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Comprehensive Parking Supply, Cost and Pricing Analysis

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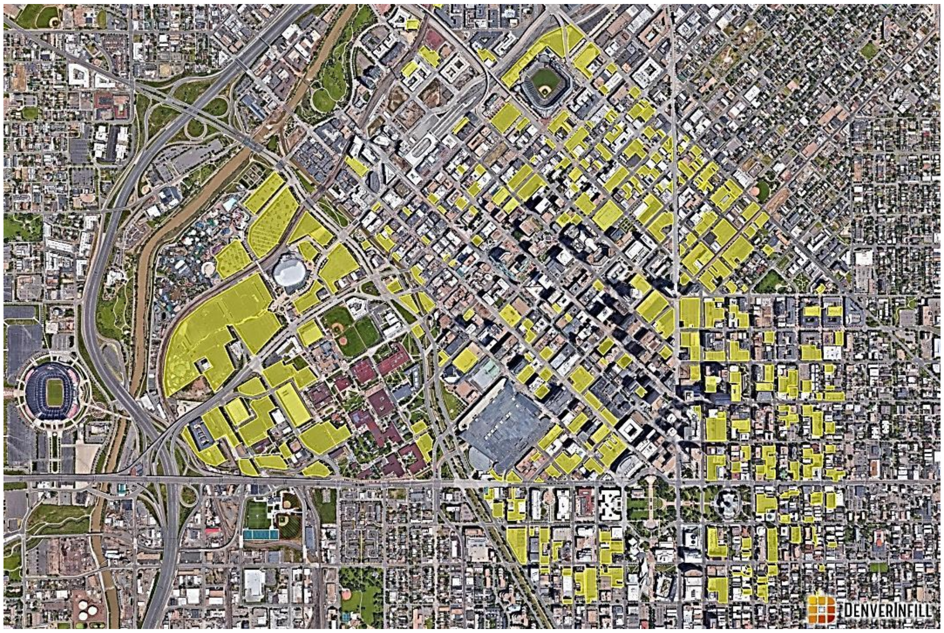
By Todd Litman

Parking facilities impose many economic, social and environmental costs. This report provides guidance for estimating the number of parking spaces that exist in an area, the full costs of these facilities, and their optimal prices. It can help calculate the potential savings and benefits that could result from more efficient parking management that reduces the number of spaces required to serve motorists' needs.

Summary

Parking facilities are a critical part of a transportation system: vehicles are typically parked about 23 hours per day and require parking at every destination. These facilities impose various economic, social and environmental costs. This report describes how to estimate the number of parking spaces that exist in an area, their total costs, and optimal pricing. This information is important for many policy and planning decisions. Recent surveys indicate that typical North American communities have three to six parking spaces per vehicle, including many seldom-used spaces. Considering land, construction and operating expenses, their total annualized costs per space typically range from about $600 for a basic surface lot on inexpensive land to more than $5,000 for high-amenity structured parking. Overall, their costs are estimated to average about $1,000 annually per space or $5,000 per vehicle-year, totaling more than a trillion dollars per year in the U.S. For every dollar a motorist spends on their vehicle somebody typically spends about a dollar on parking for its use. Most parking costs are external, resulting in higher taxes, rents and retail prices, plus significant environmental damages. These external costs are economically inefficient and unfair since they increase total parking and traffic costs, and force households that drive less than average to cross-subsidize higher-mileage motorists. More efficient parking management can provide larger savings and benefits than previously recognized.

A summary of this report was presented at the 2023 *World Conference for Transportation Research* (http://wctr2023.ca), Montreal, Canada; at www.vtpi.org/WCTR2023_parking.pdf.



This map by Ryan Keeney (https://denverinfill.com) shows the land devoted to parking in downtown Denver. Parking there consumes 237 acres, which creates an unattractive landscape and displaces other activities including businesses, housing and parks.

More efficient parking management can provide large savings and benefits. This report helps quantify those impacts.

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Introduction

Every time somebody purchases a vehicle they expect governments to provide roads and businesses to provide off-street parking facilities for their use. They complain if these are inadequate (Shenk 2023). These facilities are often unpriced, their costs are borne indirectly through higher taxes (for on-street parking), higher mortgages and rents (for residential parking), more expensive retail goods (for customer parking), and lower employee wages and benefits (for commuter parking). Housing costs are typically 10-20% higher, weekly grocery and restaurant bills a few dollars more expensive, and employees paid hundreds of dollars less each year to provide "free" parking. In addition to these financial costs, parking facilities also impose environmental costs, and underpriced parking increases vehicle travel and associated traffic congestion, crash risk and environmental costs.

Although these impacts are large and diverse, they are often overlooked in policy analysis and planning analysis. As vehicle travel grew during the twentieth century, traffic engineers were mainly concerned with correcting shortages by providing more on-street parking and mandating more off-street parking. There was little analysis of these policies' total costs. A growing body of research challenges current parking planning practices. Professor Donald Shoup's 2005 book, *The High Cost of Free Parking*, focused attention on the inefficiencies and inequities of current parking practices, and other recent publications have proposed reforms (Chester, et al. 2015; Economist 2017; Kodransky and Hermann 2011; Litman 2019; *Parking Reform Network*; Willson 2015).

Parking planning faces a paradox: motorists want abundant parking if subsidized but their demands decrease significantly if they are required to pay directly. Conventional planning often determines parking supply based on unpriced parking demands, resulting in a large number of seldom-used spaces, like the amount of food people will eat if it is free. Just as abundant, free food can lead to unhealthy diets, abundant, free parking can lead to inefficient transportation systems.

Convenient parking is important. There are many ways to serve these demands, as summarized in Table 1. Most North American communities primarily rely on unpriced parking, which is inconvenient, costly and unfair to non-drivers. More efficient management can increase motorists' convenience and significantly reduce parking supply requirements, and therefore costs, is fairer, and supports strategic goals such as housing affordability, compact development and reduced traffic problems.

Good planning requires good data. Until recently, there was a dearth of reliable parking supply, costs and price information. Some studies measured the parking supply in particular areas, and a few transportation cost studies estimated total parking costs, those were based on limited data.

The goal of this study is to provide comprehensive information on parking supply, costs and prices for typical communities. It builds on new information from recent field surveys. This report summarizes this information, describes how to calculate total parking costs in a particular situation, and uses those methods to calculate typical costs per space, per vehicle, per vehicle-mile/kilometer, and totals for the U.S. This information can help answer many policy and planning questions. For example, it can estimate the savings and benefits provided by more efficient management that reduces the number of parking spaces needed in an area; provide guidance for calculating efficient and fair parking prices; and evaluate the fairness of parking mandates.

Table 1 **Parking Supply Options** (Barter 2014)

	Subsidized	Efficient Management	Commercial
Approach	Governments supply on-street and mandate off-street parking which is generally unpriced.	Provided by governments and businesses, with cost-recovery prices. Prices are moderate.	Parking is provided by for-profit businesses. Prices are high.
Cost distribution	Borne indirectly through taxes and higher prices.	Borne by motorists except where subsidies are justified.	Costs and profits are borne by motorists.
Parking impacts	Results in parking congestion at high demand locations.	Minimizes parking congestion.	Prevents congestion were parking is priced, but increase congestion of unpriced spaces.
Traffic impacts	Low prices increase vehicle ownership and use.	Moderate prices moderate vehicle ownership and use.	High prices minimize vehicle ownership and use.

There are various ways to provide parking facilities. Subsidized parking minimizes prices which increases vehicle ownership and use, and leads to parking congestion as motorists fight over the most convenient spaces. As a result, far more spaces are needed to serve motorists' demands.

This information is helpful for addressing many current policy goals including optimal infrastructure investments; traffic congestion, crash and emission reduction; housing affordability; and social equity. Transportation economists often recommend efficient road pricing as a way to reduce traffic problems; this research suggests that efficient parking pricing can provide even greater benefits with lower implementation costs.

This report expands the "Parking Costs" chapter of *Transportation Cost and Benefit Analysis*. It should be useful to anybody who wants to better evaluate parking policy and planning decisions including policy makers, planners, engineers, developers, facility managers and other practitioners, plus social equity and sustainability advocates concerned with motor vehicle external costs.

Table 2 **Key Definitions**

Types of Parking Facilities	Types of Parking Costs
• *On-street* consists of parking lanes within public road rights-of-way. • Off-street is parking facilities on their own land. • *Surface* refers to parking lots directly on land. • *Structured* (also called parkades, garages or ramps) refers to multi-story parking buildings. • *Underground* refers to parking facilities built below a building. • *Commercial parking* refers to parking rented to the general public for a profit.	• *Land value* refers to the opportunity costs of land devoted to parking facilities. • *Construction cost* refers to the costs of building parking facilities, and repayment of those costs. • *Operating costs* include maintenance, repairs, cleaning, fee collection, and enforcement. • *Environmental costs* include stormwater management, heat island effects, habitat displacement, and aesthetic degradation. • *Traffic impacts* refers to changes in automobile ownership and use, and resulting impacts on congestion, crashes and pollution emissions.

These terms are frequently used in this report.

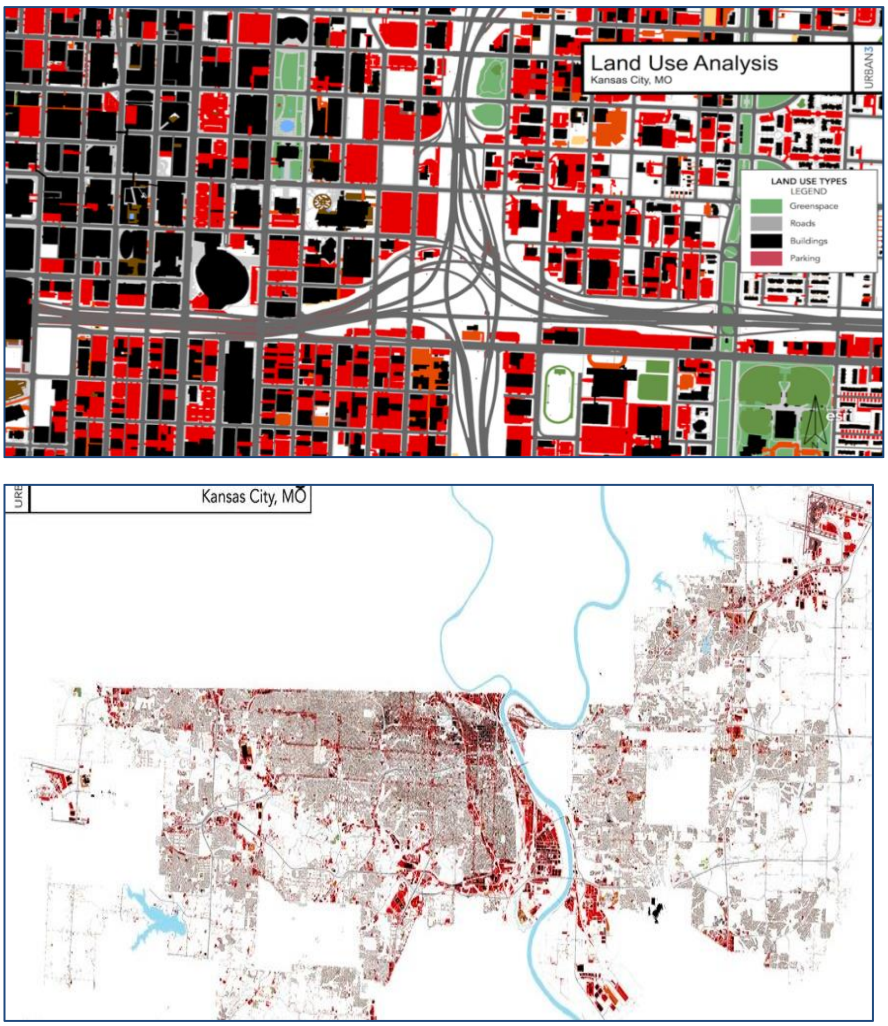
Parking Supply and Land Consumption Studies

The following studies have estimated parking supply and land consumption in various areas.

Land Area Devoted to Parking

Several studies map the land devoted to parking facilities in particular areas (usually downtowns), and calculated the portion of land they consume (Gardner 2011; Herriges 2019). The Parking Reform Network's *Parking Lot Map* (https://tinyurl.com/yvyphbsy) shows parking lot area in more than 50 U.S. downtowns. It also provides a Parking Score which measures how parking areas compare with other similar size cities. The figures below illustrate parking lots in Kansas City, Missouri, a typical U.S. city.

Figure 1 **Land Devoted to Parking in Kansas City** (Herriges 2020)



These maps illustrate the portion of land devoted to roads (grey) and parking (red) in Kansas City, a typical U.S. city. Similar maps are available for other cities.

The upper map shows the downtown area, the lower map shows the metropolitan region.

New GIS mapping tools make it easier to perform this analysis. However, such analysis requires comprehensive parking supply data; in practice, most sources are incomplete, for example, aerial images overlook most structured parking, and property inventories overlook unofficial parking facilities, so these maps tend to undercount actual parking supply.

Parking Supply Estimates

- Akbari, Rose and Taha used high-resolution aerial photos to estimate the area of various land-use types in Sacramento, California, summarized Table 4.

Table 3 **Calculated Surface-Area Percentages** (Akbari, Rose and Taha 2003)

	Tree Cover	Barren	Grass	Roof	Road	Sidewalk	Parking	Miscellaneous
Residential	14.7%	10.2%	24.5%	19.4%	12.7%	8.0%	4.9%	5.6%
Commercial/service	9.6%	7.3%	9.3%	19.8%	15.5%	3.7%	31.1%	3.8%
Industrial	8.1%	19.7%	6.0%	23.4%	7.3%	1.3%	20.0%	14.3%
Transport/communications	0.0%	4.0%	0.0%	5.0%	80.0%	1.0%	10.0%	0.0%
Industrial and commercial	2.8%	15.6%	5.6%	19.2%	10.3%	1.3%	32.1%	13.1%
Mixed urban	26.8%	2.1%	7.1%	23.7%	17.6%	4.5%	9.5%	8.7%

This table summarizes the surface area of various types of land uses in Sacramento, California.

- Chester, Horvath and Madanat estimated that in 2010 there were 105 million to 2.0 billion parking spaces in the U.S., averaging 0.5 to 8 spaces per vehicle, as indicated in this table.

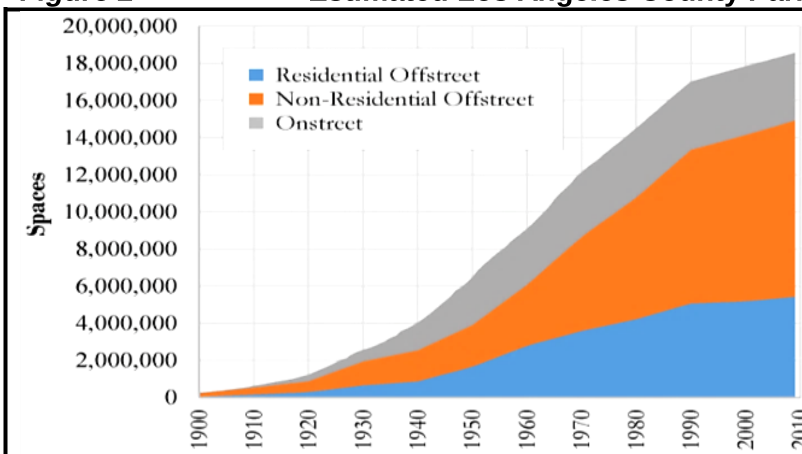
Table 4 **Millions of Parking Spaces** (Chester, Horvath and Madanat 2010)

Type	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
On-street	35	92	180	150	1,100
Surface	36	520	520	610	790
Structure	34	110	110	84	120
Total	*105*	*730*	*820*	*840*	*2,000*

This table summarizes estimates of U.S. parking supply based on various assumptions.

- Chester, et al. (2015) estimated Los Angeles County parking supply from 1900 to 2010, and analyzed vehicle travel and urban form impacts. They found 18.6 million spaces in 2010, including 5.5 million residential off-street, 9.6 million nonresidential off-street, and 3.6 million on-street spaces, as indicated below. This averages 3.3 spaces per vehicle: 1.0 residential off-street, 1.7 nonresidential off-street and 0.6 on-street spaces, with the greatest density in the urban core and most growth outside the core. In total, 14% of County land is used for parking.

Figure 2 **Estimated Los Angeles County Parking Spaces** (Chester, et al. 2015)



The number of parking spaces in Los Angeles grew significantly during the last century. For each motor vehicle there are estimated to be 3.3 spaces: 1.0 residential off-street, 1.7 nonresidential off-street, and 0.6 on-street spaces

- The study, *Inventorying San Francisco Bay Area Parking Spaces* (Chester, Helmrich and Li 2022) used satellite imagery and analysis of regulations to estimate the number and location of parking spaces in the San Francisco Bay region. These total 15 million spaces of which 6.4 million are off-street and 8.6 million are on-street, resulting in approximately 2.4 spaces per automobile and 1.9 spaces per capita. Parking and roadways make up 20% of urbanized land area.

- Davis, et al. (2010) used detailed aerial photographs to estimate the number of parking spaces in surface lots in Illinois, Indiana, Michigan, and Wisconsin. Their analysis excluded on-street parking and residential garages, and only counted the top floors of structured parking. They counted more than 43 million spaces in these four states, averaging 2.5 to 3.0 spaces per vehicle. They found that parking uses approximately 5% of urban land.

- Hoehne, et al. (2019) estimated that in 2017 the Phoenix, Arizona region had 12.2 million parking spaces, with 4.3 spaces per non-commercial vehicle. Of these, 1.3 are off-street residential, 1.3 are off-street non-residential, and 1.7 are on-street. Roads and parking facilities cover approximately 36% of the metro's total land area (10% parking and 26% roads).

- McCahill and Garrick (2012) measured the relationship between vehicle travel and parking land consumption in 12 U.S. cities. They found that a 10 point increase in auto commute mode share is associated with an additional 2.5 square meters of parking land area per capita. They found that pavement covers about 35% of most residential areas and 50–70% in non-residential areas.

- Scharnhorst (2018) developed comprehensive parking inventories and cost estimates, including on-street, off-street surface and off-street structured parking for five U.S. cities, as summarized below. Inventories were based on various data sources including property tax assessments and satellite images (for off-street), and local street data (for on-street). Per space replacement costs included land values plus $5,000 per space for surface and $50,000 per space for structured parking. It found lower per-household parking supply and costs in denser, multimodal cities like New York and Philadelphia, with the highest values in Jackson, Wyoming, an automobile-oriented resort and commercial center that attracts many tourists and regional shoppers.

Table 5 **Parking Spaces and Costs in Five U.S. Cities** (Scharnhorst 2018)

	New York	Philadelphia	Seattle	De Moines	Jackson
Population	8,537,673	1,567,872	704,352	215,472	10,529
Parking spaces	1,965,377	2,172,896	1,596,289	1,613,659	100,119
Spaces per household	0.6	3.7	5.2	19	27
Spaces per vehicle	1.0	3.7	2.7	10	14
Total value	$21 billion	$17 billion	$36 billion	$6.4 billion	$711 million
Value per household	$6,570	$29,974	$117,677	$77,165	$192,138
Value per vehicle	$6,570	$8,101	$61,935	$25,721	$51,929

Scharnhorst used various data sources to measure parking supply and costs in five cities.

- Pijanowski (2007) found approximately 3 non-residential off-street parking spaces per vehicle in Tippecanoe County, Indiana, a typical rural community.

The number of on-street spaces is somewhat arbitrary since most rural roads have shoulders suitable for parking, but located far from common destinations. In 2020 the U.S. had 4.2 million total road-miles of which 1.2 million are urban streets ("Table HM20," FHWA 2020). Assuming 65% of road shoulders are suitable for parking and 264 vehicles can park per mile (20-foot per space) there are approximately 1,500 million potential on-street spaces for 276 million motor vehicles or approximately 5.5 per vehicle, of which about 420 million are urban on-street spaces or about 1.5 per vehicle.

Table 6 summarizes these estimates. All methods overlook and undercount many types of parking, so their results are lower-bound values. For example, aerial photographs cannot count spaces shaded by trees, and most structured and underground parking, and property data overlooks some land use types that have parking such as vehicle dealers and public parks.

Table 6 **Parking Supply Estimates Summary**

Publication	Analysis Method	Parking Types Considered	Overlooked Parking Types	Per Vehicle
Davis, et al. (2010)	Aerial photographs	Surface lot spaces in four mid-western states	Shaded by trees. Most structured parking including residential garages.	**2.5-3.0**
Chester, Horvath and Madanat (2010)	Various assumptions	Total on- and off-street in the U.S.	Various types of on- and off-street parking	**0.5 to 8**
Chester, et al. (2015)	Various assumptions	On- and off-street in Los Angeles	Various types of on- and off-street parking	**3.3**
Chester, Helmrich and Li (2022)	Property data and satellite imagery	On- and off-street in the San Francisco Bay region	Various types of on- and off-street parking	**2.4**
Hoehne, et al. (2019)	Various assumptions	On- and off-street in Phoenix	Various types of on- and off-street parking	**4.3**
Litman (above paragraph)	Miles of public roads	On-street parking	Off-street spaces	**Urban: 1.5 Total: 5.5**
Scharnhorst (2018)	Property data and satellite imagery	On- and off-street in five U.S. cities	Various types	**1.0-14**
Pijanowski (2007)	Satellite imagery	Off-street spaces in Tippecanoe County	Shaded by trees. Off-street parking.	**3.0**

This table summarizes parking supply estimates of various studies. All analysis methods overlook and undercount some parking types so their results are lower-bound estimates.

The number of spaces per vehicle tends to be lower in denser areas where parking is shared and priced, and higher in suburban and rural areas where each destination must satisfy its parking demands on site. Although parking spaces close to building entrances are frequently occupied, most spaces are unoccupied most times, and many spaces are seldom or never used. For example, a typical commuter space used 240 days annually is typically occupied about 2,200 hours per year, about a quarter of annual hours, and some land uses, such as churches, have even lower load factors.

This oversupply results, in part, from the way that traffic engineers traditionally calculate parking demands. They generally assume an 85th percentile occupancy rate (a parking facility is considered full if 85% of spaces are occupied), a 10th design hour (parking lots are sized to fill only ten hours per year), and an 85th percentile demand curve (85% of sites will have unoccupied spaces during peak periods), and most parking demand studies are performed in automobile-dependent locations. These methods reflect the assumption that parking spaces should be so abundant that motorists can almost always find a convenient space, even if that results in far more parking supply than is needed at most destinations, particularly in compact, mixed, multimodal areas, or where parking can be managed more efficiently. The *#BlackFridayParking* (www.strongtowns.org/blackfridayparking) photo contest demonstrates that many retail parking lots have numerous unoccupied spaces even during Black Friday (the day after Thanksgiving), considered the busiest shopping day of the year.

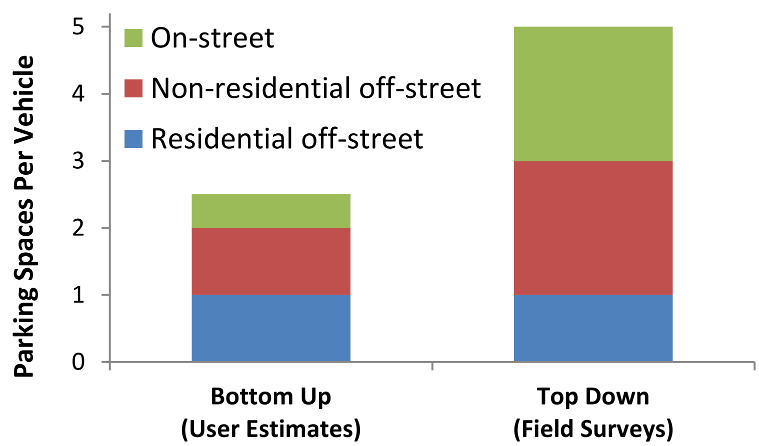
These studies suggest that in typical North American communities there are a total of three to six off-street parking spaces per vehicle, including about one residential and one commuter space, spaces at other destinations, plus numerous on-street spaces. The number of spaces per vehicle tends to be lower in denser areas where parking is shared and priced, and higher in suburban and rural areas where each destination must satisfy its parking demands on site.

Many motorists may be skeptical of these high numbers. They might say, "I use one parking space at home, one at work, and only park a few hours per week at other destinations. That totals about 2.5 parking spaces per vehicle, which is only half of this estimate. Where are the others?"

The others are the seldom-used parking spaces that result from government mandates, plus the many on-street parking spaces on most city streets and roads. These ultimately result from motorists' demand for convenient parking, expressed for example, as opposition to bus or bikelanes that may displace on-street parking, or for infill housing or commercial buildings that may increase parking congestion on their neighborhood streets.

Figure 3 illustrates how bottom-up analyses based on the spaces actually used by a typical vehicle undercount total parking supply by overlooking the many seldom-used spaces. Top-down analyses based on field surveys tend to provide much higher counts, although even those are probably underestimates since most surveys overlook some types of parking facilities because they are invisible to aerial photographs and not included in property assessment records.

Figure 3 **Parking Supply Estimates**

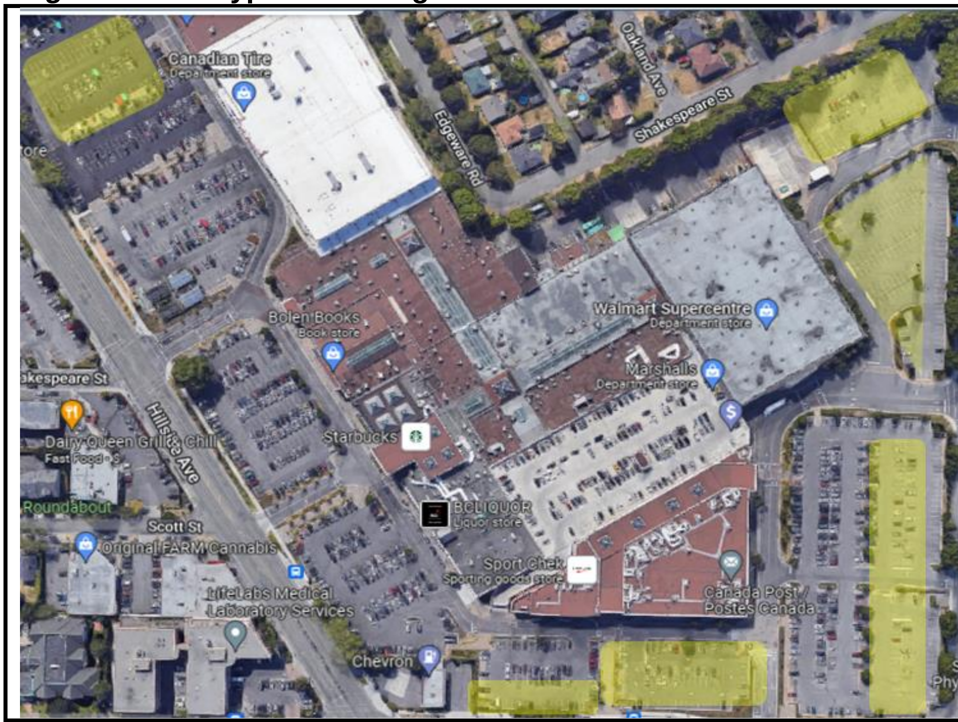


Bottom-up estimates are based on assumptions about the number of spaces used by a typical vehicle, including residential, worksite, and a share of spaces at other destinations. Top-down analyses, which are based on actual field surveys of typical communities, find far more parking spaces per vehicle, including many that are seldom or never used, but mandated by zoning codes.

There is abundant empirical evidence that many parking spaces are seldom used and provide little benefit. Field survey and satellite images, such as the one below, generally show that the spaces closest to building entrances are frequently used but more distant and less visible spaces are often unoccupied.

This can also be seen by the lack of tire marks and oil drips in less convenient parking spaces. When parking minimums are reduced, developers often supply less, indicating that minimums are higher than what consumers demand (Gabbe, Pierce and Clowers 2020).

Figure 4 **Typical Parking Lot Utilization**



Although spaces closest to building entrances are heavily used, those located further away (highlighted in yellow) are often unoccupied. With better management much of this land could be converted to more productive uses.

Better management can result in more efficient use of parking facilities. For example, parking lots can be shared between different uses (a church, a restaurant and an office building can share spaces since their peak periods differ). The most convenient spaces can be regulated and priced to favor delivery vehicles and customers, while longer-term users, such as commuters, are encouraged to use non-auto modes or occupy more distant spaces. Improved walkability can expand the range of parking facilities that serve a destination. Signs and apps can guide motorists to spaces that are less visible but available.

Parking Cost Estimates

The following studies have estimated vehicle parking costs in particular times and locations.

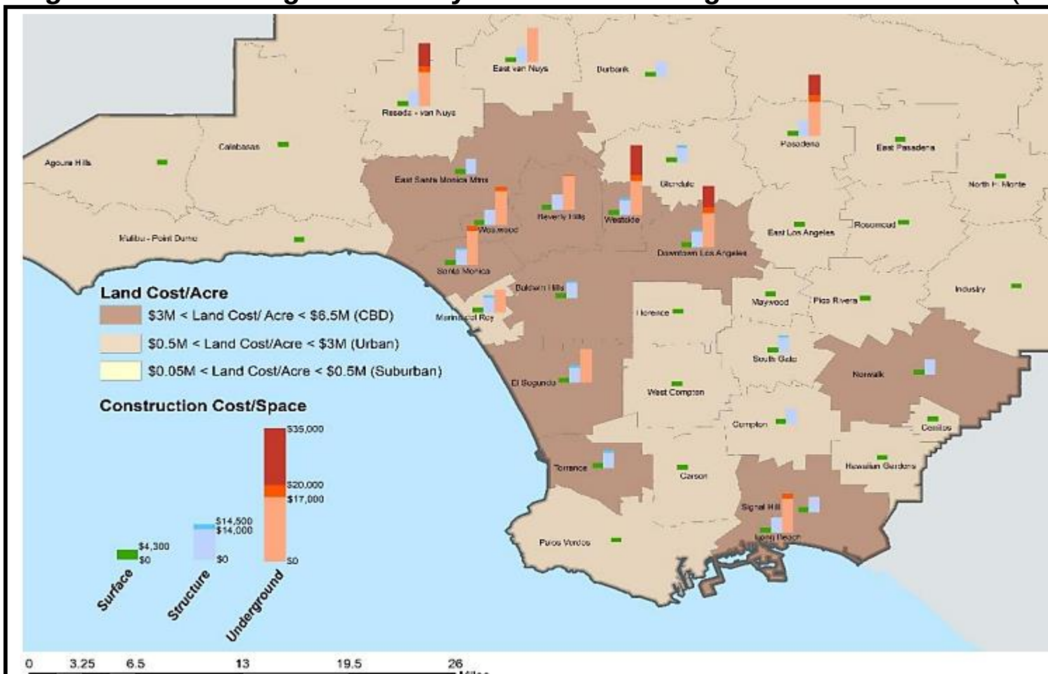
- Chester, Horvath and Madanat (2010) calculate parking facility lifecycle energy consumption, greenhouse gas and air pollution emissions based on five parking supply scenarios. Parking energy consumption is estimated to average from 14–18 kJ/Passenger-Km (Scenario 1) to 240–310 kJ/Passenger-Km (Scenario 5), and GHG emissions range from 1.3–1.7 gCO_2e/PKT (Scenario 1) to 19–25 g CO_2e/PKT (Scenario 5), which represents 0.5% to 12% of total estimated transport system lifecycle energy consumption and greenhouse emissions, and 24% to 81% other air pollutants, depending on vehicle type and scenario.

- Delucchi (1994, Table 1-6) estimated that in 1991, non-residential, unpriced, off-street parking was worth $49 to $162 billion ($106 to $353 billion in 2022 dollars), and bundled residential parking was worth $15 to $41 billion ($33 to $89 billion in 2022 dollars). He estimated that parking costs totaled $155 to $296 billion ($338 to $645 billion in 2022 dollars), which averaged $1,100 to $2,100 per vehicle-year ($2,400 to $4,578 in 2022 dollars), or 10¢ to 19¢ per vehicle-mile (22¢ to 42¢ in 2022 dollars).

- By analyzing development costs and measuring differences in prices between homes with and without off-street parking, Greenberg (2005) estimated that each additional residential parking space increases typical U.S. urban housing costs by $52,000 to $117,000 per home.

- A parking supply and demand study in Porirua City, New Zealand found that about a quarter of central city area land is devoted to parking facilities, and charging users directly for parking would increase the financial cost of driving 30-90% for an average shopping trip and about 100% for an average commuting trip (Hulme-Moir 2010).

Figure 5 **Los Angeles County Land and Parking Construction Costs** (Franco 2020)



Franco calculated parking costs based on land and construction cost data for each district in Los Angeles. Franco estimated that in 2000, surface parking typically costs $4,282, structured $13,924 to $14,522, and underground $11,637 to $34,956 per space.

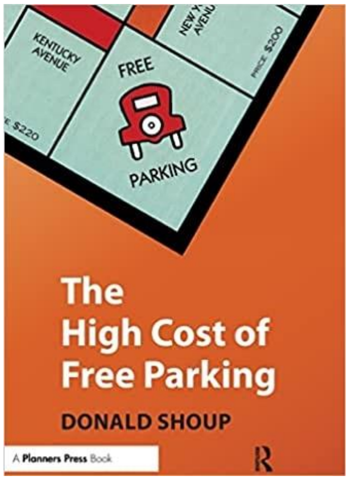
- Researcher Sofia Franco (2016 and 2020) calculated the cost of parking in various locations in Los Angeles (Figure 4). She estimated that in the Los Angeles region, a parking space typically costs approximately $4,282 in a surface lot, $13,924 to $14,522 in an above-ground structure, and $11,637 to $34,956 for underground spaces, considering land and construction costs, but not including operating or environmental costs.

- A U.S. General Accounting study, *Low-Income Housing Tax Credit: Improved Data and Oversight*, found that during 2011–2015, structured parking increased affordable housing costs $56,000 per unit (GAO 2018, p. 30).

- Klipp (2004) found the financial return to Bay Area developers on parking facilities is much less (about half) the return for housing because regulations require far more parking than consumers demand if parking was optional. Klipp estimates that developers must charge at least 28% more to get the same per-square foot rate of return on housing with parking than without. This reduces housing construction, particularly lower-priced units in areas with high land costs.

- A San Francisco Metropolitan Planning Association study estimated that total annualized costs per parking space range from $854 in suburban areas with low land prices up to $2,522 in a three-story urban parking structure, and $4,363 for Central Business District (CBD) underground parking (Nelson/Nygaard 2015).

- Manville and Shoup (2005) estimate parking spaces per hectare and job in various central business districts in the world, and calculate a *parking coverage rate*, the portion of downtown that would be devoted to parking if all parking were provided in surface lots. This varies from under 10% to more than 80%. They argue that a high parking coverage rates tend to spoil many desirable urban environment attributes, including walkability and cost efficiency.



- Detailed analysis of MIT employee parking estimated that they cost $2,500-3,500 annual per space to provide, far less than the $500-1,500 annual user fees, so automobile commuters receive about $1,000 annual subsidy, far more than what transit receive (Rosenfield 2018).

- *The High Cost of Free Parking* (Shoup 2005), estimated that in 2005, unpriced off-street parking costs $127 billion to $374 billion in the U.S., representing a subsidy averaging 5¢ to 14¢ (8¢ to 21¢ in 2022) per vehicle-mile, assuming 2.7 trillion light-duty vehicle-miles.

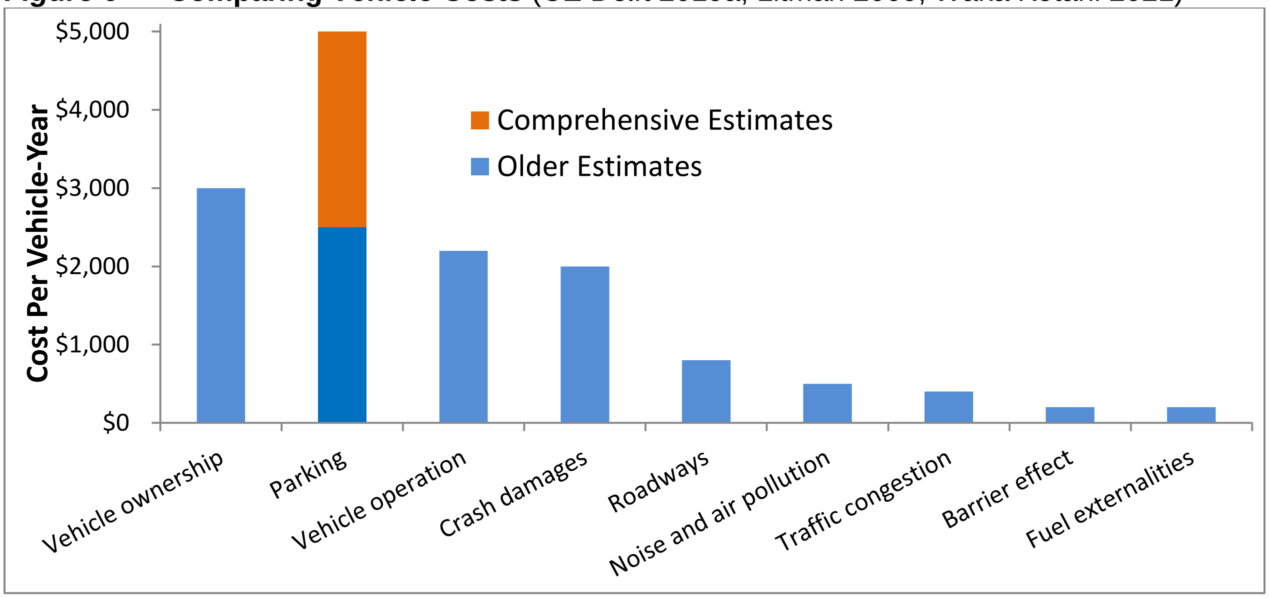
- Construction engineering firm WGI estimates that in 2020 the median construction cost for a new parking structure is $22,200 per space, not including land acquisition, design and engineering fees, financing, or other soft costs (Smith 2020).

- The National Parking Association's *Parking in America* reports (www.npapark.org), and Colliers International *Parking Rate Surveys* (Colliers 2021) provide information on parking facility costs and rates, and employee wages in various North American cities.

Motor vehicle travel involves many direct and indirect costs, including vehicle and infrastructure expenses, plus traffic congestion and barrier effect (delays to pedestrians), crash risk and pollution damages produced during fuel production and use.

Older parking cost estimates, which only considered the parking facilities actually used by a typical vehicle, rank parking as the second largest cost, after vehicle ownership costs. Comprehensive estimates that also consider the costs of seldom-used government-mandated parking spaces indicate that parking is actually the largest vehicle cost. For every dollar that a motorist spends on their vehicle, somebody must spend about a dollar on parking facilities to serve it.

Figure 6 **Comparing Vehicle Costs** (CE Delft 2019a; Litman 2009; Waka Kotahi 2021)



Motor vehicle travel involves many costs. Older estimates, which only considered the parking facilities actually used by a typical vehicle, indicate that parking is the second largest cost category, but comprehensive estimates that also consider the costs of seldom-used government-mandated parking spaces indicate that parking is actually the largest vehicle cost.

Most current transportation cost frameworks ignore or underestimate parking costs. For example, a major European Union study, *Overview of Transport Infrastructure Expenditures and Costs*, states,

> "Parking lots are considered to be part of the road infrastructure as well. However, since the data availability on expenditures on (public) parking places in Europe is rather poor, we are not able to consider these expenditures/costs in this study. Therefore, parking lots (others than on the open road) are excluded from the working definition of road infrastructure in this study." (CE Delft 2019b)

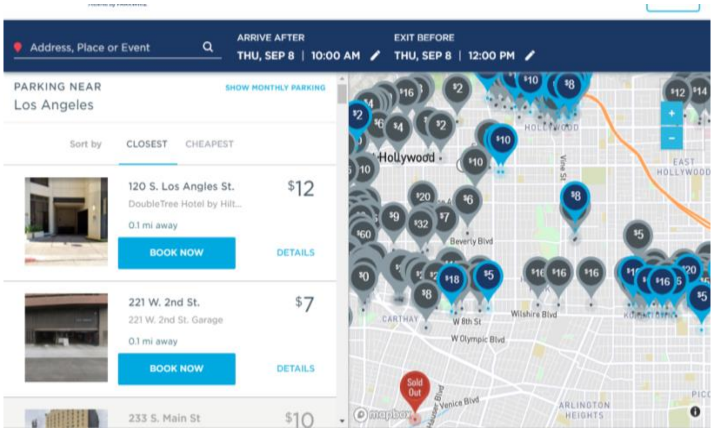
Analysis in this report suggests that this is unjustified. The costs of vehicle parking facilities are larger than most other costs and their magnitude can be estimated using a combination of field surveys and property records. Ignoring parking costs significantly underestimates the full costs of vehicle travel and the potential benefits of more efficient transportation and parking management.

Parking Pricing

This section summarizes parking pricing information sources.

In North America, most parking is unpriced or underpriced (users pay less than cost-recovery prices), estimated at about 95% of commuter parking and 99% of total parking (Shoup and Breinholt 1997). Several websites (www.bestparking.com; www.parkopedia.com; www.spotangels.com; and https://spothero.com/cities), and many local governments and businesses associates provide maps and websites showing public parking location, availability and price. The figure below illustrates an example.

Figure 7 **Los Angeles Parking Prices** (www.bestparking.com/los-angeles-ca-parking).



Best Parking maps indicate commercial parking availability and price. This example illustrates central Los Angeles.

Parkopedia's *Parking Index* reports and compares 2-hour, daily and monthly on-street and commercial parking rates in major U.S. city centers. These reports indicate that commercial parking spaces typically rent for $50 to $250 per month, or $600 to $3,000 per year. These do not necessarily reflect cost-recovery pricing, for the following reasons. Commercial operators generally charge the highest price they can based on demand. Their operations are often a temporary uses of land held for development which is not expected to pay land rents or earn a profit. Institutional operators (e.g., hospital and campuses) are generally required to recover construction and operating costs but not land costs.

Figure 8 **Average Monthly Off-Street Parking Prices** (https://bit.ly/3eDQNh3).

Rank	Country	State	City	Average monthly price USD	Rank	Country	State	City	Average monthly price USD
1	United States	NY	New York	$655.19	26	United States	VA	Alexandria	$143.13
2	United States	MA	Boston	$337.14	27	United States	MD	Bethesda	$141.67
3	United States	NJ	Jersey City	$302.15	28	United States	MN	Minneapolis	$140.50
4	United States	CA	San Francisco	$296.90	29	United States	DE	Wilmington	$140.15
5	United States	DC	Washington	$273.35	30	Canada	ON	Ottawa	$139.48
6	United States	PA	Philadelphia	$258.46	31	United States	MI	Ann Arbor	$138.75
7	United States	IL	Chicago	$241.62	32	United States	CA	San Diego	$138.12
8	United States	WA	Seattle	$230.96	33	United States	VA	Arlington	$137.87
9	United States	PA	Pittsburgh	$204.84	34	United States	CA	Los Angeles	$136.55
10	United States	RI	Providence	$201.84	35	United States	CT	Hartford	$134.29
11	Canada	ON	Toronto	$192.36	36	Canada	MB	Winnipeg	$128.27
12	United States	OR	Portland	$191.53	37	United States	LA	New Orleans	$128.26
13	United States	WA	Bellevue	$183.70	38	United States	FL	Miami Beach	$126.72
14	United States	CA	Berkeley	$179.50	39	Canada	SK	Regina	$126.00
15	United States	CO	Denver	$173.22	40	United States	TN	Nashville	$125.87
16	United States	CA	Oakland	$163.64	41	United States	TX	Fort Worth	$125.18
17	United States	SC	Charleston	$163.00	42	United States	OH	Cleveland	$124.11
18	Canada	QC	Montreal	$154.43	43	United States	MN	St Paul	$123.70
19	United States	MI	Detroit	$153.85	44	United States	AK	Anchorage	$122.74
20	United States	TX	Austin	$152.50	45	United States	TX	Dallas	$122.47
21	United States	MD	Baltimore	$152.32	46	Canada	SK	Saskatoon	$122.14
22	United States	NJ	Newark	$151.95	47	Canada	BC	Victoria	$121.97
23	Canada	AB	Calgary	$151.53	48	United States	CT	New Haven	$121.25
24	United States	HI	Honolulu	$147.40	49	United States	VA	Richmond	$120.00
25	United States	WI	Madison	$147.00	50	United States	TX	Houston	$117.67

This table from the Parkopedia's 2019 Parking Index Report *compares average monthly off-street parking prices for major North American cities.*

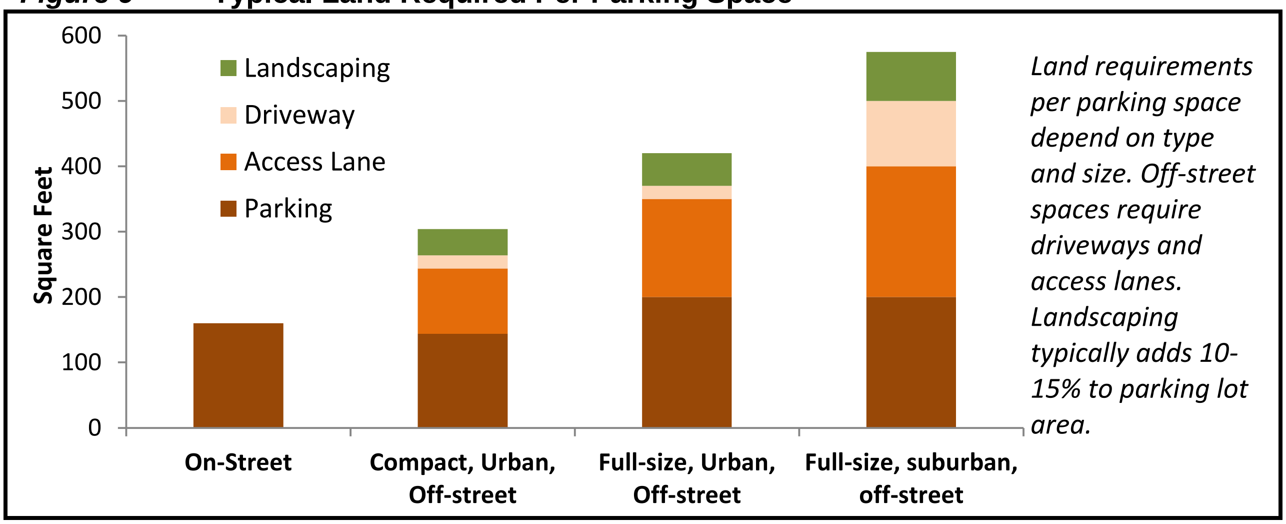
Cost Analysis

This section provides guidance for comprehensive parking cost analysis.

Land Area and Value

A typical parking space is 8-10 feet (2.4-3.0 meters) wide and 18-20 feet (5.5-6.0 meter) long, totaling 144-200 square feet (13-19 square meters) (Hunnicutt 1982). Gordon (2023) found that the North American vehicle fleet is expanding in size as motorists choose larger sports utility vehicles (SUVs), light trucks and vans over cars. This requires larger and therefore more expensive parking spaces. For example, standard commuter parking spaces are expanding from 8.5 to 9.0 feet. Off-street parking typically requires 250-350 square feet (25-35 square meters) per space, including access lanes and landscaping, allowing 125-175 spaces per acre (250-450 per hectare), depending on design. In practice, spaces per acre are often lower due to the constraints such as odd-shaped parcels or topography. One survey of six typical parking lots found that they average of 85 spaces per acre (Marshall 2014).

Figure 9 **Typical Land Required Per Parking Space**



Land costs can vary from thousands of dollars per acre in rural areas to millions of dollars per acre in cities. One study estimated that in 2010 U.S. urban land averaged about $500,000 per acre (about $680,000 in 2022 dollars) with higher values in central areas and larger cities (Albouy, Ehrlich, Shin 2018). Since parking must be located near destinations it requires relatively high-value land. For example, a building located on $5 million per acre land generally requires equally expensive land for parking rather than cheaper land located a mile away. Land devoted to parking is sometimes considered a sunk cost, but there are usually opportunity costs since unused spaces can be leased or sold, or the land used for other uses. Similarly, roadspace used for on-street parking could be used for traffic lanes, busways, bike lanes, wider sidewalks (for café seating or other commercial activities), landscaping, or small play areas called *parklets* (http://sfpavementtoparks.sfplanning.org).

Woudsma, Litman, and Weisbrod developed practical methods for valuing the land used for transport facilities, including roads, railroads and airports, based on detailed data for specific geographic areas (Woudsma, Litman, and Weisbrod 2006). They find typical values of $150 to $300 per square meter in urban areas and $0.60 to $1.00 per square meter in rural areas in 2022 Canadian dollars ($110 to $220 urban and 45¢ to 70¢ rural in 2022 US dollars).

Construction Costs

Parking facility construction costs are affected by their location, conditions (higher costs for smaller, irregular, sloped or unstable sites), design (larger spaces, more amenities and better aesthetics increase costs) (Madrigal 2022). The table below summarizes average parking structure construction costs in various U.S. cities. This indicates that building a basic structure typically costs $20,000 to $30,000 per space, and more if a site has special requirements. Construction costs have increased faster than general inflation in recent years: they more than doubled between 2002 and 2022 (Zarenski 2022).

Table 7 **Parking Structure Construction Costs, 2022**

City	Cost per Sq. Ft.	Cost per Space
Atlanta	$65.65	$21,926
Baltimore	$69.06	$23,065
Boston	$87.06	$29,078
Charlotte	$61.95	$20,690
Chicago	$87.28	$29,153
Cleveland	$73.57	$24,574
Denver	$68.38	$22,842
Dallas	$63.27	$21,134
Detroit	$76.01	$25,392
Houston	$64.53	$21,555
Indianapolis	$68.90	$23,015
Los Angeles	$79.79	$26,653
Miami	$64.61	$21,580
Minneapolis	$80.83	$27,000
Nashville	$64.91	$21,679
New York	$97.14	$32,444
Philadelphia	$85.20	$28,460
Phoenix	$65.49	$21,876
Pittsburgh	$75.65	$25,267
Portland	$74.31	$24,822
Richmond	$63.79	$21,308
St. Louis	$75.57	$25,242
San Diego	$77.87	$26,009
San Francisco	$90.77	$30,316
Seattle	$76.31	$25,490
Washington D.C.	$72.98	$24,376
National Average	*$74.09*	*$24,748*

(Carl Walker 2016 updated to 2022 values)

This table indicates average construction costs for basic parking structures in various U.S. cities. Costs are higher for:

- *Below grade (underground) construction.*
- *Site conditions that require deep foundations or grading.*
- *Extra wide spaces for increased convenience.*
- *Higher quality construction, design and materials.*
- *Enclosed or underground structures that require mechanical ventilation and fire sprinklers*
- *Energy efficient Green Garage Certification.*
- *On-site storm water retention.*
- *Enclosed stair towers.*
- *Mixed use development where the parking is integrated with office, retail, residential, or other uses.*
- *State-of-the-art parking access and revenue control system.*
- *User amenities such as pedestrian facilities, wifi and wayfinding.*

The following table summarizes results of a parking facility construction costs survey. It indicates that in 2011 costs averaged $24,000 per aboveground space and $34,000 per underground space. In addition to these hard costs, facility development usually involves soft costs for project planning, design, permits and financing, which typically add 30-40% to a project, plus any incremental land costs. This indicates that most structured parking spaces cost more than the vehicles they serve.

Since structured parking typically costs $20,000 more per space than surface lots, it typically becomes cost effective when land prices exceed about $3 million per acre, assuming 150 spaces per acre.

Table 8 **Parking Structure Construction Costs, 2011** (Shoup 2016)

	Construction Cost Per Square Foot		Construction Cost Per Space	
	Underground	**Above Ground**	**Underground**	**Above Ground**
Boston	$95	$75	$31,000	$25,000
Chicago	$110	$88	$36,000	$29,000
Denver	$78	$55	$26,000	$18,000
Honolulu	$145	$75	$48,000	$25,000
Las Vegas	$105	$68	$35,000	$22,000
Los Angeles	$108	$83	$35,000	$27,000
New York	$105	$85	$35,000	$28,000
Phoenix	$80	$53	$26,000	$17,000
Portland	$105	$78	$35,000	$26,000
San Francisco	$115	$88	$38,000	$29,000
Seattle	$105	$75	$35,000	$25,000
Washington DC	$88	$68	$29,000	$22,000
Average	*$103*	*$74*	*$34,000*	*$24,000*

This table summarizes average parking structure construction cost in twelve U.S. cities.

Operation and Maintenance

Operation and maintenance costs can include resurfacing, repairs, cleaning, lighting, security, landscaping, snow removal, access control, fee collection, enforcement, insurance, labor and administration. Parking structures may require elevators, fire control and mechanical ventilation. Private facilities must pay taxes and provide profits. Parking lots typically require resurfacing every 5-15 years, and structures require major reconstruction or replacement after 20-40 years. These costs are higher in areas with harsh climates. Fee collection costs range from less than $50 annually per vehicle for a simple pass system with minimal enforcement, to more than $500 per space for facilities with attendants or automated control systems. This suggests that operating costs typically range from about $500 per space for basic surface parking up to $2,000 for commercial parking facilities with attendants (PT 2005).

Driveway and Curbcut Costs

Off-street parking facilities require driveways with curbcuts. A short driveway typically costs $1,500 to $15,000 to construct, depending on materials and conditions (Gerhardt and Allen 2022), and imposes pedestrian delay and risk when it crosses a sidewalk. Cutting and installing a curbcut typically costs $1,000-$2,000, and most curbcuts displace one on-street parking space.

Environmental Costs

Paving land for parking imposes environmental costs (Litman 2022; Wu 2018). Impervious surfaces (also called *sealed soil*) reduce groundwater recharge and increase stormwater management costs (Arnold and Gibbons 1996). Parking lots are a major contributor to urban heat island effects, which increase ambient temperatures and associated costs, including human discomfort and health damages, building cooling expenses, and local environmental damages (Chester, Horvath and Madanat 2010; Gaworecki 2017; USEPA 2021). Parking facilities contain high levels of embodied energy and emissions (Alter 2021), particularly structured parking facilities which consume large amounts of concrete and steel (Alvarez 2021). Wu (2018) estimates that the materials and construction energy required to build one surface parking space emit 176 kilograms of carbon dioxide, or 353 kilograms including access lanes. This is equivalent to the emissions produced by 500 to 1,000 vehicle-miles for an average automobile.

The table below rates the environmental values of various land uses. Openspace, such as farms, forests and parks provide wildlife habitat, groundwater recharge, agricultural productivity and beauty. Impervious surfaces such as buildings, roads and parking are ecologically sterile and so provide the least benefit. Shifts to higher environmental values, such as from buildings and pavement to lawns, or from mono-cropped lawns to native plant gardens (Ponsford 2020), tends to increase wildlife habitat and groundwater recharge, and reduce heat island effects.

Table 9 **Land Use Environmental Values** (McConnell and Walls 2005)

Land Use	Environmental Values
Undisturbed natural open space	Wildlife habitat, groundwater recharge, beauty
Disturbed natural open space	Wildlife habitat, groundwater recharge, beauty (depending on disturbance)
Farmlands	Agricultural productivity, beauty
Urban parks	Wildlife habitat, groundwater recharge, beauty
Xeriscape gardens and lawns	Wildlife habitat, food production, groundwater recharge, beauty
Mono-crop Lawns	Beauty
Gravel roads and pervious parking	Groundwater recharge
Landscaped roads and parking	Wildlife habitat, beauty
Buildings and pavement	Ecologically sterile, impervious surface, heat island

Land uses vary in their environmental values.

There are various ways to measure and monetize these costs (EFC 2019). Some jurisdictions charge impervious surface fees based on their stormwater management costs, which average about $35 per 1,000 square feet or $12.00 per parking space (see table below). If motor vehicles require an average of three off-street parking spaces these costs average approximately $100 per vehicle-year or 0.1¢ per vehicle-mile, considering parking facility impacts only, not roadways.

Table 10 **Impervious Surface Stormwater Fees, 2022 Dollars** (PCW 2002)

Jurisdiction	Fee (original values)	Per 1000 Sq. ft. (Annual)	Per Space (Annual)
Chapel Hill, NC	$39 annual 2,000 sq. ft.	$32	$10.73
City of Oviedo Stormwater Utility, FL	$4.00 per month per ERU	$25	$8.25
Columbia Country Stormwater Utility, GA	$1.75 monthly per 2,000 sq. ft.	$17	$5.78
Kitsap County, WA	$47.50 per 4,200 sq. ft.	$19	$6.60
Minneapolis, MN	$9.77 monthly per 1,530 sq. ft.	$127	$42.17
Raleigh, NC	$4 monthly per 2,260 sq. ft.	$30	$9.90
Spokane Country Stormwater Utility, WA	$10 annual fee per ERU.	$5.16	$1.65
Wilmington, NC	$4.75 monthly per 2,500 sq. ft.	$38	$12.38
Yakima, WA	$50 annual per 3,600 sq. ft.	$23	$10.73
Averages		*$35*	*$12.02*

"Equivalent Run-off Unit" or ERU = 3,200 square feet of impervious surface. Original fees were increased by 65% to reflect 2002 to 2022 inflation.

Vehicle Travel Impacts

Increasing parking supply discourages compact development and encourages sprawl, which reduces the viability of walking, cycling and public transit, and encourages vehicle travel (Shoup 2016). In these ways, increased parking supply tends to increase vehicle ownership and use. Compared with cost-recovery pricing, unpriced parking typically increases affected vehicle ownership and use by 10-30% (Spears, Boarnet and Handy 2014), which increases congestion, crashes and pollution emissions.

Variability

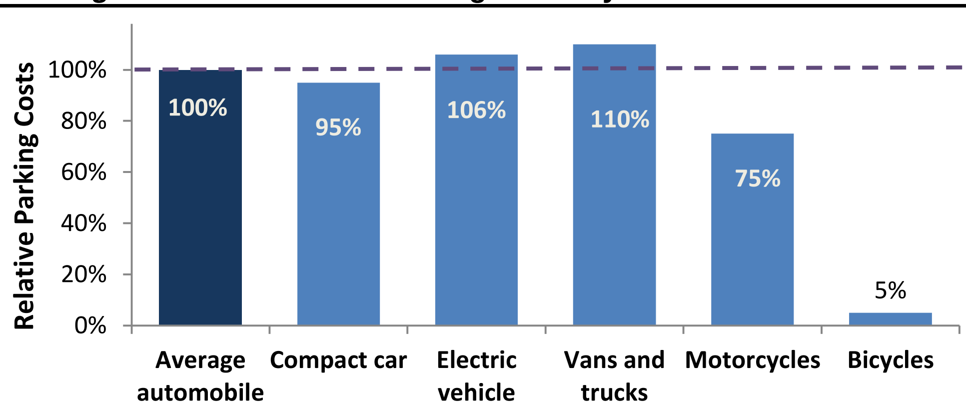
The following section examines how various factors affect parking costs.

Mode

Parking costs can vary by travel mode.

- Compact cars can sometimes use "small car" spaces. This probably reduces parking facility costs about 20% at about a quarter of destinations, for 5% overall saving.
- Electric vehicles require recharging stations at some parking spaces. Residential charging stations typically cost $500 to $1,500 for equipment plus hundreds of dollars for installation, and public stations cost many times more (Home Advisor 2022). These costs probably total $2,000-$4,000 per vehicle or about $300 per electric-vehicle-year if depreciated over ten years. Many jurisdictions require wiring for charging stations in new construction, and subsidize public stations. These costs are partly borne by people who do not own electric cars. Everybody benefits from reduced pollution, eventually most household are expected to own electric vehicles, and public recharging stations are expected to recover costs, so these subsidies may be justified over the long run, but they are still external costs.
- Full size vans and trucks require larger spaces which encourages designers to expand standard spaces. This probably increases parking costs at least 10% compared with average automobiles.
- Motorcycles can sometimes use smaller parking spaces and two can sometimes share one standard space. Assuming they use half-size parking spaces 50% of the time their parking costs are 25% lower than an average automobile.
- 10-20 bicycles can typically park in the area of one standard car space, and bikes can also be stored in otherwise unused areas, so their parking costs are estimated at 5% of those of an average car.
- Walking, ridesharing, public transit and telework incur no significant parking costs, although pedestrians sometimes use public seating and transit stops sometimes displace on-street parking.

Figure 10 **Relative Parking Costs by Mode**



This figure compares estimated parking costs of various modes relative to an average automobile. Compact cars, motorcycles and bicycles have lower costs, while electric car, van and truck costs are higher. Walking, ridesharing, public transit and telework incur no significant parking costs.

Geographic Factors

Parking supply, costs and subsidies tend to vary in the following ways:

- Parking spaces per acre and the portion of land paved for parking increase with density.
- Parking spaces per vehicle, household and person tend to decline with density.
- The portion of parking that is structured and therefore expensive increases with land values.
- The portion of parking that is priced tends to increase with land values and density.

Marginal Analysis

It is often useful to calculate marginal parking costs to evaluate the impacts of moderate changes in supply, for example, if parking supply or demand increases or declines by 20%. Existing parking facility costs are often considered sunk, implying that there are minimal savings if demand is reduced. This assumes, for example, that if vehicle trips decline, existing parking facilities will simply sit unoccupied. However, over time most parking facilities have opportunity costs since reducing demand allows them to be leased or rented, converted to other uses, or sold. Marginal costs are particularly large in areas with high land prices, where populations are growing, and in areas with high environmental values.

This analysis should take into account *load factors*, that is, the portion of parking spaces used at a particular time, or the portion of annual hours a space is used. For example, if parking spaces rent for $75 per month with a 60% average load factor, revenues average $45 per space. If an apartment building's parking costs $3,000 annually per space to provide, and a 60% occupancy rate, parking costs average $5,000 per motorist ($3,000/60%) including the costs of unoccupied spaces.

Parking facilities are sometimes valued by dividing total retail revenues by their number of spaces to determine revenue per space. If a store with 100 parking spaces generates $1,000,000 daily sales, each space is estimated to add $10,000 per day value. However, *marginal* analysis considers the benefits provided by each space. The most convenient parking spaces, typically the 20-40% located closest to building entrances, often have high load factors, but the remaining 60-80%, are only occupied during peak periods. Infrequently-used spaces only contribute to sales the few days that they are occupied by customers who would not shop if those spaces were unavailable.

Parking Cost Distribution

Most parking is unpriced: only about 5% of auto commuters pay full parking costs, and parking is unpriced at an estimated 99% of other destinations (Shoup and Breinholt 1997). Overall, probably less than 5% of non-residential parking costs are paid directly by users. Most employee parking is income tax exempt, a benefit worth more than $2,000 annually compared with cash income (Frontier Group 2014). These costs are borne by governments and businesses, and ultimately by taxpayers and consumers.

Previously-described studies indicate that most communities have many seldom-used parking spaces that exist due to motorists' demands for convenience, so their costs should be assigned to motorists as a group. As long as motorists support parking minimums they bear a share of total costs, including for parking they do not currently use but require be available. Bottom-up analyses that only consider the costs of parking used by typical motorists overlook these spaces and therefore underestimate total parking costs.

The Parking Cost Calculator

The *Parking Cost, Pricing and Revenue Calculator* (www.vtpi.org/parking.xls) calculates the total of various types of parking facilities taking into account land, construction and operating costs. The table and figure below illustrate typical results.

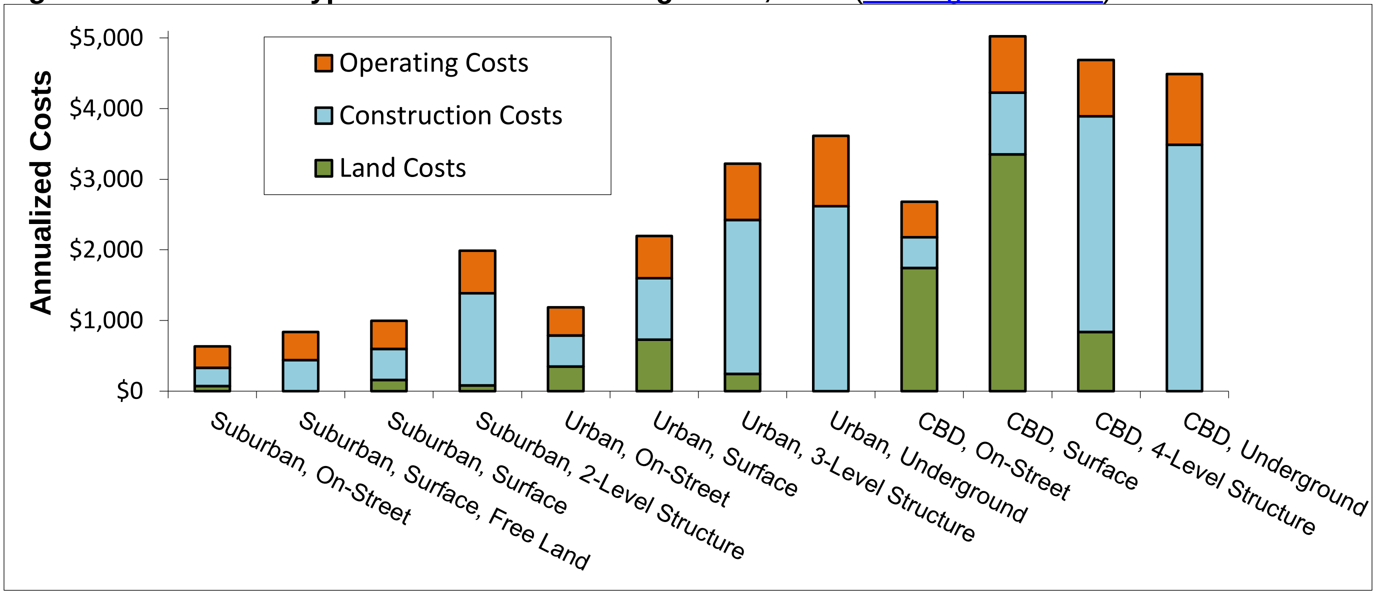
Table 11 **Typical Parking Costs, 2022** (Parking Calculator)

Type of Facility	Land Costs, Per Acre	Annualized Land Cost Per Space	Construction Costs Per Space	Annualized Construction Costs	Annual O & M Costs	Total Annual Cost	Monthly Cost
Suburban, On-Street	$200,000	$70	$3,000	$262	$300	$631	$52.61
Suburban, Surface, Free Land	$0	$0	$5,000	$436	$400	$836	$69.66
Suburban, Surface	$200,000	$159	$5,000	$436	$400	$994	$82.87
Suburban, 2-Level Structure	$200,000	$79	$15,000	$1,308	$600	$1,987	$165.59
Urban, On-Street	$1,000,000	$349	$5,000	$436	$400	$1,185	$98.72
Urban, Surface	$1,000,000	$727	$10,000	$872	$600	$2,198	$183.20
Urban, 3-Level Structure	$1,000,000	$242	$25,000	$2,180	$800	$3,222	$268.48
Urban, Underground	$1,000,000	$0	$30,000	$2,616	$1,000	$3,616	$301.29
CBD, On-Street	$5,000,000	$1,744	$5,000	$436	$500	$2,680	$223.30
CBD, Surface	$5,000,000	$3,353	$10,000	$872	$800	$5,025	$418.76
CBD, 4-Level Structure	$5,000,000	$838	$35,000	$3,051	$800	$4,690	$390.81
CBD, Underground	$5,000,000	$0	$40,000	$3,487	$1,000	$4,487	$373.95

This table shows typical values from the "Parking Cost, Pricing and Revenue Calculator."

This analysis indicates that parking facility costs range from about $1,000 annually for surface parking on low-priced land, to more than $5,000 for high-amenity parking in central business districts (CBDs). These do not include indirect and environmental costs.

Figure 11 **Typical Annualized Parking Costs, 2022** (Parking Calculator)



This figure illustrates annualized costs per parking space. CBD = Central Business District

Most North American homes have costly off-street parking facilities, including driveways and garages for single-family, and underground parking for multifamily housing. This significantly increases housing costs, particularly for lower-priced homes on high cost land (Hoyt and Schuetz 2020; Litman 2019). For example, a $50,000 parking space only adds 5% to the total costs of a million dollar home but 20% to the cost of a $250,000 condominium. This is particularly burdensome to low-income, car free households who are forced to pay for costly parking facilities they do not need (Tuttle 2021).

Analysis of 23 recent Seattle-area multifamily developments found that parking costs increase rents approximately 15% or $246 per month, although 20% of occupants own no motor vehicles and 37% of spaces were unoccupied during peak periods (London and Williams-Derry 2013). Gabbe and Pierce (2016) estimated that parking mandates increase U.S. rents 17%, averaging $142 per month. Manville (2010) found that eliminating downtown Los Angeles parking requirements resulted in less parking and more housing, including lower-priced units with unbundled parking marketed to non-drivers.

Although residential parking is considered an internal cost, since most households own vehicles, it is actually partly external since mandates force households to pay for facilities they do not need. Although residential garages have other uses, including general storage and workshops, garages have special features to accommodate motor vehicles, such as curbcuts, driveways, reinforced floors, fire resistance, and ventilation, which add costs and reduce their utility for other purposes.

Assuming that a typical urban area has two on-street and three off-street parking spaces (one residential and two non-residential) per vehicle, with annualized costs averaging $800 per on-street, $1,000 per residential off-street, and $1,200 per non-residential off-street space, this totals $5,000 per vehicle, as indicated in the table below. Costs per space are lower in suburban and rural areas due to lower land costs, but such areas tend to have more spaces so total parking costs per vehicle are probably similar.

Table 12 **Estimated Annualized Parking Costs Per Vehicle**

Type	Spaces Per Vehicle	Annual Cost Per Space	Paid Directly By Users	Directly-Paid Costs	External Costs	Total Costs
On-street	2	$800	5%	$80	$1,520	$1,600
Non-res. Off-street	2	$1,200	5%	$160	$2,280	$2,400
Residential	1	$1,000	100%	$1,000	0	$1,000
Totals	*5*			*$1,240 (24%)*	*$3,800 (76%)*	*$5,000 (100%)*

This table estimates parking costs per vehicle. Users pay directly for only about a quarter of total parking costs.

Since private automobiles average of about 11,000 annual miles (ORNL 2020, Figure 9.8), these costs average about 45¢ per vehicle-mile of which 35¢ is external, or about $5.00 per trip of which about $3.50 is external. These are lower-bound estimates that exclude indirect and non-market costs such as increased stormwater management costs, heat island effects, and other environmental damages.

There are sometimes debates as to whether unpriced parking should be considered a *subsidy* or a *bundled good*, something automatically included with a purchase (Delucchi 1998). Regardless of what it is called, parking mandates are a market distortion that underprice parking, favor automobiles over other travel modes and increase sprawl. They force non-drivers to pay for costly parking facilities they don't need, and result in households that drive less than average cross-subsidizing the parking costs of those that drive more than average. Since vehicle ownership and trips tend to increase with income, this tends to be regressive: it causes lower-income people subsidizing higher-income motorists.

Comparing Estimates

The table below compares the scope of parking facility types and costs considered in various studies.

Table 13 **Scope of Parking Cost Considered by Selected Studies**

Publication	Chester, et al. (2015)	Delucchi (1998)	Franco (2016)	Greenberg (2004)	Litman (2022)	Rosenfield (2018)
Facility Types Considered						
On-Street	✓	✓	✓		✓	
Off-street residential	✓	✓	✓	✓	✓	
Commuter	✓	✓	✓		✓	✓
Off-street non-residential	✓	✓	✓		✓	
Costs Considered						
Land	✓	✓	✓	✓	✓	
Construction	✓	✓	✓	✓	✓	
Operation		✓			✓	
Environmental		✓	✓	✓	✓	
Traffic impacts			✓	✓	✓	

This table summarizes the scope of parking studies. Many studies only consider a subset of total parking types and costs and so underestimate total parking costs and the benefits of parking supply reductions.

The table below compares per space (ps), per trip (pt), per vehicle-mile (pvm) and per household (phh) cost estimates of selected studies.

Table 14 **Parking Cost Estimate Summary Table – Selected Studies**

Publication	Costs	Cost Values	2022 USD
Delucchi (1998)	External and bundled parking	$64 to $203 billion	8.7¢ to 26¢ pvm
	Total parking costs	$155 to $296 billion	22¢ to 42¢ pvm
Franco (2016)	Surface parking land & const.	$4,282 per space	$8,000 ps
	Structured parking land & const.	$13,924 to $14,522	$26,000 ps
Greenberg (2005)	Total cost per residential space	$52,000 to $117,000	$54,000 to $120,000 ps
Litman, above (2022)	Total parking costs	45¢ per mile (2022)	45¢ pvm/$5 pt
	Parking subsidies	35¢ per mile	35¢ pvm/$3.50 pt
Nelson/Nygaard (2015)	Urban parking annualized costs	$854 to $4,363 per space	$1,070 to $5,450 ps
Rosenfield (2018)	Commuter parking	$1,000 per commuter	$1,000 per commuter
Scharnhorst (2018)	Cost per household	$6,570 to $192,138	$7,753 to $226,723 phh
Shoup (2005)	Parking subsidies	5¢ to 14¢ per vehicle-mile	8¢ to 21¢ pvm

This summarizes cost estimates of various studies described below. Values updated by the Consumer Inflation Calculator (www.usinflationcalculator.com).

This illustrates the importance of clearly defining the scope of parking cost analysis. Many studies only consider a subset of all parking facility types and costs, and so underestimate total costs. For example, many widely-citied estimates only consider commuter or off-street facilities, or only construction cost. Many estimates use bottom-up analyses which only consider the parking facilities used by a typical motorist, ignoring the many seldom-used spaces found in parking supply field surveys.

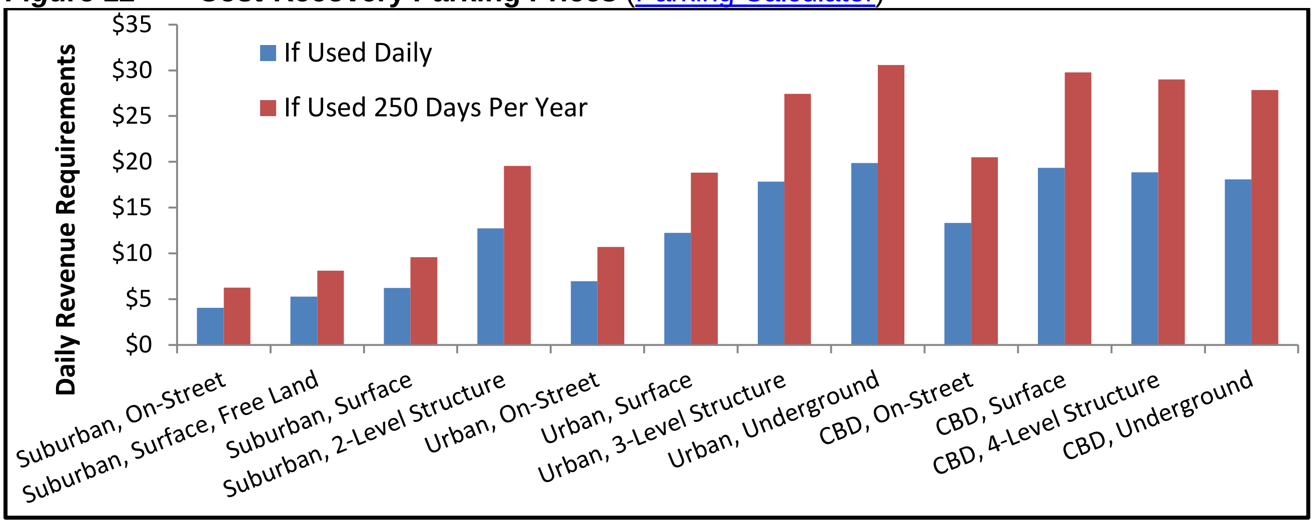
Optimal Parking Pricing and Supply

This section discusses ways to determine efficient and equitable parking prices and supply.

Optimal Prices

Two basic economic rules can help define optimal parking prices. The first is that, as much as possible, parking prices should recover total production costs and provide normal profits, as with most goods, unless there are specific reasons to subsidize it, for example, to help lower-income households obtain essential goods or to achieve strategic goals. Such prices test consumers' willingness to pay for those parking facilities and ensure that they "get what they pay for and pay for what they get." This suggests that a parking space that costs $1,000 annually to provide (including land, construction and operating costs), should be priced to earn about $2.75 per day ($1,000/365), or $4.00 per day if occupied only 250 days per year ($1,000/250). The figure below illustrates typical cost-recovery parking fees.

Figure 12 **Cost-Recovery Parking Prices** (Parking Calculator)



This illustrates daily revenue required to recover basic costs, without profit. Blue columns indicate revenue for spaces used daily. Red columns indicate revenues for spaces used 65% of days, such as for commuting.

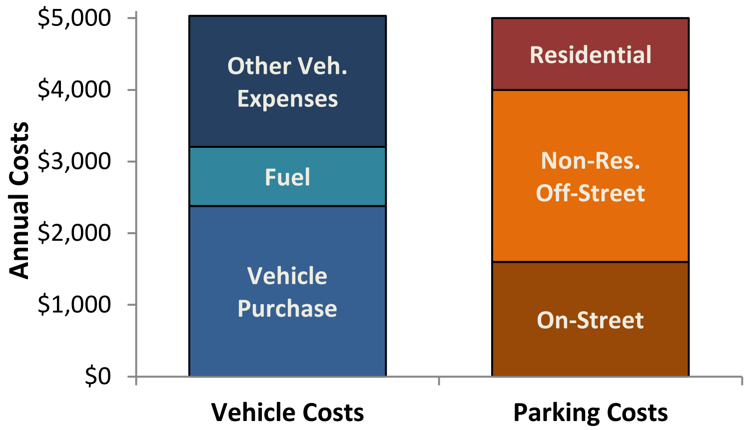
The second principle is that prices should vary to reflect marginal costs; called *responsive pricing* since it responds to changing demands. This means that fees should be higher where parking facilities are more costly to provide (for example due to high land or construction costs), for the most convenient spaces (such as those located nearest to building entrances), and when facilities are congested (demand exceeds supply); and lower at cheaper locations and during off-peak periods. To maximize convenience, prices should be set to maintain 85% occupancy to ensure that motorists can easily find a space. In a typical situation the most convenient locations should have prices that are two or three times higher than a few blocks away, and prices should double during peak periods. For example, if rates are $1.00 per hour for inconvenient spaces during off-peak periods, they should be $2.00-3.00 per hour for the most convenient spaces off-peak, and $4.00-6.00 for convenient spaces during peaks (SFPark 2017).

Efficient parking pricing ultimately benefits travellers by allowing them to make trade-offs between convenience and money. For example, it ensures that motorists can always find a convenient space when in a hurry, or save money by choosing a less convenient location, time or mode.

Price Impacts

How would efficient parking pricing affect driving costs and the amount that people drive? The figure below compares annual vehicle expenses reported in the most recent *Consumer Expenditure Survey* with estimated parking costs per vehicle (BLS 2022).

Figure 13 **Comparing Vehicle and Parking Costs** (BLS 2022)

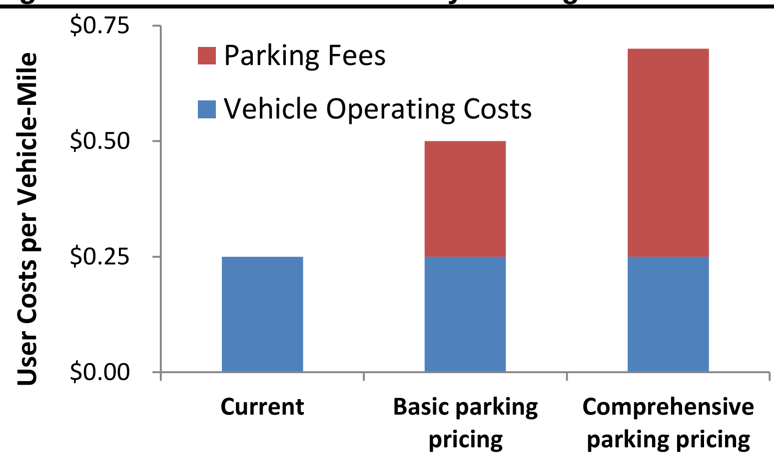


U.S. motorist spend about $5,000 annually per vehicle. There are an estimated five parking spaces per vehicle, including residential, non-residential off-street, and on-street parking, with costs totaling about $5,000 annually. For every dollar motorists spend on their vehicle, somebody spends about a dollar on parking. This averages about 45¢ per vehicle-mile, of which 11¢ is paid directly by users and 34¢ is subsidy.

Most vehicle expenses are fixed. These include purchase, financing, scheduled maintenance, insurance and registration fees. Only fuel, tire wear, and tolls are directly related to the amount a vehicle is driven. These average about 25¢ per mile. That is the price that affects motorists' short-term travel decisions.

As previously described, there are two possible ways to calculate parking supply and costs: bottom-up analyses only consider the parking facilities that a typical vehicle uses; top-down analyses also consider the many seldom-used parking spaces identified in field surveys. Bottom-up analyses estimate that parking costs average about 25¢, and top-down analyses about 45¢ per vehicle-mile. As a result, charging motorists directly for parking would typically double or triple vehicle operating costs, depending on which costs are included. This would particularly increase the price of short urban trips, which are the trips most suited to shifting to non-auto modes.

Figure 14 **How Cost-Recovery Parking Prices Would Affect Vehicle Operating Costs**



Motorists currently spend about 25¢ per vehicle-mile in operating expenses (fuel, tire wear, tolls and existing parking fees). Basic parking pricing, in which motorists pay directly for the parking they use, would approximately double this price. Comprehensive pricing, in which motorists pay for the parking they use plus their share of seldom-used parking provided for their potential use, would almost triple these costs.

Possible Justifications for Parking Underpricing

This section critically evaluates possible justifications for underpricing and therefore subsidizing parking.

Transaction Costs

Claim: Parking pricing is costly and inconvenient. Mechanical meters can be an instrument of torture, requiring motorists to insert correct change, predict the number of minutes they will be parked, and feed the meter if they want to stay longer. Staffed parking lots have high labor costs and may raise security concerns. To avoid these frustrations, many motorists prefer to pay for parking indirectly.

Response: New payment technologies can reduce or eliminate these problems. Electronic meters can automatically track the time that a vehicle is parked, requiring no action by drivers and charging only for the number of minutes the parking space is actually used. If a community standardizes payment systems, so one app or transponder works at all parking facilities, costs and effort can be minimized.

Everybody Drives, Everybody Benefits

Claim: Because most households own motor vehicles (about 90% in North America) most people use parking facilities so it is efficient and fair to "bundle" their costs with other goods.

Response: This is an exaggeration. In a typical North American community, 20-40% of travellers cannot, should not, or prefer not to drive for most trips (Litman 2017). With bundled parking, households that drive less than average subsidize the parking costs of those that drive more than average. For example, if zoning codes require two parking spaces per house, households that only own one vehicle overpay.

Motorists Fair Share of Subsidies

Claim: All travel is subsidized: walkers use public sidewalks, bicyclists use paths and roads, and transit passengers receive subsidized fares. Underpriced parking gives motorists their fair share.

Response: The subsidies provided to other modes are far smaller than those provided to motorists. Pedestrian and bicycle facilities cost orders of magnitude less per user, and even transit users receive smaller annual subsidies than road and parking facility subsidies provided for motorists (Litman 2009).

Parking Fees are Regressive

Claim: Parking fees are regressive, they harm poor people, so parking should be free.

Response: This analysis is incomplete. Although any fee is regressive, each dollar represents a larger share of income for low-income than higher-income motorists; indirect parking costs (higher taxes, rents and retail prices, and lower wages) are also regressive; and vehicle use and the costs they impose tend to increase with income. As a result, lower-income households can benefit overall if efficient priced parking eliminates indirect parking cost burdens, or if revenues are used to improve affordable modes.

Driving is Efficient and Increases Productivity

Claim: Driving is more efficient than other modes, so parking subsidies increase economic productivity.

Response: Considering all costs, driving is often less efficient than other modes. Underpriced driving increases road and parking facility costs, traffic congestion, crashes and vehicle emissions. There is no evidence that parking subsidies increase economic efficiency or productivity overall.

These arguments may justify parking underpricing in some circumstances, for example, where pricing has high transaction costs or to help lower-income motorists access essential services and activities, but they do not justify broad underpricing or minimum parking mandates.

Optimal Supply

This section discusses the efficient and equitable amount of parking that should be provided in an area.

In general, optimal parking supply is the number of spaces that could recover their costs from user fees. For example, where parking spaces cost $1,000 annually to provide, the optimal supply is the number of spaces that would earn at least $1,000 annual net revenues. Parking that cannot recover their costs should be converted to other uses, or rented or sold for other uses.

To maximize efficiency, equity and consumer benefits, travellers should have suitable parking and mobility options so they can choose the best for each trip. For example, motorists should be able to choose between more convenient but higher priced spaces for urgent errands, and less convenient but cheaper spaces when saving money is more important than saving time. Similarly, where parking is expensive, travellers should have convenient and affordable alternatives to driving.

How many parking spaces are typically needed to serve 100 commuters or apartments?

- 100 if allocated free to each worker or housing unit, and located in an automobile-dependent area.
- 80 if shared among workers or units, unpriced, and located in an automobile-dependent area.
- 60 with cost-recovery pricing, and located in an automobile-dependent area.
- 40 with cost-recovery pricing, and located in a multimodal area (good walking, bicycling and transit).
- 20 with cost-recovery pricing, and located in a multimodal area with abundant affordable housing.

Similarly, the optimal number of parking spaces needed to serve retail or entertainment areas varies significantly depending on management practices, pricing and land use factors. A shopping center needs fewer spaces if parking facilities are shared (for example, a parking lot can serve offices during the day, restaurants at night, and religious institutions on weekends), and if located in a walkable, mixed area where many customers arrive by walking, biking or public transit.

As previously described, subsidized parking may be justified for strategic reasons. Unpriced parking may be justified at special destinations, such as emergency medical centers and freight delivery centers, to avoid delays. It may be justified to allow some lower-income motorists to access essential service and activities, such as education, jobs, healthcare and basic shopping, although this is best achieved with targeted discounts so subsidies are provided to motorists who really need them.

Some current trends and emerging technologies further reduce the number of spaces needed to serve demands. For example, telework (using electronic communications and delivery services to substitute for physical travel) is significantly reducing parking demands at many worksites and shopping centers. Carsharing and ridehailing (e.g., Uber and Lyft) services are reducing vehicle ownership rates in multimodal areas. E-bikes are reducing vehicle parking demands in urban and suburban areas.

If parking is mandated, minimums should be adjusted to reflect specific conditions (Litman 2018):

- Lower where parking facilities are more expensive to provide.
- Lower for housing for people with low incomes and students.
- Lower where there are good alternatives, such as in walkable or transit-oriented neighborhoods.
- Lower where parking facilities can be shared or other management strategies are implemented.
- Lower where there are vehicle travel reduction targets.

Parking and Travel Impacts

How much would efficient pricing affect parking and travel activity? Although it is difficult to predict exactly and would depend on specific conditions, the impacts are likely to be large.

This analysis suggests that optimal pricing typically range from about $0.50 per hour for basic parking in suburban areas with low land prices, to more than $10 per hour for high-amenity parking in prime locations during peak periods. Prices of this magnitude would double or triple vehicle operating costs per trip. For example, a typical 8-mile return shopping trip that currently costs $2 would instead cost $4 with efficient parking fees, and a typical 16-mile return commute trip that currently cost $4 would instead cost $10 with efficient parking fees.

Many studies have measured the price elasticity of parking, that is, the decline in the amount of parking that motorists choose if their prices increase (Lehner and Peer 2019; Spears, Boarnet and Handy 2014). They indicate that the elasticity of vehicle trips with regard to parking prices is typically –0.1 to –0.3, so a 10% price increase typically reduces parking facility use by 1% to 3%. Shifting from free to cost-recovery parking prices, or cashing out free parking (non-drivers receive cash benefits equivalent to parking subsidies provided to motorists) typically reduces drive-alone commuting by 10-30% (Shoup 2005b). These impacts tend to be larger if parking pricing is implemented with improvements to non-auto modes and other TDM incentives.

This suggests that, if fully implemented, with cost recovery pricing applied to most parking facilities, total parking demands would decline by 40-60%. The percentage reductions are likely to be larger in denser urban areas where there are more opportunities to share parking, better travel options, and more costly parking facilities, than in automobile-dependent suburban areas with low land prices. However, since automobile-dependent areas currently have far more parking spaces per vehicle, suburban areas are likely to have larger absolute reductions in parking spaces.

Motorists respond to parking fees in various ways. Stealing parking (finding ways to avoid paying fees) tends to be a socially acceptable crime; it provides no external benefit. However, most other responses, such as reducing parking duration, shifting to a cheaper location or a non-auto mode, reduces parking costs (in the short run it reduces parking congestion and over the long run reduces the number of spaces needed), and mode shifting also reduces traffic externalities (congestion, crashes and pollution).

Table 15 **Potential Responses to Parking Fees**

	Parking Costs	Traffic Externalities
Steal parking	Increased	
Shorter parking duration	Reduced	
Cheaper parking location	Reduced	
Shift mode/ Telework	Reduced	Reduced
Shift destination	Reduced	Varies

Motorists can respond to parking fees in various ways. Most changes reduce parking facility costs and some reduce traffic external costs including congestion, crashes and pollution.

This suggests that most North American communities have far more parking supply than is economically efficient or equitable. More efficient parking management, with cost-recovery pricing and more shared parking facilities, could typically reduce the number of parking spaces needed by at least 40%, and more if implemented in conjunction with improvements to non-auto modes and Smart Growth development policies that allow more compact development.

Parking Cost Reduction Strategies

This section describes ways to reduce parking costs.

Reduce Parking Facility Costs

There are sometimes ways to reduce facility costs, for example, with innovative construction techniques, and to reduce their environmental costs, for example, by using pervious and more reflective surfaces to reduce stormwater costs and heat island effects.

Manage Parking Facilities More Efficiently

There are many ways to manage parking to reduce the number of spaces needed to serve travellers' needs, as summarized below. New technologies can support these strategies. For example, apps and websites can help motorists identify parking options near their destinations, reducing the need to serve all demands on-site. Telework, e-bikes and public transit improvements can reduce automobile travel.

Table 16 **Parking Management Strategies** (Litman 2018; Willson 2015)

Strategy	Description	Typical Reductions
Share parking	Parking spaces serve multiple users and destinations.	10-30%
Parking regulations	Regulations favor higher-value uses such as service vehicles, deliveries, customers, quick errands, and people with special needs.	10-30%
Reform minimums	Adjust minimum parking mandates to more accurately reflect demands.	10-30%
Remote parking	Provide off-site or urban fringe parking facilities.	10-30%
Smart Growth	Encourage more compact, mixed, multi-modal development.	10-30%
Improve active travel	Improve walking and bicycling conditions to expand the range of destinations serviced by a parking facility and reduce driving.	5-15%
Use facilities better	Use otherwise wasted space, smaller stalls, and car stackers.	5-15%
Mode shifts	Encourage shifts to walking, bicycling, ridesharing, transit and telework.	10-30%
Price parking efficiently	Charge motorists directly and efficiently for using parking facilities.	10-30%
Financial incentives	Provide mode shift financial incentives, such as parking cash out.	10-30%
Unbundle parking	Rent or sell parking facilities separately from building space.	10-30%
Tax reforms	Change tax policies to support parking management objectives.	5-15%
Bicycle facilities	Provide bicycle storage and changing facilities.	5-15%
Better user information	Provide convenient information on parking availability and price.	5-15%
Improve enforcement	Ensure that parking regulation enforcement is efficient and fair.	Varies
Overflow parking plans	Establish plans to manage occasional peak parking demands.	Varies

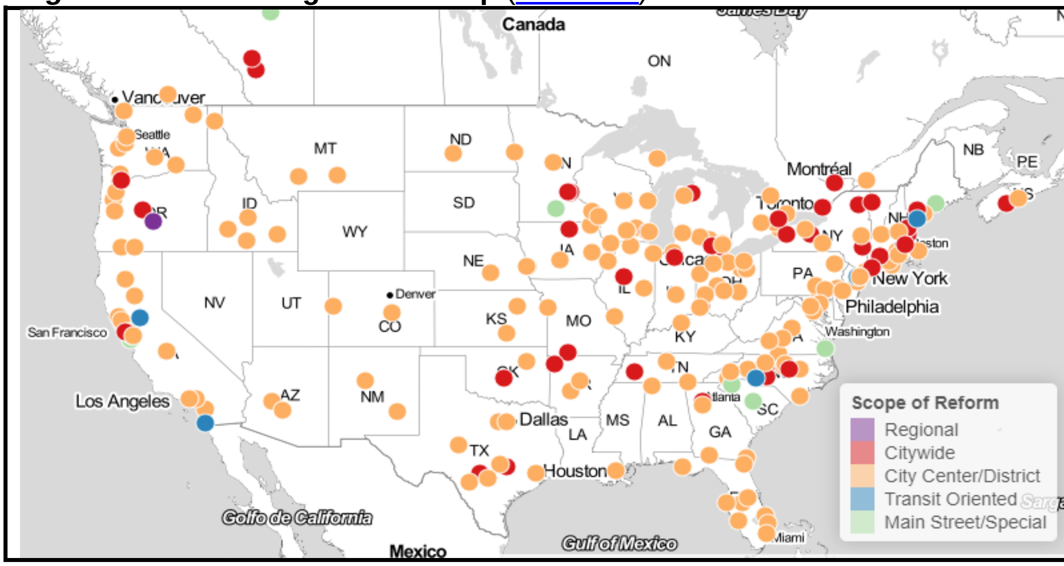
This table summarizes parking management strategies and indicates their typical reduction in parking needs.

Change Parking Demand Analysis Practices

The current methods used to determine parking demand reflect the assumption that vehicle parking should be as abundant and cheap as possible, an give little consideration to the costs and inequities of oversupply: they assume that most parking lots should be sized so that they are almost never full, they give little or no consideration to parking management strategies that reduce parking demands (Shoup 2005). To reduce costs, practitioners can change these practices to optimize the supply, price and management of parking at each location (Litman 2018). For example, rather than assuming that every house requires one or two parking spaces, efficient management rents parking separately from housing so residents rent the number of parking spaces they need; this unbundling typically reduces the number of residential spaces needed by 10-30%. Similarly, rather than giving every commute an unpriced parking space, employers can offer parking or its cash equivalent; this typically reduces the number of commuter spaces needed by 10-30%. Such reforms can significantly reduce parking facility costs.

Reduce or Eliminate Parking Minimums
Parking management can do little to reduce parking costs if jurisdictions impose excessive parking minimums. Many jurisdictions are now reforming their regulations, as illustrated below. This does not eliminate parking supply, it simply allows property owners to determine the number of spaces to provide based on market demands.

Figure 15 **Parking Reform Map** ([PRI 2022](#))



This map indicates North American cities that have significantly reduced or totally eliminated parking minimums, so property owners can decide how much parking to supply based on market demands rather than arbitrary regulations.

Establish Vehicle Travel Reduction Targets
Some jurisdictions, such as California and Washington states, have established vehicle travel reduction targets and requirements that transportation and land use planning decisions support those targets (GOPR 2018; Litman 2022b). This helps justify more efficient parking management and pricing.

Conclusions

Parking facilities are an essential but expensive part of a transportation system. Their costs are often overlooked and undervalued in policy and planning analysis. This study provides comprehensive information on parking supply, costs and prices, and guidance for estimating them in a particular situation. This is a timely issue; many stakeholders want better information.

Recent field surveys indicate that typical North American communities have three to six parking spaces per vehicle including residential, non-residential and on-street spaces. These are lower-bound estimates because most studies overlook some types of parking. For example, aerial photos undercount structured and underground spaces, property records overlook unofficial spaces, and most inventories overlook some parking-intensive land use types such as car dealers and public parks. Some large cities have fewer spaces per vehicle, but most suburban and rural areas have more.

Estimates of on-street parking supply are somewhat arbitrary; most urban and suburban streets have parking lanes and many rural roads have shoulders that can be used for parking, so the total number of potential on-street spaces is very large, but most of these spaces are located far from popular destinations and so are not very useful. Parking lanes use valuable road space that could otherwise be used for wider sidewalks, landscaping, bus- and bike-lanes, and they increase roadway construction, maintenance and environmental costs.

Total annualized costs, including land, construction and operating expenses for parking facilities and driveways, typically range from about $600/yr per space for surface parking on inexpensive land to more than $5,000/yr annually for high-amenity structured parking. Urban areas tend to have fewer but more costly spaces than suburban and rural areas, so parking costs per vehicle are probably similar. Parking costs probably average about $1,000 annually per space or about $5,000 per vehicle-year, totaling more than a trillion dollars annually in the U.S. This includes many seldom-used, government-mandated spaces that exist due to motorists' demands for convenience. Their costs should be borne by all motorists who support those mandates, even if they do not actively use them.

These comprehensive estimates indicate that parking is often the largest cost of motor vehicle travel; for every dollar a motorist spends on their vehicle, somebody spends about a dollar on parking for its use. About a quarter of these costs are borne directly by users through user fees and housing costs, but most parking costs are external, borne by taxpayers and consumers regardless of how they travel. These values are higher than most previous estimates for these reasons:

- Most previous studies only counted some parking facility types. This study considers all.
- Most older studies used bottom-up analysis to estimate parking supply: they typically counted one residential, one worksite and less than one space shared at other destinations. This underestimates total supply. Newer field surveys find far more spaces. They indicate that suburban and rural areas, where most North Americans live, have more than three off-street spaces per vehicle.
- Many previous studies only considered parking lot construction costs, ignoring driveway, land, operation, and environmental costs such as stormwater management and heat island effects.
- Urban land values and construction costs have increased significantly – almost doubling in the last two decades – so older estimates must be increased significantly to reflect inflation.

Despite the abundance of parking, motorists often have trouble finding an available space at high demand locations. This reflects underpricing, poor management and inadequate user information. Efficiency and equity require that prices reflect costs unless subsidies are specifically justified to achieve strategic goals. Optimal parking prices should reflect marginal costs, with higher rates at times and places where parking facilities are congested, so travellers can make trade-offs between price and convenience. Current prices violate these principles; most parking is underpriced and subsidized. Most parking facility costs are borne indirectly in higher taxes, rents and prices for retail goods, and lower wages. This is inefficient and unfair. Underpricing increases parking and travel demands, and therefore road and parking congestion and road and parking facility costs. Underpricing forces households that drive less than average to subsidize the parking costs of others that drive more than average, and since vehicle travel tends to increase with income, this tends to be regressive.

Economists often recommend efficient road tolls to reduce traffic congestion and other motor vehicle external costs, but that solution faces significant implementation obstacles. This research indicates that efficient parking pricing – charging motorists cost-recovery parking fees with higher rates during peak periods – can achieve those goals with lower operational and political costs. Efficient parking pricing is justified for both efficiency and fairness; it can significantly reduce traffic and parking congestion, road and parking facility costs, traffic crashes and pollution emissions, as well as reducing municipal taxes, development costs, rents and inequities.

Optimal parking supply is the amount that motorists would use if parking were efficiently priced and users had suitable parking and travel options. Most North American communities use regulations to determine parking supply. These are biased in several ways that favor oversupply: they use an 85-percentile demand curve which assumes that 85% of parking lots should never totally fill, and a 10^{th} annual design hour which means that parking lots should have empty spaces 8,750 out of 8,760 hours per year. These practices result in more parking than is necessary in most times and locations. They practices reflect the assumption that parking should be as abundant and inexpensive as possible, with little consideration to resulting costs.

Integrated parking management programs that include a combination of sharing, efficient pricing and improved user information can significantly reduce the parking supply needed to serve motorists' demands. Management strategies can increase traveller convenience by improving travel and parking options, improving user information, and ensuring that motorists can always find an unoccupied space when they are in a hurry.

More efficient parking management can help achieve many strategic planning goals. It can reduce development costs, particularly for lower-priced housing; reduce sprawl and pavement area and resulting environmental harms; reduce total vehicle travel and traffic problems including congestion, crashes and pollution; reduce total consumer costs; and increase fairness by reducing subsidy costs and improving accessibility for non-drivers.

A better understanding of parking costs can help policy makers, practitioners, developers and residents make better parking-related decisions. For example, information in this report can be used to calculate the savings provided by management strategies that reduce the number of parking spaces needed to serve motorists' needs, and the optimal prices that should be charged to ensure that motorists pay their fair share for the parking facilities they use.

References

Amy H. Auchincloss, et al. (2014), "Public Parking Fees and Fines: A Survey of US Cities," *Public Works Management & Policy*, Vol. 20, pp. 49-59 (doi.org/10.1177/1087724x13514380).

Hashem Akbari, L. Shea Rose and Haider Taha (2003), "Analyzing the Land Cover of an Urban Environment Using High-Resolution Orthophotos," *Landscape and Urban Planning* (doi.org/10.1016/S0169-2046(02)00165-2), Vo. 63/1, pp. 1–14.

David Albouy, Gabriel Ehrlich, Minchul Shin (2018), "Metropolitan Land Values," *Review of Economics and Statistics*, Vo. 100/3 (https://doi.org/10.1162/rest_a_00710); at https://bit.ly/3K6mVFG.

Lloyd Alter (2021), *How Homes for Cars Can Emit as Much Carbon as Homes for People*, The Treehugger (www.treehugger.com); at https://bit.ly/3q33pR7.

Chester Arnold and James Gibbons (1996), "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator," *American Planning Association Journal*, Vol. 62, No. 2, Spring, pp. 243-258 (www.tandfonline.com/doi/abs/10.1080/01944369608975688); at https://bit.ly/36jjTuS.

Paul A. Barter (2014), "A Parking Policy Typology for Clearer Thinking on Parking Reform," *International Journal of Urban Sciences* (dx.doi.org/10.1080/12265934.2014.927740).

BLS (2022), *Consumer Expenditure Survey*, Bureau of Labor Statistics (www.bls.gov); Table 5.4.3-9.

Carl Walker (2016), *Mean Construction Costs*, Carl Walker (www.carlwalker.com); at https://bit.ly/3BMaj3I.

CE Delf (2019a), *Handbook on Estimation of External Cost in the Transport Sector,* CE Delft (www.ce.nl) for the European Commission; at https://bit.ly/2Z9P5sE.

CE Delft (2019b), *Overview of Transport Infrastructure Expenditures and Costs*, for the European Commission (doi: 10.2832/853267).

Mikhail Chester, Alysha Helmrich and Rui Li (2022), *Inventorying San Francisco Bay Area Parking Spaces*, Mineta Transportation Institute (https://transweb.sjsu.edu); at https://bit.ly/3QgGgFo.

Mikhail Chester, Arpad Horvath and Samer Madanat (2010), "Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting," *Environmental Research Letters*, Vo. 5, No. 3 (http://dx.doi.org/10.1088/1748-9326/5/3/034001).

Mikhail Chester, et al. (2015), "Parking Infrastructure: A Constraint on or Opportunity for Urban Redevelopment?," *Journal of the American Planning Association*, Vo. 81, No. 4, pp. 268-286 (doi: 10.1080/01944363.2015.1092879); also see www.transportationlca.org/losangelesparking.

Colliers (2021) *Atlanta Parking Rate Survey*, Colliers International (); at https://bit.ly/3RhQXZJ.

Amélie Y. Davis, et al. (2010), "Estimating Parking Lot Footprints in the Upper Great Lakes Region of the USA" *Landscape and Urban Planning*, Vol. 96/2, pp. 68-77 (doi.org/10.1016/j.landurbplan.2010.02.004).

Mark Delucchi (1996), *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Vol. 6, Institute of Transportation Studies (http://engineering.ucdavis.edu/), UCD-ITS-RR-96-3 (6), Table 6-B.1.

Mark Delucchi (1998), *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Institute of Transportation Studies, UCD-ITS-RR-96-3; at www.fhwa.dot.gov/scalds/delucchi.pdf.

Ryan DiRaimo (2021), *Seattle Has the Space*, The Urbanist (www.theurbanist.org); at www.theurbanist.org/2021/03/25/seattle-has-the-space.

Kelly Alvarez Doran (2021), "Why We Need Embodied Carbon Benchmarks and Targets in Building Standards and Policies," *Canadian Architect* (www.canadianarchitect.com); at https://bit.ly/3K93Gva.

Economist (2017), "Parkageddon: How Not to Create Traffic Jams, Pollution and Urban Sprawl. Don't Let People Park For Free," *The Economist*, 8 April 2017 (www.economist.com).

EFC (2019), *Estimating Benefits and Costs of Stormwater Management*, Environmental Finance Center (www.efc.csus.edu); at www.efc.csus.edu/reports/efc-cost-project-part-1.pdf.

Sofia Franco (2016), "Parking Costs in Los Angeles County", Technical Report 2016-2-June, University of California (https://vcpa.ucr.edu); at https://escholarship.org/content/qt07z507xf/qt07z507xf.pdf.

Sofia Franco (2020), *Parking Prices and Availability, Mode Choice and Urban Form*, International Transport Forum Paper 2020/03, OECD (www.itf-oecd.org); at https://bit.ly/3R9fyQz.

Frontier Group (2014), *Subsidizing Congestion: The Multibillion-Dollar Tax Subsidy That's Making Your Commute Worse*, Transit Center (https://transitcenter.org); at https://bit.ly/3DmgZad.

C.J. Gabbe and Gregory Pierce (2016), "Hidden Costs and Deadweight Losses: Bundled Parking and Residential Rents in the Metropolitan U.S.," *Housing Policy Debate*, Vo. 27, No. 2 (https://bit.ly/2ApVELG).

C.J. Gabbe, Gregory Pierce and Gordon Clowers (2020), "How Developers Respond to Parking Reform," *Transfers Magazine* (https://transfersmagazine.org); at https://bit.ly/3SUkeK2.

GAO (2018), *Low-Income Housing Tax Credit: Improved Data and Oversight*, General Accounting Office (www.gao.gov); at www.gao.gov/assets/gao-18-637.pdf.

Charlie Gardner (2011), *We Are the 25%: Looking at Street Area Percentages and Surface Parking*, Old Urbanist (https://oldurbanist.blogspot.com); at https://bit.ly/3QP2izs.

Mike Gaworecki (2017), "Urban Heat Island Effect Could More Than Double Climate Costs for Cities," *Mongabay* (https://news.mongabay.com); at https://bit.ly/3wccieE.

Nick Gerhardt and Samantha Allen (2022), "How Much does a Driveway Cost?," *Forbes* (www.forbes.com); at https://bit.ly/3wXEz9k.

Aaron Gordon (2023), "American Cars are Getting Too Big for Parking Spaces," *MotherBoard* (www.vice.com); at www.vice.com/en/article/y3pyzx/american-cars-are-getting-too-big-for-parking-spaces.

Stefan Gössling, et al. (2016), "Urban Space Distribution and Sustainable Transport," *Transport Reviews* (dx.doi.org/10.1080/01441647.2016.1147101).

Allen Greenberg (2005), *How New Parking Spaces May Effectively Increase Typical U.S. Urban Housing Total Unit Costs by $52,000 to $117,000*, TRB Annual Meeting (www.trb.org); at https://bit.ly/3REnFEp.

Daniel Herriges (2020), *Parking Dominates Our Cities. But Do We Really *See* It?*, Strong Towns (www.strongtowns.org); at https://bit.ly/3QxGHeC.

Christopher G. Hoehne, et al. (2019), "Valley of the Sun-Drenched Parking Space: Growth, Extent, and Implications of Parking Infrastructure in Phoenix," *Cities*, Vo. 89, pp. 186-198 (doi.org/10.1016/j.cities.2019.02.007).

Home Advisor (2022), *How Much Does an Electric Car Charging Station Cost?*, (www.homeadvisor.com); at https://bit.ly/3RBrWZ7.

Hannah Hoyt and Jenny Schuetz (2020), *Parking Requirements and Foundations are Driving Up the Cost of Multifamily Housing*, Brookings (www.brookings.edu); at https://brook.gs/3RLvqbZ.

Angus Hulme-Moir (2010), *Making Way for the Car: Minimum Parking Requirements and Porirua City Centre*, Thesis, Victoria University of Wellington (http://researcharchive.vuw.ac.nz/handle/10063/1458).

James Hunnicutt (1982), "Parking, Loading, and Terminal Facilities," in *Transportation and Traffic Engineering Handbook*, Institute of Transportation Engineering/Prentice Hall, 1982, p. 651.

Stephen Ison and Corinne Mulley (2014), *Parking Issues and Policies, Transport and Sustainability Volume 5*, Emerald Group (www.emeraldinsight.com); at http://bit.ly/2EhgsFM.

Owen Jung (2009), *Who Is Really Paying for Your Parking Space?*, Department Of Economics, University of Alberta; at www.vtpi.org/jung_parking.pdf.

Luke Klipp (2004), *The Real Costs Of San Francisco's Off-Street Residential Parking Requirements*, Transportation for a Livable City (www.livablecity.org); at https://bit.ly/3RlR1b0.

Michael Kodransky and Gabrielle Hermann (2011), *Europe's Parking U-Turn: From Accommodation to Regulation*, Institute for Transportation and Development Policy (www.itdp.org); at https://bit.ly/3fgXVft.

Lewis Lehe (2018), "How Minimum Parking Requirements Make Housing More Expensive," *Journal of Transportation and Land Use*, Vol. 11/1 (https://doi.org/10.5198/jtlu.2018.1340).

Stephan Lehner and Stefanie Peer (2019), "The Price Elasticity of Parking: A Meta-analysis," *Transportation Research A*, pp. 177-191 (https://doi.org/10.1016/j.tra.2019.01.014); at https://bit.ly/3LiGuLo.

Todd Litman (2006), *Parking Management Best Practices*, Planners Press (www.planning.org).

Todd Litman (2009), *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2017), *Evaluating Transportation Diversity*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/choice.pdf.

Todd Litman (2018), *Parking Management: Strategies, Evaluation and Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man.pdf.

Todd Litman (2019), *Parking Requirement Impacts on Housing Affordability*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park-hou.pdf.

Todd Litman (2020), *Evaluating Transportation Land Use Impacts*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/landuse.pdf.

Todd Litman (2021), *Pavement Buster's Guide: Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/pavbust.pdf.

Todd Litman (2022), *Parking Cost, Pricing and Revenue Calculator*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/parking.xls.

Todd Litman (2022b), *Vehicle Travel Reduction Targets: Why and How to Reduce Excessive Automobile Travel*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/vmt_red.pdf.

Todd Litman (2023), *Parking Management: Comprehensive Implementation Guide*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man_comp.pdf.

Jesse London and Clark Williams-Derry (2013), *Who Pays for Parking? How the Oversupply of Parking Undermines Housing Affordability*, Sightline Institute (www.sightline.org); at https://bit.ly/3cFTgXu.

Laura Madrigal (2022), *How Much Does It Cost to Build a Parking Garage?*, FIXR (www.fixr.com); at www.fixr.com/costs/build-parking-garage.

Michael Manville (2010), *Parking Requirements as a Barrier to Housing Development: Regulation and Reform in Los Angeles*, Institute of Transportation Studies (www.its.ucla.edu)' at https://bit.ly/3Rt5bXw.

Michael Manville and Donald Shoup (2005), "People, Parking, and Cities," *Journal of Urban Planning and Development* (www.asce.org), December, pp. 233-245; at https://bit.ly/2NHojQc.

Wesley Marshall (2014), "On-Street Parking," *Parking Issues and Policies*, Transport and Sustainability, p. 367; at http://bit.ly/2EhgsFM.

Christopher McCahill and Norman Garrick (2012), "Automobile Use and Land Consumption: Empirical Evidence from 12 Cities," *Urban Design International*, Vol. 17, No. 3, DOI: 10.1057/udi.2012.12.

Christopher McCahill and Norman Garrick (2014), "Parking Supply and Urban Impacts," *Parking Issues and Policies*, Emerald Press (www.emeraldinsight.com), pp. 33-55; at http://bit.ly/2EhgsFM.

Nelson/Nygaard (2015), *Parking Structure Technical Report: Challenges, Opportunities, and Best Practices*, MTC (www.mtc.ca.gov); at https://bit.ly/3ek0tgx.

NPA (various years), *Parking Rate Survey*, National Parking Association (www.npapark.org); at http://weareparking.org/?page=ratestudy.

OMI (2022), *The Parking Paradox of Urban India: Creating a Demand-supply Equilibrium*, Ola Mobility Institute (https://olawebcdn.com); at https://bit.ly/3K3Dq5b.

ORNL (2020), *Transportation Energy Data Book*, Oak Ridge National Lab (https://info.ornl.gov); at https://info.ornl.gov/sites/publications/Files/Pub132663.pdf.

Parking Reform Network (https://parkingreform.org) provides information on parking impacts and costs, and guidance for more efficient and equitable management. *The Parking Lot Map* (https://parkingreform.org/resources/parking-lot-map) shows parking lot area in various U.S. cities.

Parkopedia (www.parkopedia.com) provides parking location and price for many cities and, publishes *Parking Index* (https://bit.ly/3eDQNh3) reports which analyzes and compare these for major U.S. cities.

PCW (2002), *Some Existing Water District Funding Sources*, Project Clean Water (www.projectcleanwater.org).

Bryan Pijanowski (2007), *Parking Spaces Outnumber Drivers 3-to-1, Drive Pollution and Warming*, Purdue University (www.purdue.edu); at www.purdue.edu/uns/x/2007b/070911PijanowskiParking.html.

PRN (2022), *Progress on Parking Mandates Map*, Parking Reform Network (www.parkingreform.org); at https://parkingreform.org/resources/mandates-map.

PT (2005), "What's it Cost You to Run Your Garage?," *Parking Today* (www.parkingtoday.com).

Adam Rosenfield (2018), *Driving Change: How Workplace Benefits Can Nudge Solo Car Commuters Toward Sustainable Modes*, Mass. Institute of Technology (http://web.mit.edu); at https://bit.ly/39KhRV6.

Eric Scharnhorst (2018), *Quantified Parking: Comprehensive Parking Inventories for Five U.S. Cities*, Research In. for Housing America, Mortgage Bankers Association (www.mba.org); at https://bit.ly/3dXWrua.

SFPark (2017), *Parking Rates & Policies Survey*, San Francisco (www.sfpark.org); at http://bit.ly/1N48lsC.

Henry Beers Shenk (2023), *Entitled Drivers Have Been Whining for 100 Years!*, StreetBlog NYC (https://nyc.streetsblog.org); at http://bit.ly/3Ruacjx.

Donald Shoup (2005), *The High Cost of Free Parking.* Planners Press (www.planning.org). Also see, Evan Goldin (2021), *A Cheat Sheet on Professor Donald Shoup's Groundbreaking Work*, Parkade (https://parkade.com); at https://bit.ly/3DkG31g.

Donald Shoup (2005b), *Parking Cash Out*, Report 532, Planning Advisory Service (www.planning.org/pas), American Planning Association; at http://shoup.bol.ucla.edu/Parking%20Cash%20Out%20Report.pdf.

Donald Shoup (2016), "Cutting the Cost of Parking Requirements," *ACCESS*, pp. 26-33; at www.accessmagazine.org/articles/spring-2016/cutting-the-cost-of-parking-requirements.

Donald Shoup and Mary Jane Breinholt (1997), *Employer-Paid Parking: A Nationwide Survey of Employers' Parking Subsidy Policies* (DOI: 10.1007/978-3-642-59064-1_13); at https://bit.ly/3AGxVFo.

Raymond Smith (2020), *Parking Structure Cost Outlook for 2020*, WGI (https://wginc.com); at https://wginc.com/wp-content/uploads/2020/07/Parking-Construction-Cost-Outlook.pdf.

Steven Spears, Marlon G. Boarnet and Susan Handy (2014), *Impacts of Parking Pricing Based on a Review of the Empirical Literature*, Calif. Air Resources Board (ww2.arb.ca.gov); at https://bit.ly/3czkMGg.

Fox Tuttle (2021), *Parking & Affordable Housing*, Shopworks Architecture (https://shopworksarc.com); at https://shopworksarc.com/wp-content/uploads/2021/02/2021_Parking_Study.pdf.

USEPA (2021), *Heat Island Impacts*, USEPA (www.epa.gov); at https://bit.ly/3wYDxcZ.

Waka Kotahi (2021), *Monetized Benefits and Costs Manual*, New Zealand Transport Agency (www.nzta.govt.nz); at www.nzta.govt.nz/resources/monetised-benefits-and-costs-manual.

Richard Willson (2015), *Parking Management for Smart Growth*, Island Press (http://islandpress.org); at http://islandpress.org/book/parking-management-for-smart-growth.

Clarence Woudsma, Todd Litman, and Glen Weisbrod (2006), *Report on the Estimation of Unit Values of Land Occupied by Transportation Infrastructures*, Transport Canada; at www.vtpi.org/TC_landvalue.pdf.

Simba Wu (2018), *Carbon Footprint of One Parking Space*, Shuailin Wu (www.slw-simba.net); at www.slw-simba.net/blog/carbonfootprint.

Ed Zarenski (2022), *Construction Inflation 2022*, Construction Analytics (https://edzarenski.com); at https://edzarenski.com/category/inflation-indexing.

www.vtpi.org/pscp.pdf