Supply Chain in the Digital Era – Challenges and Opportunities

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NUS Business School

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Plan

Institute of Operations Research and Analytics

The Smart City and Smart Supply Chain Around Us

Opportunities in City Logistics

Opportunities in Smart Mobility

Opportunities in Retailing

Develop a center of excellence integrating OR with Analytics in Asia

Attract top faculty, especially young talents who can be developed and nurtured into academic leaders.

Faculty

Support faculty and staff to compete for grants and generate research funding

Industry / Public

Create positive impact on the university educational programs, business community, government and the general public

Academic Community

Funding & Research Roadmap

Integrates mathematical theories with data science on real-life/applied problems

MOE Tier 3

01 Aug 2020-2024

MOE Tier 3 grant proposal awarded to the Institute to study the Science of Prescriptive Analytics

SIA Corp Lab

Oct 2020 - 2024

IORA will participate in two out of four work packages for SIA in the field of Revenue Management, Pilot Training, Crew Scheduling etc.

- Cargo Hub Operations (SF)
- Smart Manufacturing (K&S)
- Smart Locker (IMDA)
- Condition Monitoring (RESMED)
- Lottery Liability Limits Management (SPL)
- Water Resource Management (PUB)
- Limousine Service Optimization (MBS)
- **NUS RI**

Sep 2020-2024

The Institute has been invited to set up a Centre on Modern Logistics in NUS RI in Chongqing.

- Retail (BODYSHOP)
- Insurance (RHI)
- Ride Hailing (COMFORT; DIDI)

Modernization of **Data Engineering** and **Science** provides the impetus for **Operations Innovation** using **Prescriptive Analytics** that is based on Real-time state and guided by Rules, policies and Targets.

Main Message

Society evolving in unimaginable ways.

Doing good research in Operations and Supply Chains requires:

i) Good Problem Statement – Importance? Impact? Insight?

ii) Good Set of Tools to facilitate analysis

What makes a smart city?

Singapore Smart City for Surbana Jurong

Source: www.youtube.com/watch?v=Im1eivas2b8

Singapore, Helsinki and Zurich triumph in global smart city index, according to the Institute for Management Development, in collaboration with Singapore University for Technology and Design (SUTD), published in 2020.

"an urban setting that applies technology to enhance the benefits and diminish the shortcomings of urbanization for its citizens."

- **Intelligent infrastructure**
- **Convenient public service**
- **Liveable society**
- **Healthier citizens**
- **Increased Mobility**
- **Sustainability**
- **….**

What makes a smart supply chain?

GlaxoSmithKline (GSK), the largest pharmaceutical firm by volume in India, sought help from Roambee, a supply chain visibility firm, to reduce theft in its supply chain[1].

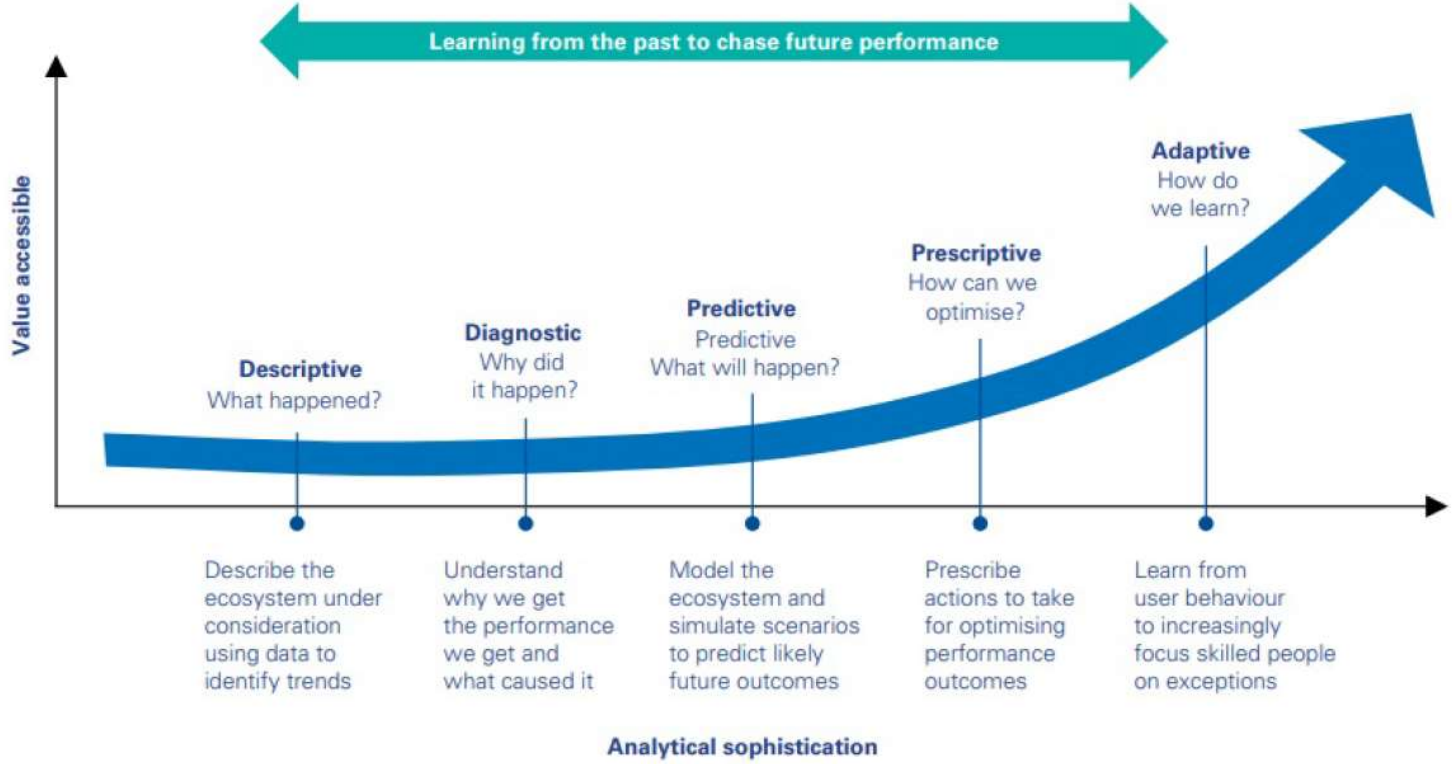
The "Bees" are tiny low power wide area network (LPWAN) modules that can be affixed to any box. Sensor data is uploaded to the cloud via a "Bee Beacon"

Roambee's real-time solution not only eliminated theft altogether, it also ultimately led to overall end-to-end optimisation of GSK's supply chain, including **better ETA predictability and reduced buffer inventory**.

https://www.reefknotinvestments.com/resources/ck/files/Supply Chain Visibility_D4.pdf

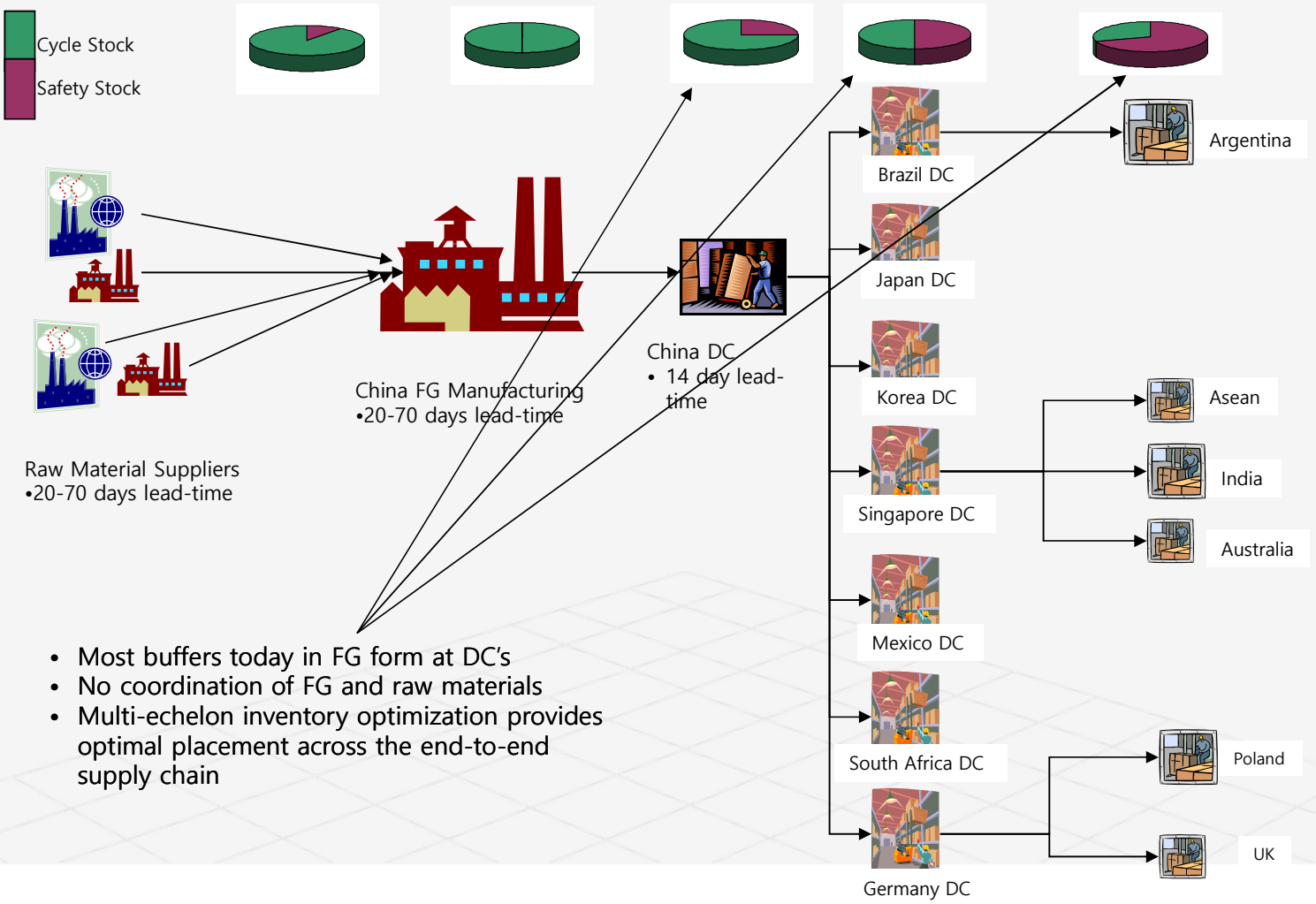
Opportunities for OM and SCM Scholars

Future supply chains will be powered by sophisticated algorithms, simulations and prescriptive analytics



Source: KPMG Operations Excellence 2017

Opportunities for OM and SCM Scholars

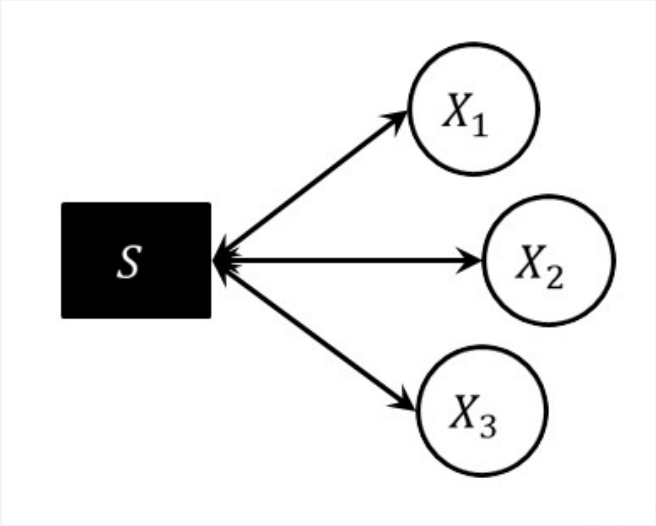


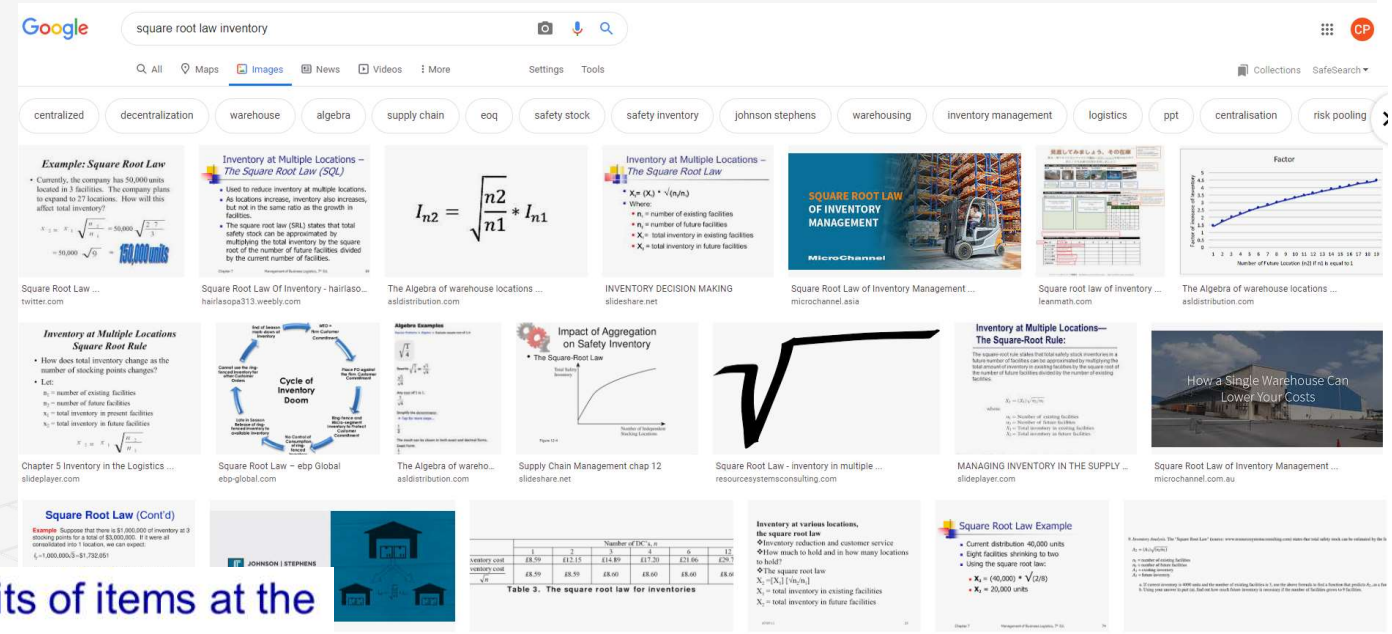
- Most buffers today in FG form at DC's
- No coordination of FG and raw materials
- Multi-echelon inventory optimization provides optimal placement across the end-to-end supply chain

Opportunities for OM and SCM Scholars

Safety Stock in a system with N iid customers. $D_i \sim \text{Normal}(\mu, \sigma^2)$.

No Visibility: Allocate before D_i realized $\rightarrow$ SS = $k\sigma\sqrt{N}$ (pooling)





The firm (supplier) orders up to S units of items at the beginning

service level requirement: $\beta_i \in (0,1)$

Opportunities for OM and SCM Scholars

With Visibility: Allocate after demand realized → no need for safety stock for N large! (Resource pooling and allocation policies to deliver differentiated service, Zhong et al. (2018, MS)).

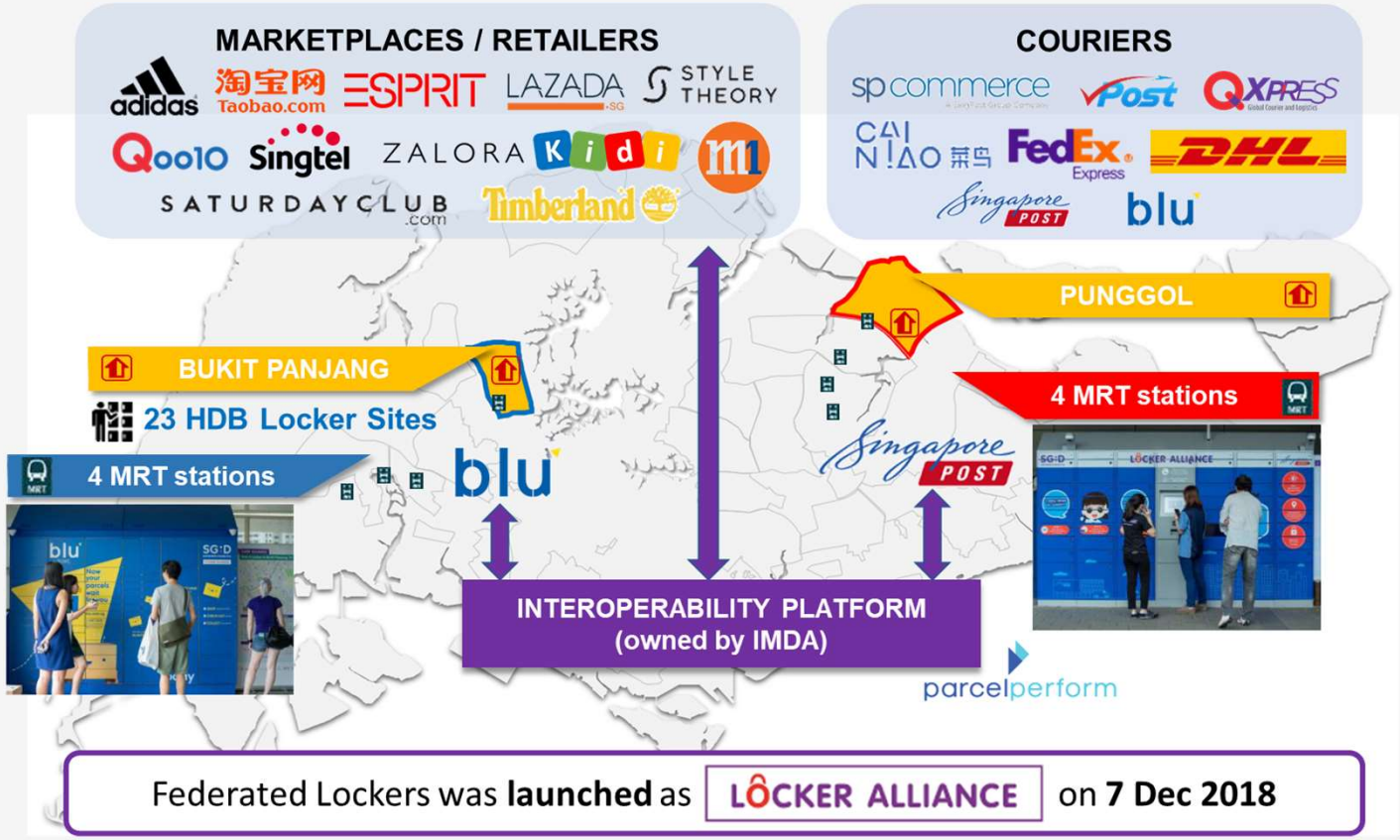
01

City Logistics

- Autonomous Logistics (e.g., drone, delivery robot)
- Connected System (e.g., IoT-based traceability)
- Shared Solution (e.g., crowd-sourcing platform)
- Contactless Delivery (e.g., parcel locker network)

As of 2019, 81 **percent** of the resident population in **Singapore lived in public housing**.

Federated Locker Alliance (LA) Network in Singapore



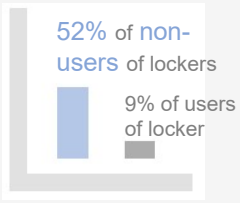
Automated Parcel Locker Technology

1. **Where to install? Near residents, or areas with high footfall ?**
2. **Commercially sustainable?**
3. **Impact on delivery efficiency? Environment?**
4. **What influences consumer adoption?**

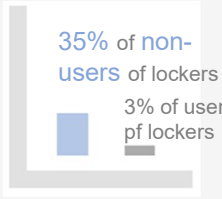
Familiarity with lockers is key to increase customer adoption

Lack of awareness of lockers **is prevalent** among potential customers

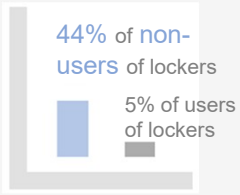
Were **not aware** of the **lockers** from the pilot before the survey



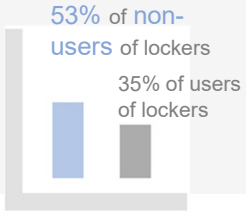
Have **not seen** the **lockers** from the pilot (before collecting item)



Didn't know where to find the nearest **locker** (before collecting item)

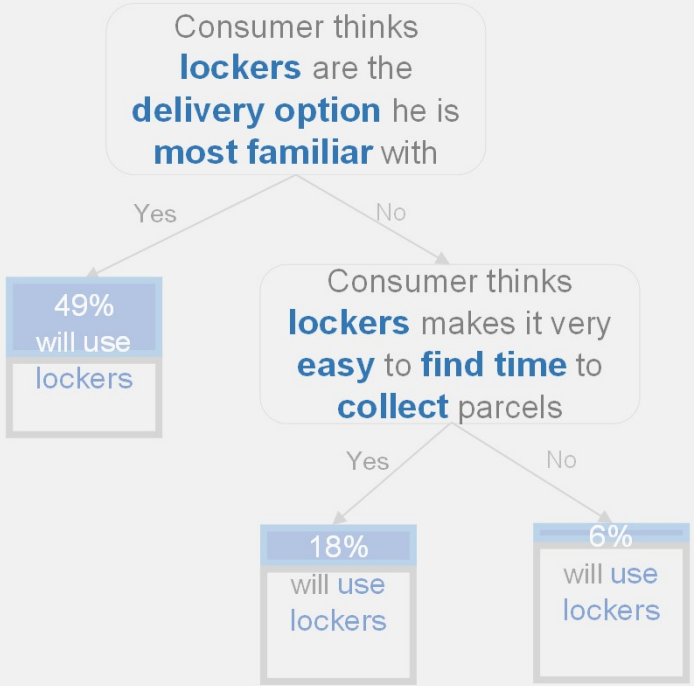


Cannot distinguish between the **lockers** from the pilot **and** bluPorts/ **POPstations**



Responses to 1st survey

Familiarity with lockers is the **most important factor** that increases probability of **using lockers**



Use of classification tree (ML) on survey responses to determine p(x) of using lockers

3 out of the top 4 reasons why potential customers **don't** want to **use lockers** are related to **lack** of **familiarity**

Using lockers is too costly compared to home delivery. Free is not enough (35% out of total feedback responses)

Lockers are **not available** during **check-out** (14%)

Other (17% out of total feedback responses)

Lockers **are far** and difficult to locate (21% out of total feedback responses)

Lockers are **difficult to use** (13%)

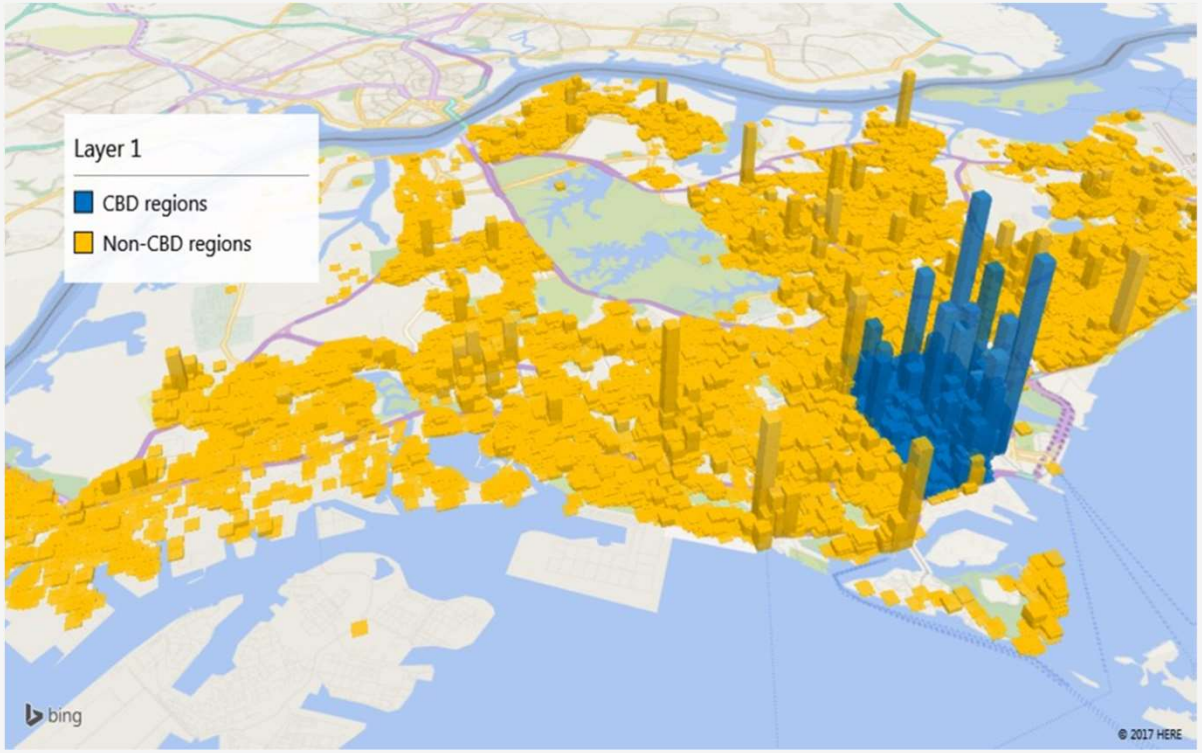
Sentiment analysis on 549 responses to feedback on using lockers from consumers, after 3rd survey

Other aspects of lockers that customers care about the most

Sentiment analysis of feedback on using lockers from consumers, after 2nd survey

LA Network: Insights from OR Modeling

Strategy! **“Installation of locker near public housing block reduces the volume of parcel delivery to CBD”**



How will the network affect parcel volume into CBD?

1. Contrary to conventional wisdom, our model does not always place lockers near areas with peak parcel volume (in pre-existing data), because the LA lockers provide another option for customers to pick up from lockers near residential areas;

2. With nation wide roll out of lockers, being closer to customers will increase adoption rate;

3. (At least) 7.5% of deliveries to CBD can be reduced if the scale of locker network is around 1500.

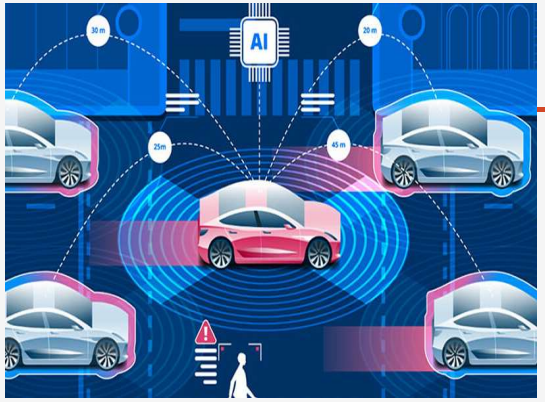
Source: Lyu, G., & Teo, C. P. (2019). Last mile innovation: The case of the locker alliance network. Forthcoming, MSOM.

02

Urban Mobility

- Autonomous Vehicles
- On-demand Transport System
- Shared Mobility (e.g., ride-sourcing platform)
- Hands-free Ticketing

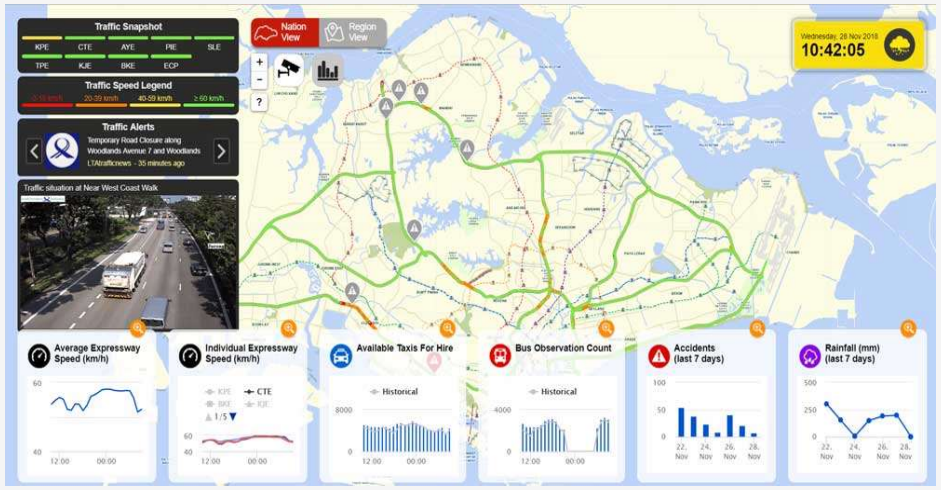
In 2019, about 12% of the country's land area is already **used for** roads, compared to about 14% for housing



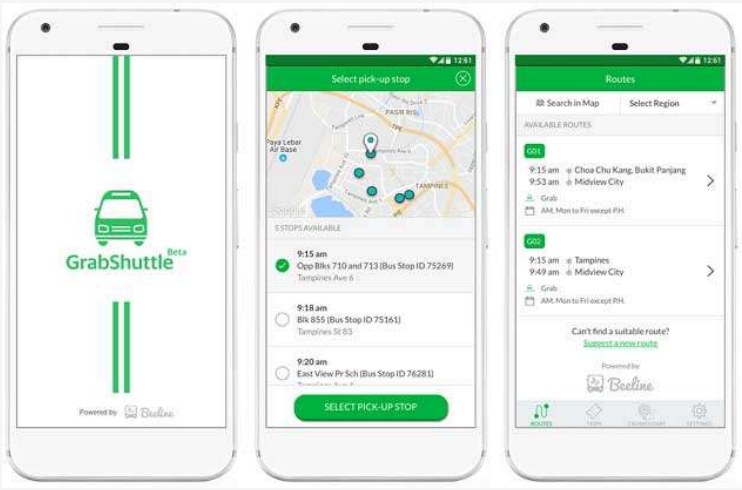
Self-driving Technology

Contactless Payment

On-demand Bus Service



Real-time Traffic Watch



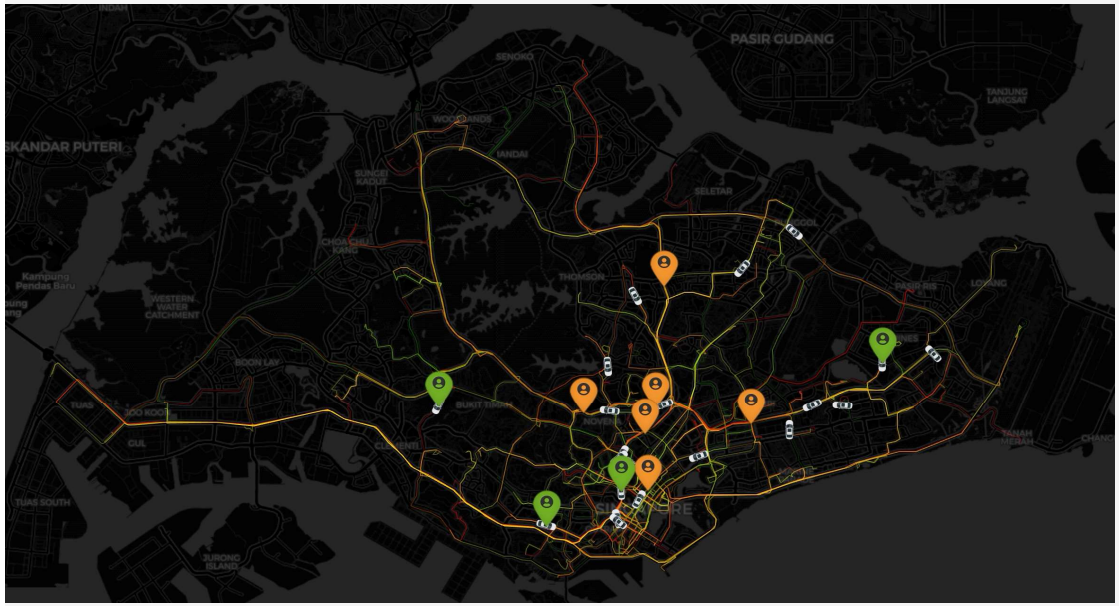
Ride-sourcing Platform (Grab Singapore)

SMART SOLUTIONS IMPROVE COMMUTES AND THE ENV; BUT SHIFTS VALUES IN THE ECO-SYSTEM

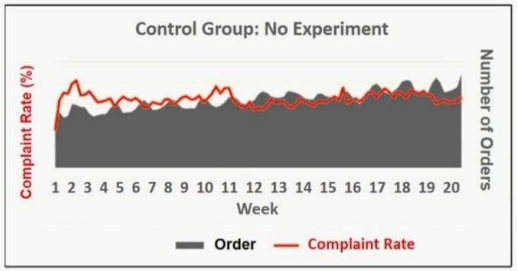
- Traffic command and control center
- Intelligent traffic lights
- Real-time road navigation
- Dynamic smart parking
- Dynamic congestion pricing
- Public transit information and management
- On-demand transport
- Predictive Maintenance
- Autonomous Vehicles
- Drones

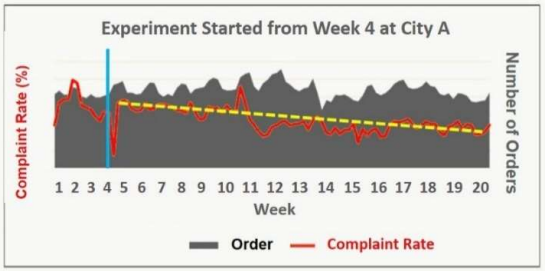
Shared Mobility: Real-time Driver Dispatch Policy

Strategy! **"Providing High Quality Service Experience is Crucial for Ride Hailing Platform"**



Quality of service versus Distance travelled?





Clever algorithm can mitigate and balance the trade-offs in the multi-objective decision problem:

- **Platform has higher revenue, drivers with higher service scores are dispatched with more orders, and passengers are more likely to be matched to drivers with higher service scores!**

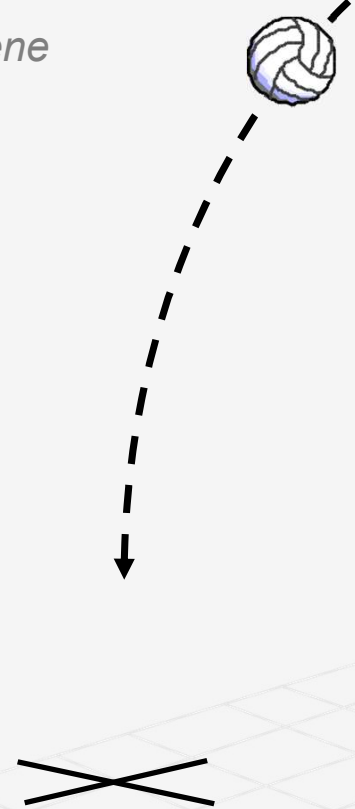
Source: Lyu, G., Cheung, W. C., Teo, C. P., & Wang, H. (2019). Multi-objective online ride-matching. Available at SSRN 3356823.

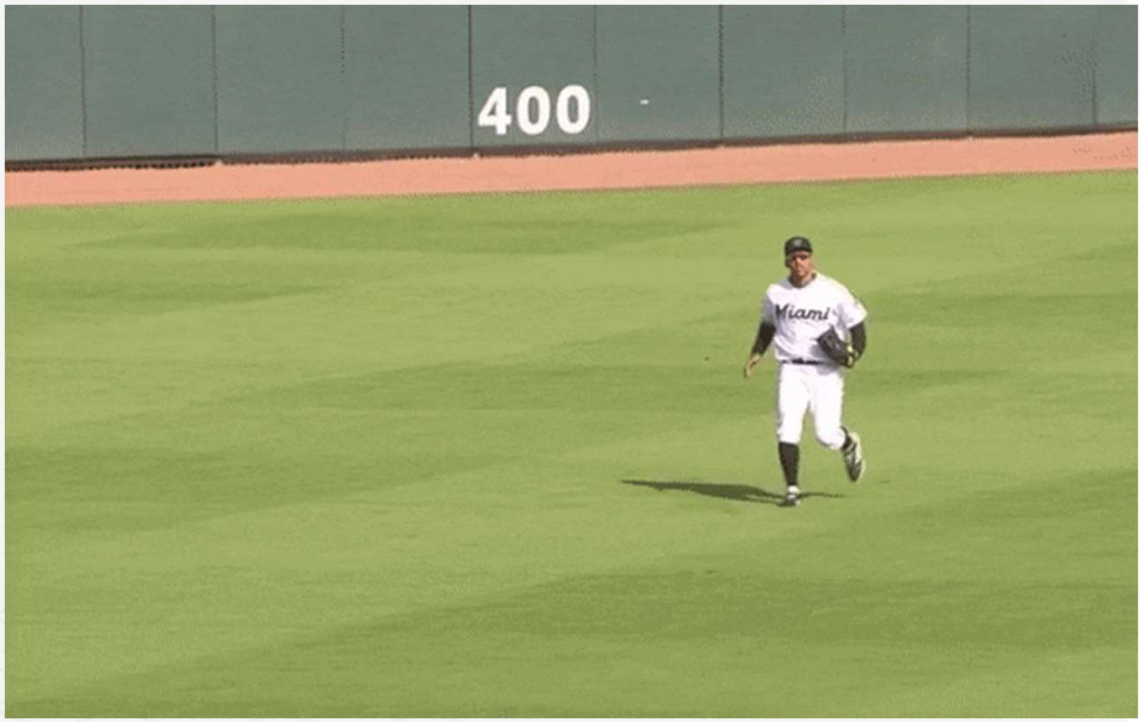
"When a man throws a ball high in the air and catches it again, he behaves **as if** he had solved a set of differential equations in predicting the trajectory of the ball. At some subconscious level, something functionally equivalent to the mathematical calculation is going on."

Richard Dawkins, *The Selfish Gene*

How to catch a flying ball?

Source: Henry Brighton

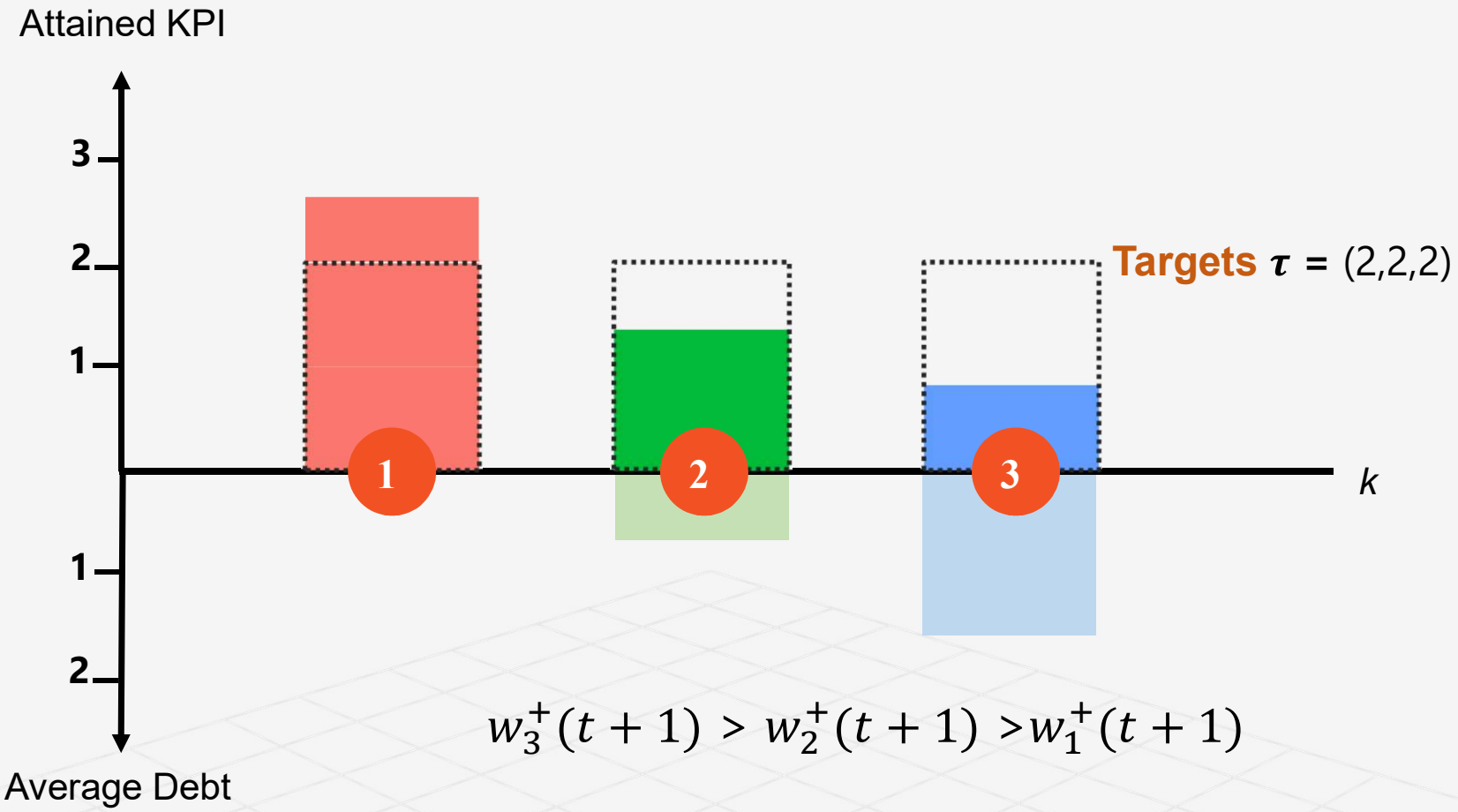




The pessimist complains about the wind; the optimist expects it to change; the realist adjusts the sails.

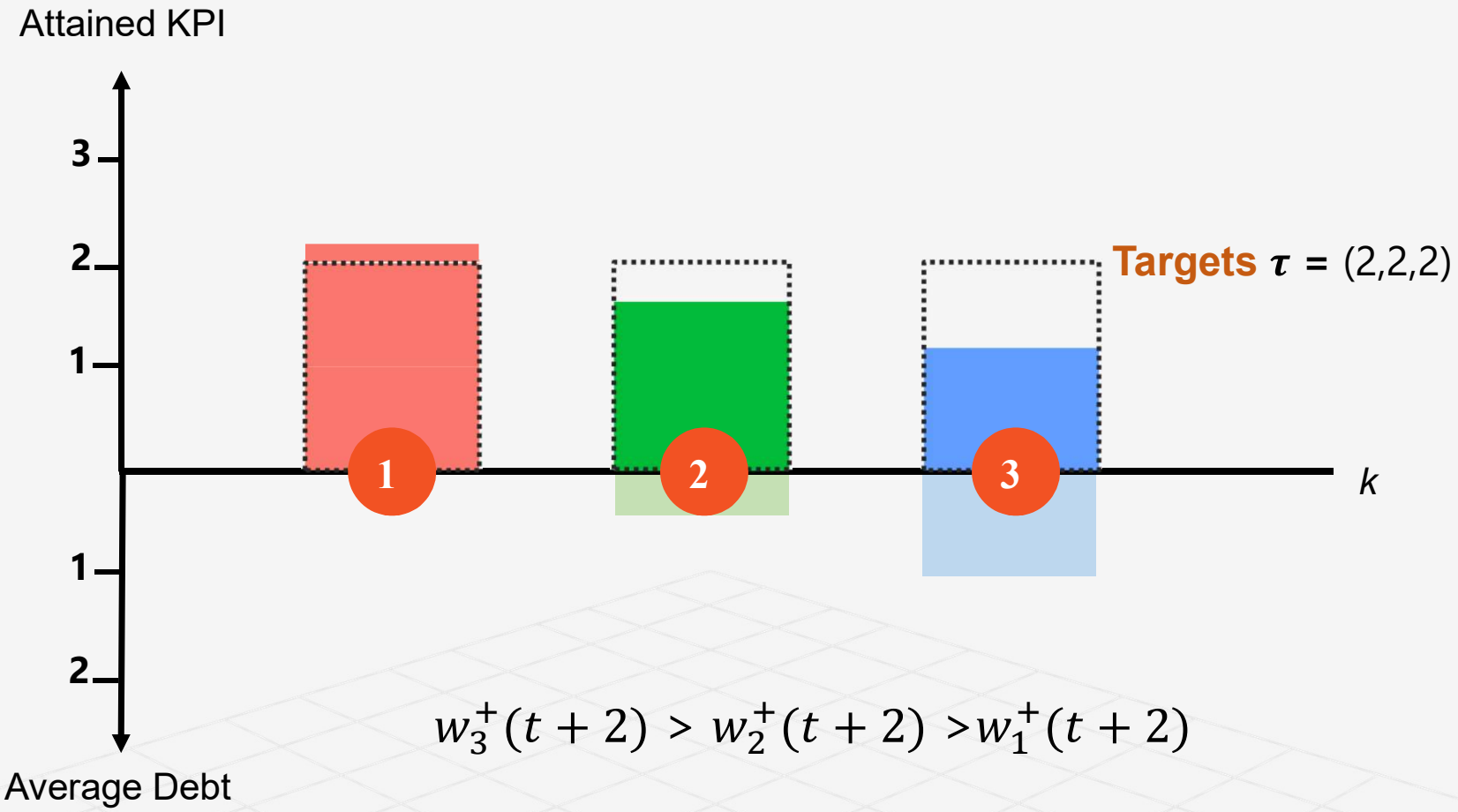
William Arthur Ward

At period (t)



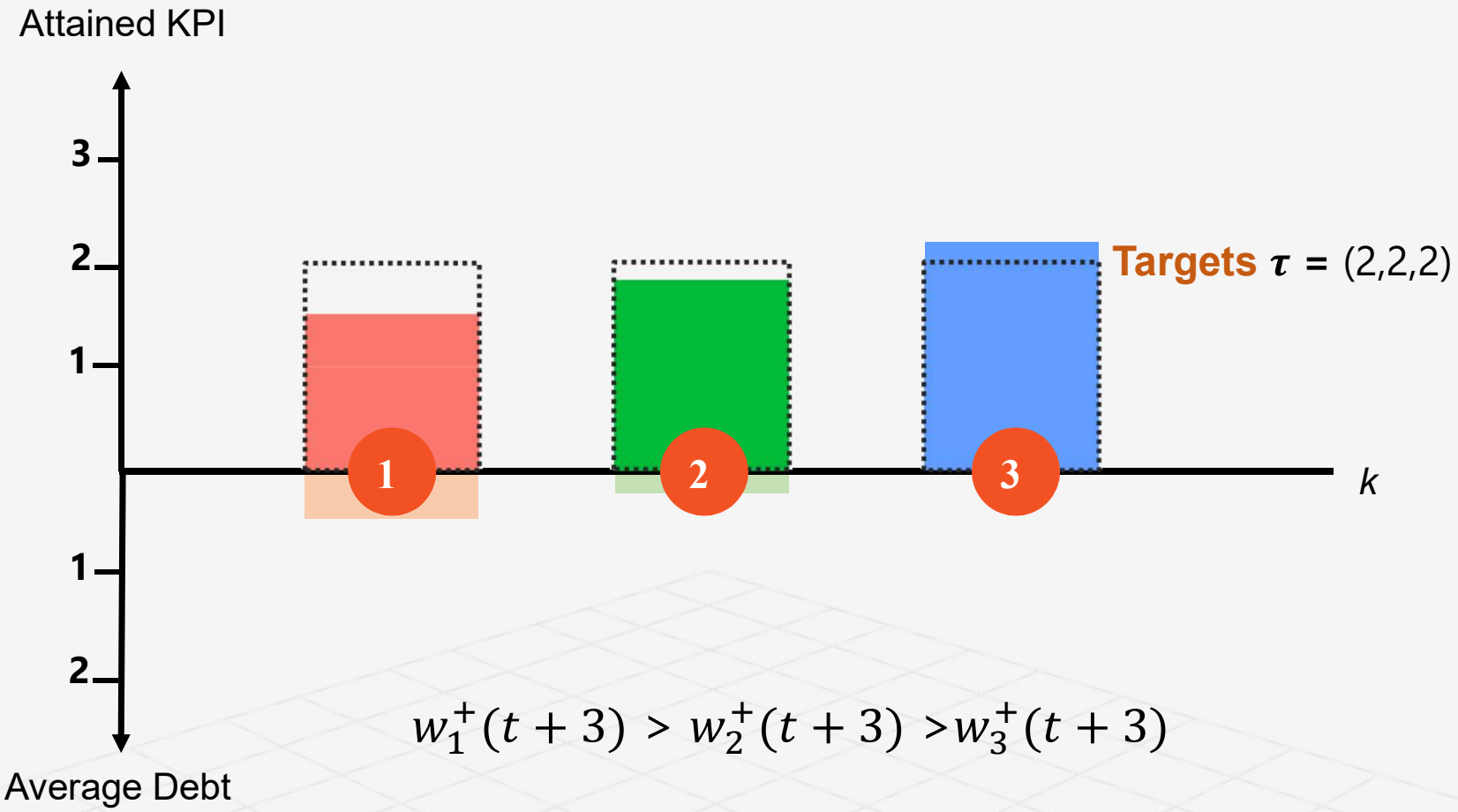
$$w_3^+(t+1) > w_2^+(t+1) > w_1^+(t+1)$$

At period $(t+1)$



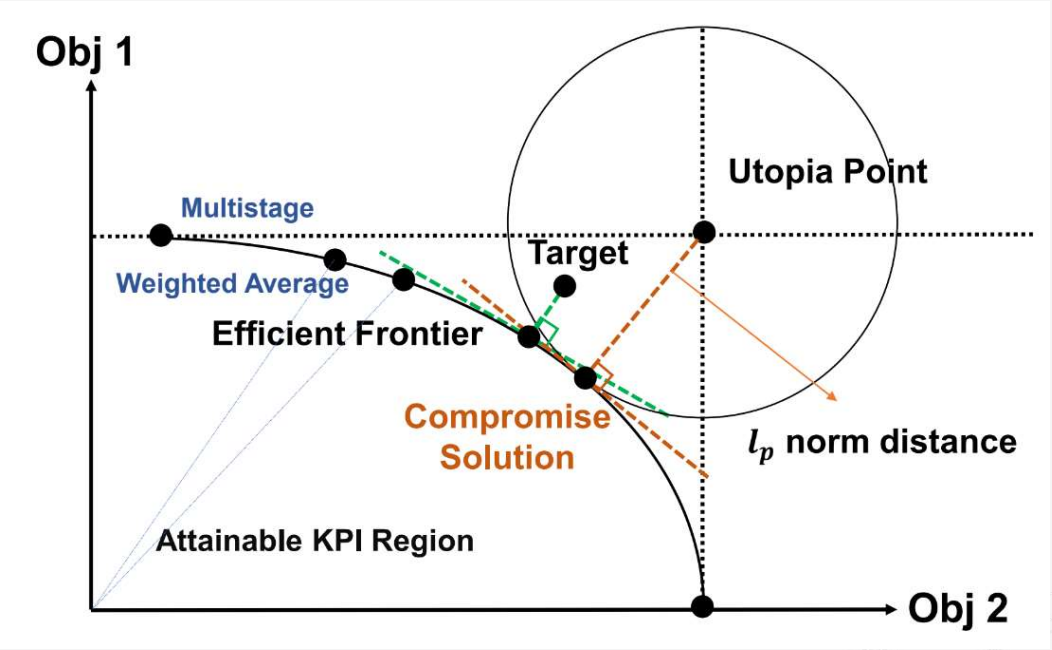
$$w_3^+(t+2) > w_2^+(t+2) > w_1^+(t+2)$$

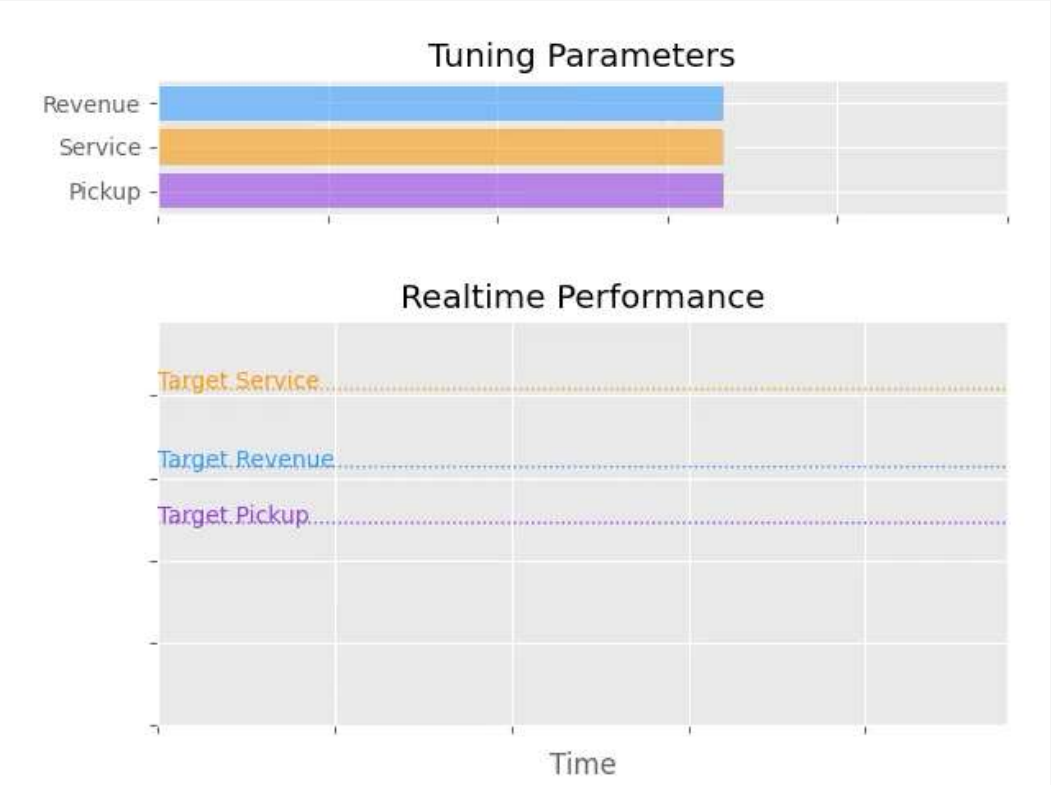
At period $(t + 2)$



$$w_1^+(t+3) > w_2^+(t+3) > w_3^+(t+3)$$

Multi-objective optimization: Given a utopia target (or any target), we derive the compromise solution, which is closest to the target, in an online fashion.





Implementation in Beijing & Hangzhou:

Our online policy presents solutions with delicate balance between multiple objectives and brings value to all the stakeholders in the ride-sharing ecosystem

Finalist

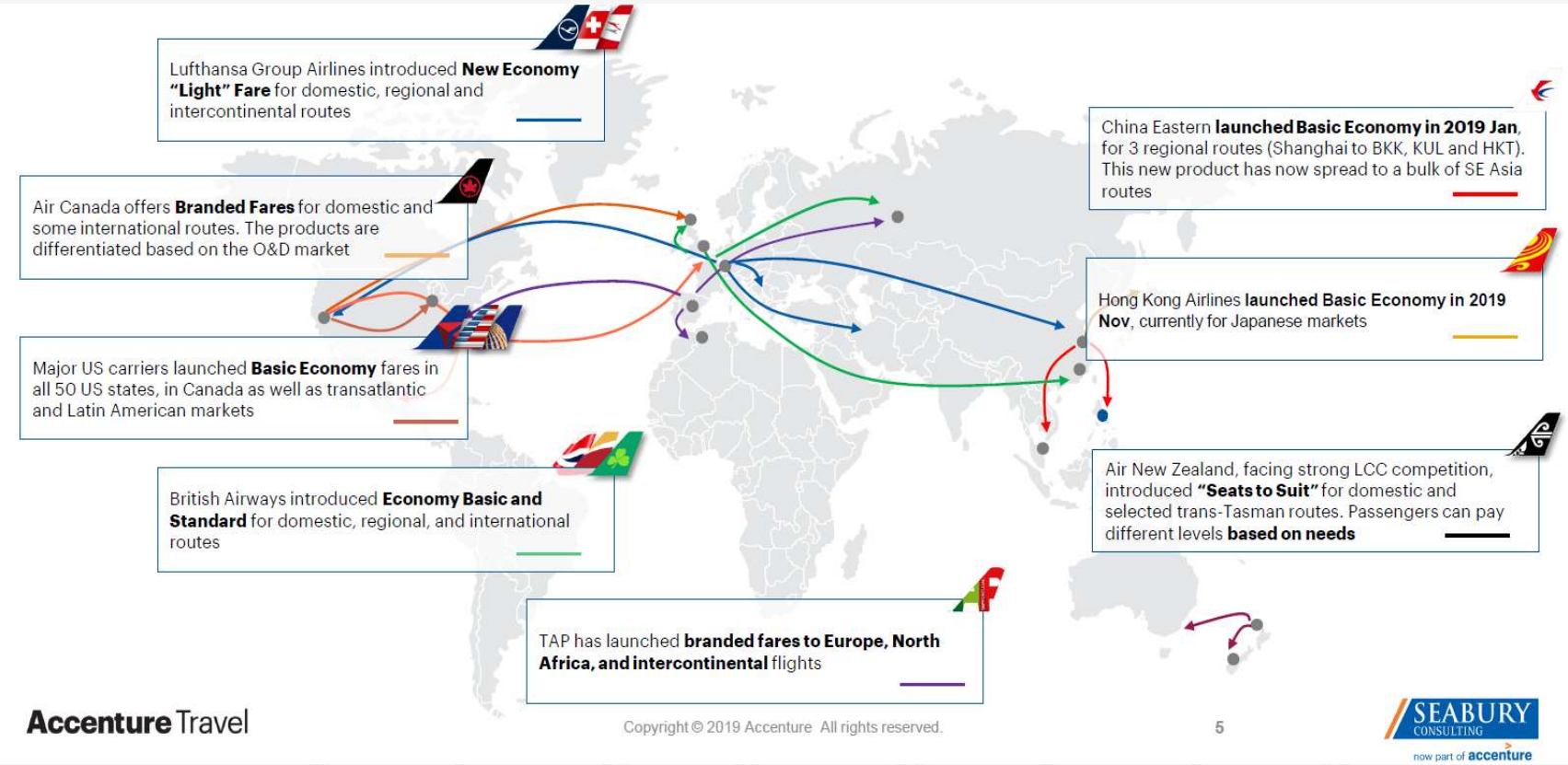
Guodong Lyu: 2019 George B.Dantzig Dissertation Award Competition Finalist.

03

Retailing

- Business Analytics & Intelligence
- Smart Warehousing
- Automated Shipping and Fulfillment
- Cross-border E-commerce

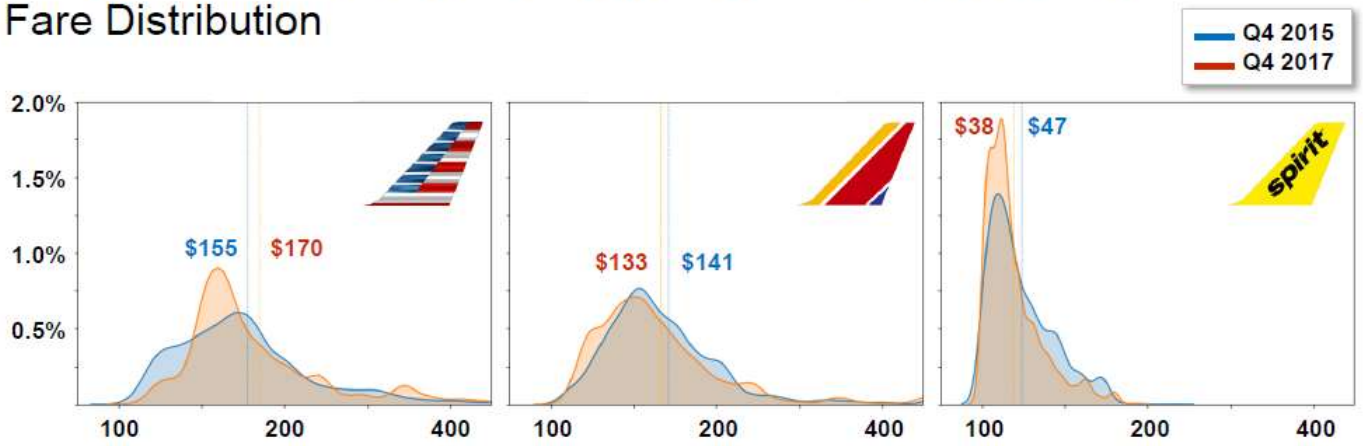
Revenue Management and Intelligent Pricing Work Package



Global network carriers face a sizeable threat from low cost carriers, which bring downward pressure on fares and offer customers varying product experiences. This results in a need to **match product and price offerings** from these carriers while also protecting yields and legacy branding

Revenue Management and Intelligent Pricing Work Package

Route performance on Dallas (DFW) – Las Vegas (LAS)
Fare Distribution



The example of the Dallas to Las Vegas route demonstrates the effect of Basic Economy: American has been able to limit the fares of $120 and achieved more up-sell to the $160 mark

In the meantime, Southwest and Spirit had to offer more low fares to be able to compete with American's lower fares; ***resulting in lower yields***

Source: VisualApproach – 'Can We Declare Basic Economy a Success?'; Seabury Consulting

Revenue Management and Intelligent Pricing Work Package

Fare family design: current SQ offering

FARE CONDITIONS	ECONOMY LITE	ECONOMY STANDARD	ECONOMY FLEXI
Baggage	30kg	30kg	35kg
Seat selection at booking	From SGD 13.70	Complimentary (Standard Seats)	Complimentary (Standard & Forward Zone Seats)
Earn KrisFlyer miles	50%	75%	100%
Upgrade with miles	Not Allowed	Allowed	Allowed
Cancellation	Not Allowed	SGD 200	SGD 70
Booking change	SGD 70	SGD 30	Complimentary
No show	SGD 130	SGD 130	SGD 130
View PPS Club / KrisFlyer privileges	SGD 798.70 SELECT	SGD 878.70 SELECT	SGD 1,268.70 SELECT

Revenue Management and Intelligent Pricing Work Package

	13:50 - 17:25 +0 14:15 - 17:55 +0	3h 35m 3h 40m	0 stops 0 stops	7h 15m	Direct	248.20	58.9%
	10:30 - 14:20 +0 10:05 - 13:40 +0	3h 50m 3h 35m	0 stops 0 stops	7h 25m	Direct	342.20	18.8%
LCC	19:50 - 23:30 +0 05:15 - 08:55 +0	3h 40m 3h 40m	0 stops 0 stops	7h 20m	Direct	148.20	12.3%
	05:30 - 09:10 +0 10:05 - 13:40 +0	3h 40m 3h 35m	0 stops 0 stops	7h 15m	Direct	228.20	9.2%
	15:25 - 22:00 +0 06:50 - 12:55 +0	6h 35m 6h 5m	1 stop 1 stop	12h 40m	Connecting	298.20	0.8%

Standard Customer Choice Model translates itinerary attributes into probabilities

$$\text{Prob}_S(i|f_i, \boldsymbol{x}_i) = \frac{e^{\boldsymbol{\beta x}_i - \alpha f_i}}{\Sigma_{j \in S} e^{\boldsymbol{\beta x}_j - \alpha f_j}}$$

But this does not work well for fare family choices!

Convex Optimization for Bundle Size Pricing Problem X Li, H Sun, CP Teo
Proceedings of the 21st ACM Conference on Economics and Computation, 637-638

Summary

Institute of Operations Research and Analytics

Why 1+1 is greater than 2

The Smart City and Smart Supply Chain Around Us

Breaking the Square Root Law Barrier in Inventory Management

Opportunities in City Logistics

Demand Endogeneity – The Case of Smart Lockers in Singapore

Opportunities in Smart Mobility

Gazing Heuristic – The Case of Matching in Ride Hailing Platform

Opportunities in Retailing

Customer Choice – The Case of Ancillary Service Bundle in Airline

More questions?

https://iora.nus.edu.sg/