FEHR PEERS

Memorandum

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From: Sarah Peters, Judith Gray, Christina Winberry, Chris Breiland

Subject: TDM Action Plan: Revised Strategy Effectiveness Analysis

PT19-0031

Introduction

In support of moving the City of Portland toward more sustainable and equitable transportation outcomes while also managing the challenges of vehicle congestion, the Portland Bureau of Transportation (PBOT) is conducting a comprehensive and strategic evaluation of its existing Transportation Demand Management (TDM) programs as well as TDM strategies in place in other cities. This evaluation will inform the development of a TDM Action Plan. Alta Planning + Design is leading the development of the Action Plan, which will direct and strategically focus PBOT's TDM work over the next two to five years.

To support the Action Plan effort, PBOT asked Fehr & Peers to evaluate a subset of TDM strategies and programs with respect to the return on investment (ROI). Specifically, PBOT was interested in the cost-effectiveness of different TDM strategies in reducing vehicle miles traveled (VMT) and single occupant and single passenger vehicle mode shares. Considerations include both capital and ongoing costs (in terms of labor or contractor costs) as well as potential revenue generated by the different strategies.

As an initial step, this memorandum evaluates the potential effectiveness, in terms of VMT reduction, of 16 TDM strategies that have been implemented in Portland or elsewhere in North America and Europe. These strategies were drawn from the longer list of TDM strategies that PBOT and Alta are evaluating for the overall Action Plan. The 16 strategies discussed below were chosen because there was evidence to evaluate their effectiveness on reducing VMT. A ROI for the TDM strategies will be evaluated at a later stage.

Finally, it is important to note that while the focus of the Fehr & Peers work is on evaluating the effectiveness of specific TDM strategies in reducing VMT, and eventually cost-effectiveness, VMT reduction is only one of the many factors that PBOT is using to select TDM strategies for the Action Plan. The selection process will involve thorough public engagement with a variety of stakeholders and a more systematic review, using PBOT's Transportation Justice Framework, of the potential TDM strategies.

Approach

To evaluate the effectiveness of TDM strategies, we asked three questions:

1. Is there evidence that the strategy leads to reductions in Vehicle Miles Traveled (VMT)?
2. How large of an effect does the strategy have on reducing VMT?
3. How confident are we in the amount and quality of evidence demonstrating that the strategy reduces VMT?

For each strategy, we answered these three questions by reviewing the existing literature on TDM strategies along with any available data on PBOT's existing programs and policies. The body of literature on VMT or single occupancy vehicle trip reductions resulting from implementing individual TDM strategies is limited for a few reasons:

- First, many of the strategies considered here are typically implemented for reasons other than reducing VMT/vehicle trips. For example, unbundled residential parking may be introduced to reduce the costs of new housing development, and fare-free transit passes may be given to seniors or youth to expand their access to school, jobs, and services.

- Second, many studies look at other effects on travel behavior that do not directly translate to reduced VMT or vehicle trip making. For example, transit-related strategies are often studied to understand how they influence transit ridership. While increased transit ridership generally results in reduced VMT, there is not a one-to-one relationship between the amount of increased transit ridership and the amount of VMT reduced, since new transit trips can come from existing riders taking more trips on transit, from new riders taking trips they would not have otherwise made, and from new riders taking transit instead of walking, bicycling, or driving.[1]

- Third, VMT/vehicle trip reductions are not straightforward to measure. Studies of travel behavior often rely on data collected by service providers (e.g. transit ridership) or data collected over relatively large geographies, like household travel surveys. These data sources either only tell part of the story of VMT reduction or are not granular enough to determine the specific effectiveness of a TDM strategy. The best data sources include workplace commute mode share evaluations, vehicle trip counts at specific locations, and GPS-based travel data. However, given the cost of these data collection methods, they are not widespread. External factors can also confound results, such as a transit service change that took place near a worksite that was unrelated to a TDM strategy.

[1] Transit Cooperative Research Program (TCRP). (2004). TCRP Report 95: Traveler Response to Transportation System Changes. Chapter 12: Transit Pricing and Fares. Retrieved from: http://www.trb.org/Publications/TCRPReport95.aspx

Given the limitations of the overall body of literature for TDM strategies, our review incorporates empirical data and case studies, as well as published research documenting experimental outcomes and research based on statistical analysis. This memorandum draws on literature reviews that Fehr & Peers has recently conducted in the TDM space for cities adopting VMT as an impact metric for development review and as part of ongoing work for the California Air Resources Board's *Zero-Carbon Buildings Feasibility Study*. While the literature provides useful indicators of TDM effectiveness, they mostly describe evaluations done for specific developments. Some care is warranted in applying the same outcomes to predict citywide impacts, but we include our interpretation of how the strategies evaluated in this report could apply to Portland.

A detailed discussion of our approach to evaluating these strategies is provided in our methodology memorandum submitted November 7, 2019. The main elements of our approach are summarized below.

Contextual factors of TDM impacts

TDM strategies typically include some measures to encourage efficient[2] transportation choices and discourage inefficient choices. There are many factors that account for travel choices and as a result it would be unwise to consider TDM strategies as acting in isolation. For example, providing free transit passes is generally considered a strategy to encourage transit use; but if it is enacted in an environment of free and plentiful parking, or if the available transit service does not meet traveler needs, then free transit passes would be limited in their effectiveness. Similarly, it is harder to encourage people to shift driving trips to bike trips in areas with incomplete or inadequate bike facilities.

Additionally, economic and environmental factors that are difficult to predict or control will have significant impacts on the TDM strategies. For example, when unemployment is high during an economic recession, commuter travel demand tends to decline. As a result, there may be less congestion and more available parking; these conditions can encourage driving rather than transit or carpooling. One of the biggest factors in the amount people drive is the cost of driving, mostly in the context of fuel costs. If fuel prices rapidly rise, people shift to other modes or consolidate vehicle trips and reduce VMT.

In evaluating potential TDM strategies, the theoretical effectiveness should be considered in light of these factors. The information presented in this memorandum is intended to report on the best documented experience and research of effectiveness to inform Portland's further TDM actions.

[2] In this context, efficient is defined as being more energy efficient, with fewer environmental impacts, and less public space consumed for travel (which may result in less congestion and/or more people being able to move in the same space).

Metrics reported

Reporting a single metric allows PBOT and its stakeholders to better compare the effectiveness of different strategies at changing travel behavior. Vehicle Miles Traveled (VMT) per person was chosen as the reporting metric for several reasons:

- A large body of research literature reports travel behavior changes in terms of VMT or metrics that can readily be converted to VMT reductions, including vehicle trip reductions, travel mode shift (e.g. from driving to bicycling), or transit ridership increases;

- VMT rises and falls with single occupant vehicle (SOV) mode share, aligning with the City of Portland's Comprehensive Plan goal of reducing SOV trips to 30 percent or less of all travel by 2035 (Transportation System Plan Policy 9.49.e);

- For the foreseeable future, VMT rises and falls with GHG emissions, aligning with the City of Portland's Climate Action Plan goal of reducing GHG emissions to 85 percent below 2013 levels by 2050 (Transportation System Plan Policy 9.49.c).

Where possible, we report strategy effectiveness in terms of the percentage VMT reduction resulting from the implementation of each strategy. Many studies report TDM strategy effectiveness in terms of vehicle trip reductions, mode shift, or transit ridership increases. Where this is the case, we report both the original metric and an estimated range of VMT reductions. Where available, the elasticity of demand for VMT in response to the level of TDM strategy is reported as well (e.g. a 10 percent increase in parking cost leads to a 1 percent reduction in VMT). The VMT reduction is reported in terms of the types of trips it affects (commute trips, school trips, etc.) and in terms of the population whose travel is affected (employees, residents, etc.).

Assessing Available Evidence

This assessment was initiated with a comprehensive list of resources from past work, including Quantifying Greenhouse Gas Mitigation Measures (California Air Pollution Control Officers Association, 2010), literature reviews that we have recently conducted in the TDM space for cities adopting VMT as an impact metric for development review, and our ongoing work for the California Air Resources Board's Zero-Carbon Buildings Feasibility Study. These studies were evaluated in terms of the quality of evidence provided. Additional research was conducted to identify more recent studies and to address topics that were not covered under prior literature review and to pull in more recent research. Program data from City of Portland programs was also evaluated.

To best assess how robust the evidence is, available evidence was sorted into five tiers, described in **Table 1**, below. Evidence from Portland and meta-analyses of an existing body of literature, and statistically sound studies are considered strong (Tiers 1 and 2). Experiments conducted in other cities, case studies, and inferential support from validated travel behavior models are considered limited evidence (Tier 3). Other types of evidence, such as stated preference surveys and evidence for engagement (but not behavior

change), is not considered substantial (Tiers 4 and 5). This level of evidence is not used to estimate a strategy's effects on VMT, but can provide useful context for strategy implementation.

Table 1: Available Research: Confidence Tiers

Tier	Description	Range of VMT Reduction Effects
Strong Evidence		
1	Experimental evidence or systematic review of literature • The strategy's effect on mode share, vehicle trips, and/or VMT is supported by at least one before/after study • Alternatively, a systematic review of existing literature (meta-analysis) establishes a statistically significant relationship between the strategy and the desired behavior change.	Reported VMT reduction range
2	Statistically significant findings from one or more studies • The strategy's effect on travel behavior is supported by at least one statistically sound study (using a statistical model such as a regression analysis, logit model, etc. that demonstrates significant findings) or at least one study that evaluates 10 or more before/after cases.	
Limited Evidence		
3	Experimental evidence or case studies outside Portland or validated model • The strategy is supported by a study that used a small but balanced example group (fewer than 10 observations), ***or*** • The strategy is supported by an experiment conducted outside Portland, ***or*** • The strategy is supported by a multivariable model that provides inferential support for a reduction in vehicle trips, SOV mode share, and/or VMT, and that has been validated against real-world conditions.	50%-125% of research- reported VMT reduction range
No Substantial Evidence		
4	Stated preference research or unvalidated model • The strategy is supported by a model that provides inferential support for a VMT reduction but which has not been validated against real-world conditions. • Alternatively, the strategy is supported by evidence using data collected on stated preference or inferential data.	No quantitative VMT reduction effect reported
5	Anecdotal or engagement-based evidence • The strategy is supported by anecdotal evidence only, or evidence is provided for user engagement but not for behavior change.	

TDM Strategies and Summary of Results

Many TDM strategies have been documented in research literature and implemented in Portland. The TDM Action Plan groups TDM strategies into several categories; the strategies evaluated below are drawn from the following four categories:

- **Information and encouragement** to encourage carpooling, transit, biking, and walking
- **Pricing**, including mobility and parking pricing
- **Incentives**, such as subsidized transit passes and other rewards for using transit, biking, and walking
- **TDM Requirements**, including regulatory requirements targeting employers and major new developments to implement site designs or programs to reduce VMT or promote other modes

Table 2 summarizes results from the evaluation of strategy effectiveness.

Table 2: Effectiveness Summary for Selected Strategies

TDM Category	TDM Strategy	Description	Range of VMT Reduction Effects	Type of Travel Affected	User Population	Research Confidence Tier
Information & Encouragement	New Mover Marketing	Individualized marketing program providing new movers with resources and information to encourage travel via walking, biking, and transit.	0.4-1.1%	Non-commute travel	New movers	Tier 1
	Neighborhood-Level Marketing	Individualized marketing program providing households within a specific neighborhood with resources and information to encourage travel via walking, biking, and transit.	0.9-3.0%	All travel	Neighborhood residents	Tier 1
	Employer-Based Individualized Marketing	Employer-Based Individualized Marketing applies the tools of individualized marketing to a workplace context.	0-3.7%	Commute travel	Employees at participating workplaces	Tier 1
	Telework Program Promotion	Provide technical support and incentives to employers that allow teleworking.	4.6-5.4%	Commute travel	Employees in telework-compatible industries	Tier 1
	App-Enabled Behavioral Feedback	Increasing user awareness of their travel behavior and its consequences through a mobile application can support the use of transit, carpooling, walking, and biking.	4.25-10.25%	Commute travel	Commuters at workplaces with paid parking and commute benefits	Tier 3
Pricing	Congestion charging zones	Area and or time-based fees to manage congestion.	11-15%	Travel within charging zone	Commuters and visitors to zone	Tier 2
	Paid permit parking on neighborhood streets	Require permits for on-street parking in neighborhoods.	0.5-1.25%	Travel for households in permit zone	Residents of and commuters to zone	Tier 3
	Paid parking at workplaces	Pay as you go fees for parking, including pricing parking daily or hourly rather than monthly.	15-30%	Commute travel	Commuters/ employees	Tier 1

Table 2: Effectiveness Summary for Selected Strategies

TDM Category	TDM Strategy	Description	Range of VMT Reduction Effects	Type of Travel Affected	User Population	Research Confidence Tier
	Paid parking meter districts with variable (demand based) pricing	Includes dynamic parking pricing for metered on-street spaces.	0-5%	Travel to parking district	Visitors to metered parking district	Tier 1
	Unbundled parking at new residential developments	Requirement that new residential developments rent parking spaces separately from housing units.	inferential	Household travel	Residents of new buildings	Tier 4
Incentives	Free or subsidized transit passes for Seniors, Youth and Low-Income Residents	Includes passes/discounts for active transportation modes like transit, bikeshare, walking, and biking for specific audiences (such as youth, neighborhoods, low-income, seniors, employees).	0-23.8%	All travel	Seniors, youth, low-income residents	Tier 3
	Employer subsidized transit passes		15-18.4%	Commute travel	Commuters/ employees	Tier 2
	Programs combining pricing parking and targeted transportation incentives		3.5-13.8%	Commute travel	Residents and employees	Tier 3
TDM Requirements	Employer Parking Cash-Out	Cash payment to employees for giving up their parking space.	2.5-30%	Commute travel	Commuters/ employees	Tier 3
	Trip Cap/ Parking Cap at new development	Established limit on the number of vehicles that can come in and out of a designated area.	anecdotal	Commute travel	Commuters/ employees	Tier 5
	Commute Trip Reduction Program	Includes regulations and programs for more efficient commute travel.	4.2-7.4%	Commute travel	Commuters/ employees	Tier 2

Information and Encouragement

Information and encouragement strategies provide users with relevant information and targeted engagement to support the use of transit, walking, biking, and telework. Portland already provides information and encouragement through many of its programs, notably the SmartTrips program which targets recent movers to and within the city. Recently, approaches from behavioral science have begun to be integrated into outreach and information-related strategies to make them more effective, with a focus on providing real-time feedback on travel behavior using web and mobile phone applications. The following individual information and encouragement strategies are discussed below:

- New mover marketing
- Neighborhood-level marketing
- Employer-Based Individualized Marketing
- Telework Program Promotion
- App-Enabled Behavioral feedback

New Mover Marketing

Description

New mover marketing programs provide information and encouragement about transit, biking, and walking to people who have recently changed their residence. Research on habit formation shows that the times when a person makes a larger life change, such as moving to a new neighborhood, becoming a parent, or starting a new job, are the best times to encourage new behaviors. These "changed decision contexts" disrupt habits like getting in the car and driving to run errands or travel to work and provide an opportunity for people to choose lower-VMT travel modes.

PBOT's Welcome SmartTrips is an individualized marketing program providing people who move to or within Portland with resources, tools, and information to encourage travel via walking, biking, and transit.

Evidence

PBOT has administered the Welcome SmartTrips program since 2011. The program began as a pilot targeting new movers in three neighborhoods (North Portland, Southwest Portland, and East Portland) with individualized program marketing, personalized follow-up by telephone and email, and monthly newsletters. Participants who pledged to reduce their drive-alone trips were also eligible to win active transportation-related prizes. Program participants and members of a control group participated in before and after travel surveys to identify behavior changes as a result of the program. The 2011 pilot program found that Welcome SmartTrips participants who requested and received ongoing information and encouragement reduced drive-alone trips by 15 percent, compared to a 10 percent drive-alone reduction among all new residents.

Since 2011, PBOT has continued to provide SmartTrips information to households that relocate within and to Portland. PBOT staff provided data and internal reports on Welcome SmartTrips programs from 2014-2018. These reports compare travel survey responses from: 1) participants in the program, who request and are provided with information and encouragement on an ongoing basis; 2) new movers who do not respond to an initial mailer offering information; and 3) new movers selected as a control group, who are not offered information on transportation options.

Year-over-year survey data from 2014-2018 shows that participants in Welcome SmartTrips reduced drive-alone trips between 5 and 8 percent compared to their mode share prior to moving, with an average reduction of nearly 7 percent. Survey data for each year was collected before and after participants received information; travel behavior for participants may have continued to change in subsequent years, but longitudinal data was not collected.

Reductions are more substantial when compared with the control group (those who were not offered information on transportation options); however, participants self-select into the program, indicating that they are more motivated to change their travel behavior than the average person. Between 8.6 percent and 13.5 percent of people who received Welcome SmartTrips postcards requested more

information. Changes to commute trips varied: in some years, participants reported that they stopped driving to work during the program at a higher rate than the control group; however, during other years, participants reported taking more driving commute trips than the control group.

Since these studies used control groups and before/after observations of travel behavior, they are classified as *Tier 1: Strong Evidence*.

Discussion

Assuming that SmartTrips participants reduce their driving equally for all trip types, the strategy would create a total VMT reduction of 5 to 8 percent for participants (equal to the reduction in driving trips). However, survey responses indicated mixed results for commute travel, perhaps due to new movers finding new work around the time of their moves. Commute trips tend to be longer than other types of trips (shopping, leisure, doctor's appointments, worship services, etc.), and people may prefer to drive if they perceive it to be more reliable than other modes. Given these factors, the VMT reductions resulting from this program are most plausibly applied to *non-commute* VMT; total VMT reductions would be lower.

To understand the program's effect on non-commute VMT for new movers, reductions should be normalized against the total population of new movers who were given the opportunity to participate. Taking the participation rates reported for 2014-2018, this would result in a non-commute VMT reduction of up to 0.4 to 1.1 percent for all new movers. The effect on all new movers would be calculated as follows:

*Calculation**:** Non-commute VMT reduction for participants x Share of all new movers who participate = VMT reduction due to program*
Low estimate: 5% x 8.6% = 0.4%
High estimate: 8% x 13.5% = 1.1%

Citations

2016 SmartTrips Evaluation Highlights. Portland Bureau of Transportation. Reviewed 2019.

Notes from the SmartTrips 2017 Performance Measures from the Surveys. Portland Bureau of Transportation. Reviewed 2019.

Cullbridge Marketing and Communications. Portland's SmartTrips Welcome Program Report. 2012. Retrieved from: http://www.toolsofchange.com/en/case-studies/detail/658

Portland Bureau of Transportation (PBOT) (a). SmartTripsChartOverall.xls [Excel spreadsheet]. Reviewed 2019.

Portland Bureau of Transportation (PBOT) (b). Welcome SmartTrips 2018: Impact Summary. Portland Bureau of Transportation. Reviewed 2019.

Neighborhood-Level Marketing

Description

Individualized marketing programs at the neighborhood level provide information and encouragement about transit, biking, and walking existing residents, often with a focus on transportation options and amenities specific to their neighborhoods. These programs can also be coordinated with the opening of new transportation infrastructure (new light rail lines, new bicycle facilities, etc.).

PBOT's SmartTrips neighborhood program was an individualized marketing program providing households in targeted neighborhoods with resources, tools, and information to encourage travel via walking, biking, and transit. The program was based on programs developed in Germany and Australia; other U.S. cities, including Bellingham, WA and Sacramento, CA, have implemented similar programs.

PBOT operated the program from 2003 – 2013, and then transitioned the program to focus on new residents or Portlanders that had moved within the city (the Welcome SmartTrips program described under the New Mover Marketing section). The neighborhood-level programs in Portland targeted 20,000-30,000 households per year from 2003 to 2007 (Dill and Mohr 2010).

Evidence

Research conducted by Portland State University faculty compared the travel behavior of SmartTrips Neighborhood program participants before and after the program to results from similar programs implemented in Cleveland, OH, Durham, NC, Sacramento, and Bellingham, WA.

In 2009, Portland used Regional Transportation Options funds to implement two SmartTrips Neighborhood programs: one in North and Northwest Portland and one targeting neighborhoods in East Portland within ½ mile of the newly opened TriMet Green Line light rail extension. Portland continued to implement neighborhood-level SmartTrips programs in 2010-2011; data for these years is drawn from internal documents provided by PBOT staff.

From 2003-2011, the SmartTrips Neighborhood program demonstrated a relative reduction in drive-alone trips of 7 to 13 percent in each project area, measured year-over-year (PBOT). Similar programs in Bellingham, Cleveland, Durham, and Sacramento found an overall decrease of 5 percent in driving trips and a corresponding increase in walking, biking, and transit use (ODOT). The 2009 Green Line SmartTrips program showed a more substantial behavior change: a reduction of 18.4 percent in drive-alone trips among program participants (Nelson\Nygaard 2012). This higher reduction is likely due to the availability of new light rail service in the neighborhood, and the specific contribution of the mode shift due to the SmartTrips Neighborhood program is not clear. Of the people who were invited to participate in SmartTrips Neighborhood between 2005 and 2011, between 12.6 and 22.7 percent

requested and received information.[3]

Which modes are substituted for driving varies widely and is likely influenced by available facilities and services. Since biking and walking trips are typically shorter than driving and transit trips, it is likely that the total percentage VMT reduction is lower than the percentage reduction in driving.

Since these studies were conducted in Portland and used control groups and before/after observations of travel behavior, they are classified as *Tier 1: Strong Evidence*.

Discussion

Assuming that SmartTrips Neighborhood participants reduce their driving equally for all trip types, the strategy would create an VMT reduction of 7 to 13 percent for participants (equal to the reduction in driving trips). Since biking and walking trips are typically shorter than driving and transit trips, it is likely that the total percentage VMT reduction is lower than the percentage reduction in driving.

To understand the program's effect on VMT for neighborhood residents, reductions should be normalized against the total population of residents who were given the opportunity to participate. Taking the participation rates reported for 2005-2011, this would result in an overall VMT reduction of 0.9 to 3.0 percent for all neighborhood residents. This is relatively more effective on a per-person basis than the effectiveness rates for New Mover Marketing. It is possible that the neighborhood-specific programming associated with this version of the program encouraged greater participation and behavior change. The new mover population may also be less likely to reduce their VMT than the average resident for demographic reasons, such as having more young children in their households and/or higher household incomes, both of which are associated with higher-than-average VMT.

The effect on all neighborhood residents would be calculated as follows:

*Calculation**:** VMT reduction for participants x Share of all neighborhood residents who participate = VMT reduction due to program*
Low estimate: 7% x 12.6% = 0.9%
High estimate: 13% x 22.7% = 3.0%

[3] PBOT's internal data for 2004 reports that 64 percent of people who were invited to participate in SmartTrips Neighborhood did so, but this may be an outlier given subsequent participation rates.

Citations

Dill, Jennifer and Cynthia Mohr. 2010. Long-Term Evaluation of Individualized Marketing Programs for Travel Demand Management. The Oregon Transportation Research and Education Consortium (OTREC)

Nelson\Nygaard Consulting Associates. 2012. Metro Regional Travel Options 2012-2017 Strategic Plan: Appendix D. Metro Regional Governments. Retrieved from: https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf

Oregon Department of Transportation (ODOT). "Mosaic Individualized Marketing Report" Oregon Department of Transportation. Retrieved from: https://www.oregon.gov/ODOT/Planning/Documents/Mosaic-Individualized-Marketing-Programs.pdf

Portland Bureau of Transportation (PBOT). SmartTripsChartOverall.xls [Excel spreadsheet]. Portland Bureau of Transportation. Reviewed 2019.

Employer-Based Individualized Marketing[4]

Description

Employer-Based Individualized Marketing applies the tools of individualized marketing to a workplace context.

One of the largest examples is SmartTrips Downtown, conducted by PBOT from 2006-2009 in response to the construction of a new light rail line that required the closing of the transit mall and a reduction in road capacity. The project targeted large central city employers with the objective of shifting drive alone commuters to more efficient modes to mitigate peak hour stress on an even more limited right of way. SmartTrips Downtown partnered with 135 central city employers and invited 27,000 employees to order free transportation options information. Over 6,700 central city employees ordered information.

Evidence

The project surveyed participants six months and 12 months after receiving information, and at the project's end. Participants surveyed 12 months after receiving information reduced their drive-alone trips by 15 percent. Using the individual participant mode shift, their residential and employer address, the project calculated 522,000 net vehicle miles reduced during the project period.

The project found particular success with segmented mini-campaigns within the participant base, which focused on a particular mode for a targeted audience. For example, staff sent a carpool promotion to participants reporting driving by car that lived outside the inner city with information about the regional ride-sharing matching database. Participants receiving this promotion increased their carpooling commuting rate by 178 percent and reported a relative drive-alone commuting reduction rate of 37 percent. The project had similar successes with a transit promotion (PBOT.).

Since these studies used before/after observations of travel behavior, they are classified as *Tier 1: Strong Evidence*.

Discussion

Assuming a one-to-one relationship between commute drive-alone trip reductions and commute VMT, SmartTrips Downtown participants reduced their commute VMT by 15 percent. This represents an upper bound of potential effectiveness, since some drive-alone commute trips would have been replaced with carpool trips, which reduce but do not eliminate VMT, and because people who replaced driving trips with walking and biking trips may have shorter-than-average commutes.

[4] Draft strategy description and evidence summary prepared by PBOT staff. Discussion of evidence prepared by Fehr & Peers staff.

To understand the program's effect on VMT for all employees at participating employers, reductions should be normalized against the total population of employees who were given the opportunity to participate. Taking the participation rates reported for 2006-2009 (6,700 participating employees out of 27,000 total employees, or 25 percent), this would result in an overall VMT reduction of up to 3.7 percent for all employees at participating employers.

*Calculation**:** VMT reduction for participating employees x Share of all employees who participate = VMT reduction due to program*
Estimate: 15% x 25% = 3.7%

Citations

Portland Bureau of Transportation (PBOT). SmartTrips Downtown Final Report. Reviewed April 2020.

Telework Program Promotion

Description

Telework is substitute for commute travel, although not all workers are able to work remotely. Telework is most effective for people with jobs in the communications, professional services, computer science, accounting/finance, administration services, and government. Some cities support telework by providing tax incentives to employers offering telework to their workers and by adopting telework targets. In its current Comprehensive Plan, the City of Portland adopted a telework target of 10 percent for all workers beyond its commute mode share goals (Transportation System Plan Policy 9.49.f).

Currently, 7.6 percent of employed Portlanders work from home, compared to 6.6 percent of all employed Oregonians and 4.7 percent of all U.S. workers (2013-2017 American Community Survey 5-year estimates).

Evidence

Many studies have evaluated the effects of telework on total VMT. Two meta-analyses provide specific insights: one conducted in 2010 evaluating 100 studies on the impacts of information and communications technology on personal activities and on travel (Andreev et al., 2010), and one conducted in 2013 that focused specifically on studies evaluating VMT before and after telework policies were implemented at locations on the West Coast (Handy et al., 2013). Since each of these studies evaluate substantial amounts of evidence, including before-and-after studies, they are classified as *Tier 1: Strong evidence*.

The studies found that, for workers who telework, this strategy reduced *commute* VMT by approximately 77 to 90 percent on days when workers telecommute, accounting for some work-related trips on days when people spend most of the day working remotely (Andreev et al. 2010, Handy et al. 2013). However, teleworkers often make non-commute trips on days when they telework: for example, instead of stopping by the grocery store on their way home from the office, teleworkers s may make a separate trip during their lunch hour. As a result, the effect on a teleworker's total personal VMT is smaller than the effect on their commute VMT. The studies found that *total* VMT fell by 65 to 67 percent on days when workers teleworked (Andreev et al. 2010, Handy et al. 2013). If pro-telework policy is oriented to workplaces or reducing peak demand, it makes sense to look at the effect on commute VMT alone, since that VMT is attributable to the workplace.

Discussion

Simply making telework available does not reduce VMT across the board. Many people who are allowed to telework choose not to, many people work remotely on just a few days per week, and many workplaces offer telework to just some of their workers (Handy et al. 2013). To accurately estimate the effects of a new telework policy on overall employee commute VMT, we must make assumptions about how many employees might adopt telework and how often they would telework. A study that modeled VMT and greenhouse gas (GHG) reductions estimated that up to 20 percent of employees might adopt

telework up to 1.5 days per week (Cambridge Systematics, 2009). Adopting these assumptions, we find this leads to a maximum reduction of 4.6 to 5.4 percent in commute VMT from introducing telework. Anecdotally, the COVID-19 pandemic led to a rapid increase in telework as offices were closed. As a result, employers and employees may be more comfortable with teleworking once the pandemic has been contained, which would increase telework adoption rates and the overall effectiveness of telework as a VMT reduction strategy above what was reported in the research literature.

*Calculation**:** Commute VMT reduction for teleworkers x Share of workers telework x (telework days/all workdays) = Commute VMT reduction due to introducing telework*
Low estimate: 77% x 20% x (1.5/5) = 4.6%
High estimate: 90% x 20% x (1.5/5) = 5.4%

Citations

Andreev, Pavel, et al. 2010. Review: State of Teleactivities; Transportation Research Part C: Emerging Technologies Volume 18, Issue 1, February 2010, Pages 3–20

Cambridge Systematics. 2009. Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Technical Appendices. Prepared for the Urban Land Institute. (Table 5.14).

Handy, Susan, et al. 2013. Policy Brief on the Impacts of Telecommuting Based on a Review of the Empirical Literature. California Air Resources Board.

Handy, Susan, et al. 2013. Technical Background Document on Impacts of Telecommuting Based on a Review of the Empirical Literature. California Air Resources Board

App-Enabled Behavioral Feedback

Description

The rise of smartphone applications ("apps") has made it easier to both track one's travel behavior and to receive feedback on that behavior. People who receive information on their travel choices may be inclined to change how they travel, particularly if they are given information about how their travel affects the environment or their health or how their travel compares to their peers.

Evidence

App-enabled behavioral feedback has been shown to reduce VMT in small experiments. A 2012 experiment conducted on 135 UC Berkeley students examined the effects of increasing user awareness of their travel behavior and its consequences on mode share and VMT. Participants tracked their travel using a smartphone app, which provided feedback on the cost, calories expended, and carbon dioxide emitted by their travel choices and compared their travel emissions with peer groups. The study found a 33 percent reduction in weekly VMT for participants, although it was not able to distinguish whether the information about "travel footprint" or peer comparisons played a larger role in the outcome (Jaiyasunant et al. 2015).

These results are from university students, who are likely to be more cost-sensitive and more flexible in their travel than other travelers who may have greater work and household obligations (Sengupta and Walker 2015). Like many other university students, UC Berkeley students are provided with free local transit passes during the school year and must pay to park on campus. Although the study is well-designed, its results are based on a limited application to a small group whose lives as university students differ from those of most people; to reflect these limitations, it is classified under *Tier 3: Limited evidence*.

A much more robust study evaluated the effects of letters and emails (rather than app notifications) on the commute behavior of nearly 70,000 employees at an airport outside a major European city. Employees were provided with information about the airport's carpooling service, personalized travel planning, and carpool matches; they were also provided with free bus passes to encourage transit use. The study found no significant effects from these interventions. The authors noted that employees were given free parking spaces as a workplace benefit and hypothesized that the "nudges" in their experiments were not strong enough to overcome this built-in incentive to drive (Kristal and Whillans 2019).

Discussion

Given the limited applicability of the data to a non-university context, we estimate that providing app-enabled behavioral feedback to participants could result in reducing the VMT of participants by 17 to 41 percent (a range of 50-125 percent of the effect report in the UC Berkeley study). The results of implementing this strategy would likely vary substantially depending on the transportation options available to participants and their flexibility around household duties and work schedules.

Moreover, the results from the UC Berkeley study reflect the behavior of students who chose to participate in the study and were able to do so. Given this likely self-selection effect, we would estimate that no more than 25 percent of people provided with this information at their workplace or school would respond as the study participants did. Participants must also have viable alternatives to driving and a financial incentive not to drive, so this strategy would likely be most effective when implemented at a workplace or school that provides transit commute benefits and charges for parking (or is in an area with a cordon toll or other fee).

With these limitations in mind, the total effectiveness of app-enabled behavioral feedback would be in the range of 4.25 to 10.25 percent commute VMT at workplaces and schools that provide other commute benefits and require employees to pay for parking.

*Calculation**:** VMT reduction for participants x Estimated share of population who participate = VMT reduction due to program*
Low Estimate:17% x 25% = 4.25%
High Estimate: 41% x 25% = 10.25%

Citations

Kristal, Ariella S. and Ashley V. Whillans. (2019). What we can learn from five naturalistic field experiments that failed to shift commuter behaviour. *Nat Hum Behav* 4, 169–176 (2020). https://doi.org/10.1038/s41562-019-0795-z

Jerald Jariyasunant, Maya Abou-Zeid, Andre Carrel, Venkatesan Ekambaram, David Gaker, Raja Sengupta & Joan L. Walker. (2015). Quantified Traveler: Travel Feedback Meets the Cloud to Change Behavior, Journal of Intelligent Transportation Systems, 19:2, 109-124, DOI: 10.1080/15472450.2013.856714

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Pricing

The price of travel and associated costs, such as the cost of paid parking, can have a substantial effect on how people choose to get around. By instituting new prices and adjusting existing prices, cities and other government agencies can influence the mode choices made by travelers.

While roadway or bridge tolls have traditionally been used in the U.S. to generate revenue for capital projects, there is growing interest in pricing roadway travel for the purpose of managing congestion and demand on the roadway system. Some freeway tolling demand-management projects have been implemented or are being studied, including in the Portland region. There are a few examples of cordon pricing in cities - London, Singapore, and Stockholm – which charge vehicles to enter a geographically defined zone. No cordon pricing projects have been implemented in the U.S., but several are being evaluated. New York City appears closest to implementation, with several hurdles remaining before Manhattan's proposed cordon pricing program can be put into practice. Tolled managed lanes are becoming increasingly common in the U.S., with examples in both Washington and California, where prices are used to keep traffic flowing at a targeted speed.

Decades of research shows that abundant, unpriced parking encourages private automobile travel and is associated with high rates of driving. Many cities, including Portland, have reduced or eliminated minimum parking requirements for new development and/or instituted parking maximums to support non-auto travel and to reduce the cost of building housing. Pricing and/or reducing parking supply at destinations such as offices can make commuting by auto less attractive. Doing the same at residential development can further disincentivize driving and automobile ownership.

The following section presents our findings on five strategies that have been used to manage parking and travel demand through pricing. It should be noted that in several instances the pricing is used for a direct purpose and any VMT reduction is a secondary impact. For example, on-street parking is typically priced to achieve a performance metric associated with parking occupancy and turnover. Neighborhood parking permits are typically used to manage competing demands between residents and visitors, customers, and employees parking. As such, programs may be developed or modified toward a particular objective which may increase or reduce the effects on VMT.

This section evaluates the following strategies:

- Congestion charging zones
- Paid permit parking on neighborhood streets
- Paid parking at workplaces
- Paid parking meter districts with variable (demand based) pricing
- Unbundled parking at new residential developments

Congestion Charging Zone

Description

Congestion charging zones, also known as "cordon pricing," have been adopted in a few major cities around the world, notably London, Singapore, and Stockholm. Under these programs, vehicles are charged to enter a geographically defined zone, typically a central business district. Fees are generally instituted during business hours or peak commute periods. These programs are typically instituted to manage traffic congestion by disincentivizing auto travel during peak congestion hours, making transit, bicycling, and off-peak auto travel comparatively cheaper. To the extent that these programs spur people to shift from driving alone to carpooling, using transit, bicycling, or walking, they reduce VMT. In the U.S., New York City has adopted a plan to create a congestion charging zone in Manhattan south of 60th Street in 2021 and other cities, such as Seattle and San Francisco, have studies charging zones, but have not yet identified whether they will implement a charge.

Evidence

London, Stockholm, Singapore, Milan, and Gothenburg have all implemented congestion charging zones, leading to substantial reductions in vehicle trips and GHG emissions. These programs have reduced motor vehicle trips into the charged zones by 12 to 44 percent, and carbon dioxide emissions by up to 22 percent (Seattle Department of Transportation 2019). Available evidence on VMT reductions from Stockholm and London's programs is described below.

An evaluation of Stockholm's congestion pricing pilot program, which operated from 2005 to 2006, found that VMT within the charging zone declined by 14 percent during the pilot (Burt et al. 2010). The program has since been made permanent and expanded to Sweden's second-largest city, Gothenburg; drivers who enter either city during a weekday must pay a fee which varies depending on the time of day they enter.

The London Congestion Charging Zone (CCZ) program has been substantially documented by Transport for London, the city bureau in charge of the program, and by outside researchers. The program resulted in substantial mode shifts in favor of transit and active transportation. Implemented in 2003, the CCZ program prices auto travel into London's Central Business District during business hours (7am-6pm). The program imposed charges on private autos, vans, and trucks, while exempting taxis, buses, ad motorcycles. In its first year of operation, the program reduced overall four-wheeled vehicle traffic entering central London during charging hours by 18 percent, which includes increased travel by exempt vehicles, and chargeable vehicle traffic by 27 percent. Within the first four years of operation, chargeable vehicle traffic had been reduced by 30 percent (Evans 2008). Research found that 55 to 60 percent of drivers shifted to public transit and 8-15 percent shifted to other modes such as walking, biking, and taxi services. Up to 30 percent of vehicle drivers diverted their trips around the CCZ, and 10 percent of vehicle drivers made vehicle trips outside of charging hours or reduced their trip frequency (Broadus 2015). The CCZ resulted in a VMT decrease of 15 percent in Inner London and 11 percent in the Western Extension of the pricing zone (Burt et al. 2010). An internal research summary

prepared by Transport for London noted that the mode shift for people entering the CCZ led to VMT reductions of up to 2.5 percent in areas outside the CCZ (Evans 2007).

While congestion charging zones have not been widely implemented, the price elasticity of VMT in the U.S. has been well researched, with long-term elasticities generally in the range of -0.15 to -0.35 (Dong, et. al, Oak Ridge National Laboratory, 2012). Similar responses have been documented in the U.K., indicating that

Taking the larger body of evidence into account, the evidence for this strategy is classified as *Tier 2: Strong evidence*.

Discussion

While the evidence for VMT reductions due to congestion charging zones in Stockholm and London is robust, evidence on the price elasticity of VMT indicates that the effectiveness of congestion charging would vary substantially based on the price of the charge. Based on the results observed in London and Stockholm, we would expect a congestion charging zone implemented in Portland to reduce VMT *within the zone* between 11 and 15 percent (assuming a similar fee/toll is charged). The amount of VMT reduction would be determined based on the price structure chosen, hours of operation, and how some residents/businesses may be exempt from the charges. The mode shifts toward transit and biking documented in London, Stockholm, and elsewhere would lead to additional VMT reductions from commute trips that enter and exit the zone; however, data on total VMT reduction was not available.

Citations

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Evans, Reg. (2007). Central London Congestion Charging Scheme: ex-post evaluation of the quantified impacts of the original scheme. Transport for London.

Evans, Reg. (2008). Demand Elasticities for Car Trips to Central London as revealed by the Central London Congestion Charge. Transport for London.

Seattle Department of Transportation. (2019). Seattle Congestion Pricing Study: Phase 1 Summary Report.

Paid Permit Parking on Neighborhood Streets

Description

Paid parking permit programs are common in cities where on-street parking is in high demand, particularly in residential areas near transit stations, downtowns, shopping districts, and college campuses. Cities typically institute permit parking programs when on-street parking becomes overcrowded. Requiring paid parking permits to park in residential areas and near neighborhood commercial corridors can make driving less attractive and reduce auto ownership, thereby reducing VMT.

Portland's Area Parking Permit Program (APPP) manages residential and business parking permits for areas in the NW and SW quadrants and the Inner Eastside that are affected by commuter parking. Permits cost $75 per year; business permits are limited based on the number of full-time employees and the parking zone.

Seattle's Restricted Parking Zone (RPZ) program restricts parking near commuter destinations to residents and short-term parkers. Residents must pay up to $65 every two years for an RPZ decal, although residents with low incomes can pay less. Eugene, Oregon has a residential parking permit program to manage parking near the University of Oregon campus; depending on location, residents must pay between $40 and $600 per year to park on street for more than two hours.

Evidence

There is limited research available on how paid permit parking affects VMT, although, as mentioned above, there is substantial evidence on how VMT varies with increasing costs (of which parking is included). One study examined the impact of supplying street parking on car ownership of New York City area households by measuring the off and on street parking from aerials and street images. Results showed that free street parking increases residential car ownership by 9 percent, implying that removing free street parking could decrease residential car ownership by as much as 9 percent (Guo 2013). However, people who already own vehicles may prefer to keep them and purchase a permit rather than give up their cars.

To understand the effects of paid permit parking on auto ownership and VMT, researchers have used travel models to evaluate how households respond to increased costs of vehicle ownership and use. A study that modeled responses to a variety of TDM strategies estimated that instituting reduction of less than one percent VMT for households in neighborhoods where parking permit requirements were implemented. These reductions are based on the elasticity of demand for VMT in response to changes in trip price and assumes that priced parking permits would lead to reduced auto ownership. Permits would cost $120-250 per year (updated from 2009 to 2019 dollars), and the modeled response reflects conditions in cities with 50,000 to 1 million inhabitants where 20-30 percent of the population relies on unpriced street parking (Cambridge Systematics 2009). Since it reflects the results of modeled (rather than observed) behavior, this study is classified as *Tier 3: Limited Evidence*.

Portland's existing Area Parking Permit Program may already reduce VMT by reducing auto trips by commuters and reducing vehicle ownership among residents in neighborhoods where parking permits are required; however, data comparing travel behavior in neighborhoods in the APP Program to similar neighborhoods was not available.

Discussion

Since the best evidence found for VMT reductions resulting from paid permit parking districts is based on travel model tests, rather than real-world observations, this evidence is classified as Tier 3: Limited Evidence. Based on this classification, we would assume that actual effectiveness is 50 to 125 percent of the reported effectiveness., reducing VMT by 0.50-1.25 percent in neighborhoods where paid permit parking is instituted. Higher parking rates could increase the amount of VMT reduction but may be difficult to implement equitably.

*Calculation**:** VMT reduction modeled in response to price increases x Low or High range variable = VMT reduction due to program*
Low Estimate: 1% x 50% = 0.5%
High Estimate: 1% x 125% = 1.25%

Citations

Cambridge Systematics. (2009). Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Technical Appendices. Urban Land Institute.

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May 20, 2020

Paid Parking at Workplaces

Description

Free workplace parking is a common benefit at workplaces in the U.S. – some studies have found that up to 95 percent of workplaces provide free parking to their employees. This acts as a subsidy for employees who drive to work. To manage scarce parking supplies and reduce automobile commuting, some workplaces have instituted paid parking for their employees. Paid parking is also typical in dense areas like downtown Portland where land is scarce and the cost to provide parking is very high. Note that even in dense areas like downtown Portland, parking fees still do not tend to cover the cost of building and maintaining parking, so even with charges in place, there is often a subsidy for people driving to work. Requiring commuters to pay for parking at their workplaces provides a disincentive to driving and encourages commuters to use other modes, thereby reducing VMT. Several employers, notably the Gates Foundation and Seattle Children's Hospital, have begun to require that employees pay for parking on a daily basis (as opposed to a monthly parking fee), which may reduce driving further by making the cost of parking clearer to drivers.

Evidence

A meta-analysis of commuter parking demand elasticity evaluated a total of 169 parking demand elasticity estimates from 25 studies in North America, Europe, Asia, and Australia and constructed a regression model to explain why people respond differently to changes in parking pricing in different contexts. The study found that parking demand in the U.S. fell by 3.9 for every 10 percent increase in price (an elasticity of demand of -0.39). The study also evaluated explanatory variables in these studies to address the range of results. Depending on the change in price and the availability of alternatives, increased parking pricing could decrease commute VMT to participating workplaces by as much as 30 percent (Concas and Nayak 2012).

Other studies have found that commuters may be less sensitive to workplace parking pricing. One study that examined the effects of instituting parking pricing at workplaces in Los Angeles, Ottawa, and Washington D.C. between 1969 and 1991 found that parking demand fell by an average of 1.5percent for every 10 percent increase in price (an elasticity of demand of -0.15) (Shoup 1994, cited in TCRP 2005). It is likely that the effect of parking pricing varies substantially on the location where it is instituted and the availability of transit, carpooling, and other alternatives to driving alone for commuting. In other words, if there is not a convenient alternative to driving, the elasticity of parking with respect to price will be lower.

Taken together, these two studies indicate a potential commute VMT reduction of 15 to 30 percent due to implementing paid parking at workplaces where parking is currently free. Since these studies rely on before-and-after data (Shoup 1994) and a meta-analysis, they are classified as *Tier 1: Strong evidence*.

Anecdotal evidence from Gates Foundation offices in Seattle indicates that charging for parking on a daily basis makes the cost of parking more salient to commuters, resulting in greater shift away from driving than when parking is paid on an annual or monthly basis (Gutman 2017). Therefore, daily paid parking programs would be expected to yield a higher elasticity than monthly or annual programs, although these programs are too new to draw any quantitative conclusions.

Discussion

Given the elasticities of demand reported above, converting workplace parking from free to paid is likely to result in a commute VMT reduction of 15 to 30 percent for employees commuting to workplaces where it is implemented, with a greater reduction in areas near high-quality transit and bicycle facilities. VMT reductions could be higher or lower depending on the price that is charged to employees and could potentially be higher if parking is paid on a daily rather than monthly or yearly basis.

Citations

Concas, Sinsinnio and Nagesh Nayak (2012) A Meta-Analysis of Parking Price Elasticity. Presented at the 92nd Transportation Research Board Annual Meeting; accessed via http://amonline.trb.org/1spbip/1spbip/1.

Gutman, David. (2017). "The Not-so-Secret Trick to Cutting Solo Car Commutes: Charge for Parking by the Day," *Seattle Times*, accessed via www.seattletimes.com/seattle- news/transportation/the-not-so-secret-trick-to-cutting-solo-car-commutes-charge-for-parking- by-the-day.

Miller, G. K., and Everett, C. T., "Raising Commuter Parking Prices - An Empirical Study." Transportation 11 (1982).

Shoup, Donald C, (1994). Cashing Out Employer-Paid Parking: An Opportunity to Reduce Minimum Parking Requirements. University of California Transportation Center Working Paper, Berkeley, CA. Cited in TCRP 2005.

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Paid Parking Meter Districts and Variable (Demand Based) Pricing

Description

Requiring drivers to pay for parking at the curb is a time-tested approach for ensuring that parking spaces are available in locations with high demand, such as in downtown areas and shopping districts. Paid or metered parking works in tandem with other parking management strategies, such as enforcing time limit restrictions in locations with high turnover and requiring residential and/or employee permits to park within a specific neighborhood.

An on-street occupancy rate of 80-85 percent is frequently cited as ideal to maximize parking utilization while reducing unnecessary circulation as drivers look for parking. Traditionally, paid parking districts have charged fixed hourly prices within specific time limits (e.g. $1.60 per space per hour, 8-6 PM Monday-Saturday). To better respond to varying demand in different locations and at different times of day, some cities have instituted variable parking pricing, increasing the price of parking in locations during times of day with high demand, and lowering the price in response to lower demand. San Francisco's SF*park* program is an example of variable on-street parking pricing. Seattle also has variable on-street parking prices throughout downtown. Washington, D.C. has operated several demand-responsive parking pricing pilots since 2008 through its parkDC program.

Since paid parking effectively raises the cost to drive and park at one's destination, it can also encourage people to carpool, take transit, bike, or walk to their destinations rather than driving alone, thereby reducing VMT for the district. In locations with high latent demand for parking, reduced VMT in response to pricing will also result in reduced circulation of drivers cruising for parking (Shoup 2011). This strategy is most effective at reducing VMT when the priced area is not near locations where parking can be had for free or at a low cost.

Currently, Portland has five metered parking districts where fixed hourly rates are charged for on-street parking. The metered areas of the Northwest parking district were expanded in fall 2019-spring 2020 in response to overcrowding on adjacent non-metered streets.

Evidence

A meta-analysis of parking pricing studies, focusing on the effects of parking pricing on VMT, found that the best evidence for VMT reductions due to parking pricing was provided by modeling parking demand. However, there are many observations of the effect of parking pricing on parking demand with generally consistent results.

A meta-analysis of multiple U.S. studies found that on-street parking demand tends to fall by 1-6 percent for every 10 percent increase in price (Spears et al. 2013). A study focused on San Francisco's *SFpark* program, instituted as a pilot program from 2011-2013, evaluated parking meter occupancy data to assess how parking occupancy changed in response to price changes. The study found an average elasticity of demand of -0.40, meaning that a 10 percent increase in price led to a four percent decrease in parking demand. However, elasticity of demand varied substantially based on location: as

low as -0.21 in the Mission, a residential and neighborhood commercial district, and as high as -0.53 in the Fisherman's Wharf tourist district. It also varied substantially based on time of day and in response to the initial price (Pierce and Shoup 2013). Taken together, these studies present strong evidence for the effect of parking pricing on parking demand, and less certain evidence for the effect of parking pricing on VMT. None of these studies estimated the effect of variable parking pricing on VMT directly. If the reductions in parking demand is the result of people choosing to walk, bike, carpool, or take transit instead of driving alone, we can assume that the parking reductions reported in the literature represent an equivalent reduction in VMT. However, some amount of parking demand reductions could result from people reducing the number of trips they make or traveling to a more convenient location to shop or dine. Therefore, we can assume that the parking demand elasticities reported reflect an upper bound for VMT reductions resulting from this strategy.

An additional reduction in VMT has been documented due to the decrease in circulating VMT as drivers search for parking spaces. Cruising can contribute to VMT within the districts where parking is metered. According to one study of traffic in central Stuttgart, Germany, 15 percent of traffic was comprised of people looking for parking spaces (Hampshire and Shoup, 2018). Observations in cities around the world between 1927 and 1993 found an average of 30 percent of traffic was comprised of people cruising for parking and estimated that 8000 VMT per day were the result of drivers cruising for parking in one Los Angeles neighborhood alone (Shoup 2007). A 2013 study of SF*park* found that the program reduced cruising by up to 50 percent (Millard-Ball et al. 2013). A review of Washington, D.C.'s parkDC program found that total cruising on weekday mornings and afternoons declined in locations where parking meters were priced to reflect changeable demand (Kittelson 2019). While the VMT from cruising is very small compared to total VMT, variable parking pricing can substantially reduce that VMT.

Given the robust amount of evidence on how people respond to changed parking prices, the evidence for this strategy is classified as *Tier 1: Strong evidence*.

Discussion

Based on data from San Francisco, raising parking prices in a meter district by 10 percent would result in a 0-5 percent reduction in VMT from visitor trips to the area where parking prices are raised. Higher VMT reductions could be achieved with higher parking fee increases, although that may have undesirable effects, such as encouraging some people to park just outside of the paid parking area. *Cruising VMT* could also be reduced by implementing variable parking pricing to ensure that curb spaces are no more than 80-85 percent occupied). However, if variably priced parking reduces overcrowding enough to make driving and parking more convenient, it has the potential to make driving more attractive, thereby increasing VMT from visitor trips.

Citations

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May 20, 2020

Unbundled Parking at New Residential Developments

Description

Requiring new residential development to "unbundle" the cost of parking space from the rental price of the property effectively increases the apparent cost of vehicle ownership, which induces some households to shed or not purchase vehicles, thereby reducing VMT. To be effective at reducing VMT, surrounding streets must have parking restrictions in place, such as metered parking, time limits restricting overnight parking, and area parking permits for which the new development's residents are not eligible.

Evidence

Inferential evidence compiled by the Victoria Transport Institute indicates that unbundling the cost of parking from the cost of renting a home may reduce auto ownership, thereby reducing VMT. A 10 percent increase in total vehicle costs typically reduces vehicle ownership 4-10 percent, resulting in a reduction in vehicle ownership in response to instituting monthly parking charges. These results are highly inferential.

A recent study using data from the American Housing Survey finds that households with bundled parking are 60 percent less likely to have zero vehicles than households without bundled parking (Manville 2017). Public housing residents (and therefore affordable housing recipients in general) seem to be more responsive: households with bundled parking are 25-40 percent more likely to have a vehicle than housing units without bundled parking.

Given the inferential nature of the evidence available for this strategy, the evidence is classified as *Tier 4: No substantial evidence*.

Discussion

Unbundling parking prices from rents sends a strong price signal to renters that could discourage them from owning a vehicle. However, given the inferential nature of available evidence, we cannot confidently estimate the effects of this strategy on VMT.

Citations

Litman, Todd. (2016) Parking Requirement Impacts on Housing Affordability. Victoria Transport Policy Institute. Accessed March 2017 from http://www.vtpi.org/park-hou.pdf. Vehicle Ownership Reductions From Residential Parking Pricing) (p. 8, Table 3)

Manville, Michael. (2017) Bundled parking and vehicle ownership Evidence from the American Housing Survey. Journal of Transport and Land Use, Vol. 10, No. 1 (2017), pp. 27-55. Accessed February 2019 from: https://www.jstor.org/stable/26211720

Incentives

Providing transit subsidies, such as discounted or free transit passes, is a longstanding and successful practice for commute focused TDM programs. Recently, Portland has begun providing free transit for public high school students and has begun offering discounted transit passes to residents and workers within specific districts where street parking is scarce. The following sections discuss our findings on the transportation incentive programs listed below:

- Free or subsidized transit passes for Seniors, Youth, and Low-Income residents
- Employer subsidized transit passes
- Programs combining pricing parking and targeted transportation incentives

Free or subsidized Transit Passes for Seniors, Youth, and Low-Income Residents

Description

Free transit pass programs for seniors, youth, people with disabilities, and people with low incomes generally increase mobility for people with limited access to automobiles. To the extent that transit trips taken by passholders replace auto trips, these programs can also reduce VMT. Examples of these programs include the ORCA Opportunity Youth Program, which provides free, unlimited 12-month transit passes to all high school students in Seattle Public Schools, and the Senior Ride Free Program in Chicago, which provides free transit passes for seniors enrolled in the income-limited Illinois Aging Benefits Program. High school students in the Portland area are currently provided with a farecard (Hop card) integrated into their student ID and that allows them to ride TriMet for free during the school year.

Transit agencies in the U.S. commonly provide discounted fares for seniors, youth, people with disabilities, and people with low incomes. TriMet and other local transit agencies provide discounted transit fares for youth 17 and under, adults over 65, and people who receive disability benefits, Medicare, or means-tested food and cash benefits.

Some transit agencies have eliminated fares entirely. Fare-free systems have been adopted in many smaller European cities (notably Talinn, Estonia) and have been tested in many U.S. cities. In late 2019, Kansas City, Missouri's city council voted to eliminate fares on the city's bus system. TriMet operated fare-free transit (the "fareless square") in downtown Portland and the Lloyd District from 1975 through 2012; the program was discontinued during agency budget cuts in 2012.

Evidence

Research evaluating these strategies in a US context is limited, largely because most transit systems provide discounted fares to youth and seniors. A study of a free transit pass program for high school students in Oakland found no correlation between providing free bus passes for youth and increased transit mode share or reduced VMT (McDonald et al. 2003). Driving mode share increased over the course of the study, likely for reasons unrelated to the bus pass program. Students who received free bus passes reported greater trip making using transit. The study observed just two years in the life of the free bus pass program; the authors stated that a longer study timeframe would yield more meaningful results. Providing free transit passes for students, staff, and faculty at public universities has been shown to reduce commute mode share, but these results should not be generalized to the general population (Brown et al. 2003).

An analysis of the 2009 National Household Travel Survey respondents found that youth and young adults are most likely to ride transit, with 15 to 20 percent of respondents under age 30 reporting riding transit in the past two months (Brown et al. 2016). Transit use rates decline steadily until retirement age and then hold steady, with around 5-7 percent of survey respondents over 65 using transit in the past two months. Low-income adults are also more likely to ride transit than adults with higher incomes.

Another study from 1980 reports that senior citizens increased their use of transit by 33 percent and students by 38 percent when transit was made fare-free (elasticities of -0.33 and -0.38, respectively). These were single instances, similar to the average response of a 32 percent increase in transit use for all fare-free systems (TCRP 2004).

Taken together, these findings indicate that further subsidizing the use of transit for all seniors may result in a greater VMT reduction than subsidizing youth and young adults or adults under 65 who have low incomes, since these groups already use transit at relatively high rates. The total increase in transit use would likely range between 0 and 38 percent for seniors and youth. Only part of this increase in transit use would likely result from decreased driving, since some transit may be new trips or replacing walking trips. We estimate that up to half of the increased transit use results from reduced driving, working out to a VMT reduction of 0 to 19 percent for seniors and/or youth.

Given the age of this data and the limited instances studied, this evidence is classified as *Tier 3: Limited evidence*.

Discussion

Based on the review of literature, we found that providing free transit passes for seniors or youth could reduce VMT for these populations. Free transit passes would likely increase mobility for these groups as well. However, there is limited research in this area.

Based on the available studies, free transit passes appear to increase transit use between 0 and 38 percent for seniors and youth, with stronger evidence for the effects on travel by seniors. Only part of this increase in transit use would likely result from decreased driving, since some transit may be new trips or replacing walking trips. We estimate that up to half of the increased transit use results from reduced driving, working out to a VMT reduction of 0 to 19 percent for seniors and/or youth. Given the Tier 3 rating assigned to the existing literature, we would estimate that fare-free transit would result in a VMT reduction of 0-23.8 percent for seniors and/or youth (or up to 125 percent of the estimated VMT reduction in the literature).

*Calculation**:** VMT reduction demonstrated in response to free passes x Low or High range variable = VMT reduction due to program*
Low Estimate: 0% x 50% = 0%
High Estimate: 19% x 125% = 23.8%

Citations

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Employer subsidized transit passes

Description

Requiring employers to provide either partially or fully subsidized transit passes for all employees encourages commuters to use transit rather than driving, thereby reducing VMT. Employer-provided discounted or free transit passes are a common feature of employer TDM programs. Currently, TriMet is one of many transit agencies that operate discounted annual pass programs for employers that provide transit passes to their workers.

Evidence

A robust body of evidence demonstrates that reducing transit fares increases transit ridership (Handy et al. 2013). The introduction of transit pass programs in Seattle during the 1990s increased transit ridership at participating employers by 140 percent (TCRP 2004). Recent evidence for employer-subsidized transit passes as a stand-alone strategy is somewhat limited, however, since subsidized transit pass programs are a standard feature in employer TDM programs that provide other commuter benefits as well.

A regression analysis of employee commute survey data from 830 employers in the Portland metro area found that providing subsidized transit passes reduced drive alone mode share for commute trips by 18.4 percent (Dill and Wardell 2007). The study authors noted that all participating employers volunteered to share data with the research team and that results might be less impressive for wider sample of employers.

A recent large-scale study of commuting behavior in the New York-New Jersey region investigated the effects of various commute subsidies, including transit fare subsidies. The study determined the effects of transit benefits on employee travel behavior through a multinomial logit model based on a total of 18,965 household travel diaries from the 2010-2011 Regional Household Travel Survey. It found that adding subsidies for transit reduces the likelihood of driving to work by 16 percent and increases transit use by 15 percent (Bueno et al. 2016). If transit commute trips and driving commute trips are typically of similar length, this amounts to a 15 percent reduction in commute VMT. The study concluded that commuter benefits play a significant role in explaining observed travel patterns and are an effective policy to encourage the use of public transit. However, the study did not differentiate between the effects of different levels of transit benefits.

The evidence for this strategy is drawn from surveys and regression analyses on robust datasets and is classified as *Tier 2: Strong evidence*.

Discussion

Assuming that the increase in transit use and reduction in drive-alone mode share reported in the literature is equal to the reduction in VMT, we would estimate that the commute VMT reduction would range between 15 percent (Bueno et al. 2016) and 18.4 percent (Dill and Wardell 2007).

Citations

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Programs combining pricing parking and targeted transportation incentives

Description

Today, PBOT offers targeted incentive programs that provide a transportation options benefit in two Parking Districts in the city: Northwest Parking District (NW) and Central Eastside Industrial District (CEID). The targeted incentive programs, known as the Transportation Wallet, provide users with a suite of passes and memberships that substantially discount the cost of riding TriMet, the Portland Streetcar, BIKETOWN, and electric scooters. Residents and employees of businesses in the NW and CEID paid parking districts can purchase Transportation Wallets for a low annual fee or exchange one parking permit for a free Transportation Wallet. Like the employee transit benefits described above under "Employer Subsidized Transit Passes," Transportation Wallets may be more effective at reducing driving because they are provided in locations where street parking is priced.

Evidence

In a September 2018 Parking and Transportation Survey of PBOT's Transportation Wallet users, the Transportation Wallet program induced mode shifts from vehicle trips to active transportation trips. While the survey did not assess shifts in mode share or VMT reductions, it found that 43 percent of respondents used TriMet more, 44 percent used Streetcar more, and 40 percent used BIKETOWN more than they had previously. By September 2018, 652 Transportation Wallet holders had ridden a cumulative 16,000 miles on BIKETOWN. Survey responses from the 100 residents who traded in their street parking passes for Transportation Wallets stated several reasons for doing so: "got rid of car" was the most popular reason cited, followed by the expense and difficulty of on-street parking.

By November 2018, 221 businesses in the NW and CEID (CEID) parking areas opted out of 1,135 employee parking permits in favor of the wallet. The opt-out resulted in a 7 percent reduction of employer parking permits in NW and a 11 percent reduction in the CEID. As of October 2019, there are 3,948 Transportation Wallets in circulation, with opt-outs representing 60 percent and purchases representing 40 percent of total.

While it is likely that some people who traded in a parking permit for a Transportation Wallet reduced their driving, there is likely a strong self-selection bias and insufficient data was collected to fully estimate the effects of this program on driving mode share and VMT. Given the limitations of the data available, we would classify this evidence as *Tier 3: limited evidence*.

Discussion

Surveys of residents who purchased or traded in parking permits for Transportation Wallets did not quantify VMT reductions resulting from the program; however, survey responses indicate that Transportation Wallet holders drive less and use other modes more than before they participated. The effect of the program on employee commute VMT can be inferred from the reduction in employer parking permits in NW and C/EID under the program. Based on the reported 7 to 11 percent reduction in parking passes and the study's limitations, we would estimate that commute VMT fell by 3.5 to 13.8

percent in the CEID area (or 50-125 percent of the reported reductions in parking pass purchases). Expanding the Transportation Wallet program to other paid parking districts may have similar effects on commute VMT; however, the NW and CEID areas have very strong transit access compared to the rest of the city and may represent an upper bound to the effectiveness of this strategy in Portland and similar cities.

Calculation: Commute VMT reduction demonstrated in response to free passes x Low or High range variable = VMT reduction due to program
Low Estimate: 7% x 50% =3.5%
High Estimate: 11% x 125% = 13.8%

Citations

Email Communication with Sarah Goforth, PBOT TDM Strategist. October 2019.

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TDM Requirements

TDM programs have long focused on reducing commute trips through workplace-based incentives and encouragement. TDM programs often incorporate several of the strategies described previously to provide employees a range of options to driving alone to work. Increasingly, city, regional, and state governments have imposed TDM program requirements on employers whose operations substantially contribute to commute traffic. In general, TDM program requirements have been shown to substantially reduce commute VMT, with the most successful programs having dedicated staff to manage commute options, educate employees, and adapt to changing transportation services and employee residential location preferences.

Examples include Washington State's Commute Trip Reduction program, which targets worksites with 100 or more full-time employees who commute during peak hours in the nine most populous counties in the state. Worksites develop and manage their own programs based on locally adopted VMT or drive alone reduction targets and the TDM strategies that work best for their employees. Worksites have to biennially submit the results of a commuter survey and their progress to their VMT or mode share goal. If they are not meeting their mode share goal, worksites must describe changes to the program to encourage less driving and report on progress in the next biennial report.

The City of Portland currently requires that TDM Plans be approved for new development in Campus Institutional Zones and Commercial/Mixed Use Zones before issuing a building permit. This requirement was adopted in May 2018, and information on the outcomes of this policy are not yet available.

The following sections present our findings on workplace TDM requirements, focusing on these strategies:

- Employer Parking Cash-Out
- Trip Cap/ Parking Cap at New Development
- Commute Trip Reduction Program

Employer Parking Cash-Out

Description

Parking "cash-out" rules require employers to provide workers who choose not to drive to work with the cash value of the parking space they would otherwise use. These rules directly incentivize the use of transit, carpooling, biking, and walking for commute trips, thereby reducing VMT.

Parking cash-out has been required for employers in California since the 1990s and must match the market rate for parking spaces that would otherwise be purchased by the employer. This strategy can only be applied in locations where parking costs are already "unbundled" from office rents, and therefore is most common at office buildings in areas where parking is typically rented in garages.

Evidence

In 1992, California passed a law requiring employers who rent parking separately from office space to provide employees with the opportunity to "cash out" the value of parking they choose not to use. A study of eight employers in Southern California found that parking-cash out reduced commute VMT by an average of 12 percent, with reductions ranging from 5 to 24 percent at different workplaces (Shoup 1997). The VMT reduction was driven by a reduction in solo driving and a corresponding increase in carpooling, transit use, walking, and bicycling.

A separate study modeled potential greenhouse gas reductions for a range of TDM strategies and estimated that providing parking cash-out at workplaces would reduce commute VMT by 5.4 to 7.7 percent (Cambridge Systematics 2009).

Given that the available evidence is drawn from case studies and that corroborating evidence is drawn from modeled rather than from observed data, the evidence for this strategy is classified as *Tier 3: Limited evidence*.

Discussion

Implementing parking cash-out at workplaces where employers currently subsidize their employees parking could reduce commute VMT at those workplaces by 2.5 percent to 30 percent (50-125 percent of the reported range). Greater reductions in VMT are more likely to occur at workplaces that have reliable and convenient alternatives to driving, such as frequent transit service and good bicycle connections, and workplaces located within dense neighborhoods.

*Calculation**:** VMT reduction demonstrated in response to parking cash-out x Low or High range variable = VMT reduction due to program*
Low Estimate: 5% x 50% =2.5%
High Estimate: 24% x 125% = 30%

Citations

Cambridge Systematics. Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Technical Appendices. Prepared for the Urban Land Institute. (Table 5.13) Accessed via: http://www.reconnectingamerica.org/assets/Uploads/2009movingcoolerexecsumandappend.pdf

Shoup, D. (1997). Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies. Transport Policy 4(4), 201-216.

Trip Cap/ Parking Cap at New Development

Description

Several cities, primarily in the San Francisco Bay Area and Puget Sound areas, have begun to implement mode share requirements and trip caps at new developments, primarily at large employers in the technology sector, but increasingly at residential and general office developments as well. These requirements impose externally monitored performance targets and typically include privately-run TDM programs. The mandatory nature of these requirements generally encourages a greater commitment of resources to the TDM program from employers and residential property managers. For the most part, these requirements have been in place since 2016, so data on program performance is limited.

Evidence

Detailed information on the effectiveness trip caps and mode share targets is limited, largely because these regulations are relatively new. Some large technology employers have operated under trip caps and mode share targets for several years and have collected internal data on program performance. Anecdotal evidence from these employers show that aggressive commute programs that include subsidized transit passes, long-distance direct commuter buses, and in some cases parking fees and restrictions, can reduce the drive-alone commute mode share from 70-80 percent to 50-55 percent. As a specific example, the Bill and Melinda Gates Foundation, which employs more than 1,200 people in Seattle, has seen its drive alone mode share fall from 90 percent to 34 percent at its new headquarters, where the Foundation is subject to a transportation management plan mandated by the City of Seattle. Anecdotally, we have heard about other drive-alone reductions in the 20-30 percent range from large technology employers, although officially published data are uncommon.

To date, the most effective trip cap requirements at private employers have been at employment sites operating under daily trip limits that are monitored and enforced by local agencies, who will fine employers if performance standards are not met or deny/delay future building expansions. Some of these employers have additional incentives to provide robust commute programs, including the need to compete for employees with technical skills, the desire to manage parking demand on their campuses, pressure from public interest groups, and the need to win public agency approval for future expansions.

Since only anecdotal evidence is currently available for the effectiveness of these programs, the evidence for them is classified as *Tier 5: No substantial evidence*.

Discussion

Providing robust commute programs and incentivizing employers to meet performance targets increases program effectiveness. Additionally, the regulatory nature of these programs provides additional assurance that commute VMT reductions in the range of 15-30 percent would not be unreasonable to expect. It should be noted that the anecdotal successes reported above represent outcomes at large organizations with substantial financial resources devoted to managing employee commutes.

Citations

Confidential program performance data from Bay Area and Puget Sound technology employers.

Commute Trip Reduction Requirements

Description

Commute Trip Reduction (CTR) programs use a variety of education, encouragement, and support strategies to reduce the number of drive-alone commute trips to the project. CTR program requirements have been in place in Washington State since the 1990s, and many employers across the US voluntarily provide CTR programs as benefit to their workers. Tools include transit pass subsidies; subsidies and incentives to encouraging walking, bicycling, and other non-drive alone modes; carpooling encouragement and carpool formation support; ride share assistance; flexible/alternative work schedules; vanpool assistance; and facilities to support bicycling, such as secure bike parking, showers, and changing rooms. Program managers actively monitor and react to changes in mode share. CTR program requirements typically require that employers track and report commute mode share and/or trip generation; however, unlike the requirements identified above in the "Trip Cap/Parking Cap at New Development" section, they typically do not include substantial penalties for missing performance targets.

Evidence

In 1991, the Washington State Legislature passed a statewide requirement mandating that large employers (100+ employees per worksite) implement CTR programs. In 2006, this law was revised to include city- and county-level performance targets. This mandate includes requirements that employers track and report commute trips; however, the State does not impose substantial penalties for missing performance targets. From 2007 to 2016, CTR programs in Washington State reduced commute VMT by 7.4 percent (Washington State Commute Trip Reduction Board 2017). The combined rate of transit use, carpooling/vanpooling, walking, biking, and telework rose from 34.3 percent to 39.1 percent at employers with CTR programs, while remaining relatively flat at non-CTR employers (rising from 26.9 to 27.4 percent non-drive alone).

A study of 64 employers participating in the "Best Workplaces for Commuters" partnership with the US Environmental Protection Agency found a 4.2 to 4.8 percent reduction in commute VMT at participating worksites. These results are consistent with the typical performance of employer TDM programs that focus on encouragement and whose performance is monitored but which are not tied to penalties for noncompliance. In general, the effectiveness of employer led CTR programs varies substantially depending on the level of employer investment and the specific strategies employed to reduce trips. A survey of 82 employer-led programs found that employers who support CTR programs by providing information, hiring transportation coordinators, supporting ride sharing, and promoting commute alternatives saw commute trip reductions of 19 percent overall, versus 15 percent for less involved employers (TCRP 2010).

Due to the wide range of employers where data was collected, this evidence is classified as *Tier 2: Strong evidence*.

Discussion

The relatively strong performance of employers in Washington State could be due to a number of factors, including the presence of performance targets at the local level, mandatory performance reporting, the presence of a regional CTR program manager community and knowledge base, more support from local governments, better existing alternatives for commuters, and/or higher expectations among employees for their commute options. Based on the range of effectiveness reported in the literature, we estimate that implementing a Commute Trip Reduction requirement at the City level would reduce commute VMT between 4.2 and 7.4 percent.

Citations

Herzog, Erik, Stacey Bricka, Lucie Audette, and Jeffra Rockwell (2006) Do Employee Commuter Benefits Reduce Vehicle Emissions and Fuel Consumption? Results of Fall 2004 Survey of Best Workplaces for Commuters. Transportation Research Record 1956, 34-41.

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