential areas throughout the city.

The analysis confirms that not paying parking fees is economically rational. Fig. 3 illustrates the probability of parking violations being detected in the city center (zone 1), for each hexagon-hour. At fine levels of €10, it was economically rational (at the time of writing, in April 2021) to not pay the fee in 86.1% of hexagon-hours, i.e. when detection likelihoods are below the threshold of 32% (75 out of 540 hexagon-hours; green & yellow fields). As fees have been doubled to €20 in July 2021, it is now rational to not pay a fee during 61.3% of hexagon-hours (209 out of 540 hexagon-hours, green fields). Fig. 3 also shows that control risks are specifically high in a few hexagons, where control likelihoods are high throughout the day.

In zone 2, it was rational to not pay parking fees 99.9% of the time, as the likelihood of detection was above 26% in only one out of 810 hexagon-hours. Even though the €10 fine was higher in relation to fees in zone 2, fewer controls reduce detection risks. Raised fines in July 2021 increased risks, but it is still economically rational to not pay fees where detection risks are below 13%. This is the case during 45 out of 810 hexagon-hours, i.e. even with the doubled fee, it will remain economically rational during 94.4% of hexagon hours to not pay parking fees in zone 2. It needs to be noted that figures do not consider the varying number of parking spaces in each hexagon in zone 1 and 2, which are not known.

Finally, zone 3 is characterized by the lowest parking fees and detection risks. While data does indicate very low detection risks, there are too few observations of violations in this zone to draw statistically valid conclusions. This is equally true for Sundays and bank holidays in all three parking zones. It should also be noted that parking violations such as parking outside demarcated areas can entail more significant fines. Figs. 3 and 4 refer to parking fees and fines.

Data was then evaluated to determine the correlation between patrols and parking violations, as well as fines and violations. As fines are set at the federal level, focus is here on control densities. Fig. 5 shows a positive linear and statistically significant correlation between control density and parking violations (entire data set; Spearman's ρ (rho); $r = 0.83$; $p=<0.0001$). This suggests that increasing control frequencies (currently between zero and nine during the week) can be expected to increase registered violations proportionally, as there is no evidence of saturation. Specific regression analyses for zones 1 and 2 (weekdays and Saturday) suggest that an increase in control densities from 25 to 40 per day in zone 1 will lead to a rise in detected violations by 36% ($r = 0.64$; $p=<0.0001$). In zone 2, an increase from 4 to 8 patrols will lead to an increase in detected violations by 55% ($r = 0.80$; $p=<0.0001$). The expectation is thus that in zone 1, increasing controls by 60% will lead to a rise in registered violations from 92,306 to 125,508 (weekdays and Saturday) and additional fines amounting to €332,000 (at €10 per fine). In zone 2, doubling controls from 4 to 8 per day will see a rise in registered violations from 41,297 to 63,876, corresponding to €225,000 in fines.

Based on working schedules of 30 officers and the number of daily violations registered throughout the city.

Theoretically, control densities reach an optimum when no welfare losses occur, i.e. when detection risks are 32% or higher in zone 1 and 26% or higher in zone 2, throughout all hexagon-hours (at €10). Data also allows for the calculation of the level of fines that would make it economically rational for drivers to pay fees during half of all hexagon-hours. To achieve this, fines would have to increase to €25.43 in zone 1 and €98.15 in zone 2. This is the point where the likelihood of detection and the associated cost of the fine are equal to the price of the parking fee. Fines as established in July 2021 should thus be too low to influence driver behaviour. Results also point at the importance of structured fines, as these need to be higher where controls are less frequent.

5. Discussion and conclusions

Interviews with officials and city statistics reveal that parking pressure in Freiburg is high and growing. From an urban planning and local governance perspective, it is thus desirable to discourage car ownership and commuting into town, for which parking management is essential. Results suggest that in Freiburg, controls do cover the entire city, though control frequencies vary. As findings indicate, a significant share of violations remains undetected, representing a welfare loss to society and a subsidy to drivers. This makes the car more attractive, and thus represents a barrier to transport system change. The enforcement agency maintains that a tough approach to enforcing parking rules is difficult, as it will result in public backlash. There is also a view that the income from parking is already high and that more frequent controls will not yield significantly more revenue, while entailing an additional employment cost. Hopes are placed in higher fines to increase parking violation risks. Officials and officers also highlight the positive effects of car sharing opportunities and plans for lower minimum parking requirements in new residential areas. The overall expectation is that various measures will somehow reduce parking pressure. However, there is no longer-term vision for the transport system, including trends towards growing numbers of SUVs or growing car ownership levels per household.

The analysis of parking violations provides new insights. Even though a high number of parking violations are registered every year,

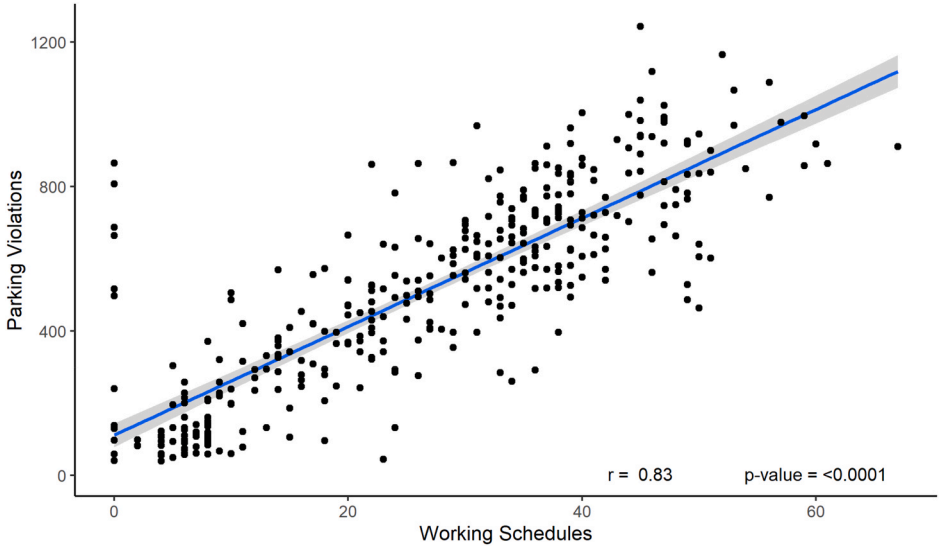

Fig. 5. Correlation between patrols and registered parking violations.

results show that detection risks are low in relation to fines. The current system thus encourages opportunistic behaviour: In most parts of the city, it is economically rational not to pay parking fees during most of the day. Three options are available in principle to make parking gambles less attractive: i) to reduce parking fees, ii) to increase fines in relation to fees, or iii) to increase control densities. With regard to i), reduced fees will not resolve the problem of parking violations unrelated to fee payments. Reduced parking fees will also encourage automobility. Rather, the evidence is that parking fees should be raised, also because they continue to be low in comparison to other European cities. This will presuppose that fines are raised in tandem, an option that is however unavailable to cities, as fine levels are set by the federal government. While this confirms the importance of empowering cities to make their own decisions in relation to both fees and fines, the only option currently available to the enforcement agency in Freiburg is thus to increase control densities. This should possibly go hand in hand with a tougher interpretation of parking regulations. To employ more stuff for this purpose is economically viable.

Several other insights with relevance for transport planning emerge from this research. First, findings confirm that fees, fines and controls are in an equilibrium. Mogridge et al. (1987) proposed this originally for transport mode choices, but similar equilibria exist in other contexts: Available parking, fees, fines and controls determine the attractiveness of car ownership and vehicle use. This again influences negative externalities such as noise and air pollution, as well as cruising for parking, or higher injury risks. Where imbalances in parking equilibria exist, this will have repercussions for automobility, opportunistic behaviour, and welfare losses.

Overall, results suggest that city planners and decision-makers need to carefully consider interrelationships of space, pricing and policing. Basic federal laws in Germany make it impossible for cities to efficiently organize parking. Power over parking decisions should be given to cities (Kirschner and Lanzendorf 2020), though on the basis of *de minimis* federal laws setting baselines. This will provide opportunities for progressive cities to more rapidly transform transport systems.

Author statement

Conceptualization: Andreas Humpe, Stefan Gössling, Tim Freytag, Rafael Hologa, Nils Riach; Data curation: Andreas Humpe, Rafael Hologa, Nils Riach; Formal analysis: Andreas Humpe, Rafael Hologa, Nils Riach, Stefan Gössling; Methodology: Stefan Gössling, Tim Freytag, Andreas Humpe; Project administration: Stefan Gössling, Andreas Humpe; Validation: Andreas Humpe, Stefan Gössling, Tim Freytag, Nils Riach, Rafael Hologa; Visualization: Nils Riach, Rafael Hologa, Andreas Humpe; Writing – original draft: Stefan Gössling; Writing – review & editing: Stefan Gössling.

Declaration of competing interest

None.

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