n: number of clusters T: # periods

$x_{i_t} = \begin{cases} 1, & \text{station at cluster } i \text{ during } t \\ 0, & \text{otherwise} \end{cases}$ $t \in 1, \dots, T$

y_{i_t} = # bikes in station of cluster i during t $t \in 1, \dots, T$

z_{i_t} = # docks in station i during $t \in 1, \dots, t$

$x_{i_t} \leq z_{i_t} \leq M_i x_{i_t}$ (1) where M_i is the maximum number of docks for station i $\forall i$ $\forall t$

$x_{i_t} \leq y_{i_t} \leq z_{i_t}$ (2) $\forall i$ $\forall t$

m_{ij} = average # times a bike started from somewhere in cluster i and ended-up in cluster j

$\sum_j m_{ij}$ = # times a bike started from i

$\sum_i m_{ij}$ = # times a bike ended up in j

$m = \sum_i \sum_j m_{ij}$ = total number of trips

$\frac{1}{2m} \left(\sum_j m_{ij} + \sum_j m_{ji} \right)$ = proportion of demand for a station at cluster i

a_{ik} = number of k buildings in cluster i

where k = [residential, commercial, school, university, hospital, library]

p_k = weight for k building

~~[illegible]~~

(see pg. 4 for reworked version)

objective function: = social_value

c_1 = cost of making a dock + $\left(\frac{\text{hangar cost}}{\text{docks/hangar}}\right)$

c_2 = cost of making a bike

C_{car} = user cost for car fuel/time

C_{max} = maximum amount of money we can expend

p_{car} = proportion of population initially using car

- $total\_cost = c_1 \sum_i \bar{z}_i + c_2 \sum_i \bar{y}_i$

- environmental_value =

$= p_{car} C_{car} \sum_i \sum_j m_{ij} h_{ij} \bar{x}_i$

where h_{ij} = average time to go from i to j

$total\_cost \leq C_{max}$ (3)

environmental_value ≥ (proportion) *

* (total cost for car fuel for all residents in a e.g. month) (4)

CS CamScanner

5 forced underperforming stations open regardless of viability

if $m_{ij} > m_{ji}$

$\text{total\_cost} \leq \ell_1 \cdot \text{social\_value} + \ell_2 \cdot \text{environmental\_value}$

6 maybe?

!!! Constraint 7: extra docks for more bikes based on previous stats (confidense interval)!!!

CamScanner

$$\bar{x}_i = \sum_{t=1}^{T} x_{it} \quad \forall i \in 1,\dots,n$$: 1 if station i ever opened, 0 otherwise

$$\bar{\varphi}_i = \sum_{t=1}^{T} \varphi_{it} \quad \forall i \in 1,\dots,n$$: # of bikes ever put @ i

$$\bar{z}_i = \sum_{t=1}^{T} z_{it} \quad \forall i \in 1,\dots,n$$: # docks put @ i over all periods

8

$\bar{x}_i \leq 1$: (can only open i once)

d_t = % reduction of social value associated w/ opening stations in period t $\left(d_t \in [0,1] \ \forall t\right)$

(obj. f(x))
(max)
social value: $\sum_t \sum_k \sum_i d_t P_k a_{ik} \sum_j (m_{ij} + m_{ji}) \varphi_{it}$

q_t = % of total budget (c_{max}) available during period t $\left(q_t \in [0,1] \ \forall t \wedge \sum_t q_t = 1\right)$

9

periodic costs : $\sum_i c_1 z_{it} + c_2 \varphi_{it} \leq q_t C_{max} \quad \forall t \in 1,\dots,T$