Sensor Independent Rate Adjustments (SIRA) Methodology and Implementation Plan

May 14, 2014

Introduction

The SF*park* on-street rate adjustment policy uses demand-responsive parking meter rates to achieve parking availability. By improving the availability of on-street parking, the SFMTA aims to reduce circling and double parking, as well as improving the safety and efficiency of the transportation system.

During the SF*park* pilot, the SFMTA used in-ground parking sensors to measure parking demand in SF*park* pilot and control areas. Since August 2011, the SFMTA has implemented 13 demand-responsive rate adjustments using occupancy calculated from parking sensor data. At the end of 2013, parking sensors reached the end of their useful lives and were deactivated.

The SFMTA has also collected meter payment data from smart parking meters that can wirelessly communicate payment statuses. Using data from parking sensors and parking meters collected throughout the SF*park* pilot, the SFMTA has developed a model to estimate parking occupancy using meter payment data. The SFMTA's goals for a Sensor Independent Rate Adjustment (SIRA) model are to support the existing on-street rate adjustment policy, address inherent uncertainty in using models to estimate outcomes, and provide for flexibility in expanding demand-responsive pricing citywide.

The SFMTA's SIRA model supports these goals and the agency intends to use the model to continue demand-responsive rate adjustments using the existing policy, beginning with a first SIRA-based rate change in June 2014.

This document provides an overview of the existing SF*park* on-street rate adjustment policy, explains how the SFMTA derived the SIRA model, and outlines issues to be considered for expanding the use of SIRA.

SF*park* on-street rate adjustment policy overview

Block time bands

Parking demand varies geographically and temporally. To accommodate this, the SF*park* rate adjustment policy allows rates to vary by the following dimensions:

- **Block.** Blocks are generally defined as both sides of a street between major intersections.
- **Time of day.** Most meters in the city operate on a 9am to 6pm schedule. The SFMTA has divided operating hours for those meters into the following time bands:

9am-Noon
Noon-3pm
3pm-6pm

  Where meters operate on a different schedule, time bands have either been added or extended. See the SF*park* on-street rate adjustment policy for more details.
- **Weekdays vs. weekends.** Because weekend parking trends differ significantly from weekday parking trends, demand-responsive rate adjustments have separated weekdays from weekends.

For each block, rates can vary by weekday and weekend, and at least three time bands per weekday/weekend. The SFMTA refers to each possible combination of block, time of day, and weekday/weekend combination as a "block time band." The table below illustrates this concept by showing all block time bands and current rates for the 500 block of Hayes Street (where meters operate from 9am to 6pm), the unit block of Hawthorne (where meters operate from 7am to 6pm), and the 100 block of Berry Street (where meters operate from 9am to 10pm):

Block	Day Type	From Time	To Time	Current Rate
Hayes St 500	Weekday	9:00 AM	12:00 PM	$2.50
		12:00 PM	3:00 PM	$4.00
		3:00 PM	6:00 PM	$3.50
	Weekend	9:00 AM	12:00 PM	$3.75
		12:00 PM	3:00 PM	$4.00
		3:00 PM	6:00 PM	$4.00
Hawthorne St 0	Weekday	7:00 AM	12:00 PM	$4.00
		12:00 PM	3:00 PM	$4.25
		3:00 PM	6:00 PM	$4.00
	Weekend	7:00 AM	12:00 PM	$2.50
		12:00 PM	3:00 PM	$2.75
		3:00 PM	6:00 PM	$2.50
Berry St 100	Weekday	9:00 AM	12:00 PM	$4.25
		12:00 PM	3:00 PM	$4.25
		3:00 PM	6:00 PM	$4.25
		6:00 PM	10:00 PM	$0.75
	Weekend	9:00 AM	12:00 PM	$3.50
		12:00 PM	3:00 PM	$3.75
		3:00 PM	6:00 PM	$3.75
		6:00 PM	10:00 PM	$0.75

Most blocks in the City have meters that operate from 9am to 6pm and have the same block time bands as the 500 block of Hayes Street. However, the unit block of Hawthorne and the100 block of Berry illustrate how time bands can differ.

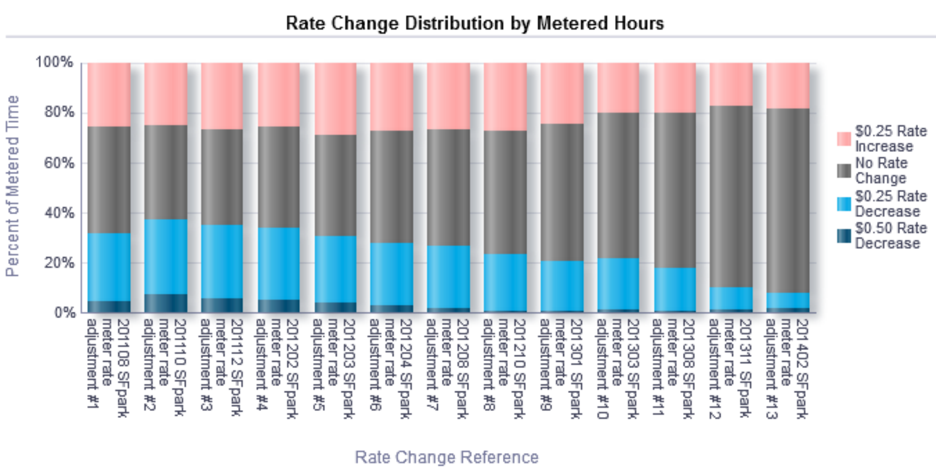
The block time band is the minimum analytical unit for the SF*park* on-street rate adjustments. During the SF*park* pilot, rate adjustments using sensor data were implemented over 2,500 block time bands.

On-street pricing formula

Each time rates are adjusted, the SFMTA analyzes occupancy for each block time band over the analysis period (typically two weeks). Rates are adjusted based on occupancy as described in the table below:

Occupancy Range	Rate Adjustment
80% - 100%	+$0.25
60% - 80%	No change
30% - 60%	-$0.25
0 – 30%	-$0.50

If occupancy falls within the target occupancy range of 60-80 percent, then no changes are made to rates for that block time band. Otherwise, rates are raised or lowered accordingly. The chart below shows the distribution of changes made to rates by metered hours over the past 13 rate adjustments:



The SF*park* on-street rate adjustment policy and enabling legislation in the Transportation Code specify that rates may be changed as often as once every 30 days. In practice, the SFMTA has adjusted rates about every six to eight weeks. Longer periods of no rate changes have existed over the past three years that were due to operational or evaluation needs.

Over the course of the 13 adjustments, the SFMTA has made no changes to rates an increasing share of the time. For the most part, this indicates that adjusting rates according to demand has led to achieving the target availability a greater percent of time that parking is managed.[1] Additionally, the share of

[1] The "no rate change" category also includes blocks where rates were not changed due to operational issues such as removal of parking sensors due to construction projects. However, these issues are a small share of the "no rate change" category.

metered time when rates have been reduced by $0.50 has been very small (five percent at most), and has decreased over time.

The Transportation Code also specifies that rates may vary between $0.25 and $6.00 in SF*park* areas. These minimums and maximums have been reached in some blocks.

Calculating occupancy rate and payment rate

The development of the SIRA model was based on an analysis of two metrics:

Parking occupancy rate

At any snapshot in time, the parking occupancy rate can be calculated as the share of total spaces available that are also occupied.

During the SF*park* pilot, the SFMTA measured parking occupancy using continuous data from parking sensors and calculated occupancy in units of seconds. This information was filtered through the SFMTA's database of parking meter configurations and regulations to calculate the General Metered Parking (GMP) occupancy rate. The GMP occupancy rate only considers metered time that was available for parking to the general public, and where parking was not available due to restrictions such as commercial loading or peak period towaway time.[2]

Specifically, the parking occupancy rate is calculated as:

$$Occupancy\ rate = \left(\frac{Total\ occupied\ time}{Total\ occupied\ time + Total\ vacant\ time}\right) * 100$$

Meter payment rate

At any snapshot in time, the meter payment rate can be calculated as the share of total spaces available that are also paid.

Similar to the parking occupancy rate, the SFMTA calculates meter payment rate using real-time payment information from smart meters in units of seconds. This information is also filtered through the SFMTA's database of parking meter configurations and regulations to calculate the General Metered Parking (GMP) meter payment rate. The GMP meter payment rate only considers metered time that was available for parking to the general public, and where parking was not available due to restrictions such as commercial loading or peak period towaway time. The meter payment rate is calculated independent of the hourly price for parking at each meter.

Specifically, the hourly meter payment rate is calculated as:

$$Payment\ rate = \left(\frac{Total\ paid\ time}{Total\ paid\ time + Total\ unpaid\ time}\right) * 100$$

[2] See the SF*park* parking sensor data guide for more detail.

Defining the base dataset

Since the purpose of the SIRA model is to support demand-responsive rate adjustments, the SFMTA analyzed occupancy and payment rates at the block time band level.

The SFMTA calculated the occupancy and payment rate for each block time band by calendar month (e.g., June 2012). The SFMTA used the following filters and parameters to remove outliers and ensure that the relationship between occupancy rate and payment rate was as accurate as possible:

1. **Use sensor data from periods when the dataset was the most geographically complete.** The SFMTA analyzed data between July 1, 2011 and June 30, 2012. Starting in late 2012, major construction projects and early battery degradation in some parking sensors reduced the number of spaces with accurate sensor data. While the SFMTA filtered out spaces with known issues from rate adjustments and the availability feed, this did not affect processing of meter data. Applying this filter better ensures that the data is collected from spaces and time periods where both sensor and meter data were available.
2. **Use meter data from IPS meters only.** For the SF*park* pilot, the SFMTA used smart meters from IPS and Duncan. These meters wirelessly communicated payments in real time to the SFMTA via XML transmissions. The SFMTA uses those transmissions to calculate payment rate. However, the SFMTA still continues to use physical coin collection receipts to determine revenue collection as that data is carefully audited for financial purposes. To validate the accuracy of XML transmissions, the SFMTA validated them against actual revenue collection. The SFMTA found XML data from Duncan to be incorrect by as much as 10 percent, while IPS data was 99 percent accurate.
3. **Use blocks that participated in the first ten SF*park* rate adjustments.** The SFMTA took great care to ensure that sensor data used for each rate adjustment was as complete and as accurate as possible. By using blocks from these adjustments, the SFMTA leverages that extra level of scrutiny. Additionally, this filter is consistent with the SFMTA's evaluation of SF*park*.
4. **Exclude invalid records**. The SFMTA filtered out records with values that were zero, 100, or null. Values of zero would imply that all spaces on a block over the course of one month were never occupied or paid, which is highly unlikely. Similarly, values of 100 would imply that all spaces on a block were always occupied or paid. Null values indicate no data for payment or occupancy rate.
5. **Remove blocks where non-payment is high.** Not everyone pays the meter, and the purpose of the SIRA model is to account for the natural difference between payment and occupancy rates. However, the difference between payment and occupancy is artificially high for some blocks. This may be due to a concentration of legal methods of parking without paying the meter (e.g., use of disabled placards) or other behaviors that lead to systemic non-payment. For each block, the SFMTA calculated the ratio of payment rate to occupancy rate and removed blocks with low payment/occupancy ratios (less than 0.4). See Appendix A for more details.

Variables in base dataset

While the primary metrics are payment rate and occupancy rate, the SFMTA included other attributes that were readily available through the system the agency uses to manage parking data and the rate adjustment process. Each record contains the following attributes for each block time band:

- Parking Management District (PMD)
- Block (e.g., Hayes 500)
- Calendar Month
- Spaces per Block
- Day Type (i.e., weekday/weekend)
- Time Band (e.g., 9am-noon)
- Payment Rate
- Occupancy Rate

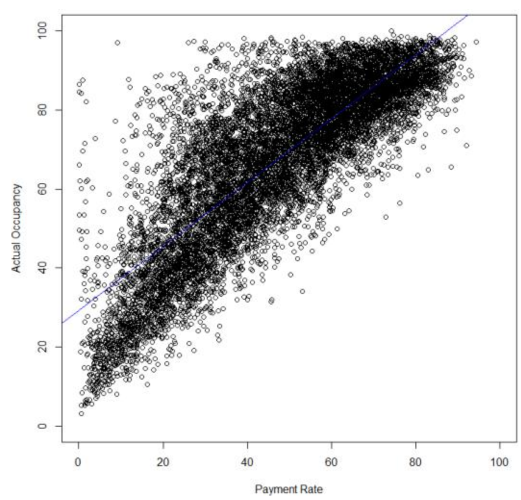
Developing the SIRA model

The purpose of the SIRA model is to use payment rate to estimate occupancy rate. The SFMTA performed a statistical regression analysis to explore the relationship between occupancy rate, payment rate, and other variables to develop a model to support demand-responsive rate adjustments.

Analyzing payment rate and occupancy rate

The SFMTA first examined the relationship between these two variables alone.[3]

The SFMTA found a strong positive relationship between payment rate and occupancy rate.[4] This makes sense because while not everyone pays the meter, more meters are generally paid when more spaces are occupied. Conversely, when fewer spaces are occupied, fewer meters are paid.



The SFMTA used payment and occupancy data to create the following linear regression model:

*Occupancy Rate = (Payment Rate)*0.808 + 29.283*

The equation is discussed in further detail in a following section. However the y-intercept of 29.283 indicates that this model will not perform well in estimating low occupancy rates.

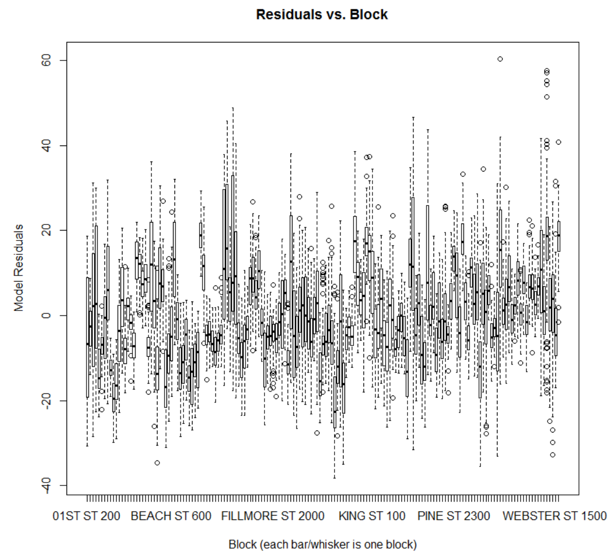
3 In these analyses, payment rate is an independent variable and occupancy rate the dependent variable.
4 This relationship is statistically significant at the p<0.01 level. The Pearson's r-value is 0.82.

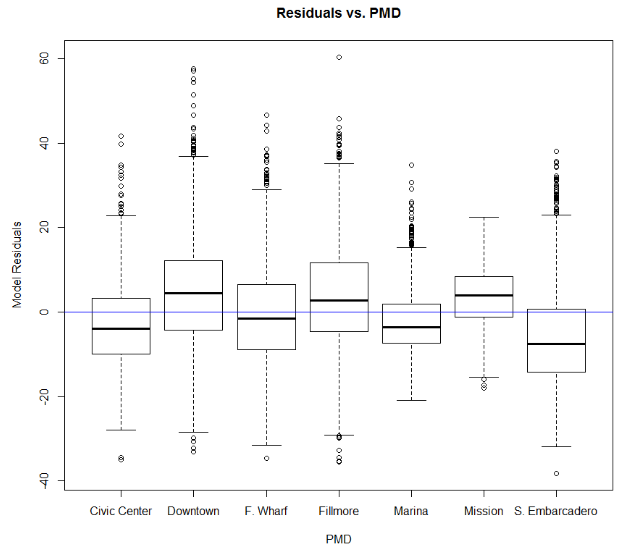
Expanding model to include other factors

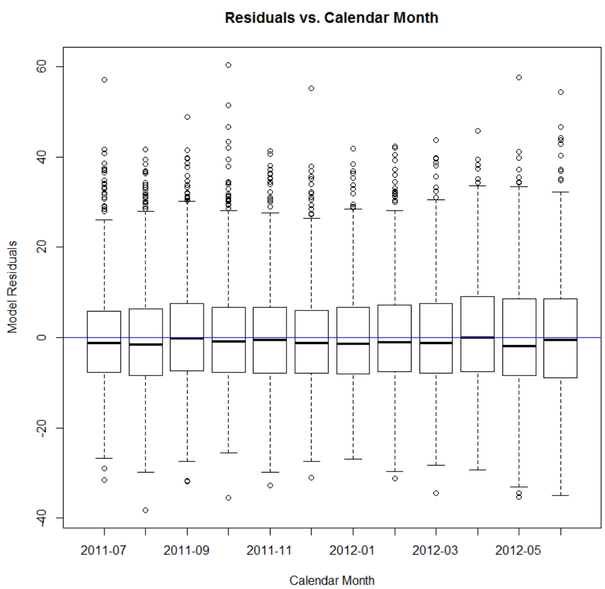
When using a simple model to estimate occupancy across many districts of the city at different times of day, 100 percent accuracy is unreasonable. Additionally, meter non-payment (whether legal or illegal) introduces a natural source of error. However, introducing other variables into the model can help account for some sources of error and improve accuracy.

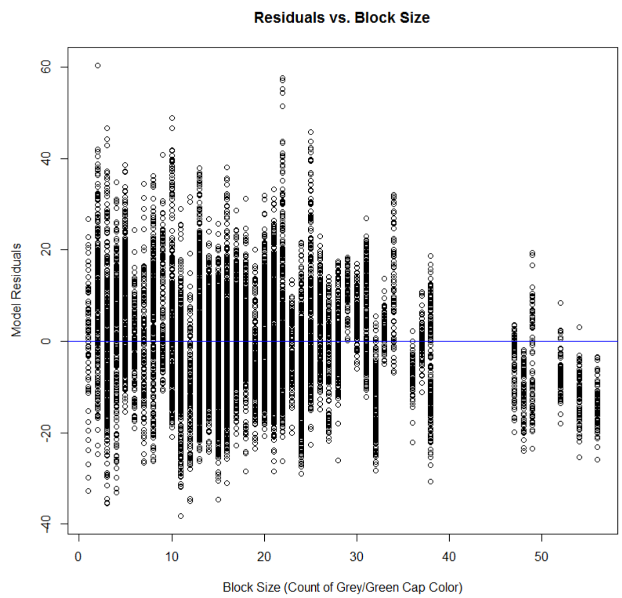
The SFMTA analyzed the residuals (i.e., error) of the simple linear regression model against the other variables in the base dataset. A pattern between error and other variables suggest that accounting for that variable in the model would improve accuracy; a random distribution of error may mean that a certain variable has no explanatory power. Additionally, care should be taken not to over fit a model to the data.

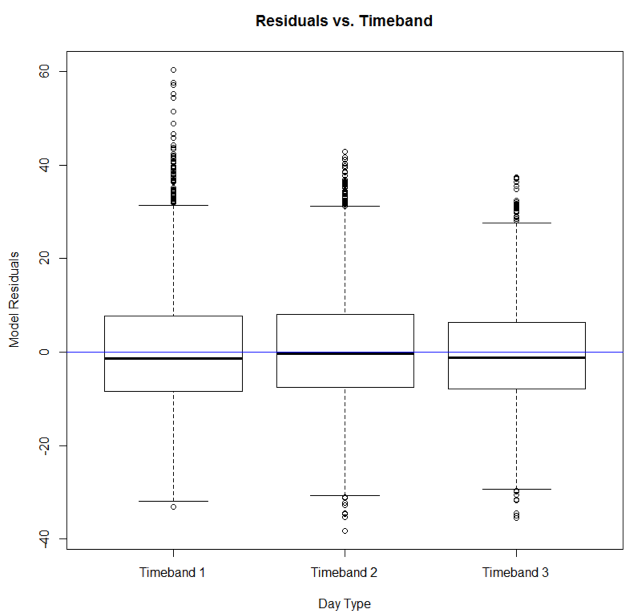
The following charts show the distribution of the residuals of the simple linear model against the other variables in the dataset.

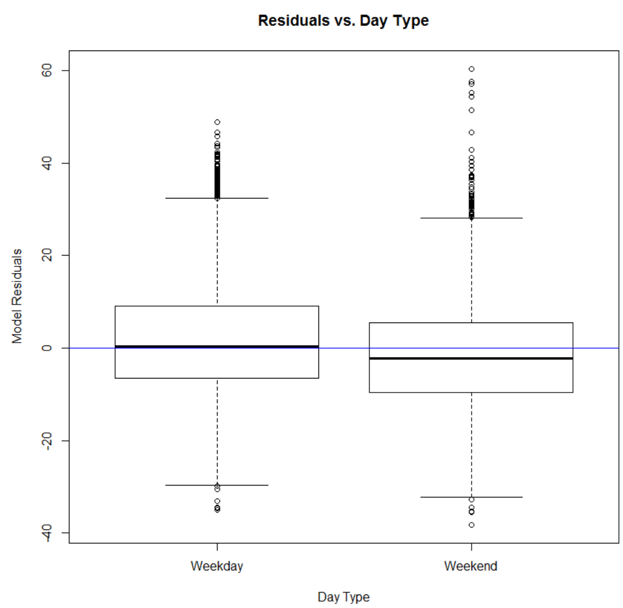

Residuals vs. Block
Model Residuals
60
40
20
0
-20
-40
01ST ST 200
BEACH ST 600
FILLMORE ST 2000
KING ST 100
PINE ST 2300
WEBSTER ST 1500
Block (each bar/whisker is one block)


Residuals vs. PMD
Model Residuals
60
40
20
0
-20
-40
Civic Center
Downtown
F. Wharf
Fillmore
Marina
Mission
S. Embarcadero
PMD


Residuals vs. Calendar Month
Model Residuals
60
40
20
0
-20
-40
2011-07
2011-09
2011-11
2012-01
2012-03
2012-05
Calendar Month


Residuals vs. Block Size
Model Residuals
60
40
20
0
-20
-40
0
10
20
30
40
50
Block Size (Count of Grey/Green Cap Color)


Residuals vs. Timeband
Model Residuals
60
40
20
0
-20
-40
Timeband 1
Timeband 2
Timeband 3
Day Type


Residuals vs. Day Type
Model Residuals
60
40
20
0
-20
-40
Weekday
Weekend
Day Type

These charts show that:

- There is considerable variation in error in both PMD and Block.
- There is little variation in error by month.
- There is little variation in error by the number of spaces per block.
- There may be a slight pattern to error by timeband.
- There is some variation in error between non-payment and weekdays/weekends.

ADJUSTING FOR NEIGHBORHOOD TYPE

The notable variation in error by both PMD and by block indicates that non-payment changes most significantly by geography. Incorporating variables for PMD and/or block into the model would considerably improve the accuracy of the model. However, including block into the model would not support demand-responsive pricing citywide since block-by-block data only exists for the SF*park* pilot. In other words, a block-specific adjustment factor can be estimated as part of the model for blocks in the SF*park* pilot area, but not in the rest of the city.

Similarly, including an adjustment factor (i.e., adding another variable or set of variables) to the model for each PMD would not support citywide expansion since data only exists for the seven districts areas that were part of the SF*park* pilot (and there are roughly 40 PMDs defined for the whole city). However, some of the SF*park* districts are neighborhood commercial while others include unique areas such as the Financial District and Fisherman's Wharf:

Neighborhood Commercial PMDs	Non-neighborhood commercial PMDs
Marina	Downtown
Fillmore	South Embarcadero
Mission	Civic Center
	Fisherman's Wharf

The SFMTA chose to expand the model to account for differences in non-payment between districts that are primarily neighborhood commercial areas compared to those that are not. The model will treat the three neighborhoods commercial areas (Marina, Fillmore, and Mission) similarly with one adjustment factor while it will utilize separate adjustment factors for each of the non-neighborhood commercial areas (Downtown, South Embarcadero, Civic Center, and Fisherman's Wharf). These areas each have a set of unique characteristics (e.g., density, high saturation of office and institutional land uses, tourism, and development) that set them apart from neighborhood commercial corridors that may explain inherent differences in parking behavior and non-payment.

ADJUSTING FOR WEEKDAYS/WEEKENDS

Given the slight variation in non-payment by day type, the SFMTA also chose to expand the model to include an adjustment factor for weekdays/weekends.

Models Developed

In addition to the model previously described that only uses payment rate as a predictive factor, the SFMTA prepared two additional models – one using a line and another using a curve – that incorporate PMD type and weekday/weekend.[5] The three model equations are provided below, and a full statistical output is provided in Appendix B.

MODEL 1 (SIMPLE LINEAR)

$$Occupancy\ Rate = 29.283 + 0.808 * (Payment\ Rate)$$

- This equation is a simple (i.e., using only one predictive factor) linear model.
- For example, a payment rate of 50 percent would yield an estimated occupancy rate of about 70 percent.

MODEL 2 (MULTIPLE LINEAR)

$$\begin{aligned} Occupancy\ Rate \\ &= 36.395 + 0.749 * (Payment\ Rate) - 3.423 * (Weekend\ Dummy) + 2.424 \\ &* (Downtown\ Dummy) - 9.273 * (South\ Embarcadero\ Dummy) - 6.063 \\ &* (Civic\ Center\ Dummy) - 3.399 * (Fisherman's\ Wharf\ Dummy) \end{aligned}$$

- This equation is a multiple (i.e., using many predictive factors) linear model.
- If no dummy variables are applied, then the occupancy estimate applies to neighborhood commercial corridors on weekdays.
- If a dummy variable condition applies (e.g., an estimate is being developed for a block in Fisherman's Wharf), then the dummy variable is set to 1. Otherwise, then the dummy variable is set to 0.
- For example, if an estimate is desired for neighborhood commercial areas on weekends, then the weekend dummy variable is equal to 1

[5] Since both the neighborhood type and weekday/weekend variables are categorical and not numerical, the adjustment factors for these variables are dummy variables in the regression equation.

MODEL 3 (MULTIPLE LOG-LOG)

$$\log(Occupancy\ Rate) = 2.502 + 0.466 * \log(Payment\ Rate) - 0.059 * (Weekend\ Dummy) + 0.055 * (Downtown\ Dummy) - 0.211 * (South\ Embarcadero\ Dummy) - 0.117 * (Civic\ Center\ Dummy) - 0.067 * (Fisherman's\ Wharf\ Dummy)$$

- This equation is a multiple (i.e., using many predictive factors) log-log model.
- If no dummy variables are applied, then the occupancy estimate applies to neighborhood commercial corridors on weekdays.
- If a dummy variable condition applies (e.g., an estimate is being developed for a block in Fisherman's Wharf), then the dummy variable is set to 1. Otherwise, then the dummy variable is set to 0.
- For example, if an estimate is desired for neighborhood commercial areas on weekends, then the weekend dummy variable is equal to 1.

Evaluating models

The SFMTA analyzed the following factors in evaluating models:

- **R-squared.** The R-squared value (also known as the coefficient of determination) indicates what percent of variation in occupancy can be explained by the model.[6] Most values for R-squared were around 0.7, meaning that models could account for about 70 percent of the variation in occupancy. While the R-squared value is a key measure of how well data fits a model, using this value alone does not consider the distribution of error or differences between estimated and actual occupancy.
- **Rate adjustment outcome (RAO) accuracy.** The SFMTA ran hypothetical rate adjustments using both estimated and actual occupancy values and compared the outcomes (i.e., keep rates the same, increase rates, or reduce rates). This method is most closely tied to the purpose of the SIRA model; however, an incorrect outcome does not reflect the amount of error involved. For example, an estimated value of 61 percent and an actual value of 59 percent involve an error of only a two percentage points, but the estimated outcome would be to keep rates the same, while the actual outcome would be to decrease rates. Similarly, an estimated value of 61 percent with an actual value of 79 percent involves an error of 18 percentage points, but the outcome of a rate adjustment would be the same.
- **Distribution of error.** The SFMTA examined the distribution of residuals (similar to as shown in the previous section) as well as the distribution of error in RAO accuracy.

[6] When examining models with multiple independent variables, the SFMTA considered the adjusted R-squared value.

Revised rate adjustment formula

Additionally, the SFMTA considered RAO accuracy with regard to the current rate adjustment formula as well as a revised formula. This revised formula removes the -$0.50 category and simplifies the process. Over the past three years, occupancy rates have rarely been low enough to warrant a $0.50 reduction. In the last on-street rate adjustment, rates were reduced by $0.50 for only two percent of all metered hours.

Current

- When occupancy is 80-100 percent, the hourly rate will be raised by $0.25.
- When occupancy is 60-80 percent, the hourly rate will not be changed.
- When occupancy is 30-60 percent, the hourly rate will be lowered by $0.25.
- When occupancy is 0-30 percent, the hourly rate will be lowered by $0.50.

Revised

- When occupancy is 80-100 percent, the hourly rate will be raised by $0.25.
- When occupancy is 60-80 percent, the hourly rate will not be changed.
- When occupancy is 0-60 percent, the hourly rate will be lowered by $0.25.

Model Performance

The following table shows the accuracy of the three models considered:

Model	Model Type	Predictor Variables	N	R-squared	Rate Adjustment Outcome (RAO) Accuracy	
					Existing formula	*Revised formula*
Model 1	Linear	Payment rate	11,674	0.67	61%	67%
Model 2	Linear	Payment rate, neighborhood type, and day type	11,674	0.71	63%	68%
Model 3	Log-Log	Payment rate, neighborhood type, and day type	11,674	0.69	64%	69%

Overall, Model 1 estimates occupancy fairly well, and Models 2 and 3 do so with slightly better accuracy than Model 1. Model 2 has the highest R-squared value (the model explains 71 percent of the variation in occupancy rate), while Model 3 has the highest RAO accuracy under the revised rate adjustment formula (the model leads to the same outcome 69 percent of the time). Given that the R-squared and RAO accuracy results should be considered together and relative to other models, Models 2 and 3 are slightly stronger than Model 1 and are about 70 percent accurate. Additionally, the using the revised rate adjustment formula can simplify the rate adjustment process and improves the accuracy of the SIRA model.

The SFMTA also examined the error in RAO accuracy, particularly the distribution of incorrect outcomes (e.g., keeping rates the same instead of decreasing rates). For each outcome, the SFMTA calculated the difference in "steps" between the estimated RAO from the actual. If the erroneous outcome was the result of an estimate that was too low, then the difference was a negative step. Similarly, if the erroneous outcome was the result of an estimate that was too high, then the difference was a positive step. The following table shows the difference in RAO outcomes for Models 2 and 3 under the revised rate adjustment formula.

Difference in Estimated RAO from Actual	Interpretation		Model 2	Model 3
-2	Rates incorrectly low	Rates decreased instead of increasing.	1%	1%
-1		Rates decreased instead of staying the same, or rates stayed the same instead of increasing.	19%	15%
0	Rates correct	Rates correctly increased, decreased, or stayed the same.	68%	69%
1	Rates incorrectly high	Rates increased instead of staying the same, or rates stayed the same instead of decreasing.	12%	15%
2		Rates increased instead of decreasing.	0%	0%

The vast majority of error is only one RAO step away for both Model 2 and Model 3 – this means that when the model leads to an incorrect outcome, the result will only be slightly off. When Model 2 is incorrect, rates are more likely to be set too low (20 percent with a negative difference compared to 12 percent with a positive difference). When Model 3 is incorrect, rates are equally likely to be set too low or too high (16 percent with a negative difference and 15 percent with a positive difference).

Using Model 2 as the SIRA model

The SFMTA's goals for a SIRA model are to support the existing on-street rate adjustment policy, address inherent uncertainty in using models to estimate outcomes, and provide for flexibility in expanding demand-responsive pricing citywide.

While a SIRA model and statistical models in general can produce precise numbers, it is critical to remember that the output is still an estimate, and accuracy should be considered more as a range than an exact number.

Both Model 2 and Model 3 support the existing policy with a reasonable accuracy rate of about 70 percent (considering both R-squared and RAO accuracy). Additionally, by including adjustment factors for neighborhood type, Model 2 and Model 3 differentiate between neighborhood commercial corridors and unique districts such as Fisherman's Wharf where the nature of parking occupancy and payment are different. However, to address the inherent uncertainly in estimating parking occupancy rates using a model rather than parking sensors, the SFMTA prefers Model 2 -- when it is wrong, it is more likely to set rates that are too low rather than too high.

Using this as an approach to changing rates will allow the SFMTA to continue doing demand-responsive rate adjustments with slightly less accuracy that using parking sensors, but any errors will tend to result in lower rather than higher meter rates. This may slightly reduce its comparative effectiveness, but will enable the SFMTA to continue to promote the benefits of demand-responsive pricing without the additional cost of parking sensors.

Improving and expanding use of the SIRA model

The SIRA model was developed using data from the SF*park* pilot – this represents a quarter of San Francisco's metered spaces over a distinct period in time. When considering if and how the model needs to be recalibrated, thoughts should be given to the assumptions under which it was built.

The key measure is non-payment, or the difference between the payment rate and the occupancy rate. The SFMTA can influence non-payment through parking policies and practices, including:

- Legal forms of meter non-payment (such as disabled placards and official business permits)
- Time limits
- Payment methods
- Parking enforcement strategies
- Enforcement fines

The SFMTA will continue to refine and update the SIRA model as necessary. The development of this model is part of the SF*park* pilot and can lay the foundation for demand-responsive pricing in other areas of the city.

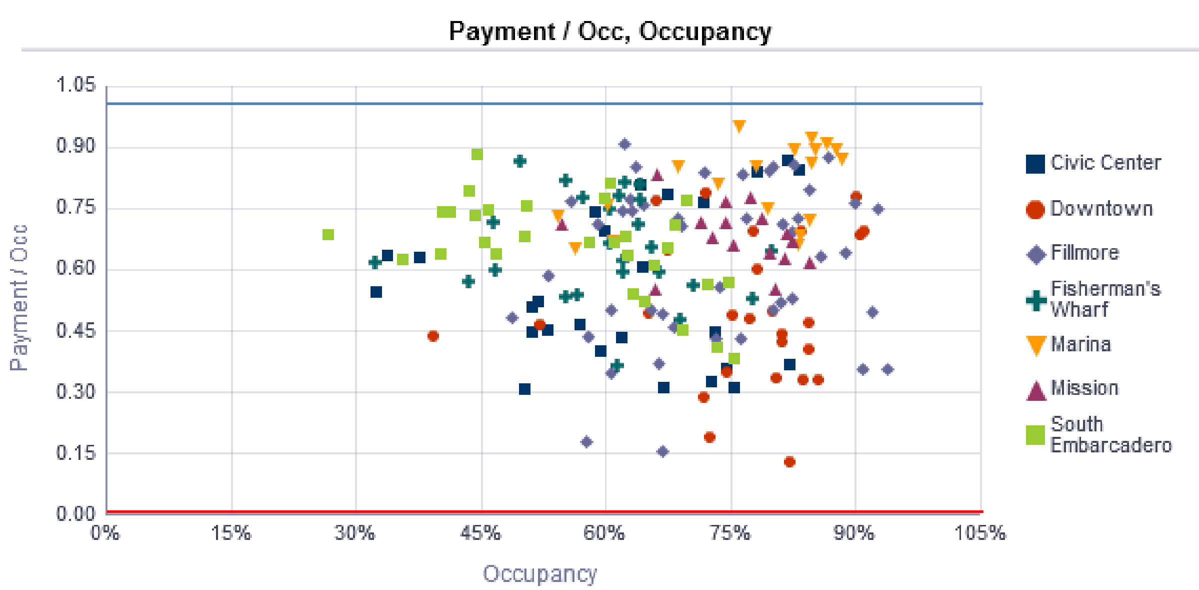
Appendix A: Explanation of payment/occupancy ratio

Definition

The Payment to Occupancy Ratio (P/O) is a measure of the relationship between paid time and occupied time. P/O, calculated here at the block level, is the percent of time paid divided by the percent of time occupied.[7] In the example below, the P/O value would be 67% (paid time) divided by 75% (occupied time), or 89.

	Minutes												
	5	10	15	20	25	30	35	40	45	50	55	60	Hourly rate
Paid	■	■	■	■					■	■	■	■	40/60 = 67%
Occupied	■	■	■		■	■			■	■	■	■	45/60 = 75%

Payment divided by Occupancy (P/O) is a way to compare nonpayment rates across different occupancies. A scatterplot of occupancy and P/O shows the distribution of the proportion of paid time to occupied time by occupancy by PMD. The red line is where P/O is 0, meaning that no one paid, and the blue line is where P/O is 100, meaning that paid time was equal to occupied time:



[7] P/O is similar to payment compliance, which is the amount of occupied paid time divided by the amount of occupied time, with one key difference: in the P/O calculation, payment that occurs when a space is empty is still counted as payment, and payment and occupancy are independently rolled up to the hour.

Specifications

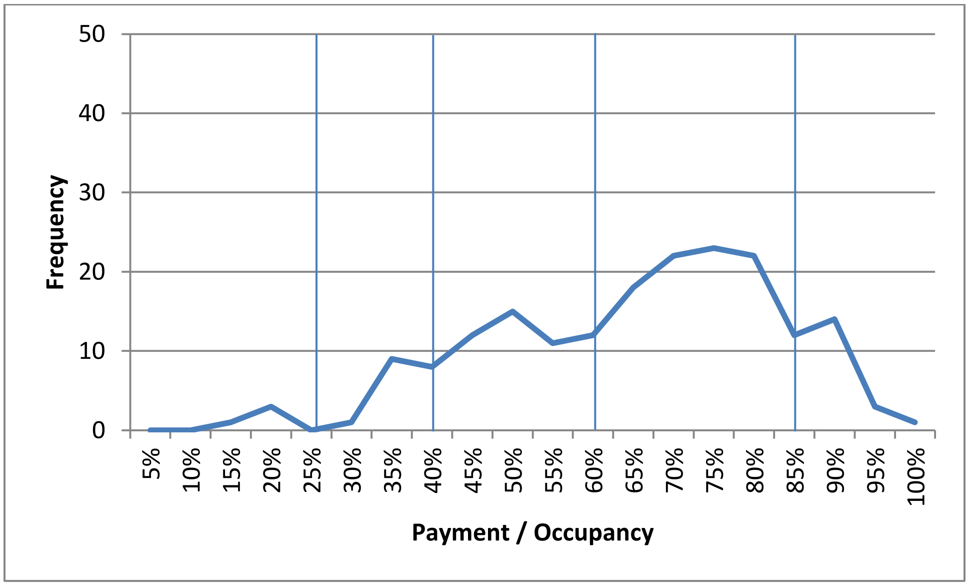
The BI dataset that was used to generate the P/O reports had the following filters applied:

- Day type: Weekday, weekend (excluding holidays)
- RA 1-10 blocks (only the 187 blocks that went through all of rate adjustments 1 through 10)
- Meter Vendor: IPS
- Cap color: green, grey
- From July 1, 2011 to June 30, 2012

P/O categories

To incorporate the P/O metric into evaluations, the continuum of P/O values was divided into five discrete categories: 0%-25%, >25%-40%, >40%-60%, >60%-85%, >85%.

These categories were established based on the distribution of frequencies of the data used (see Specifications section above):

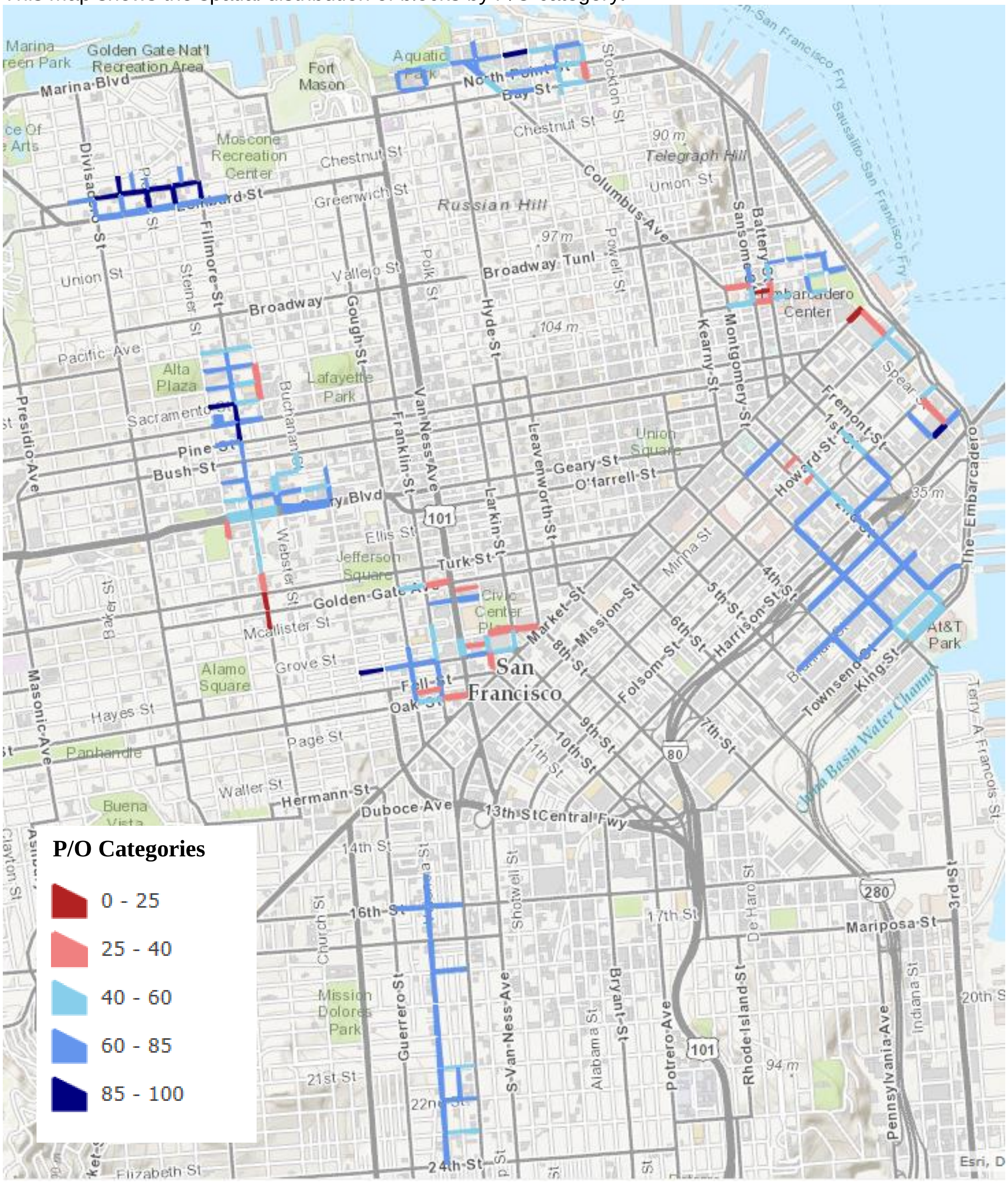


The lowest category is made up of blocks with occupancy much higher than payment. The second category shows an increased payment percent as compared to occupancy, up to the highest category with payment percent nearly as high as occupancy percent.

The table below shows the distribution of blocks by each category by PMD:

Max	Civic Center	Downtown	Fillmore	Fisherman's Wharf	Marina	Mission	South Emb.	**Total**
25%	0	2	2	0	0	0	0	4
40%	7	5	4	1	0	0	1	18
60%	8	11	14	9	0	2	6	50
85%	10	8	20	14	9	14	22	97
100%	1	0	5	1	10	0	1	18
Total	26	26	45	25	19	16	30	187

This map shows the spatial distribution of blocks by P/O category.



Appendix B: Statistical regression output for models

MODEL 1 SUMMARY

```
lm(formula = MonthlyBTB3$Occupancy ~ MonthlyBTB3$Payment)

Residuals:
    Min      1Q  Median      3Q     Max 
-38.135  -7.854  -0.931   7.339  60.334 

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)    
(Intercept)         29.283429   0.271164     108   <2e-16 ***
MonthlyBTB3$Payment  0.808288   0.005247     154   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 11.77 on 11672 degrees of freedom
Multiple R-squared:  0.6703,	Adjusted R-squared:  0.6703 
F-statistic: 2.373e+04 on 1 and 11672 DF,  p-value: < 2.2e-16
```

MODEL 2 SUMMARY

```
lm(formula = MonthlyBTB3$Occupancy ~ MonthlyBTB3$Payment + 
MonthlyBTB3$DayType + 
    PMD.DT + PMD.SE + PMD.CC + PMD.FW)

Residuals:
    Min      1Q  Median      3Q     Max 
-40.627  -7.619  -0.803   6.721  57.187 

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)    
(Intercept)                36.395481   0.342385 106.300  < 2e-16 ***
MonthlyBTB3$Payment         0.749417   0.005413 138.453  < 2e-16 ***
MonthlyBTB3$DayTypeWeekend -3.422837   0.205714 -16.639  < 2e-16 ***
PMD.DT                      2.424419   0.350899   6.909 5.13e-12 ***
PMD.SE                     -9.273317   0.308401 -30.069  < 2e-16 ***
PMD.CC                     -6.063189   0.347741 -17.436  < 2e-16 ***
PMD.FW                     -3.398652   0.311644 -10.906  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 11.05 on 11667 degrees of freedom
Multiple R-squared:  0.7098,	Adjusted R-squared:  0.7096 
F-statistic:  4755 on 6 and 11667 DF,  p-value: < 2.2e-16
```

MODEL 3 SUMMARY

```
lm(formula = log(MonthlyBTB3$Occupancy) ~ log(MonthlyBTB3$Payment) + 
    MonthlyBTB3$DayType + PMD.DT + PMD.SE + PMD.CC + PMD.FW)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.1752 -0.0989  0.0054  0.1098  3.7008 

Coefficients:
```

```
                              Estimate Std. Error t value Pr(>|t|)    
(Intercept)                   2.501958   0.014152 176.786  < 2e-16 ***
log(MonthlyBTB3$Payment)      0.466291   0.003466 134.519  < 2e-16 ***
MonthlyBTB3$DayTypeWeekend -0.059360   0.004129 -14.375  < 2e-16 ***
PMD.DT                        0.055321   0.007107   7.784 7.64e-15 ***
PMD.SE                       -0.211236   0.006098 -34.643  < 2e-16 ***
PMD.CC                       -0.116970   0.007021 -16.660  < 2e-16 ***
PMD.FW                       -0.066726   0.006278 -10.628  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.223 on 11667 degrees of freedom
Multiple R-squared:  0.6936,   Adjusted R-squared:  0.6934 
F-statistic:  4401 on 6 and 11667 DF,  p-value: < 2.2e-16
```