SHARE-North Squared

Parking for sustainable cities

- **How to understand innovative parking development**

Author:

Michael Johansson[a]

[a] department of service studies, Lund university, Campus Helsingborg, Sweden

This study has been carried out by Tekn. Dr. Michael Johansson at the Inst. for Service Studies at Lund University, Campus Helsingborg. The work was carried out within the framework of the ongoing international Interreg North Sea research project SHARE-North Squared (SN^2):

Interreg North Sea

Co-funded by the European Union

SHARE-North Squared

SHARE-North squared (SN^2) has the following objectives:

The project aims to increase the sustainability, resource and spatial efficiency of real estate developments as well as the affordability of housing by integrating shared mobility as a means of supporting multimodal travel behavior and for reducing car ownership, car dependency and the demand for parking.

The author himself is responsible for the content with interpretations, calculations and final results. Note that the study is a general review of Swedish municipalities' parking situation.

The author would like to take the opportunity to express a big thank you to all the people who took the time to contribute in various ways with input to the study.

Michael Johansson

Keywords: Parking, pricing, space impact, parking requirement, urban natural ecosystem services, sustainable urban planning

Innehåll

1. Introduction 4
1.1. Background 4
1.2. Problematization 4
1.3. Aim and purpose of the report 6
2. Theoretical framework 6
2.1. Conceptual foundations 6
2.1.1. Smart growth 6
2.1.2. New urbanism 6
2.1.3. Location efficient development 6
2.1.4. Transit oriented development 7
3. The context of urban planning 7
3.1. The example of Sweden 7
3.2. General process for developer who wants to build new housing areas in Sweden 7
3.3. Relevant stakeholders in the construction and building market 9
4. Parking management 11
4.1. Local policies 11
4.2. Additional effects of parking 12
4.2.1. Effects of parking on car ownership and use 12
4.2.2. Effects of parking on land use 12
4.3. Parking policies 13
4.3.1. On-street parking 13
4.3.2. Residential parking 13
4.4. Parking as a service 14
4.4.1. Shared Parking 14
4.5. Parking facility costs 15
4.6. Parking fees and regulations 15
4.6.1. On-street parking 16
4.7. Efficient parking pricing 16
4.8. The new parking paradigm 16
4.9. Additional policy issues 18
4.9.1. Car-sharing 18
4.9.2. Public transport 18
5. How to measure parking 18
5.1. Monetary value of parking 18
5.2. Urban space value of parking 20
5.3. Ecological value of parking 22
6. Discussion 24
7. Conclusions 26
8. References 27

1. Introduction

1.1. Background

The urbanization phenomenon has significantly increased and cities around the world are facing significant challenges when it comes to transportation. The number of cars on the roads, leading to congestion, air pollution, and greenhouse gas emissions has highly increased since then. As now cities seek to reduce their carbon footprint and improve the quality of life for their residents', parking policy is increasingly being recognized as a key area where changes can be made.

Stakeholder engagement is therefore crucial for the development of innovative parking ordinances as it ensures that the perspectives and needs of various stakeholders are considered in the decision-making process. Developing innovative parking ordinances involves adopting creative and forward-thinking approaches to address urban mobility challenges, promote sustainable practices, and enhance the overall urban environment.

Developing "living as a service" (LaaS) solutions involves creating innovative and integrated services that enhance various aspects of daily life for individuals. The concept is often associated with the integration of technology to provide seamless, personalized, and efficient experiences and different modes of transportation.

Most parking jurisdictions around the world require a certain number of off-street parking spaces at most homes. Parking minimums increase parking supply beyond what property owners would voluntarily provide, to improve motorists' convenience and reduce eventual spillover problems. Property owners, in that perspective, force many households to pay for expensive parking facilities they don't perhaps need, and increase total housing costs as a result.

There are other ways to satisfy parking demands.

Eliminating parking minimums does not necessarily eliminate parking supply, but it simply allows developers to provide parking based on market demands. Hence, it leads to separation resulting in that parking rented separately from building space, so households only pay for the number of spaces they actually need, and with that encourages more efficient parking management so fewer spaces are needed to serve parking demands.

Many jurisdictions are reforming parking policies for equity and efficiency's sake. These reforms can typically reduce the costs of basic, lower-priced housing by 10-20%, and provide additional savings and benefits by increasing affordable housing in high-opportunity multimodal neighborhoods (Litman, 2023). Parking policies have significant environmental and economic implications, which have often been left unconsidered (Russo et al, 2019).

1.2. Problematization

Parking is an essential component of the transportation system. Vehicles must park somewhere. Parking convenience affects the ease of reaching destinations and therefore affects overall accessibility. Parking is not just one of the most important intermediate goods in the economy, it is also a vast use of land (Inci, 2014). Despite the facts that cars are parked 95% of the time (Shoup, 2005) and that vast amounts of land are used for parking (Jakle &

Sculle, 2004), more focus has been on trying to deal with the problems caused by cars when they are in motion rather than when they are parked (Inci, 2014). In fact, cars create perhaps less visible but equally serious problems when parked (Shoup, 2005). This perhaps makes parking one of the most important intermediate goods in the modern market economy (Hasker & Inci, 2014).

We know that underpriced parking is particularly an issue for some special forms of parking. For example, employers often provide parking to employees at no cost, shopping malls typically provide parking to their customers for free, and cities provide parking to residents at nominal prices lower than market prices.

Parking facilities are at the same time a major cost to society, and parking conflicts are among the most common problems facing designers, operators, planners and other officials. Such problems can be often defined either in terms of supply (too few spaces are available and/or somebody must build more parking) or in terms of management (available parking are used inefficiently and should be better managed).

We therefore often hear that buildings “generate” parking demands, but of course we know that it is incorrect, parking demands are generated by vehicles, and the number of vehicles owned by residents can vary significantly. For example, a three-bedroom apartment could be occupied at various times by households that own zero, one, two or even three vehicles.

To ensure sufficient parking to serve their needs, zoning codes often require two parking spaces for a three-bedroom apartment although that will sometimes be too many and sometimes too few for occupants’ actual demands. It is not an easy task. But these requirements are in many ways both inefficient and unfair and they most certainly increase housing costs, vehicle ownership and sprawl, and force many households to pay for costly parking spaces they don’t even need.

Hence, in every city as vehicle traffic increases, so does the demand for parking. When car drivers cannot find a parking space nearby, they tend to start complaining, spend a lot of time searching for a space, and sometimes park inconsiderately or illegal.

Parking management can be an integral part of the broader concept of "living as a service" (LaaS), especially in urban environments and new housing developments where efficient use of space and scarce resources is crucial. Efficient parking management is essential for sustainable urban mobility services within a LaaS framework. As part of the integrated living experience, individuals may have access to shared transportation options. Proper parking management ensures the availability of parking spaces for these shared vehicles.

We also know that effective parking management helps to reduce traffic congestion by optimizing parking space utilization. This aligns with the goals of LaaS, which often aims to create more sustainable and efficient urban living environments especially in new housing development areas. And, as part of a down-stream effect environmentally conscious living approach, parking management can promote the use of electric mobility and allocate spaces for eco-friendly transportation options.

1.3. Aim and purpose of the report

This report investigates typical residential parking requirements, estimates the costs of various types of parking facilities, and their impacts on housing costs, vehicle travel and development patterns.

The report also discusses optimal parking supply and factors that affect parking demands. This report should be of interest to policy makers, planning practitioners, developers, affordability advocates and anybody who wants more affordable, fair and livable communities.

Finally, This report reviews the relevant literature to provide a deeper understanding of the main environmental and economic consequences of common parking policies.

2. Theoretical framework

2.1. Conceptual foundations

The theoretical frameworks in this report provide a conceptual foundation that guides the design, execution, and a certain interpretation of this study. The theoretical framework, in this report based on smart growth, new urbanism, location efficient development, transit oriented development, helps in clearly defining and understanding the key concepts, variables, and relationships about parking for sustainable cities.

The theoretical framework also helps to guide the literature review process in this report by directing to relevant scientific studies and it helps in organizing existing knowledge, identifying gaps, and understanding the evolution of ideas in the chosen parking research area:

2.1.1. Smart growth

Smart growth is an urban planning and development approach and theory that emphasizes sustainable and responsible land use, community design, and sustainable transportation strategies. The aim of smart growth is to create vibrant, livable communities that balance economic development, environmental sustainability, and social equity. This approach seeks to address challenges associated with urban sprawl, congestion, and environmental degradation by promoting compact, efficient, and well-connected development patterns.

2.1.2. New urbanism

New Urbanism is an urban planning and design theory that emerged in the United States in the 1980s as a response to the challenges posed by suburban sprawl and the desire to create more sustainable, walkable, and community-oriented urban environments. New Urbanism seeks to address issues such as automobile dependence, social isolation, and environmental degradation by promoting compact, mixed-use neighborhoods that prioritize pedestrians, cyclists, and public transit.

2.1.3. Location efficient development

Location efficient development is a theory focusing on creating compact, mixed-use, and transit-oriented communities, with an emphasis on reducing residents' dependency on personal automobiles. The goal of location efficient development is to design neighborhoods and developments that provide convenient access to various amenities and services while promoting sustainable transportation options.

2.1.4. Transit oriented development

Transit-Oriented Development (TOD) is an urban planning and design theory and approach that focuses on creating mixed-use communities with high-density development in close proximity to public transportation hubs. The primary aim of TOD is to encourage residents to use public transit, reduce dependence on private automobiles, and promote sustainable, walkable, and livable urban environments.

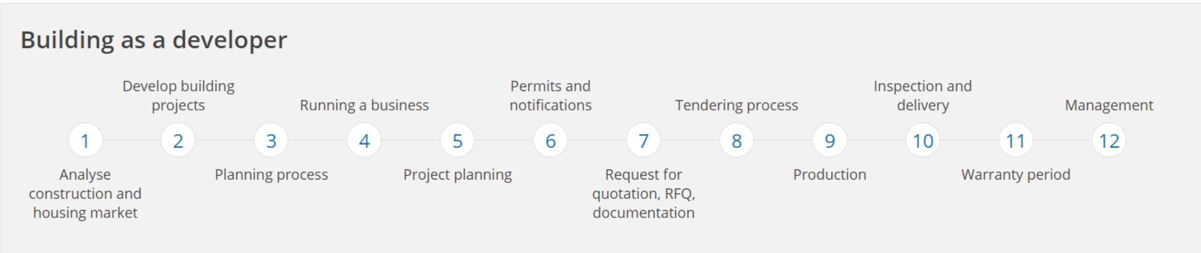
3. The context of urban planning

3.1. The example of Sweden

Urban issues are increasingly important on national policy agendas. Cities and metropolitan areas are major contributors to national economies and play a key role as nodes in global markets. Sweden does not have a national urban policy, but it does have several national initiatives that focus on urban development. Most important among national initiatives is the National Platform for Sustainable Urban Development, which was launched in 2014. It is co-ordinated by the National Board of Housing, Building and Planning (Boverket), with the involvement of the Swedish Energy Agency (Energimyndigheten), the Swedish Environmental Protection Agency (Naturvårdsverket), the Swedish Agency for Economic and Regional Growth (Tillväxtverket) and the Swedish Transport Administration (Trafikverket) (Boverket, 2015; OECD, 2015).

The Ministry for the Environment and Energy oversees urban development. The role includes co-ordinating sustainable urban development within the government. Responsibility for grants within the area of housing, planning and building; and laws and regulations concerning planning and construction, as well as regional policy is handled by the Ministry of Enterprise and Innovation. The text below is a summary from Boverket (2023):

3.2. General process for developer who wants to build new housing areas in Sweden



1. Analyse construction and housing market

As a developer, it is important to follow how the housing market is developing. This can be done through statistics and from forecasts of future needs. It is also important to know what forms of tenure that exist and what they mean.

2. Develop building projects

Land access can be through acquisition of land or through a long-term lease agreement. In addition to the cost of the land and the contract, developing a property entails a number of costs for the developer.

3. Planning process

If the land is unexploited, then a detailed development plan process generally needs to be initiated. It is always only the municipality that decides if a detailed development plan shall be developed and, if so, when the work shall commence.

4. Running a business

There is plenty of support available for setting up a business in Sweden. Verksamt.se is a collaboration among several Swedish government agencies, for anyone who is considering to start, already is running or developing a business.

5. Project planning

The project planning begins with design ideas that gradually become concrete as details of drawings and other construction documents are presented. As a developer, it is important that you know which laws and regulations affect the design of the building.

6. Permits and notifications

Building permits are usually required for new construction, extensions or other changes to an existing building. To find out if you need a building permit for the project you are planning, please contact the building committee in the municipality where the property is located.

7. RFQ documentation

The RFQ documentation is the collection of documents that the developer gives to the contractors in a procurement. The documentation shall contain all conditions for procurement of contracts in construction projects. Administrative instructions, drawings, descriptions and bills of quantities can be included.

8. Tendering process

After the contractor has obtained the RFQ documentation, the tender count begins and is concluded with the contractor submitting a tender. After this the developer, in its capacity as the client, evaluates which contractor(s) are to be awarded the contract.

9. Production

The production can start once the developer has obtained all permits and decisions required. During the production phase, the contractor carries out the assignments procured by the client in accordance with the contract.

10. Inspection and delivery

When the building is considered to be completed it is time for final inspection, also known as the contract inspection. The content of the final inspection shall be based on the contract agreement(s).

11. Warranty period

The term of liability is ten years from the approval of the contract and begins with a warranty period, valid for five years for the contractors work. The warranty period for materials and goods is at least two years.

12. Management

Property management involves the management and maintenance of a property and its buildings. The property owner has a number of obligations that need to be fulfilled, both towards the tenants and the wider community.

3.3. Relevant stakeholders in the construction and building market

Swedish construction and housing market

In planning and building processes, both the state and municipalities as well as other parties are involved. Examples of other parties include project developers, developers and property owners.

The Swedish Parliament and Government

The Swedish Parliament and Government set the framework for planning and building through the planning and building legislation, laws and ordinances.

County administrative boards

It is mainly the local county administrative board that represents and safeguards the state's interests in the various processes of the Planning and Building Act. The county administrative board has various roles in the processes, both an advisory role and a supervisory role through its possibility to reconsider certain decisions.

The county administrative board is also the first instance in appeals of for example preliminary decisions, permits, start decisions and completion decisions. Ultimately, the county administrative board will follow up the municipalities' application of the planning and building legislation and give the municipalities advice and support, among other things in the form of supervision guidance.

National Board of Housing, Building and Planning

The National Board of Housing, Building and Planning, Boverket, is the national authority that has the task of guiding, investigating and analysing issues that concern urban planning, building and housing. The authority is responsible for the follow-up of the application of the Planning and Building Act, PBL.

Boverket has the possibility of issuing regulations in the cases where the government has mandated the authority to do so. Boverket also has the right to decide on general guidelines regarding the planning and building legislation. Boverket's Building Regulations, BBR, is an example of such regulations and general guidelines.

Municipality

The municipality has several roles in the planning and building legislation. A municipality is an authority, but can also be a property owner. It is the municipality that prepares and adopts general plans, detailed development plans and special area regulations. The municipality is also responsible for water, sewerage and waste.

Local building committee

Every municipality must have a local building committee. The local building committee is a local authority committee consisting of elected representatives. The committee has an administration with public officials to assist it. The local building committee decides on permits, preliminary decisions, start decisions and completion decisions, and handles the other phases in the building process. The local building committee is also responsible for supervision to ensure compliance with the planning and building legislation.

Other municipal committees and administrations

Opinions from the emergency services and the environmental authority in the municipality are important in the handling of permits and construction. Other municipal committees and administrations, such as those responsible for streets, parks, water and sewerage, can also contribute professional expertise in permit and building matters. This can take place through a circulation for comment or consultation process.

Lantmäteriet

The Swedish Cadastral and Land Registration Authority, Lantmäteriet, manages and updates geographical information, maps of individual properties, elevations and other data that is linked to maps. The information is continuously updated to show the right owner of land and correct property boundaries.

Lantmäteriet also manages all property information in Sweden. This encompasses all registrations of ownership and changes to property boundaries. In some municipalities, there are also municipal land survey authorities and they have the same role and responsibility as the national Lantmäteriet.

Developer

The developer is the party that, on its own behalf, performs or contracts out project design, construction, demolition or ground works. This role is defined in the Planning and Building Act, PBL, and is associated with a special responsibility.

The developer must ensure that all construction, demolition or ground measures are done according to the regulations in the Planning and Building Act, and in accordance with the regulations or decisions given pursuant to the act. The developer can also have obligations according to other laws, ordinances and regulations. The developer need not be a physical person, but can be a juridical person, such as a company, a tenant owner association, a municipal administration or an authority.

Inspection manager

For measures subject to permits or registration, the developer must normally have an inspection manager. The inspection manager shall assist the developer with expert knowledge and must be certified for the assignment. The inspection manager must, together with the developer, prepare a proposed inspection plan for the measure in question.

Property owner

Owners of structures have a responsibility to care for and maintain the structure so that the design and technical features in particular are preserved. Plots must be cared for and managed so that the risk of accident is limited and that no significant inconvenience for the surroundings and traffic arises. The property owner is also obliged to perform for example ventilation and lift inspections.

Acquisition of land

Land may be acquired through acquisition of land or through a long-term lease agreement. The proceedings differ depending on whether it concerns private or publicly owned land. The land may be previously undeveloped and not subject to detailed development plan or it may be land with a detailed development plan, either developed or undeveloped. When land acquisition refers to private land, this is a commercial transaction between landowner and buyer. Acquiring publicly owned land is subject to certain rules.

A municipal land allocation is an agreement between a municipality and a land developer that gives the developer the sole right, for a defined period of time and under defined conditions, to negotiate with the municipality on transferring or letting an area of municipal land for building. By using municipal land allocation agreements, municipalities can set conditions that control what is built: the form of tenure and the size of residential buildings for example. Municipalities that allocate land shall adopt guidelines for land allocation. The guidelines shall include:

- the municipality's basis and goals for transferring or letting of land areas for building
- processing routines
- basic conditions for allocation of land
- routines and principles for pricing land.

4. Parking management

4.1. Local policies

Parking management often refers to local policies and programs that result in more efficient use of parking resources. Parking management includes several specific strategies. When appropriately applied parking management can significantly reduce the number of parking spaces required in a particular situation, providing a variety of economic, social and environmental benefits. When all impacts are considered, improved management is often the best solution to parking problems.

Nevertheless, it involves various strategies and measures to efficiently allocate, regulate, and optimize the use of parking spaces to address the challenges associated with limited parking availability, congestion, and land use. The goal of parking management is to enhance mobility, reduce traffic congestion, promote sustainable urban development, and improve the overall quality of life in a community.

To reach the full potential of parking management, cities need to adopt a holistic and adaptive approach, integrating various strategies and technologies while considering the unique characteristics of their urban environments. Community engagement, data-driven decision-making, and a commitment to sustainability are crucial elements in realizing the benefits of effective parking management.

4.2. Additional effects of parking

4.2.1. Effects of parking on car ownership and use

Parking accounts for a substantial share of the costs of car ownership and use (Russo et al, 2019). For example, drivers pay directly only 20-25% of private parking costs (Litman & Doherty, 2018).

Empirical evidence indicates that parking space availability has a significant impact on car ownership (Johansson, 2017). For example, residential parking space availability has been shown to be a more important determinant of car ownership than income and other household characteristics (Guo, 2013)

In addition to increased car ownership, the underpricing of parking space induces more car travel. As already mentioned, a common cause of additional car travel is cruising for parking, with estimates of the share of cars cruising in downtown traffic ranging from 8 to 74 percent depending on the city (Shoup, 2006). Cruising is the result of an unpriced (or underpriced) external cost: the time cost that a driver occupying a parking space imposes on those who are in search of a vacant space in that vicinity. This external cost varies across space and its magnitude increases with the attractiveness of the location where the parking space is located (Small & Verhoef, 2007).

Cruising does not only imply more vehicle-kilometres travelled: cars cruising for parking contribute to congestion and pollution disproportionately, as they slow down other vehicles (Russo et al, 2019; Inci, 2015).

The underpricing of parking space also leads to more car trips. For example, car owners are more likely to commute by car when they have access to free parking in proximity of their home (Weinberger, 2012). Again, a simple calculation suggests that the effect is important (see chapter X for examples).

4.2.2. Effects of parking on land use

Parking is responsible for the over- consumption of enormous amounts of land worldwide. Road infrastructure, including parking, covers for example between 1.8 % and 2.1 % of total land area in France, Germany, and the United Kingdom, and almost 3.5 % in Japan (Kauffman, 2001). On-street parking space typically represents 20-30% of urban road space (Litman, 2012)

Building parking spaces has important environmental costs which, in the absence of corrective taxes, are most often neglected by developers and not reflected in actual land prices (Russo et al, 2019). These costs are due to the loss of open space and biodiversity and can be particularly high in certain areas.

Hence, the costs of land consumption associated with parking are to some extent related to inefficient local policies. Generous minimum parking restrictions are among the most important reasons behind the overallocation of land to parking space. Such restrictions are often designed to cover peak demand for free parking, entailing that developers have to provide much more parking than what they would under efficient market conditions.

Nevertheless, parking tariffs cannot for obvious reasons account for the distance driven by each car to reach the parking space, and therefore for its exact contribution to congestion and pollution. Furthermore, parking tariffs cannot be used to price the negative externalities caused by pass-through trips (Glazer & Niskanen, 1992; Small & Verhoef, 2007).

4.3. Parking policies

4.3.1. On-street parking

One of the most important aspects of parking in urban areas is its interaction with road congestion, primarily due to cruising for parking.

In cities cars are searching for a parking spot, spending on average about 8 minutes cruising for parking per trip (Shoup, 2006).

According to Russo et al (2019) cruising for parking is essentially a side-effect of parking space underpricing. When the price of parking is too low, demand for on-street parking exceeds supply and saturation of parking space occurs. Thus, some cars must drive around looking for a free spot. Curbside parking capacity is fixed in the short run, the optimal parking price should be so high that at least one parking spot is always available (Russo et al, 2019).

In most cities around the world, on-street parking in central parts and areas is saturated, most indicating that prices are too low. However, when pricing of parking spaces is not optimal, duration limits can eliminate cruising by discouraging long-term parking users (Arnott & Rowse, 2013).

On-street parking regulation and pricing can only be effective if they are properly enforced. Yet, enforcement is a challenge in many cities, owing to the lack of sufficient resources or of strong incentives for local authorities (Russo et al, 2019).

4.3.2. Residential parking

In numerous cities, minimum parking requirements apply to residential and office buildings. Historically, residential buildings had to include at least one parking space per residential unit, and commercial and office buildings had to have a minimum number of parking spaces per square meter. Minimum parking requirements have usually been established with a view to satisfy peak demand for free parking (Shoup, 1997; Shoup, 1999).

According to Russo et al (2019) minimum parking requirements unfortunately create an incentive for developers to build more parking than the market requires and stimulate car use. Empirical evidence confirms that they lead to a higher parking supply, more vehicles on the road and a lower population density (Cutter & Franco, 2012; Manville & Shoup, 2013). Minimum parking requirements also harm housing affordability, as they decrease the costs of driving at the expense of increasing development costs (Litman, 2016; Manville & Shoup, 2013; Shoup, 1999). The effect can be significant, as it has been estimated that parking accounts for about 10 % of the development costs of a typical building (Litman & Doherty, 2018).

According to Russo et al (2019) empirical evidence of the effectiveness of replacing minimum parking requirements with maximum ones comes from London's 2004 major parking policy reform. The reform led to a remarkable 49% reduction of parking spaces in new residential developments, freeing up space for other uses.

Given the presence of cruising for parking in many areas, this implies that visitors are willing to pay much more than residents for curbside parking. The reason is that visitors stay only for a few hours, so their marginal willingness to pay per hour is larger than that of residents. The second inefficiency caused by underpriced residential parking permits is that they drive up the costs of providing parking space. Because curbside parking is granted to residents for a very low price, additional parking space is needed to accommodate non-residents (e.g. shoppers).

4.4. Parking as a service

To identify parking as a service (PaaS) it refers to the concept of providing parking solutions as a comprehensive and integrated service, often facilitated through digital platforms and technologies. This approach aims to streamline and enhance the overall parking experience for users, making it more convenient, efficient, and user-friendly.

In this perspective, PaaS often involves the use of digital platforms, mobile apps, and online services to provide users with information about available parking spaces, pricing, and other relevant details. Users can therefore reserve and pre-book parking spaces in advance through digital platforms. This feature allows for better planning, reduces uncertainty, and ensures that users have a guaranteed parking spot upon arrival.

The concept of PaaS also incorporates dynamic pricing models, where the cost of parking adjusts based on factors such as demand, time of day, or special events. This approach helps manage parking demand efficiently and encourages users to consider alternative transportation options during peak periods. Integration with navigation apps allows users to seamlessly find parking options along their route. Users can receive real-time information on parking availability and navigate to their chosen parking location.

PaaS can also be seen to integrate with various other transportation modes, including public transportation, ride- and carsharing, and related bike-sharing services. This supports a more comprehensive approach to urban mobility and encourages users to consider a wide range of transportation options.

Parking as a Service aligns with the broader trend of Mobility as a Service (MaaS), where transportation services are integrated into a single, user-centric platform. This approach aims to make urban mobility more seamless, efficient, and sustainable in the future of cities.

4.4.1. Shared Parking

Shared parking refers to a parking management strategy that optimizes the use of parking spaces by allowing multiple users or activities to share the same parking facility at different times (Gies et al, 2021). This approach recognizes that certain parking spaces experience peak demand at specific times, and during off-peak hours, the same spaces can be utilized by different users or for different purposes. The goal is to maximize the efficiency of parking resources, reduce the need for excessive parking infrastructure, and promote sustainable land use.

4.5. Parking facility costs

The costs associated with a parking facility can vary widely based on several factors, including location, size, design, technology integration, and local regulations. A major benefit of parking management is its ability to reduce these parking facility costs. Parking facilities are expensive, and their costs are usually paid indirectly through higher taxes, rents and/or prices for other goods, so we believe that most people have little idea of parking facility costs and the potential savings from more efficient management.

A typical parking space is approximately 20-30 m2. Off-street parking of course requires driveways and access lanes, therefore the large span of space. Parking covers a major portion of urban land use (Kisin 2022). On-street parking requires less land per space than off-street parking, since they do not require access lanes, but their opportunity costs can be high if they use road space needed for traffic lanes or sidewalks (Litman, 2023). Other related issues concerning cost of parking is what we define as indirect costs such as for example increased stormwater management costs and heat island effects, plus increased vehicle traffic and sprawl (Johansson, 2018).

4.6. Parking fees and regulations

Parking fees and regulations have been widely applied since the early days of car usage. If well designed, they can be efficient instruments for controlling access to scarce parking space (Verhoef et al, 1995). Nevertheless, the efficiency and equity effects of parking policies are challenging to evaluate for several reasons.

Parking supply is a complex mix of on-street, off-street and garage space. Some parking space is controlled publicly, and other space is private. Some is open to the public, some is reserved for business and some is reserved for residents. Residential parking is provided for people living in single-family homes, apartments and condominiums. Parking is provided at Park & Ride facilities to encourage motorists to use public transport for part of their trips.

Parking fees and regulations are also complex. Parking is prohibited at certain times of day and on certain days of the week. Some parking spaces are reserved for mobility-impaired people, and others for electric vehicles so that they can be recharged. Some curbside parking is free, but subject to a time limit. Other parking places charge flat hourly rates despite large fluctuations in demand over the day, and still other parking places charge hourly parking rates that vary with parking duration.

Parking fees and regulations are set with a mix of objectives: to facilitate accessibility to homes, businesses and other destinations; to raise revenue, to control parking and traffic congestion, to reduce pollution, to improve safety for pedestrians and bicyclists and so on. Many policies are both inefficient and inequitable. Parking subsidies in the form of free off-street parking at workplaces, businesses and residences encourage car ownership and driving, and effect land use.

4.6.1. On-street parking

Free or underpriced on-street parking is often in short supply. Drivers waste time cruising in search of it, and delay through traffic while they search. Privately-owned garages that charge high prices for off-street parking exacerbate the problem by increasing the demand for on-street spaces.

4.7. Efficient parking pricing

Parking Pricing means that motorists pay directly for using parking facilities, with prices that vary to reflect facility and parking congestion costs (Shoup 2005). This may be implemented as a parking management strategy mainly just to reduce parking problems, as a mobility management strategy to reduce transport problems or to recover parking facility costs (Litman, 2020).

Currently, most parking is inefficiently priced; it is often provided free, significantly subsidized, or bundled, i.e., automatically included with building purchases and rents, forcing consumers to pay for parking facilities regardless of whether they want it or not. When motorists do pay directly for parking, it is often a flat annual or monthly fee, providing little incentive to use an alternative mode occasionally (Shoup 2006). Efficient pricing can include (Litman 2017):

- Expand when and where municipal parking is priced, including meters and permits required for on-street parking,
- Parking cash out means that non-drivers receive the cash equivalent of parking subsidies provided to motorists,
- Parking unbundling, which means that parking is rented separately from building space, so rather than paying per month to rent an apartment with a parking space occupants pay for the apartment and for each parking space they use, so car-free households are no longer forced to pay for costly parking facilities they don't use,
- Shorter payment periods, such as charging buy the hour rather than the day, or the day rather than month or year (Gutman 2017).

4.8. The new parking paradigm

Parking planning in general is undergoing a paradigm shift, a fundamental change in how parking challenges are perceived and what potential solutions evaluated (Belmore, 2019; Litman, 2021; Litman, 2023; Pressl & Rye, 2020). This paradigm emphasizes innovative solutions that go beyond conventional parking models. The old parking paradigm assumed that the goal was to maximize motorists' convenience by making parking as abundant and cheap as possible, with little regard to cost or other local goals and strategies.

The new paradigm instead strives to optimize parking supply and manage it for sustainable efficiency, so fewer spaces are needed to serve motorists' needs. The general output is that too much parking considers to be as harmful as too little, and underpricing as harmful as overpricing. The table below compares the old and new (The table is based on Litman, 2023):

Scope	Old parking paradigm	New parking paradigm
Definition of transportation	Transportation means driving vehicles.	Not everybody uses vehicles. Transportation systems are multimodal.
Problem definition	Inadequate parking supply.	Inadequate or excessive parking supply. Too high or too low prices. Inefficient management.
Goal	Maximize parking supply.	Too much supply is as harmful as too little supply.
Proximity of parking	Parking demand should be satisfied on-site with minimal walking distances.	Parking can be provided off-site allowing parking facilities to serve multiple local destinations.
Parking pricing	Parking should be unpriced or as cheap as possible and funded indirectly.	Users should pay directly for parking facilities with efficient prices that reflect real marginal costs.
Prioritization	Parking should be available on a first-come basis.	Parking should be prioritized to favor higher value users.
Scope of analysis	Analysis should focus on motorists' convenience.	Analysis should consider all impacts including strategic local goals.
Role of parking management	A last resort to be applied only if expansion is feasible.	Parking management strategies should be implemented whenever cost effective and fair.
Role of innivation	Innovation faces a high burden of proof.	Innovation should be encouraged since even unsuccessful experiments provide useful information.

Table 1. Parking management changes the way parking problems are defined and solutions evaluated (Litman, 2023).

According to Table 1, the new paradigm expands the range of solutions that can be applied to solving identified parking problems. For example, if parking is highly congested in a certain area, the old paradigm assumed that the solution is for developers and local governments to increase parking supply. Hence, the new paradigm instead considers various management strategies, such as more sharing, improvements to non-auto modes, and efficient pricing, which are often quicker to implement, more cost effective, and more consistent with other community goals.

The old paradigm may be appropriate in affluent suburban and rural areas where most travel is by automobile, land is cheap, and properties are mainly dispersed (Litman, 2023). However, this is inefficient and unfair in municipalities with much multimodal travel, high land prices, and compact development where motorists can use off-site parking facilities, as well as in communities that place a high value on affordability and environmental protection.

4.9. Additional policy issues

4.9.1. Car-sharing

A sensible strategy to reduce the need for parking spaces is to decrease the number of cars on the road. Car-sharing offers some promise in this sense. There is a two-way connection here, because several cities are using parking to incentivize car-sharing. In Amsterdam, as in many other cities, car-sharing companies get dedicated parking spaces. In Antwerp, Belgium, residents who are members of car-sharing schemes receive the equivalent of a residential permit so that they can park shared vehicles near their residence (Kodransky & Hermann, 2011).

4.9.2. Public transport

According to Russo et al (2019) shortages in parking capacity can also be dealt with by providing alternatives to car travel. These include public transport and cycling. Many of the cities mentioned in this paper are gradually redesigning their transport systems in this direction. Although this topic is too large to be treated in this report, it is worth noting that the economic literature suggests that, while monetary subsidies are effective in stimulating a modal shift towards public transport (Parry & Small, 2009).

5. How to measure parking

5.1. Monetary value of parking

Building parking entails costs for the owner of the parking space. If no fee is charged, for example parking spaces in a residential area, the costs are spread over the rents of all residents (Norrköping municipality, 2011). The cheapest way in this context is to build on-ground parking which cost around SEK 15 000 (1 500 Euro)/parking space (Malmö Stad, 2010) but it is at the same time the most surface demanding forms of parking. A parking space in a garage, for example, constitutes approximately 12 % of the total construction cost for an apartment of 75 m^2 (25 000 – 30 000 SEK/m^2) (Örebro, 2016).

The environmental consequences of parking manifest themselves in open space and biodiversity losses caused by the construction of parking space, and in emissions of greenhouse gases and air pollutants occurring while cars are cruising for parking (Johansson, 2017; Russo et al, 2019).

According to Russo et al (2019) economic consequences are reflected in the time costs incurred while cruising for parking, and in time losses from traffic congestion caused by cruising. These costs come on top of construction and maintenance costs, as well as the opportunity costs of alternative land uses. As long as these environmental and economic costs are not reflected in parking prices and decisions over parking supply, they cause social welfare losses (Russo et al, 2019). Hence, this is a common failure, which also induces individuals to underestimate both car use costs and, thus, travel more kilometres and cause more emissions of greenhouse gases and air pollutants, and more congestion.

From an urban planning point of view, it is not a sustainable solution to build new on-ground parking in central areas. Although it is a cheaper parking solution than, for example, parking garages. The calculation below clarifies the potential possibilities of parking revenue at 80 % occupancy rate (8 hours/day) in a normal parking with 500 parking spaces:

Street land	**Parking revenue at 80 % occupancy rate (8 hours a day)**		
Cost	**Per day**	**Per month (30 days)**	**Per year (52 weeks)**
SEK 5/hour.	2 000 SEK	60 000 SEK	720 000 SEK
SEK 10/hour.	4 000 SEK	120 000 SEK	1 440 000 SEK
SEK 15/hour.	6 000 SEK	180 000 SEK	2 160 000 SEK
SEK 20/hour.	8 000 SEK	240 000 SEK	2 880 000 SEK
SEK 25/hour.	10 000 SEK	300 000 SEK	3 600 000 SEK
SEK 30/hour.	12 000 SEK	360 000 SEK	4 320 000 SEK
SEK 50/hour.	20 000 SEK	600 000 SEK	7 200 000 SEK
SEK 100/hour.	40 000 SEK	1 200 000 SEK	14 400 000 SEK

Figure 1. Example of parking revenue at 80 % occupancy rate (8 hours/day).

The calculation example above shows potential revenue opportunities only through parking fees. Hence, total surface requirement for parking spaces in the above-mentioned example could in practice amount to a need of approx. 1 hectare of parking space which is a great loss of biodiversity. The calculation example refers to a constant occupancy rate of 80 %, which is an occupancy rate that many Swedish municipalities strive for (Uppsala municipality, 2014). The City of Stockholm (2013) shows an occupancy rate of approx. 90 % on average during the autumn of 2011, daytime in paid parking. The occupancy rate in Stockholm (2013) has varied between 88 % and 92 % since 2007. 80 % occupancy thus means the equivalent of a constant 400 parked passenger cars/hour which could create a lot of negative externalities such as search traffic and congestion.

According to Fredriksson (2005), price is surprisingly not always the most important factor when choosing parking. The price comes as factor two, along with the fact that it should be easy to park and the number of available parking spaces. Proximity to the destination is the most important factor when choosing parking (Fredriksson, 2005). Hence, studies show that parking fees seem to have a greater impact on car use than, for example, environmental taxes in the form of petrol price (Trafikverket, 2015). Time regulation as the mentioned example can be applied to parking spaces, depending on the purpose of parking:

- 1-2 hour/s can, for example, be applied to various service functions, or businesses that require shorter errands and where there is a large need for parking.
- 3-4 hours can be applied for e.g. healthcare centres and training functions, cultural facilities (such as museums, theaters and cinemas), but also at larger shopping centers where several purchases/errands can be carried out at the same time.

According to the Swedish Transport Agency (2015), parking fees can contribute to increasing the competitiveness of alternative means of transport, such as public transport, pedestrian and bicycle traffic. Which in turn can give further increased effect of the measures that stimulate these. Figure 2 below shows construction cost in Sweden for various forms of parking options with the above-mentioned example of 500 parking spaces:

Type of parking	Construction cost excl. land cost (SEK/car space)	Cost example Construction cost 500 parking spaces (SEK)
On-ground gravel parking	10 000 – 20 000 SEK	5 000 000 – 10 000 000 SEK
On-ground asphalt parking	20 000 – 30 000 SEK	10 000 000 – 15 000 000 SEK
Simple parking house	70 000 – 100 000 SEK	35 000 000 – 50 000 000 SEK
Parking garage	150 000 – 400 000 SEK	75 000 000 – 200 000 000 SEK
Underground garage (1 floor)	300 000 – 750 000 SEK	150 000 000 – 375 000 000 SEK

Figure 2. Example of construction costs depending on parking options (Norrköping Municipality, 2011).

The calculation example corresponds well with the construction cost per parking space, depending on the type of parking in Malmö (2010):

Type of parking	Production cost per parking space (SEK)
On-ground parking	15 000 SEK
Parking garage	120 000 SEK
Garage floor -1	250 000 SEK
Garage floor -2	350 000 SEK
Garage floor -3	450 000 SEK

Figure 3. Estimated construction cost per parking space depending on type of parking (Malmö, 2010).

Depending on chosen pricing (SEK 5 - 100 /hour) (according to previous calculation examples), the parking area with 500 parking spaces could theoretically bear its own construction costs in connection with gravel on-ground parking, already after one year at a pricing between SEK 10 - 25/ hour. At a pricing level of SEK 5/hour, it could take up to approximately 5 years to finance the construction cost of an on-ground parking. Apart from this, there are of course also costs for operation and maintenance, which according to Shoup (2018) is estimated at about USD 500/year (about SEK 5000/year).

A high pricing strategy can also have a deterrent effect, which could mean that the higher the parking fees, the less willing car owners are to pay. At the same time, it is important that parking spaces are paid for by the users, and not financed by everyone else, i.e., even those who do not have, or need access to their own car.

5.2. Urban space value of parking

The calculation example below assumes that a parking space takes about 12.5 m^2 in surface area, but the total need for space is 20 m^2 with surrounding driving areas required to park. Figure 4 below shows that parking standards (p-norm) are of great importance in reducing the need for parking.

A fairly low parking standard (p-norm), in this example 0.3 (i.e., 0.3 parking spaces per apartment) and accessible car-sharing options, are thus effective strategic tools for sustainable urban planning. The biggest effect is a combination of low parking standards (p-norm) and car-sharing service. At the same time, a low parking standard requires access to a car-sharing service.

The example below shows, for example, that a theoretical increase in the number of inhabitants (due to urbanisation) by 50 000 inhabitants would in practice require a parking area corresponding to approx. 62 football pitches. This is based on a continued car ownership of for example 441 cars per 1 000 inhabitants (just as in Helsingborg, Sweden), that is, if nothing is done to change the mode of transport. This means that if the parking norm is 1 (one parking space per apartment) and the trend for current car ownership continues, the conditions for parking needs of 1 000 new residents corresponding to 1.2 football pitches. A football pitch in this case is estimated to be 7 140 m^2 (which is the field size for Friends Arena in Stockholm and Olympia in Helsingborg). Instead, halving the parking standard (0.5 parking spaces per apartment) reduces the parking requirement to 0.6 football pitches. One car-sharing car replaces five private cars in Sweden (Indebetou & Börefelt, 2014). Although the car-sharing car itself requires a parking space, the car-sharing service frees up parking space corresponding to 4 private passenger cars (which corresponds to a parking space of 80 m^2).

Figure 4. Table of expected population increase through urbanisation, car ownership parking figures and expected need for parking space in the form of football pitches.

Urbanization (population growth)	Car ownership (441 cars/1,000 inhabitants)	Parking number (parking lot/apartment)	Expected need for parking space
1 000 inhabitants	441 cars	1 0.5 0.3	1.2 football pitches 0.6 football pitches 0,37 football pitches
10 000 inhabitants	4 410 cars	1 0.5 0.3	12 football pitches 6 football pitches 3,7 football pitches
25 000 inhabitants	11 025 cars	1 0.5 0.3	31 football pitches 15.5 football pitches 9,2 football pitches
50 000 inhabitants	22 050 cars	1 0.5 0.3	62 football pitches 31 football pitches 18,5 football pitches

As previously mentioned, the calculation example is of a theoretical nature, but shows the strength of actively working to reduce the need for parking spaces through low parking numbers in new residential housing areas. This applies in many cases to several densification processes regardless of city and country. The example may not necessarily imply a need for new construction of parking spaces, but it is assumed that already existing parking spaces may be used in the first place. Then, in the case of new production of parking spaces, the question must be asked whether to build parking garages, parking garages and/or curbside parking and on-ground parking.

5.3. Ecological value of parking

By producing new parking spaces, there is also a cost except monetary to other qualities and values in the city. One negative effect is the loss of green areas or other forms of vegetation and by that loss of important biodiversity. The value and qualities of green urban space arise through the so-called natural ecosystem services, which are the functions of ecosystems that benefit us humans for free. This by maintaining, but also improving, people's well-being and living conditions. Green areas also have the ability to bind carbon dioxide through so-called carbon storage (carbon sink).

In addition to working for people's well-being and acting as a carbon sink, according to Fitter et al (2010), urban nature also delivers other different ecosystem services, such as e.g. supply services (provides the opportunity to grow food and generates plant material that can be used as biofuels or soil improvement), regulatory services (purifies air and water, regulates temperature and wind in the city, stores carbon dioxide, prevents erosion and provides pollination), cultural services (enables recreation, health and tourism) and supporting services (contributing to several basic functions such as soil formation, photosynthesis and the nutrient and water cycles).

But, in the example below, the focus is on the importance of the green space as a carbon sink where approximately 19 tons of carbon store per hectare in the city of Lund (Bengtsson, 2012). The storage capacity of the vegetation in the city naturally depends on a variety of factors such as geographic region, soil fertility, climate conditions, and human control of vegetation establishment. Earlier ecological research shows that CO_2 storage in vegetation often are underestimated as carbon storage in urban areas.

A number of scientific studies have calculated the ability of urban areas to store carbon, and in Leicester (England) the carbon stock in the city's vegetation amounts to 31 tonnes per hectare (Davies et al, 2011), while in Leipzig (Germany) the trees are estimated to store 11 tonnes per hectares (Strohbach et al, 2012) and in Hangzhou (China) the carbon stock amounts to 30 tonnes per hectare, although then only counting trees with a diameter at breast height above 4 cm (Zhao et al, 2010). In Seattle (USA), the carbon stock in urban trees amounts to 18 tons per hectare, but then only trees with a diameter at breast height greater than 5 cm were counted (Hutyra et al, 2011). In trees in Chicago (USA), the carbon stock amounts to 11 tons per hectare (Nowak, 1992).

It is thus difficult to make comparisons with other cities, regions and countries because carbon storage reserves depend on many different factors, such as the total extent of the city's green space and the number of large trees (Bengtsson, 2012). The challenge with verifying mentioned figures is that they were experimentally produced from field studies in mixed, typical urban vegetation.

Most literature regarding the potential of vegetation for storage of organic carbon has previously been based on vegetation studies in non-urban ecosystems, i.e. beech forest, spruce forest, etc., after which the values have been implemented on the conditions of the urban green spaces. What makes the values different from different cities is the fact that they are located in different plant geographical zones, i.e., different plant and climate types with different biomass production. Another important factor is how old the vegetation is allowed to become. The species composition is also of central importance, i.e., if the species are perennial, or annual.

Figure 5. Effects of land use on urban ecosystem services in relation to possible carbon storage.

City	Parameter	Calculation (area*hectares)	Carbon storage (+) Carbon uptake/ton	Hard-made surface (-) Carbon loss/ton
Helsingborg	Green space Hard-made surface Parking area	1818*19 1801*19 120*19	34,600	 34,300 2,280
Stockholm	Green space Hard-made surface Parking space	24223*19 12294*19 681*19	460,238	 233,587 12,939
Gothenburg	Green space Hard-made surface Parking space	12870*19 7302*19 367*19	244,530	 138,738 6,973
Malmö	Green space Hard-made surface Parking area	3564*19 3652*19 232*19	67,716	 69,388 4,408

In the calculation example above, green space, according to Sweden's Statistics Central Bureau, means all areas covered with vegetation, which together create the overall green structure within the boundaries of the urban area. This can apply to public parks and open grass areas as well as other areas covered with trees or grass, green impediment areas, residential gardens, green areas between apartment buildings or industrial buildings and also green lanes between roads, etc. However, green roofs and green walls have not been included in the calculations due to their yet relatively limited distribution. Hard surface is defined as artificially landscaped land that lacks vegetation. This includes the roofs of buildings, parking, streets and roads, railways, and other hard surfaced infrastructure.

The calculation example, however, makes it clear that the proportion of green space (vegetation) in Helsingborg contains, among other things, a total carbon storage (stored organic carbon in plants and soil) of approx. 35,000 tonnes. And the total amount of parking space in Helsingborg thus means a loss of stored organic carbon in plants and soil of approx. 2,280 tons. In Stockholm, for example, the parking area itself means a carbon loss of about 13,000 tons, and in Gothenburg about 7,000 tons and Malmö about 4,500 tons.

A parking space thus has an ecological value. In this case in the form of loss of the carbon storage of green areas in urban environments. The lower the parking standard would in practice mean the smaller the area required for parking and thus increased potential as a carbon sink.

6. Discussion

The objective of this report was to fill this gap by providing a better understanding of the environmental and economic consequences of parking policies. To achieve this objective, the report relies on an extensive review of the relevant literature, on real-world policy examples mainly from Europe and theoretical calculations for illustrations.

Car travel causes negative externalities, including emissions of greenhouse gases and air pollutants, road congestion, noise, and traffic accidents. While the environmental and other external costs of car travel have been the object of numerous research efforts, much less attention has been paid to the investigation of the negative externalities associated with another important dimension of car use: parking.

This is probably surprising given that the average car is parked roughly 97 % of the time and large amounts of land are consumed by parking. External costs occur when a production or consumption activity imposes costs on others which are not reflected in the prices of goods or services being produced or consumed. For example, in the absence of corrective taxes, the emissions produced by a car are an external cost, as the environmental and health damages they cause are typically ignored by the car driver.

The estimated social cost of a parking spot varies significantly across space, but it is particularly high in urban areas. Provided its importance in terms of land use and its decisive role in car ownership and travel decisions, parking deserves a much higher level of scrutiny than the one it has thus far received. This also holds for parking policies: despite usually being developed at the local level. The environmental and economic problems associated with parking are largely the result of policies encouraging the oversupply of parking space and parking tariffs set at levels lower than the social costs of parking provision.

The environmental and economic consequences of parking occur through land-use change and increased car use. Paving land to provide parking spaces entails open space and biodiversity losses. Furthermore, drivers parking in central areas cause a negative externality to other users who have to continue driving around the vicinity of their destination in search of a vacant parking spot. However, cruising is not the only channel through which parking induces more car use, and therefore more congestion and emissions: abundant supply of parking at low prices reduces the costs of car travel and induces more individuals to drive, instead of using other transport modes, to reach their destinations.

For every car and vehicle trip, parking is viewed as a necessity from beginning to end and over the last century, urban planning has put a focus on parking minimum policies in nearly all types of new developments, based on the premise that cars would be the dominant mode of transport and a necessity for travel in and around cities. Requirements for new construction developments included designating a corresponding amount of space to off-street parking typically one space for every residential unit, regardless of resident demand or vehicle ownership. This has led to the chaotic conditions we see in cities worldwide an overconsumption of unnecessary off-street parking and garages, all valuable space that could have been allocated to more housing, community space, or other commercial uses.

In the past decade, we have also learned that the provision of expansive and low-cost parking serves to induce more driving and unsustainable uses of urban space. Systemic policies that have created so much available parking space has led to built environments that are overall less walkable and cycling-friendly, and less accommodating for key public transit networks. This has created urban transport systems that makes driving appear to be the optimal choice for both essential and non-essential trips and has led to several negative consequences for the environment, particularly when it comes to rising emissions and worsening air quality in many cities.

This experience of parking minimums has ultimately driven down the cost of parking in many cities by providing an excess of free and low-cost parking space, compelling drivers to take more trips by car with the assumption that there will always be a place to park.

A sustainable parking policy can be an integral part of sustainable urban planning and a key area where changes can be made to address these issues. On the other hand, sustainable urban planning is strictly linked to the so-called parking policies. Making urban planning sustainable means having a holistic approach to urban development that takes into account the long-term social, environmental, and economic impacts of urban growth and development. Sustainable urban planning aims to create livable, vibrant, and resilient communities that are environmentally sustainable, socially equitable, and economically viable.

Many cities, policymakers, and urban planners worldwide now recognize that the ways in which they approach the construction, enforcement, pricing, and management of parking is a very powerful tool. Used equitably, it can begin to rectify past car-focused policies, invest in better urban transport, and direct more people to modes of travel that are healthier, more affordable, and more sustainable than driving. We cannot continue the status quo of expanding low-cost and free parking in our cities that prioritize car owners and drivers while placing the physical, financial, and environmental burdens on everyone. Rather, we need cities to take action now to reallocate and re-envision urban space and resources for public transit, housing, and cycling and pedestrian infrastructure that puts people, and the planet, at the forefront.

7. Conclusions

This report provided an extensive discussion of the external costs of parking and the implications of various parking policies for the urban environment. Interactions between parking and car-sharing and alternative transport modes have also been briefly considered.

It is important to note, however, that urban form, accessibility to public transport and frequency of public transport service, and quality of infrastructure for non-motorised transport vary significantly across cities and are important determinants of the effectiveness, efficiency and distributional effects of parking policies. Parking policies should be tailored to the specificities of the local context, but the suggestions outlined below can help achieve more environmentally sustainable and cost-effective outcomes.

The prices of curbside and, where applicable, public garage – parking should be set at levels reflecting the social costs of parking provision. Parking prices should at least account for the costs of parking space construction, the opportunity costs of alternative land uses, and the external costs of open space and biodiversity losses and of time losses due to cruising.

Especially in busy central areas, setting efficient parking tariffs is necessary to prevent parking capacity saturation and avoid cruising for parking, while also ensuring high occupancy rates (80-90%). Given fluctuations in demand, achieving these rates requires a dynamic parking pricing system, where tariffs vary over space and time using information on occupancy in surrounding areas. For a smooth introduction of efficient on-street parking pricing, a necessary condition is that local communities are well-informed about the expected environmental and economic benefits of the policy.

Finally, it is important to highlight that many of the existing implicit subsidies to parking, as well as minimum parking requirements, are regressive, in the sense that their benefits are mainly focused on higher-income groups. Based on this discussion, the report provides a set of suggestions for the development of more efficient and environmentally sustainable parking policies. Key suggestions is to:

- Identify appropriately pricing on-street parking and residential parking permits to prevent both cruising and capacity underutilization, and
- reviewing, and if possible, removing, minimum parking restrictions for new housing development areas residential to eliminate parking overprovision and increase housing affordability.

8. References

Arnott, R. & Rowse, J. (2013). Curbside parking time limits. Transportation Research Part A: Policy and Practice, Vol. 55, pp. 89-110, http://dx.doi.org/10.1016/J.TRA.2013.07.009.

Belmore, B., (2019). Rethinking Parking Minimums. ITE Journal, Vol. 89/2, p. 4 (www.ite.org).

Bengtsson, A. (2012). Ekosystemtjänster från urbana grönytor - En systemstudie med fokus på kollagring och biobränsleproduktion i Lunds kommun. Examensarbete 2012. Institutionen för Teknik och samhälle, Miljö- och Energisystem, Lunds Tekniska Högskola.

Boverket (2023). Building as a developer. https://www.boverket.se Reviewed: 25 September 2023.

Boverket (Sweden National Board of Housing and Planning) (2015). Platform for Sustainable Cities", 2015, Boverket, Karlskrona, Sweden, www.boverket.se/en/start-in-english/planning/platform-for-sustainable-cities/.

Cutter, W. & Franco, S. (2012). Do parking requirements significantly increase the area dedicated to parking? A test of the effect of parking requirements values in Los Angeles County", Transportation Research Part A: Policy and Practice, Vol. 46/6, pp. 901-925, http://dx.doi.org/10.1016/j.tra.2012.02.012.

Davies, Z.G., Edmondson, J.L., Heinemeyer, A., Leake, J.R.., & Gaston, K.J. (2011). Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale. Journal of Applied Ecology, Volume 48, Issue 5, 1125-1134.

Fitter, A., Elmqvist, T., Haines-Young, R., Potschin, M., Rinaldo, A., & Setälä, H. (2010). An Assessment of Ecosystem Services and Biodiversity in Europe. i R. Hester, & R. Harrison, Ecosystem services (ss. 2-21). Cambridge: The Royal Society of Chemistry.

Fredriksson, M. (2005). Parkeringsledningssystemet i Helsingborg. Utvärdering och förbättringsåtgärder. Lunds Tekniska Högskola, Institutionen för Teknik och samhälle, Avdelning Trafikplanering. ISSN 1651-1182.

Gies, J., Hertel, M., & Tully, S., (2021). Parking Standards as a Steering Instrument in Urban and Mobility, Sustainable Urban Mobility Plans (https://park4sump.eu); at https://bit.ly/36EJUF1.

Glazer, A. & Niskanen, E. (1992). Parking fees and congestion. Regional Science and Urban Economics, Vol. 22/1, pp. 123-132, http://dx.doi.org/10.1016/0166-0462(92)90028-Y.

Guo, Z. (2013). Does residential parking supply affect household car ownership? The case of New York City. Journal of Transport Geography, Vol. 26, pp. 18-28, http://dx.doi.org/10.1016/j.jtrangeo.2012.08.006.

Gutman, D., (2017). The Not-so-Secret Trick to Cutting Solo Car Commutes: Charge for Parking by the Day," Seattle Times, at https://bit.ly/2iLwp0R.

Hasker, K., Inci, E., (2014). Free parking for all in shopping malls. Int. Econ. Rev. 55, 1281–1304.

Hutyra, L.R., Yoon, B., & Alberti, M. (2011). Terrestrial carbon stocks across a gradient of urbanization: a study of the Seattle, WA region. Global Change Biology, volym 17, nummer 2, 783-797.

Inci, E. (2015). A review of the economics of parking. Economics of Transportation, Vol. 4/1, pp. 50-63, http://dx.doi.org/10.1016/j.ecotra.2014.11.001.

Inci, E., (2014). A review of the economics of parking. Economics of Transportation 4 (2015) 50–63.

Indebetou, L., & Börefelt, A. (2014). Effekter av Sunfleet bilpool - på bilinnehav, ytanvändning, trafikarbete och emissioner. Trivector, Rapport 2014:84, 2014.

Jakle, J., & Sculle, K., (2004). Lots of Parking: Land Use in a Car Culture. University of Virginia Press, Charlottesville.

Kauffman, R. (2001). Paving The Planet: Cars and Crops Competing For Land, Alert, Worldwatch Institute. https://transportgeography.org/?page_id=4811.

Kisin, K., (2022). Every Parking Lot in the U.S., KatWorld (http://kat.world); at http://kat.world/map.html. Described in, Less Parking, More People Space, Strong Towns (www.strongtowns.org/journal/2022/6/20/less-parking-lots-more-people-space).

Kodransky, M. & Hermann, G. (2011). Europe's Parking U-turn: From Accommodation to Regulation, Institute for Transportation and Development Policy, New York, NY.

Litman, T. & Doherty, E. (2018). Parking Costs. In Transportation Cost and Benefit Analysis II, Victoria Transport Policy Institute, Victoria, BC, http://www.vtpi.org/tca/tca0504.pdf

Litman, T. (2012). Transportation Land Valuation, Victoria Transport Policy Institute, Victoria, BC, https://www.vtpi.org/land.pdf.

Litman, T. (2016). Parking Requirement Impacts on Housing Affordability, Victoria Transport Policy Institute, Victoria, BC, http://www.vtpi.org/park-hou.pdf.

Litman, T., (2017). Parking Requirement Impacts on Housing Affordability, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park-hou.pdf.

Litman, T., (2021). Parking Management: Comprehensive Implementation Guide, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man_comp.pdf.

Litman, T., (2023). Parking Requirement Impacts on Housing Affordability The Costs of Residential Parking Mandates and Benefits of Reforms. 20 November 2023, Todd Litman Victoria Transport Policy Institute.

Malmö stad (2010). Parkeringspolicy och Parkeringsnorm för bil, mc och cykel i Malmö.

Manville, M. (2013). Parking Requirements and Housing Development: Regulation and Reform in Los Angeles. Journal of the American Planning Association, Vol. 79/1, pp. 49-66, http://dx.doi.org/10.1080/01944363.2013.785346.

Norrköpings kommun (2011). Riktlinjer för parkering i Norrköpings kommun. KS-202/2011

Nowak. (2006). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, volym 4, nummer 3–4, pp 115-123.

OECD (2015). Regional Outlook Survey Results: Sweden.

Örebro kommun (2016). Flexibla Parkeringstal - Parkeringsnorm för Örebro kommun. Örebro kommun, Sam 768/2014.

Parry, I. & Small, K. (2009). Should Urban Transit Subsidies Be Reduced?. American Economic Review, Vol. 99/3, pp. 700-724, http://dx.doi.org/10.1257/aer.99.3.700.

Pressl, R., & Rye, T., (2020). Good Reasons and Principles for Parking Management, Sustainable Urban Mobility Plans (https://park4sump.eu); at https://bit.ly/3pNTw84.

Russo, A., J. van Ommeren, J., & Dimitropoulos, A. (2019). The Environmental and Welfare Implications of Parking Policies. OECD Environment Working Papers, No. 145, OECD Publishing, Paris, https://doi.org/10.1787/16d610cc-en.

Shoup, D. (1997). Evaluating the effects of cashing out employer-paid parking: Eight case studies. Transport Policy, Vol. 4/4, pp. 201-216, http://dx.doi.org/10.1016/S0967-070X(97)00019-X.

Shoup, D. (1999). The trouble with minimum parking requirements. Transportation Research Part A: Policy and Practice, Vol. 33/7, pp. 549-574, http://dx.doi.org/10.1016/S0965-8564(99)00007-5.

Shoup, D. (2006). Cruising for parking. Transport Policy, Vol. 13/6, pp. 479-486, http://dx.doi.org/10.1016/j.tranpol.2006.05.005.

Shoup, D. (2018). Parking and the City. SBN 9781138497122. 2018 by Routledge. 534 Pages

Shoup, D., (2005). The High Cost of Free Parking, Planners Press (www.planning.org).

Shoup, D., (2006). Quantity Versus Quality in Off-Street Parking Requirements. Journal of the American Planning Association, Vol. 72, No. 3, Summer, pp. 296-308; at http://shoup.bol.ucla.edu/QuantityVersusQualityInOff-StreetParkingRequirements.pdf.

Small, K. & Verhoef, E. (2007). The Economics of Urban Transportation, Routledge, Abingdon, UK.

Stockholms stad. (2013). Framkomlighetsstrategi. Parkeringsplan. Mars 2013.

Strohbach, M.W., Arnold, E., & Haase, D. (2012). The carbon footprint of urban green space - A life cycle approach. Landscape and Urban Planning, nummer 104, 220-229.

Trafikverket. (2015). Effektsamband för transportsystemet. Fyrstegsprincipen. Version 2015-04-01. Steg 1 och 2. Tänk om och optimera

Uppsala kommun. (2014). Riktlinjer för parkering i Uppsala kommun. Antagen 2014-01-27

Weinberger, R. (2012). Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive", Transport Policy, Vol. 20, pp. 93-102. http://dx.doi.org/10.1016/j.tranpol.2011.08.002.

Zhao, M., Kong, Z.-h., Escobedo, F., & Gao, J. (2010). Impacts of urban forests on offsetting carbon emissions from industrial energy use in Hangzhou, China. Journal of Environmental Management, volym 91, nummer 4, 807-813.