Accuracy Study of Parking Duration Data from Patrol Survey

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Patrol Survey

Patrol Survey

Average parking duration

http://davidmunro.blogspot.com

Patrol Survey

e.g., interval δ=30 minutes

Patrol Survey

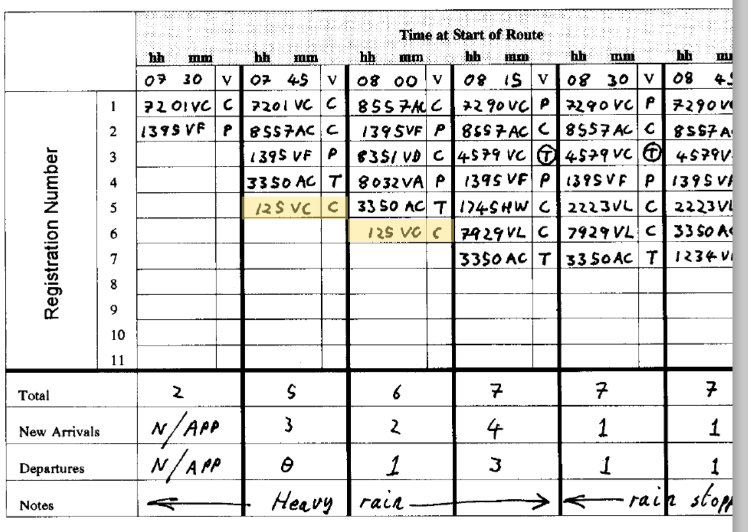
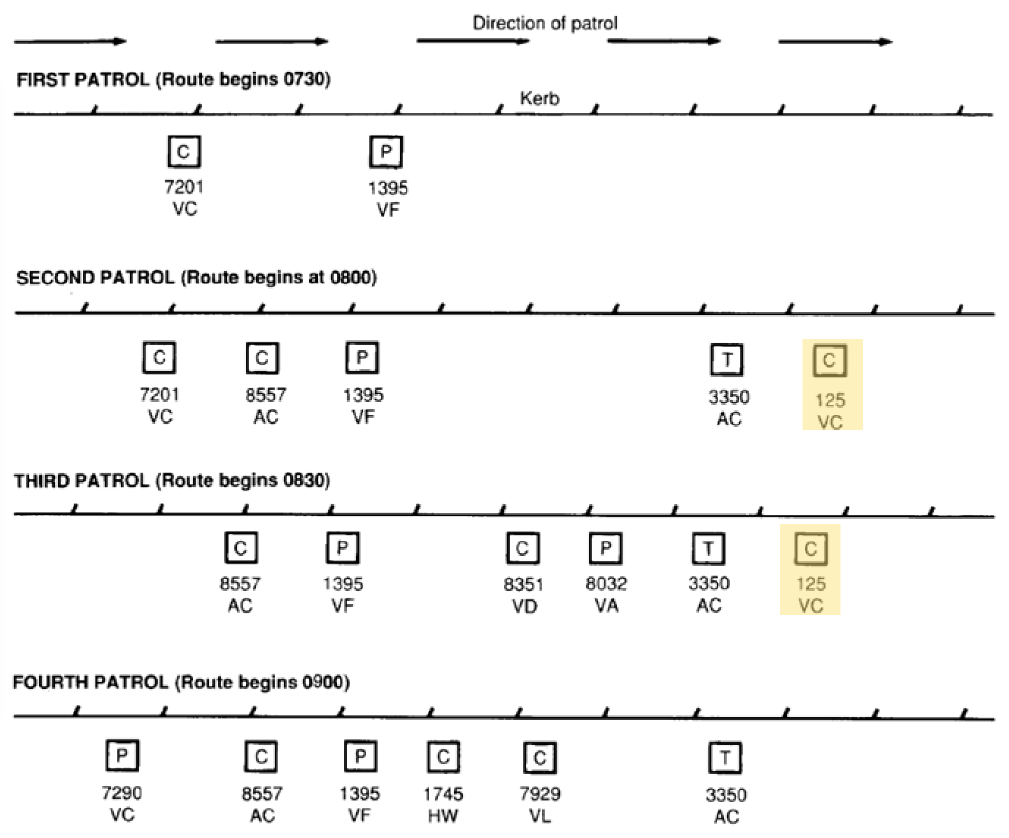


Figure 4.3 Parking Patrol Survey form: Example

		Time at Start of Route (hh mm)											
		07 30	V	07 45	V	08 00	V	08 15	V	08 30	V	08 4	
Registration Number	1	7201VC	C	7201 VC	C	8557AC	C	7290VC	P	7290VC	P	7290 V	
	2	1395 VF	P	8557AC	C	1395VF	P	8557AC	C	8557AC	C	8557 A	
	3			1395 VF	P	8351 VD	C	4579 VC	(T)	4579VC	(T)	4579V	
	4			3350 AC	T	8032VA	P	1395 VF	P	1395VF	P	1395 V	
	5			125 VC	C	3350 AC	T	1745HW	C	2223VL	C	2223V	
	6					125 VC	C	7929VL	C	7929VL	C	3350 A	
	7							3350 AC	T	3350AC	T	1234 V	
	8												
	9												
	10												
	11												
Total		2		5		6		7		7		7	
New Arrivals		N/APP		3		2		4		1		1	
Departures		N/APP		0		1		3		1		1	
Notes		←		Heavy		rain →				← rain		stop	

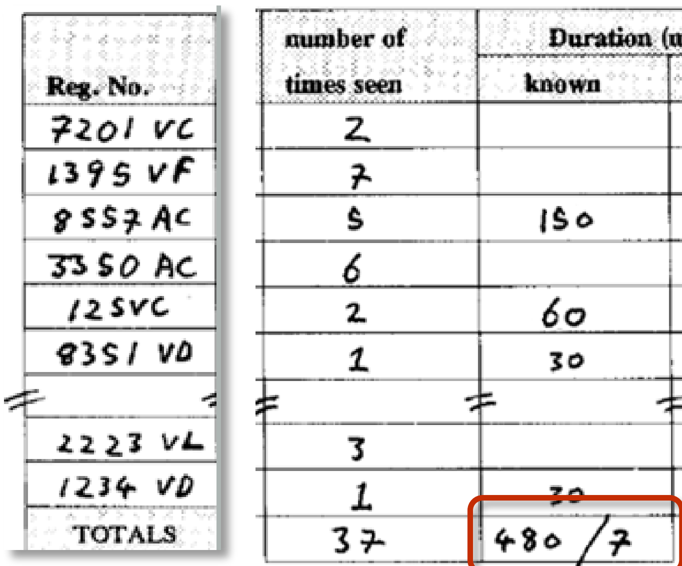
(Circled letters indicate double-parked vehicles)



Source from "Urban road traffic surveys"

Patrol Survey

Patrol Survey



Reg. No.	number of times seen	Duration (w known
7201 VC	2	
1395 VF	7	
8557 AC	5	150
3350 AC	6	
125VC	2	60
8351 VD	1	30
2223 VL	3	
1234 VD	1	30
TOTALS	37	480/7

Average parking duration(APD)

Estimated APD≈ Real APD

Accurate?

Expensive?

Current solution: Tradeoff

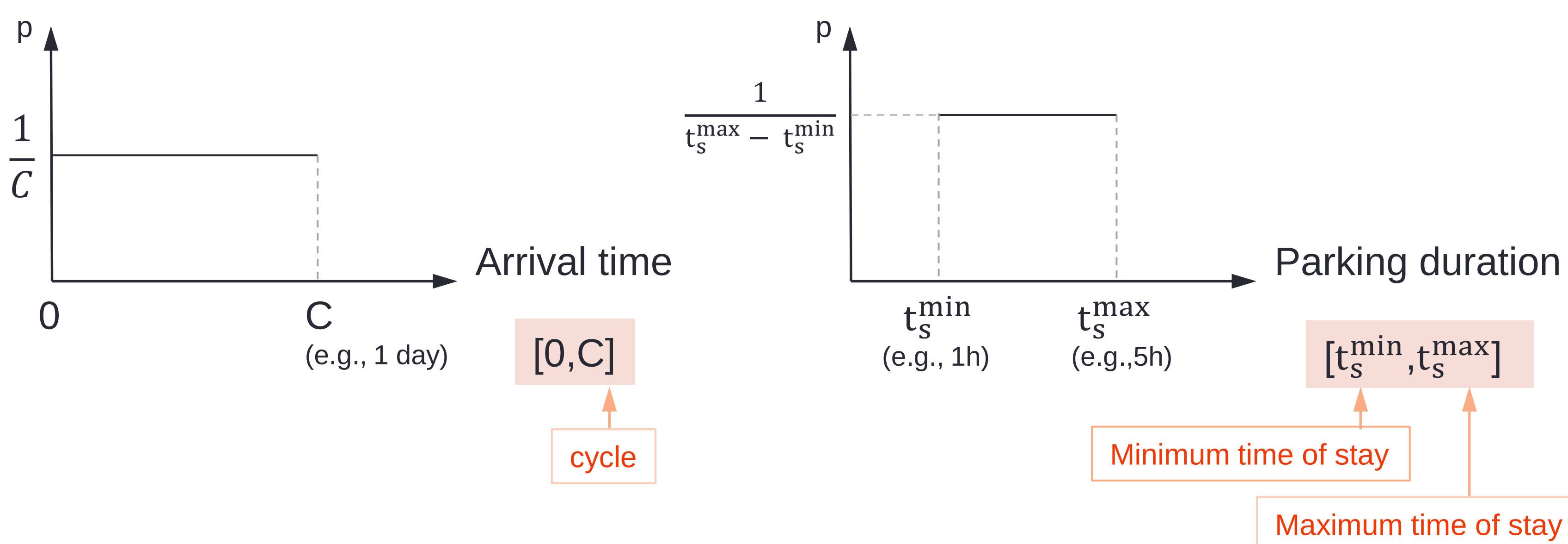
Source from “Urban road traffic surveys”

Goals

- The necessity to make a tradeoff is unknown as the current accuracy is unknown. → Find the current accuracy
- What did the tradeoff brought? In other words, how much did the accuracy increase by more investment? → Find the improvement of accuracy from a tradeoff
- Is there another way to increase the accuracy besides a higher budget? → Find another method to improve the accuracy

Assumptions

- Imagine a simple parking scenario, a public parking area with enough supply and no restrictions of time and payment.



Model

δ observation interval

APD
average parking duration

β the ratio of t_s^{max} and t_s^{min} $= \frac{b}{a}$

$\overline{T}^{real}$ real APD $= \delta \cdot \frac{a+b}{2}$

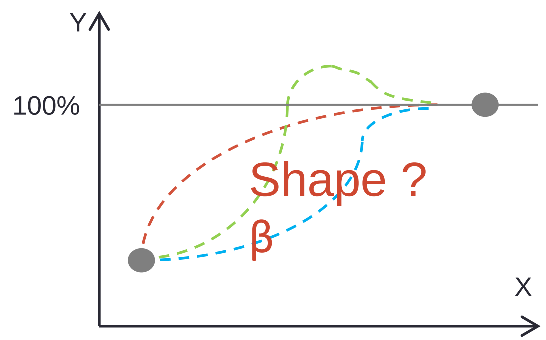
$\widetilde{T}^{obs}$ estimated APD $= \delta \cdot \sum_{i=1}^{[b]} i \cdot \left(\frac{p_i}{p^{obs}}\right)$

"survey intensity"

$$X = \frac{\widetilde{T}^{obs}}{\delta}$$

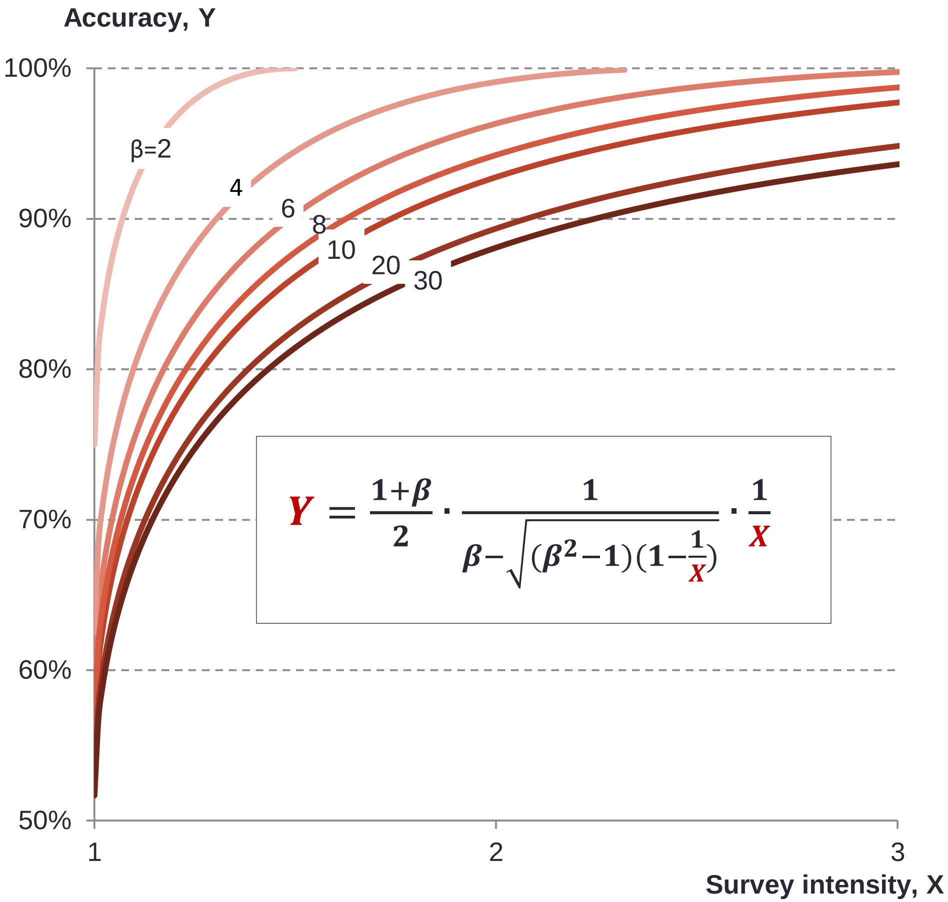
"accuracy"

$$Y = \frac{\overline{T}^{real}}{\widetilde{T}^{obs}}$$



$$Y = \frac{1+\beta}{2} \cdot \frac{1}{\beta - \sqrt{(\beta^2-1)(1-\frac{1}{X})}} \cdot \frac{1}{X}$$

Model



$$Y = \frac{1+\beta}{2} \cdot \frac{1}{\beta - \sqrt{(\beta^2-1)(1-\frac{1}{X})}} \cdot \frac{1}{X}$$

While $\delta \in [t_s^{min}, t_s^{max}]$

- For a given β, the value of X varies from 1 to $\frac{1+\beta}{2}$, a higher X corresponds to a lower δ.
- The average parking duration is always overestimated, the minimum value of the accuracy is $\frac{1}{2} + \frac{1}{2\beta}$.
- For a given survey intensity X, the accuracy is higher with a smaller β. Hence, one can find the lowest possible accuracy for a given range of β.

Numerical Example

- A basic range of β could be obtained in a survey by approximating the longest and shortest parking duration.
- A patrol survey with interval δ=3 hours, the data and results are analyzed.

Table 1 Survey results of the numerical example

No.	δ	No. of vehicles observed	Percentage/times			$\tilde{T}^{obs}$	X
			1	2	3		
1	$\delta_1 = 3$	271	38%	45%	17%	5.4	1.79
2	$\delta_2 = 6$	199	92%	8%	-	6.5	1.08
3	$\delta_3 = 9$	164	100%	-	-	9	1

$t_s^{min} < 3$

$t_s^{max} \leq 9$

$t_s^{max} \in [6,12]$

Numerical Example

- We can assume a conservative value(i.e., 0.3 hours) as a minimum duration for vehicles base on real life experience. It means that, a person only parks the car when he/she needs to stay for more than 0.3 hours.

$t_s^{max} \in [6,9]$

$t_s^{min} \in [0.3,3]$

$\beta \in [2,30]$

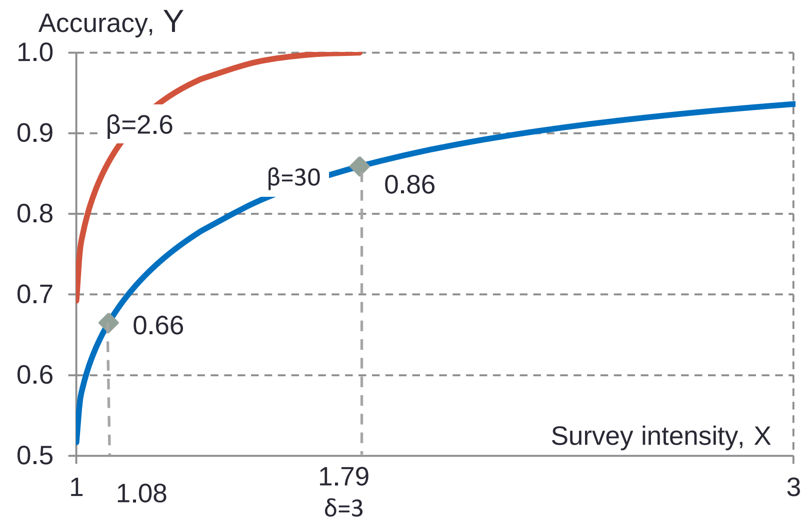
So β ϵ[2.58,30], then we can find both the lower and upper bounds for the accuracy of the survey as a function of X.

No.	δ	$\tilde{T}^{obs}$	X
1	$\delta_1 = 3$	5.4	1.79
2	$\delta_2 = 6$	6.5	1.08
3	$\delta_3 = 9$	9	1

$X \epsilon \left[1, \frac{1+\beta}{2}\right]$

X=1.79 when δ=3

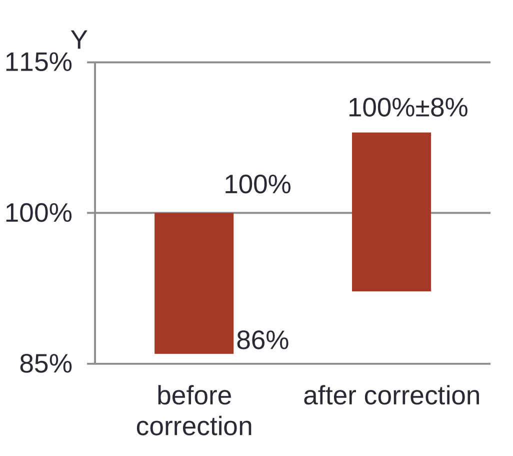
$\beta > 2.58$



Results and correction

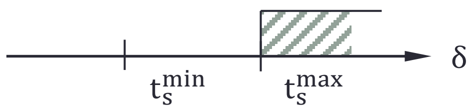
interval	δ	3	hours
estimated APD	$\tilde{T}^{obs}$	5.4	hours
survey intensity	X	1.79	
accuracy of APD	Y	above 86%	
real APD	$\overline{T}^{real}$	[4.64, 5.4]	hours

APD:average parking duration

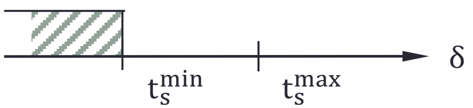
Correction	
Goal:	making the relative error in a smaller range
Measure:	adjusting $\tilde{T}^{obs}$ to 5 hours
Results:	

Model

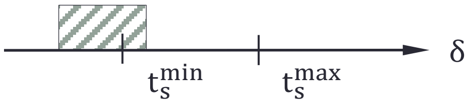
Note that the conclusions above only hold when $\delta \in [t_s^{min}, t_s^{max}]$. Fortunately, it is possible to verify this condition using the same survey data:



- When X=1, then $\delta \geq t_s^{max}$ and clearly the accuracy is low.



- When all the observed cars are observed at least twice, then $\delta \leq t_s^{min}$ and the survey intensity is simply higher than needed, survey cost could be reduced by extending the observation interval.

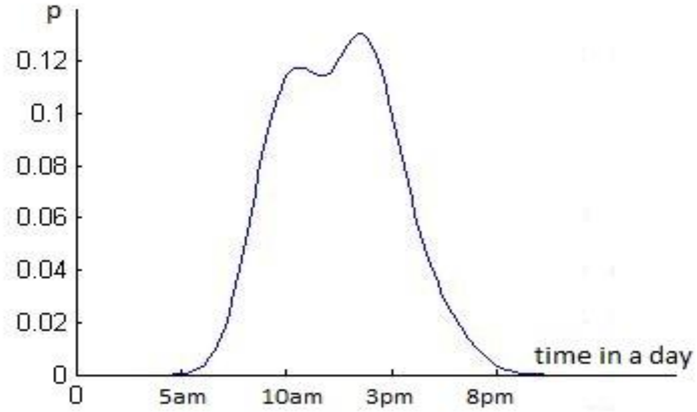


- When the percentage of cars being observed only once (i.e.,$\frac{p_1}{p_{obs}}$) is very low, then $\delta \approx t_s^{min}$ and it's possible to reduce the survey intensity without losing much accuracy.

Assumptions

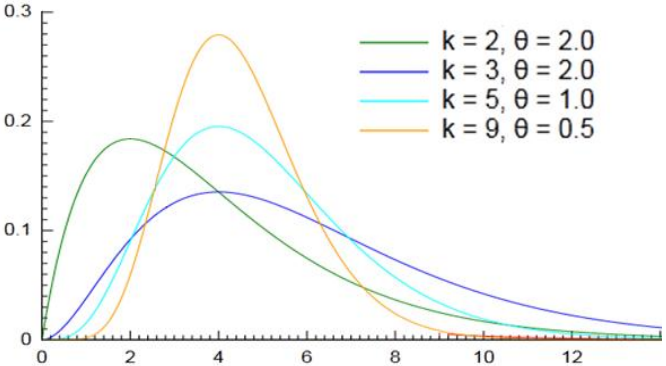
Arrival time

500 vehicles arrive the parking area during a day following a continuous double peak distribution.



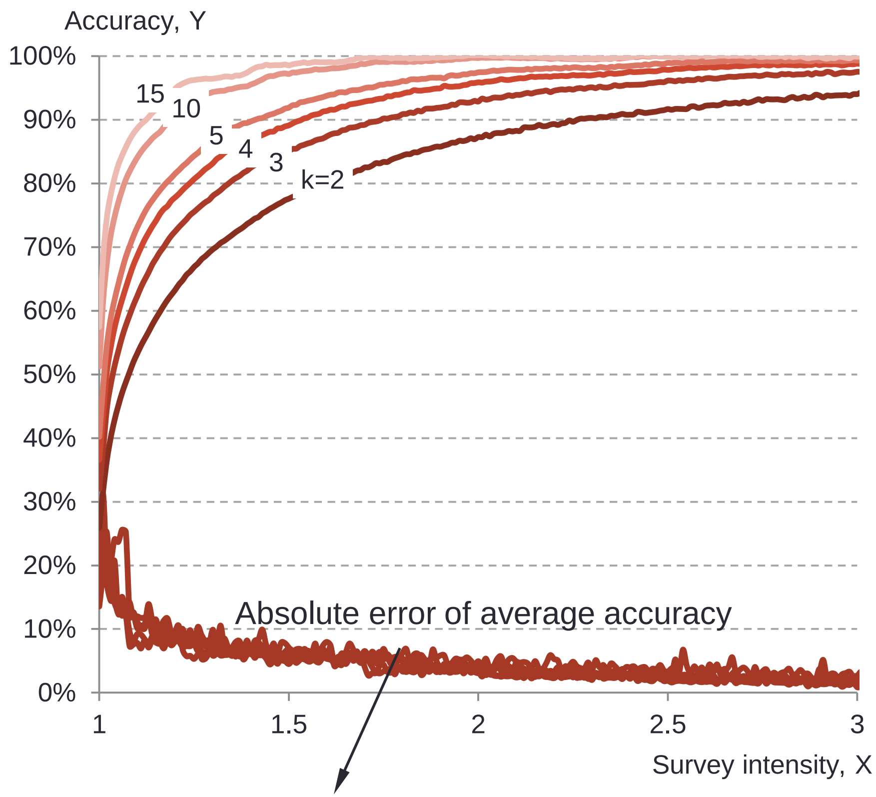
Parking duration

Gamma distribution is denoted by $G(k, \theta)$, the probability density function (PDF) is $f(x;\ k, \theta) = \frac{1}{\theta^k \Gamma(k)} x^{k-1} e^{-\frac{x}{\theta}}$.



Findings from Simulations

- For each value of k among {2, 3, 4, 5, 10, 15}, 3500 simulations have been ran with a changing value of θ.



Caused by natural variations

- The real average duration is typically overestimated.
- For a given X, the accuracy is very much influenced by k. (the “shape parameter” of gamma distribution)
- For a given X, a higher accuracy correspondences to a larger k.
- The absolute error of average accuracy is up to 30% in the simulation, but it becomes quite small (below 8%) for X>1.5. For instance, accuracy is 90%±8%.

Conclusions

- A method is supplied to estimate the accuracy
- The balance of survey input (intensity & cost) and accuracy is illustrated
- A method to obtain on average a higher accuracy is used in the numerical example

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1. We have found that the most influential factor to the accuracy is the shape parameter of the parking duration distribution. Former survey experiences or results can be used to support fitting the distribution and estimating this value.
2. The coordination between survey costs and accuracy could be done by choosing a proper value of survey intensity. Higher survey intensity means a more expensive survey while it also gives better accuracy. Based on the model, we could find a proper value of survey intensity to guarantee that both are acceptable, or the minimum possible cost for a desired level of accuracy.
3. Through our study, it is proved that when survey intensity is below 1.5, the survey could be quite misleading, not only because a comparatively low accuracy, but also because the data recorded have with large natural variations.

Definitions

$\boldsymbol{\delta}$ observation interval

$$a = \frac{t_s^{min}}{\delta}$$

$$b = \frac{t_s^{max}}{\delta}$$

$$M = \frac{C}{\delta}$$

$$\boldsymbol{\beta} = \frac{t_s^{max}}{t_s^{min}} = \frac{b}{a}$$

p_i Probabilityof a vehiclebeenobserved i times

$$p^{obs} = \sum_{i=1}^{\lceil b \rceil} p_i$$

$$= \sum_{m=1}^{M} \left\{ \begin{array}{c} \int_{(m-1)\delta}^{m\delta - t_s^{min}} f(t_a) \left[\int_{m\delta - t_a}^{t_s^{max}} f(t_s) dt_s \right] dt_a \\ + \\ \int_{m\delta - t_s^{min}}^{m\delta} f(t_a) \left[\int_{t_s^{min}}^{t_s^{max}} f(t_s) dt_s \right] dt_a \end{array} \right\}$$