EXPLORING PARKING PRICING FOR CONGESTION MANAGEMENT USING THE SFCTA ACTIVITY-BASED REGIONAL PRICING MODEL

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ABSTRACT

This paper compares the potential benefits and impacts of two types of congestion pricing: road- or cordon-based, and parking-based, that the San Francisco County Transportation Authority studied as a part of the Mobility, Access, and Pricing Study. The study is evaluating comprehensive pricing and mobility-enhancing packages to improve access and offer more sustainable travel choices to and within San Francisco. The Study Team evaluated the cordon and parking congestion charges using the SF-CHAMP regional travel demand model (also known as RPM-9). This paper discusses the current representation of parking in SF-CHAMP and its limitations, and then summarizes the development of an improved parking representation including additional data needs.
INTRODUCTION

In recent years, the Texas Transportation Institute has ranked the San Francisco-Oakland urban area as among the most congested regions in the U.S. in terms of the Travel Time Index, or the ratio of peak period travel time to free flow travel time (TTI 2009). The Travel Time Index for the auto commute to the major employment centers of San Francisco is particularly high, with half of the vehicle hours of peak period trips spent in delay. The Focus Area, shown in FIGURE 1, includes routes facing substantial congestion today and includes San Francisco’s key employment centers: the neighborhoods commonly referred to as the Downtown, Civic Center, and South of Market (SoMa). As the figure also shows, transit in and around the Focus Area suffer from effects of heavy traffic congestion and are generally below 8 mph during peak periods, while peak period auto speeds in that area average below 12 mph.

FIGURE 1 Focus Area and congested streets.
Red lines indicate streets with peak period transit speeds below 8mph.
Orange lines indicate roads and highways with peak period speeds below 30 mph.

MOBILITY, ACCESS AND PRICING STUDY

Since 2008, the San Francisco County Transportation Authority (SFCTA) has been studying the feasibility of congestion pricing in San Francisco, funded by the United States Department of Transportation’s Value Pricing Program. The Mobility, Access and Pricing Study (MAPS) aims to
evaluate whether congestion pricing makes sense in San Francisco, where significant future growth is expected in the downtown and eastern areas of the city, which already have a largely mature street network with few opportunities to accommodate additional automobile traffic.

The vision of the MAPS Team is to study roadway congestion pricing as part of comprehensive demand and system management. Congestion pricing is an efficient way to fulfill numerous goals by simultaneously managing auto travel, enhancing transit and auto speeds, and earning revenue to invest in improving access for non-auto modes. This integrated strategy has been effective in several cities, such as Singapore, Stockholm, and London, as a way to improve mobility for all travelers. In order to test how various congestion pricing scenarios might affect travel choices, the SFCTA refined its activity-based travel demand model in several ways, including the incorporation of value-of-time distributions, enhanced peak-spreading models and the explicit tracking of toll of payers at the disaggregate level. This refined model, SF-CHAMP4 (also referred to as RPM9, or the 9-County Regional Pricing Model), proved to be a useful tool for MAPS, complementing the comprehensive economic and policy analysis on roadway congestion pricing (Sall 2010). The output from SF-CHAMP4 helped the Study Team move toward a set of preferred scenarios and the model informed the Team for the overall feasibility analysis. In addition, the Study Team evaluated how congestion pricing might enhance quality of life, improve productivity and even contribute to the economic vibrancy of charging zones, just as programs in other cities have.

When the MAPS Team conducted community outreach in early 2010 presenting the current study findings, various stakeholders requested the inclusion of a parking pricing scenario for comparison to the cordon-based scenarios. The rest of this paper discusses the results of an initial comparison between cordon and parking congestion charges using the existing SF-CHAMP4 model, and goes on to present methodology and data needs for a more refined analysis.

Concurrent to MAPS, the San Francisco Municipal Transportation Agency (SFMTA) is launching a pilot program, SFpark, that will institute variable parking charges to target an 85% occupancy rate in metered spots. This will likely increase availability and cost of on-street parking as well as reduce circling time. SFpark additionally hopes to install parking sensor technology that can interface with mobile devices and therefore further reduce parking search time. The SFpark project collected parking inventory and occupancy data in 2009, has been collecting data on parking search time, and will implement new meters and rates in several neighborhoods in 2010.

**PRICING SCENARIOS**

This paper will compare two priced scenarios: the *Northeast Cordon Charge*, and the *Focus Area Parking Charge*. In the first scenario, a Northeast Cordon (depicted in blue in FIGURE 2) would encapsulate the Focus Area and surrounding neighborhoods. This cordon boundary was developed through an iterative process: for each boundary examined, the Study analyzed traffic diversions to neighboring areas; this Northeast Cordon boundary minimizes disruptive effects while reducing congestion in the Focus Area. Autos would be charged $3 each time they cross the boundary during weekday peak periods, but travel within the boundary would not be charged. In the Focus Area Parking Charge scenario, autos driving to or from the Focus Area during the morning or evening peak period are tolled an additional $3 over the normal parking cost. Through trips are not priced. In both cases, drivers would be charged $3 during the morning and evening weekday commute periods.

Note that the Focus Area Parking Charge scenario directly targets congestion in the Focus Area by pricing the large off-street supply, while SFpark targets the on-street supply and city-owned garages only. The reason for studying parking pricing using this strategy rather than one more similar to SFpark is that SF-CHAMP4 currently has limited capabilities for modeling SFpark pricing. While the model is being enhanced to better represent the nature of parking and parking-related fee programs in the future, at present there are still data needs before this refinement will be fully operational. The current limitations, as well as the enhancements and related data needs will be described in more detail in the Future Work section.
Implementation Issues

Ideally the tolling technology will be seamless to the driver with easy payment options, such as a camera-based system that scans license plates or a system similar to the FasTrak toll-device system currently used on Bay Area bridges. Implementation of the Focus Area Parking Charge scenario is likely not as easy nor as inexpensive as it might seem at first glance, because most of the parking supply in the Focus Area consists of privately owned garages. Thus, parking pricing infrastructure might consist of tolling mechanisms at the curb cuts for parking garages in the priced area. Assuming implementation along these lines, two issues arise. First, travelers arriving at or leaving a parking spot are likely to be more sensitive to privacy concerns because this data is more indicative of an actual origin or destination than the crossing of a cordon. Second, the implementation would need to include policy measures to ensure that the additional parking fee is passed on to the consumer to ensure that it has a demand-management effect. This is necessary because employers and retail stores habitually subsidize the parking cost of individual users: more than 33% of commuters to downtown San Francisco do not pay for their parking (SFCTA 2002), and an even larger percentage pay only a fraction of the face value of the true cost to park.
In 2009-2010, the San Francisco Municipal Transportation Agency conducted a parking inventory in preparation for the SFpark pilot program (San Francisco Municipal Transportation Agency 2010). This parking data record, thought to be a complete accounting of the city’s off-street inventory, included capacities and categorizations for both lots and garages by access type (public, private, customer-only, etc). Within the Focus Area, the inventory categorized off-street spaces as 90% public, 6% commercial and 4% permit-holder only; additionally these off-street facilities were found to be fairly large, averaging 160 spaces per lot or garage. Note that the public designation merely means the spots are publicly available, and that while the dataset includes some pricing information, the actual user fees paid are uncertain. This is due to the fact that an unknown number of parkers pay by the month or by the hour, and employer and merchant subsidies are also unknown. However, given the capacity portion of the dataset, and assuming an implementation that ensures that parking tolls can be passed on to the parker, tolling 171 of the largest parking facilities would affect 90% of spaces in the Focus Area, and a 95% charge rate could be achieved by tolling 213 facilities (FIGURE 3). This is fairly comparable with the 496 lanes requiring detection that define the Northeast Cordon.

**FIGURE 3** Percent of spaces affected in Focus Area given number of lots priced.

![Graph showing percent of spaces affected](image)

Source: 2009 sfMTA Parking Inventory

**REPRESENTING PARKING MODULE IN SF-CHAMP4**

The current SF-CHAMP4 parking module represents the following parking-related components of travel: walking time, parking price, and parking search time. The time it takes to park a car and walk to a destination is represented by a terminal time in the highway skimming process, and is thus included in the utility equations for the destination and mode choice models. The terminal time is based on the area type, which is a categorization based on population and employment densities. This represents the additional time required to park and walk between a traveler’s destination and their vehicle. In denser
downtown areas, the terminal time tends to be higher, while in more suburban areas where parking is presumed to be abundant and close to any given destination, terminal time is short.

The price of parking is determined separately for work and non-work trips. For work trips, each zone has a variable that denotes the percentage of workers that pay for parking themselves as opposed to having parking subsidized or free. In the model, each work trip is randomly assigned to have either free or paid parking based on this percentage. If a driver pays, the hourly work parking cost is computed and factored into the disutility of the auto modes for the mode choice and destination choice models. Similarly, the parking cost for non-work trips is computed based upon the destination TAZ. The hourly work and non-work parking costs are estimated based on costs from 2002 combined with adjustments to each land use scenario based on changes in employment density (SFCTA 2002). The coefficients for cost within the utility equation are segmented by income level, because model estimation found that parking cost disutility varied by income group, tending to be higher for lower income individuals.

The time it takes to find a parking spot is represented by a parking availability index. This index reflects the demand in the destination zone (based on households, employment and visitors) given the supply, represented by the variable totalParking. The parking availability index is included in the tour mode choice submodel to represent the disutility of driving to a destination where parking is perceived to be difficult. These variables are implemented into the overall SF-CHAMP4 model stream as shown in FIGURE 4.
There are several limitations to the existing treatment of parking in SF-CHAMP4. First, SF-CHAMP4 assumes all travelers park in their destination traffic analysis zones (TAZ) – an unrealistic assumption in downtown San Francisco where TAZs are as small as one city block. This is important for studying the effects of both a cordon and parking-based congestion fee, as it is likely that some drivers (particularly those destined to a location near the edge of the charged zone) will find utility in parking outside the cordon and walking to their destination. Second, the current structure of the parking charge does not easily allow a mandatory fee to be imposed on top of the parking fees that emerge from a varying subsidy level and activity duration. Thus, for this initial comparison of parking and cordon pricing, the Study
Team treated model parking pricing in a similar manner to the cordon-fee: as a value-toll on the centroid connectors in the focus area. A detailed account of how SF-CHAMP4 models value tolls can be found in Sall et al 2010.

MODEL ANALYSIS

The MAPS Team modeled the effects of both parking and congestion pricing scenarios using San Francisco’s Regional Activity-Based Travel Demand Model, or SF-CHAMP4. The parking pricing submodel could not simply utilize the parking costs variables already present in the model because of the parking subsidy implementation. That is, the goal was to add a flat toll on top of all parkers driving during the congested peak periods, regardless of whether they received subsidies towards their existing parking cost. In this way, the additional parking toll could achieve a substantial demand management effect and reduce congestion during the peak. Thus, to represent the parking fees within the study zone, a $3 peak period toll was added to the inbound and outbound centroid connectors for all TAZs within the Focus Area. However, this implementation has several limitations:

• Parking location was not represented separately from the trip origin or destination. Thus, the model does not capture parking diversions, where drivers park outside of the study area and walk the remainder of the distance to their destination.
• Since the additional parking fee was modeled using the same toll mechanism as the cordon-based toll implementation, the same coefficient applies to this cost as to the original tolls in the utility equation. Although anecdotal evidence indicates that these coefficients may differ because drivers are accustomed to parking fees in high-demand areas, responses to the SFCTA’s stated preference survey on congestion pricing was inconclusive on this matter.
• Finally, this implementation is oblivious to “kiss and ride.” If parking pricing were implemented, this would be a likely outcome for some commuters in order to avoid the parking charge, but the model does not capture this behavior.

This Focus Area Parking Charge scenario was run for the model year 2015 and compared to a 2015 Baseline (No Project) scenario in order to see how the resulting travel demand shifts compare to those seen with the Northeast Cordon alternative. Note, however, that because only a sketch analysis has been done on the Focus Area Parking Charge scenario, this alternative did not run with a transit package adapted to suit the resulting transit needs using the parking fee revenue. From this perspective, the below results do not fully reflect an apples-to-apples comparison of alternatives, and so the mode shifts to transit in the Focus Area Parking Charge scenario can be regarded as conservative. Nonetheless, the results still provide enough insight into the effects of these alternatives to be worthy of discussion.
EVALUATION AND RESULTS

TABLE 1 compares some key results for the two pricing scenarios. Since the modeled charges were the same in both scenarios ($3), the fact that the Focus Area Parking Charge scenario has substantially fewer charged trips means that the scenario will earn much less revenue for reinvestment into transit service improvements, enhancements for nonmotorized access and roadway improvements. Additionally, it is noteworthy that the parking pricing scenario is the only scenario resulting in an overall reduction in citywide trips; the reasons for this shall be discussed below.

TABLE 1 Key results compared to a baseline scenario.

<table>
<thead>
<tr>
<th></th>
<th>Northeast Cordon Charge</th>
<th>Focus Area Parking Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Daily Charged Trips</td>
<td>250,000</td>
<td>145,000</td>
</tr>
<tr>
<td>Δ Total Daily Trips Citywide</td>
<td>~</td>
<td>-3%</td>
</tr>
<tr>
<td>Δ Peak Vehicle Trips to/from/within Focus Area</td>
<td>-14%</td>
<td>-22%</td>
</tr>
<tr>
<td>Δ Peak Vehicle Trips to/from/within NE Cordon</td>
<td>-12%</td>
<td>-12%</td>
</tr>
<tr>
<td>Δ Daily Non-Work Trips to/from/within Focus Area</td>
<td>~</td>
<td>-4%</td>
</tr>
<tr>
<td>Δ Daily VMT, Focus Area</td>
<td>-10%</td>
<td>-9%</td>
</tr>
<tr>
<td>Δ Daily VMT, Citywide</td>
<td>-5%</td>
<td>-3%</td>
</tr>
<tr>
<td>Δ Peak Period Transit Trips to/from Focus Area</td>
<td>+12,000</td>
<td>+15,500</td>
</tr>
<tr>
<td>Δ Peak Period Walk/Bike Trips to/from Focus Area</td>
<td>+6,000</td>
<td>-500</td>
</tr>
</tbody>
</table>

Summary of Scenario Effects. The following effects are observed for the Northeast Cordon scenario:
1. Some travelers shift modes and times of day (note this is much more likely for non-work trips than work trips);
2. Some new trips are induced because there is less congestion within the cordon;
3. Some peak period auto trips traversing the cordon are suppressed; and
4. New trips are created within the Focus Area because auto travelers prefer to stay within the cordon thus other within-cordon destinations become more appealing.

The first two effects are also observed in the Focus Area Parking Charge scenario. However, the third effect differs: the smaller subset of auto trips destined to or originating from the Focus Area are targeted and therefore exhibit trip suppression, rather than all trips traversing the cordon. Finally, the fourth effect does not hold true at all: auto travelers with origins in the Focus Area are incentivized to drive and park outside of the Focus Area rather than to stay close within the Cordon.

Peak Vehicle Trips To/From/Within the Focus Area and the NE Cordon. Since all trips originating from or destined to the focus area are charged in the Focus Area Parking Charge scenario, it is not a surprise that this scenario results in the largest reduction in auto trips going to, from, and within the Focus Area. In comparison, the Northeast Cordon scenario, by virtue of targeting cordon crossings, has no effect on trips within the cordon. Rather, the cordon induces some additional auto travel within the cordon because of the faster roadway speeds from the reduced levels of congestion.

Non-Work Trips To/From/Within the Focus Area. Non-work trips tend be largely optional or elective compared to trips for work or for school. Combined together, the four Northeast Cordon effects result in a negligible daily net change in non-work travel to, from or within the Focus Area. Similar effects are seen for the Focus Area Parking Charge scenario, with the exception of the third and fourth effects as described above. Thus, when taken together, the net effect for this scenario is a slight decrease of non-work trips to/from/within the focus area. Because this category of trips is of particular concern to businesses in the Focus Area, it will make sense to study a duration-based Parking Charge rather than the flat fee modeled here, so as not to discourage these non-work trips. Essentially, the issue here is the blunt method in which the parking fee is being modeled, and an incremental hourly cost (along the lines
of the SFpark implementation) would be preferable. In the Future Work section below, parking submodel enhancements are discussed which will enable SF-CHAMP4 to more realistically model these nuances of parking pricing.

**Peak Period Transit Trips To/From the Focus Area.** Peak period transit trips to and from the focus area increase more in the Focus Area Parking Charge scenario because of the more precise targeting of the charge. While all peak period auto trips to and from the focus area are encouraged to shift to transit in this scenario, the Northeast Cordon scenario does not encourage this mode shift for those peak auto trips that are within the cordon, with an origin or destination within the Focus Area. Note this transit trip increase is conservative for the Focus Area Parking Charge scenario compared to the Northeast Cordon scenario. This is because, as described above, the Focus Area Parking Charge scenario does not include any transit improvements that would be necessary to mitigate the mode shift effect of the charge. For both scenarios, the number of new transit riders is important because San Francisco’s transit systems are near capacity at peak, so handling the new ridership would require additional operating budget.

**Peak Period Non-Motorized Trips To/From the Focus Area.** The change to the non-motorized modes is negligible in the Focus Area Parking Charge scenario, especially compared with the non-trivial increase in the Cordon alternative. This is due to destinations and trip lengths; the Northeast Cordon scenario, by virtue of charging inbound and outbound links in a boundary ring, effectively encourages closer destination choices and shorter trips, which are more conducive to non-motorized modes. The Focus Area Parking Charge scenario has no such effect and so it does not particularly encourage non-motorized travel.

**VMT in the Focus Area and Citywide.** Finally, the VMT numbers in the table are also intuitive given this discussion. Within the focus area, the Parking Pricing and Northeast Cordon scenarios directly target auto demand. However, by virtue of the cordon discouraging boundary crossings, trips that are still made by auto are likely to be shorter if a within-boundary destination can satisfy the trip’s purpose.

The study team also performed a sensitivity analysis for each scenario to each type of event. FIGURE 5 illustrates the effect of the cordon charge on cordon crossings and Focus-Area parking events, as well as the effect of the parking charge on those same attributes. Given the similarity of implementation for the two scenarios in the model – link toll charges that factor into mode choice and destination choice submodels the same way – SF-CHAMP4 shows fairly congruous sensitivity for each scenario to its own toll. That is, the cordon charge depresses cordon crossings by 26%, while the parking charge depresses parking events by 21%.
FIGURE 5  Cordon crossings vs. parking events for peak periods.

CONCLUSION

Despite the exploratory nature of this Parking-based congestion pricing model, these results have been instructive and non-intuitive enough to have made this analysis worthwhile. The issues of suppressed trip-making as compared to the cordon-pricing alternatives are worth further analysis, especially given the potential economic impacts of such an effect on businesses in the Focus Area. Further, the much higher transit loads were somewhat surprising and a definite concern, given the lower revenues anticipated with this alternative that would be available to mitigate against this increased burden on the transit system.

There is a common perception that parking pricing is a familiar burden for drivers while roadway pricing is virtually unknown in the U.S. outside of toll-based highways. There will therefore continue to be interest in demand management through pricing parking and how this more publicly accepted form of pricing performs compared to roadway pricing. Thus, the SFCTA plans to continue to study of this issue.

FUTURE WORK

Because San Francisco is very interested not only in value tolls, but in parking policy and behavior, the SFCTA decided to develop an enhanced parking module in SF-CHAMP. In anticipation of SFPark as well as the next phase of evaluation for congestion pricing, the modeling team is developing a set of refinements to the parking model. These enhancements incorporate several key ideas.

Parking Submodel Enhancements and Data Needs

First, in order to more accurately represent parking behavior, trips are split into two sets: those trips with reserved parking at their destinations, and those trips requiring the traveler to search for parking. This is because the second group is not well represented in the existing model; these travelers may park far from
their destination, and they must therefore trade off parking search time, walk distance and parking cost.
By contrast, the reserved parkers do not make such decisions; they merely park at their reserved spots and so they are modeled using the original parking variables described in the section above.

Once trips are split into these two groups, the second group is required to route their trip through a parking link on the way to their destination. Parking links can represent parking locations at a much finer grained level, such as one link per parking garage or one link for several on-street parking blocks. Thus non-reserved parkers now have parking locations explicitly represented in the network, and the congested time function on those parking links represent the tradeoff between search time and available capacity. The inbound parking links also include the parking cost as a link toll, while the links that connect the parking link to the walkable TAZs nearby represent the walk time. In this way, the general cost equation used for roadway assignment captures the tradeoff between search time, walk distance and parking cost.

However, the parking submodel enhancements require a fair amount of data for calibration. While off-street parking inventory has become available and is used to generate corresponding parking links, the model is quite sensitive to the mismatch between (unreserved) parking supply and demand. At this juncture, on-street parking inventory data is still forthcoming, as is validation data for search time. The on-street parking inventory is expected to become available in the next few months, with a longer time frame for search time as SFpark goes into full swing.

REFERENCES


San Francisco County Transportation Authority. "San Francisco Travel Demand Forecasting Model Development: Data Development." October 1, 2002.

