POLICY BRIEF

Parking Pricing

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Program Description

This project reviews and summarizes empirical evidence for a selection of transportation and land use policies, infrastructure investments, demand management programs, and pricing policies for reducing vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions. The project explicitly considers social equity (fairness that accounts for differences in opportunity) and justice (equity of social systems) for the strategies and their outcomes. Each brief identifies the best available evidence in the peer-reviewed academic literature and has detailed discussions of study selection and methodological issues.

VMT and GHG emissions reduction is shown by effect size, defined as the amount of change in VMT (or other measures of travel behavior) per unit of the strategy, e.g., a unit increase in density. Effect sizes can be used to predict the outcome of a proposed policy or strategy. They can be in absolute terms (e.g., VMT reduced), but are more commonly in relative terms (e.g., percent VMT reduced). Relative effect sizes are often reported as the percent change in the outcome divided by the percent change in the strategy, also called an elasticity.

Summary

Strategy Description

Increasing existing parking prices, charging for parking that is currently offered for free, or offering alternatives to free parking (e.g., parking cash-outs) have the potential to reduce vehicle travel (as measured by vehicle miles traveled (VMT)) and encourage mode switching by increasing the cost of private vehicle trips. As a result, they may also have the potential to reduce greenhouse gas emissions.

Behavioral Effect Size

The evidence shows a strong effect of parking pricing on parking demand. A meta-regression of 50 parking demand studies found that increasing parking prices by 10% is associated with a reduction in parking volume for commute trips of more than 5% (Lehner & Peer, 2019). For non-commute trips, they found that a 10% increase in parking prices at the destination is associated with a more than 3% reduction in parking volume. Fewer studies estimate actual change in VMT or vehicle trips. But those that do also show significant reductions in VMT or vehicle trips are due to increases in the cost of workplace parking (Miller & Wilson, 2015), parking cash-out programs (Shoup, 1997, 2005), and adaptive parking pricing (Krishnamurthy & Ngo, 2018).

Strategy Extent

Parking pricing policies tend to be fast-acting, with effects seen quickly after implementation. In addition, parking policies are adaptable and can be implemented at many different scales, from a particular project to an entire state.

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However, parking pricing policies might not have the same effects in all contexts. Most of the studies presented in this brief were conducted in urbanized areas. The effects could be lower in suburban or rural areas, in part due to having fewer transportation alternatives in those areas.

Strategy Synergy

Pricing parking can work in concert with other types of parking restrictions (like residential parking maximums and residential parking permits) and complete streets or active travel projects that reduce parking spaces. Pricing on-street parking or increasing the cost of parking lots and garages can help prevent parking spillover from the parking restrictions and further encourage workers, residents, or visitors to change their travel modes, make fewer auto trips, or even reduce car ownership.

Equity Effects

Charging for parking is considered a regressive user fee because the fee generally does not change based on the driver's income and is thus relatively more expensive for lower-income drivers. But the aggregate effect can be much different because lower-income commuters are less likely to drive to work than higher-income commuters and are also less likely to own vehicles in general. Furthermore, parking pricing programs can be designed to promote transportation equity by providing compensation to those who are disproportionately affected or subsidies for non-auto travel modes.

Strategy Description

Increasing existing parking prices, charging for parking that is currently offered for free, or offering alternatives to free parking (e.g., parking cash-outs) have the potential to reduce vehicle travel (as measured by vehicle miles traveled (VMT)) and encourage mode switching by increasing the cost of private vehicle trips. As a result, they have the potential to reduce greenhouse gas emissions. The strategies for which the most empirical evidence exists include:

Workplace Parking Pricing: Studies have found that the vast majority of employees park at their workplace for free. According to a recent estimate based on data from the Society for Human Resource Management, 85% of United States employers provide free on-site parking to their employees (Golden et al., 2024). Because free workplace parking is primarily the result of employer subsidies, programs have targeted these subsidies in an attempt to manage private vehicle travel demand. Other examples of workplace parking pricing include charges for single occupant vehicles and "cash-out" programs that offer employees cash in lieu of subsidized parking. Another example is increasing the total cost of parking lots and garages in employment centers, such as through government-imposed taxes or fees.

On-street Parking Pricing: This can be used to manage parking congestion and increase turnover to favor short-term parking. It can also incentivize would-be drivers to either use another travel mode or not make their planned trip. In the long run, pricing on-street parking can also incentivize area residents to reduce car ownership by restricting their access to previously free parking. The revenue from on-street parking can be used to pay for streetscape improvements or transit subsidies in the area to further incentivize alternative travel modes. For example, Pasadena reinvests its on-street parking meter revenue into the business districts in which the revenue was generated (Kolozsvari & Shoup, 2003).

Adaptive Parking Pricing: Adaptive pricing – also called performance-based pricing – adjusts parking prices to obtain a target on-street occupancy rate. It does this by varying the prices by location and time of day to balance parking supply with demand on a block-by-block basis. This is the most sophisticated use of pricing to manage parking demand. San Francisco pioneered the use of adaptive parking pricing with SFpark, which was implemented in seven pilot zones in 2011, and then expanded to all parking meters in the city in early 2018. Seattle implemented a similar performance-based parking program in 2011 around its commercial core and major neighborhood business districts.

Strategy Effects

Behavioral Effect Size

While an increasing number of empirical studies have examined the effect of pricing policies on parking demand, very few have focused on the impact of parking pricing on VMT directly. Often, parking pricing is included as one component of a bundle of travel demand management (TDM) and infrastructure measures, making separate evaluation difficult. Travel demand management is the term for policies that are designed to affect the amount, time, or place that people travel.

Table 1 summarizes the effect sizes for the parking pricing studies presented here.

Most of the empirical literature focuses on pricing workplace parking and is consistent in showing reductions in VMT or related outcomes, like vehicle counts, drive-alone mode share, or parking volume. With respect to VMT, Shoup (1997) examined the effects of parking cash-out programs at seven sites in Los Angeles County, California, and found a 12% reduction in VMT/capita. A more recent study found that a tax increase on parking providers in Chicago, Illinois, reduced vehicle counts on the major roadways used to access the central business district by 3.1%, which equated to an elasticity of about -0.3 (Miller & Wilson, 2015). A number of other studies also indicate that pricing workplace parking reduces regional VMT, but they rely on simulation modeling rather than empirical analysis and so are not included in Table 1 (Deakin et al., 1996; Dueker et al., 1998).

The majority of empirical studies on workplace parking estimate the effect on either commute mode choice or parking demand. A recent study conducted a meta-analysis of 50 studies that estimated elasticities of parking demand with respect to parking price (Lehner & Peer, 2019). They found a baseline elasticity of workplace parking volume of -0.52, based on revealed preference studies. They also found an elasticity of -1.07 based on stated preference studies, but indicated that the elasticity based on revealed preference studies would likely be more accurate.

With respect to mode choice, Khordagui (2019) analyzed California Household Travel Survey data from 26 counties and estimated that a 10% increase in parking price would reduce the probability of driving alone to work by 1.3% to 2.6% (an elasticity of -0.13 to -0.26). Two other studies found similar results. Su and Zhou (2012) estimated an elasticity of -2.3 in the Seattle, Washington region. And Peng et al. (1996) estimated elasticity ranges of -0.12 to -1.346 for urban residents in the Portland (Oregon) region and -0.091 to -1.151 for suburban residents. A fourth study estimated that having free workplace parking (and no other workplace-related transportation benefits) increased drive-alone mode share by 20.7 percentage points in Washington, DC (Hamre & Buehler, 2014).

Parking pricing has also been shown to be effective outside of the workplace and commute context. Lehner and Peer (2019) assessed the effect of parking price on parking volume for non-commute trips.[1] Their meta-analysis estimated an elasticity of -0.32, based on revealed preference studies, and an elasticity of -0.87, based on stated preference studies. They noted that the lower-magnitude elasticity would likely be more accurate in areas with high parking demand and occupancy, while the higher-magnitude elasticity would be more accurate in areas with occupancy rates significantly lower than 100%.

With respect to adaptive pricing, Krishnamurthy & Ngo (2018) estimated that the SFpark program reduced average daily weekday vehicle counts per Census block by 6% (albeit not a statistically significant result) and reduced average daily weekend vehicle counts by 12%. Millard-Ball et al. (2014) studied the first two years of SFpark and estimated that the adaptive parking pricing program reduced cruising for parking by 50% relative to what was estimated for control blocks that were not part of the adaptive pricing program. This could translate into a substantial reduction in VMT (Shoup, 2007). However, Millard-Ball et al.'s (2014) findings were based on a simulation and they did not attempt to quantify the effect on VMT. Other studies have also analyzed the effects of SFpark (Pierce & Shoup, 2013) and Seattle's performance-based parking program (Ottosson et al., 2013) on parking occupancy, but those results cannot as easily be translated into VMT. For example, parking occupancy must be divided by dwelling time to calculate parking volume. As a result, those studies are not included in Table 1.

Beyond reducing VMT (and associated greenhouse gas emissions), the potential co-benefits that could be realized through parking pricing include increased commercial activity and congestion relief. Commercial activity may be enhanced by using parking pricing strategies, such as on-street parking pricing (adaptive or not), that free up space in business districts that would otherwise be taken by commuters. Kolozsvari and Shoup (2003) detail how pricing on-street parking in downtown Pasadena – and using the revenues to fund public services and infrastructure improvements in the same area – rapidly increased the district's sales tax revenue. In addition, decreasing demand for parking spaces through pricing may make more space available for development or preservation as open spaces. Furthermore, the revenue from on-street parking can also be used to pay for streetscape improvements or transit subsidies in the area to further incentivize alternative travel modes.

To some extent, parking pricing may provide congestion relief with pricing strategies that encourage parking outside of congested central business districts (CBDs). Where congestion is lowered within CBDs, local air pollution may be reduced as well. To be effective, alternatives must be available that allow trips into the CBD by non-car modes.

[1] Lehner and Peer (2019) derived the price elasticity of parking for "non-commuting trips" from the studies they reviewed that did not explicitly focus solely on commuting trips. Some of those studies focused just on shopping or leisure trips, while other studies did not distinguish between trip purposes. Some of the studies looked solely at on-street parking, while others included off-street parking like garages.

Table 1: Summary of Parking Price Studies

Study	Study Location	Study Context	Study Years	Parking Treatment	Statistical Method	Results	
						Effect Type	Effect Size
Hamre & Buehler (2014)	Washington, DC	Urban core and inner suburbs	2007/2008	Free workplace parking	Discrete choice model	Commute mode choice	20.7 percentage point increase in drive alone mode share
Khordagui (2019)	California	26 counties	2012	Parking price at workplace location	Discrete choice model	Commute mode choice	1.3% to 2.6% reduction in probability of driving alone with a 10% increase in parking price (-0.13 to -0.26 elasticity)
Peng et al. (1996)	Portland, Oregon	Urban core and suburbs	1994	Parking price at workplace location	Discrete choice model	Commute mode choice	Urban core residents: 1.2% to 13.5% reduction in probability of driving alone with a 10% increase in parking price, depending on baseline parking price (-0.12 to -1.346 elasticity) Suburban residents: 0.9% to 11.5% reduction in probability of driving alone with a 10% increase in parking price, depending on baseline parking price (-0.091 to -1.151 elasticity)
Su & Zhou (2012)	King County (Seattle region), Washington	All areas within county (including urban, suburban, and rural) Only includes employees at worksites with ≥100 full-time employees	2005	Parking price at workplace location	Discrete choice model	Commute mode choice	2.3% reduction in probability of driving alone with a 10% increase in parking price (-0.23 elasticity)

Table 1 (continued): Summary of Parking Price Studies

Study	Study Location	Study Context	Study Years	Parking Treatment	Statistical Method	Results	
						Effect Type	Effect Size
Yan et al. (2019)	University of Michigan (Ann Arbor, Michigan)	Only includes faculty and staff commuters to the University of Michigan	2012-2015	Parking permit price at workplace location (four permit options)	Discrete choice model	Commute mode choice	2.1% to 18.9% reduction in probability of using a given parking permit with a 10% increase in the cost of that permit (-0.21 to -1.89 elasticity), but the probabilities of using another parking permit type correspondingly increased (positive cross-elasticities)
Lehner & Peer (2019)	Global (including 15 studies in the US)	Varies	1977-2016 (dates of publication for included studies)	Parking price at destination (non-residential only)	Meta-regression	Parking space demand (volume)	Elasticities of parking volume with respect to parking price (95% confidence interval in parentheses): Commute trips: -0.52 (-0.41 to -0.63; revealed preference studies) -1.07 (-0.90 to -1.23; stated preference studies) Non-Commute Trips: -0.32 (-0.18 to -0.45; revealed preference studies) -0.87 (-0.75 to -0.98; stated preference studies)
Krishnamurthy & Ngo (2018)	San Francisco, California	Urban core	2011-2012	Dynamic parking pricing program (SFpark)	Difference-in-differences regression	Daily vehicle counts (in Census blocks with treatment or control blocks)	6% reduction in average daily weekday vehicle count per Census block (not statistically significant) 12% reduction in average daily weekend vehicle count per Census block (statistically significant)

Table 1 (continued): Summary of Parking Price Studies

Study	Study Location	Study Context	Study Years	Parking Treatment	Statistical Method	Results	
						Effect Type	Effect Size
Miller & Wilson (2015)	Chicago, Illinois	Focuses on travel to the central business district	2011-2012	Parking tax that applied to all parking providers charging >$12/day and some providers charging >$240/month. In general, the tax increased parking costs between $1-$2 per day.	Difference-in-differences regression	Commute-period vehicle counts (on roads commonly used to access the district during commute hours)	3.1% reduction in vehicle trips (-0.3 point-slope elasticity)
Shoup (1997, 2005)	Los Angeles County, California	Eight businesses in urban areas with ≥120 employees	1993-95	Parking cash-out programs	Percentage change	VMT per employee	12% reduction in VMT per employee (weighted result from seven of the eight studied businesses)

Strategy Extent

Parking pricing policies tend to be fast-acting, with effects seen quickly after implementation, as illustrated by the studies of specific policies like SFpark (Krishnamurthy & Ngo, 2018), Chicago's parking tax (Miller & Wilson, 2015), and the employer cash-out programs in California (Shoup, 1997, 2005). In addition, parking policies are adaptable in scale. They are often implemented at the project or neighborhood level. But they can also be implemented citywide, such as with SFpark or Chicago's parking tax, or even statewide, as with California's parking cash-out law that requires qualifying employers across the state to offer cash-out options.

However, parking pricing policies might not have the same effects in all contexts. Most of the studies presented in this brief were conducted in urbanized areas. Peng et al. (1996) found that pricing workplace parking still reduced the probability of suburban residents driving alone to work, but the magnitude of the effect was smaller than for urban residents. Peng et al. (1996) also found that the effect of pricing workplace parking was greater for residents who had better access to transit service.

Equity Effects

Charging for parking can be nominally seen as a regressive tax, in that it is relatively more expensive at the margins for lower-income drivers. But the aggregate effect can be much different. For one, lower-income commuters are less likely to drive to work than higher-income commuters (Manville & Goldman, 2018), and they are also less likely to own vehicles in general (Currans et al., 2023). This indicates that lower-income households are less likely to be affected by parking pricing in general. However, that does not change the fact that charging for parking burdens lower-income drivers more than higher-income drivers at the margins.

Lower-income drivers might also be relatively more affected by pricing street parking. Chatman and Manville (2018) examined the effects of SFpark on lower-income drivers and found that lower-income people are overrepresented among street parkers. Using race and ethnicity as a proxy, they found that black and Hispanic drivers were overrepresented at meters by about double their population share. However, they did not find evidence that the pricing scheme displaced lower-income drivers (e.g., forced them to park further away, which can trigger safety concerns in higher-crime areas). They concluded that higher prices made lower-income drivers less likely to use street parking, but also less sensitive to prices if they did park on the street, possibly because their trips were less discretionary than those of higher-income street parkers.

While parking pricing programs can disproportionately burden lower-income drivers at the margins, they can also be used to promote transportation equity by compensating those who are most overburdened or subsidizing non-auto travel modes. For example, parking cash-out programs in California must subsidize alternatives to parking (like transit, bicycling, and walking) as much as they subsidize parking (Shoup, 1997). Beyond the workplace context, local governments can use revenue from metering on-street parking to fund alternative transportation modes. San Francisco, for example, uses its parking meter revenue to subsidize public transit (Pierce & Shoup, 2013).

Strategy Synergy

Pricing parking can work in concert with other types of parking restrictions (residential parking maximums, residential parking permits, etc.) and complete streets or active travel projects that reduce parking spaces. Pricing on-street parking or increasing the cost of parking lots and garages can help prevent parking spillover from the parking restrictions and further encourage workers, residents, or visitors to change their travel modes, make fewer auto trips, or even reduce car ownership. Pricing parking is also likely to be more effective in areas with better transit access and active travel networks (Peng et al. 1996) – if alternatives to driving are limited, pricing parking is likely to be less effective in reducing VMT. More broadly, parking pricing is just one of the many policies and factors affecting the cost vehicle ownership and use, which can cumulatively have a large effect on VMT.

Confidence

Evidence Quality

The available evidence on the direct impact of parking pricing on VMT is relatively scarce. However, the evidence on the price effects on parking space demand (volume) and commute mode choice has proved quite robust. Lehner and Peer's (2019) meta-analysis of 50 studies from across the globe, including 16 studies in the US, found that every 10% increase in parking price produces a reduction of at least 3% in the demand for parking spaces from non-commute trips and at least 5% in the demand for parking spaces from commute trips.

Caveats

One major caveat is that relating parking space demand to changes in VMT can be problematic, as drivers may attempt to avoid parking charges or select alternative destinations (Peng et al., 1996; Yan et al., 2019). For example, Yan et al. (2019) analyzed the effect on commute mode choice of on-campus parking pricing at the University of Michigan. They found that while some drivers would change modes as permit prices increased, many would just park in a different location.

A second caveat is that the effect of pricing workplace parking on total household VMT might be more complicated than simply reducing commute VMT. Several studies have found that workplace parking pricing has the potential to significantly discourage single-occupant commuting trips (see Table 1). However, more information is needed on the relationship between individual commute VMT reduction and overall household VMT.

A third caveat is that pricing measures are often implemented and modeled as part of a comprehensive package of travel demand management measures. Careful consideration must be given to situations where alternatives to car commuting are lacking or where parking alternatives exist, as these conditions may lead to deviations from the results indicated here (Peng et al., 1996). At the regional level, consideration must also be given to the potential decentralizing effects of parking pricing on both residences and businesses, especially where large differences in pricing policy exist between localities.

A fourth caveat is that increased use of ride-hailing, ridesharing, and autonomous vehicles could dampen the effect of parking pricing strategies, since the traveler would not need to park a vehicle at their destination (except at home or another final garaging location).

A fifth caveat is that most of the evidence on the VMT-related effects of parking pricing comes from locations where parking was already priced, rather than places where parking had been free and pricing was instituted anew. The elasticities of parking demand with respect to parking pricing, such as those reported in Lehner and Peer (2019), can inform but cannot be directly used to estimate the VMT-related effects of instituting pricing in areas where parking had previously been free.

Technical & Background Information

Study Selection

We started with the studies cited in the original 2014 parking pricing brief. We then searched Google Scholar for relevant articles that cited the studies from the original brief. Finally, we searched Google Scholar in the winter of 2023-2024 for relevant articles that have been published since the 2014 brief, using the following search terms: "parking pricing" AND ("VMT" OR "ownership" OR "volume" OR "demand").

We included both peer-reviewed studies and high-quality “gray” literature. We then focused on empirical studies based on observed data, rather than theoretical studies or those that use simulation modeling. We also focused on studies in the United States, rather than foreign studies that might be less generalizable to California contexts. As a result, we omit from Table 1 some of the studies that were included in the original brief. However, the omitted studies came to largely similar conclusions and we reference some of them in the textual discussion. Lehner and Peer’s (2019) meta-regression of the price elasticities of parking demand also includes 34 foreign studies in addition to the 16 US studies. We do not separately include any of the parking demand studies analyzed by Lehner and Peer (2019).

The studies we found and include in this brief can be categorized according to the three aforementioned parking strategies: pricing workplace parking, pricing on-street parking, and adaptive parking pricing. We do not include studies about overall parking supply or other types of restrictions, such as minimum parking standards or residential parking permits.

Methodological Considerations

Very few empirical studies have examined the impact of parking pricing on VMT directly. Most of the empirical research on parking pricing focuses on parking demand. Parking demand can be measured in multiple ways, including parking occupancy (the percentage of time that a given spot is occupied), parking dwell time (how long vehicles remain parked), and parking volume (the total number of vehicles using a given spot, which should equal the parking occupancy divided by the average dwell time). We focus on parking volume in this brief because it can be the most easily translated into vehicle trips and thence VMT (vehicle trips * by average trip length = VMT).

Most parking demand studies report the effect sizes as elasticities, i.e., the percentage change in parking demand divided by the percentage change in parking pricing (Equation 1). An elasticity of -1.0 means that parking demand will decrease by the same percentage as the increase in parking price.

$$\text{Elasticity} = \%\text{ Change in parking demand}/\%\text{ Change in parking price} \qquad \text{(Equation 1)}$$

However, a 10% reduction in parking volume does not always translate into a 10% reduction in vehicle trips. As discussed, drivers may attempt to avoid parking charges by parking elsewhere or select alternative destinations entirely (Yan et al., 2019). In addition, changes in commute trip VMT due to workplace parking might not translate into equivalent reductions in total household VMT if workers decide to make more non-commute trips via auto (for instance, if they used to trip chain other destinations on the way to and from work, but now have to make those other stops separately, e.g., the grocery store).

Another important consideration is that elasticities can be estimated using either stated preference or revealed preference data, which can produce different results (usually revealed preference studies estimate lower magnitude elasticities than stated preference studies). Lehner and Peer (2019) discuss this issue and recommend using elasticities based on revealed preference studies for workplace parking pricing. Outside of the commute context, they recommend using the lower-magnitude (revealed preference) elasticity in areas with high parking demand and occupancy, and using the higher-magnitude (stated preference) elasticity in areas with occupancy rates significantly lower than 100%.

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