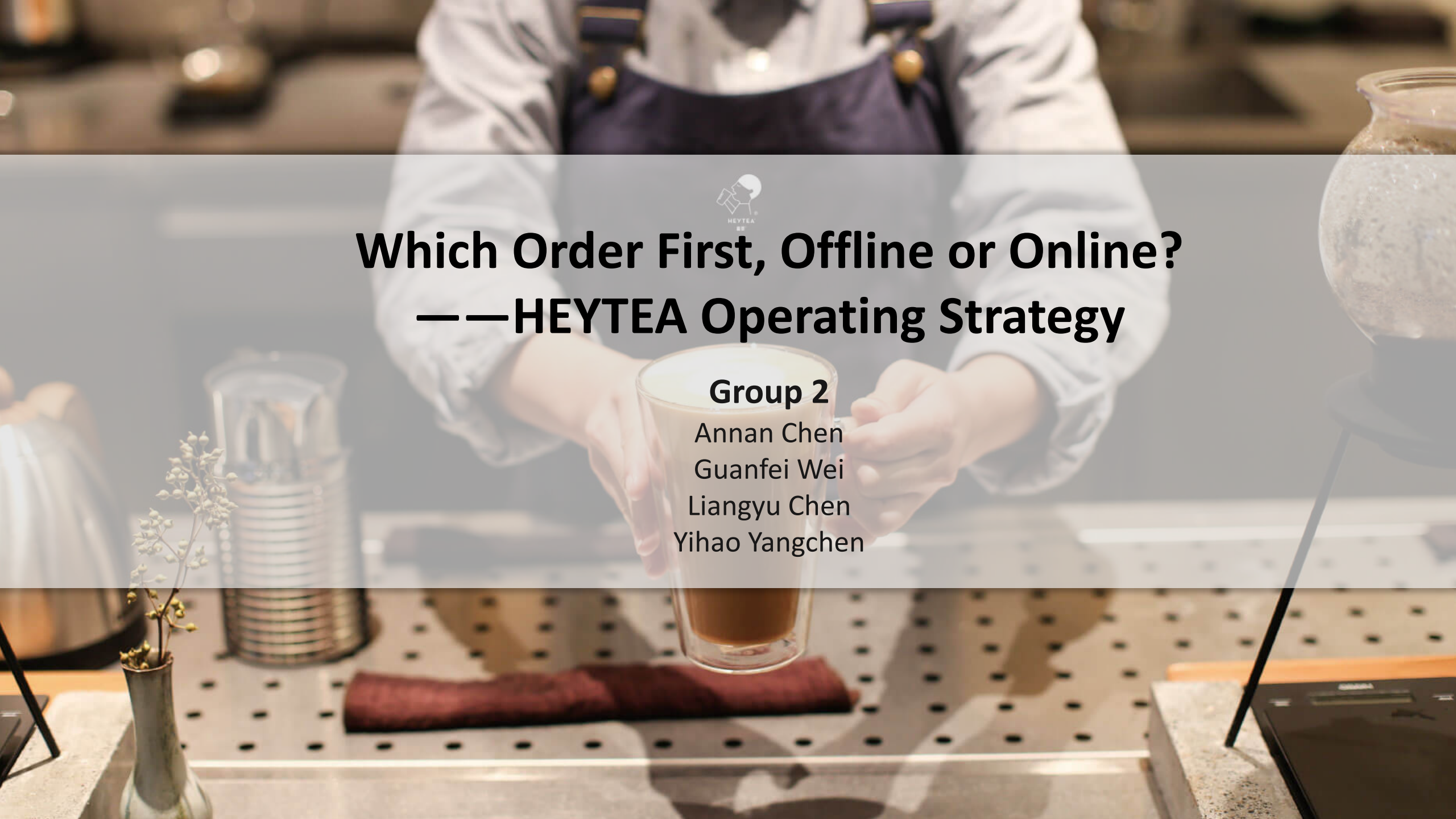

# Which Order First, Offline or Online?
# ——HEYTEA Operating Strategy


**Group 2**

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# Content

I. Background & business question

II. Model & implementation

III. Results & analysis

IV. Conclusion & value proposition

# I. Background & business question

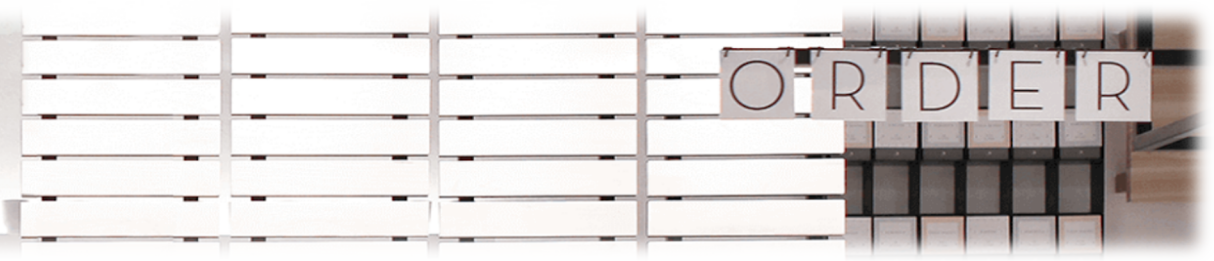
***Famous young tea brand***

HEYTEA (喜茶) is one of the most famous tea brands in China founded in 2012, providing drinks such as milk tea, fruit tea and cheese tea for especially young customers.


***Long queue year-end***

Warm welcome by customers and rapid expansion arise HEYTEA's reputation but also bring about efficiency management problems, especially **how to best prioritize the orders from different channels (offline & online).**

## II. Model: scenarios & assumptions




- **Time scale:**
  - Simulate typical **rush hours** for HEYTEA from 11:00AM to 16:00PM. Any customers arriving before 15:00PM will be served

**Customers**

- **Type of customers:**
  - Offline customers and online customers (two types only)
- **Arrival rate:**
  - $\lambda_{online} = 240$ per hour and $\lambda_{offline} = 120$ per hour
- **Number of drinks ordered:**
  - Geometric distribution with $p_{offline} = 0.9$ and $p_{online} = 0.7$

**HEYTEA**

- **Number of workers:**
  - n=10
- **Serve rate:**
  - Online - Offline = 1
- **Queue limit:**
  - online limit $\gamma_{online} = 200$ and $\gamma_{offline} = 30$
- **Products:** (Table 1)

Table 1: HEYTEA's product matrix

| Type | Price | Probability | Serve rate $\mu$ |
|---|---|---|---|
| 1 | 22 | 0.30 | 32 |
| 2 | 25 | 0.25 | 30 |
| 3 | 28 | 0.20 | 28 |
| 4 | 30 | 0.15 | 25 |
| 5 | 32 | 0.10 | 22 |

## II. Model: strategies & goals

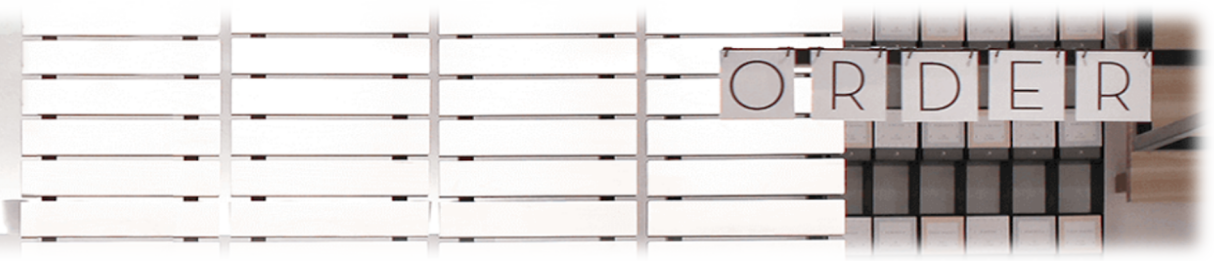
- **Strategy 1: FIFO**
  - Based on the time of arrival, orders are fulfilled sequentially, regardless of the online/offline channel
- **Strategy 2: Priority Balance**
  - We first set a **parameter $\theta$** indicating the ideal ratio of online and offline orders. On each customer arrival, if the ratio of cumulated number of finished online orders to offline orders is higher than $\theta$, the first offline customers will be served when next worker is available, regardless of the arrival time of the customer

- **Goal 1:**
  - Maximize total revenue
- **Goal 2:**
  - Minimizing average waiting time of customers
- **Goal 3: [Closest to reality]**
  - Maximize total revenue with waiting time penalty

$$Total\ revenue\ with\ wating\ time\ penalty = \sum_{i=1}^{N} total\ price_i \times (1 - at_i)$$

Choose $a$=20%, the total price for each customer is discounted by 20% for every hour waited

## II. Implementation




- **Overall guideline:**
  - For each above goal, we search the optimal $\theta$ by simulating the system by 100 arounds

- **Step 1:**
  - Try a sequence of $\theta$ from 0.01 to 100 and compare the mean, standard deviation and 95% confidence interval of each goal variable
- **Step 2:**
  - Use **Antithetic Method** for variance reduction
- **Step 3:**
  - Compare results to Strategy 1, which is our benchmark case

# III. Results & analysis

## ➢ Goal 1: Total revenue

Table 2: Output of Goal 1

*Panel A: STRATEGY 2*

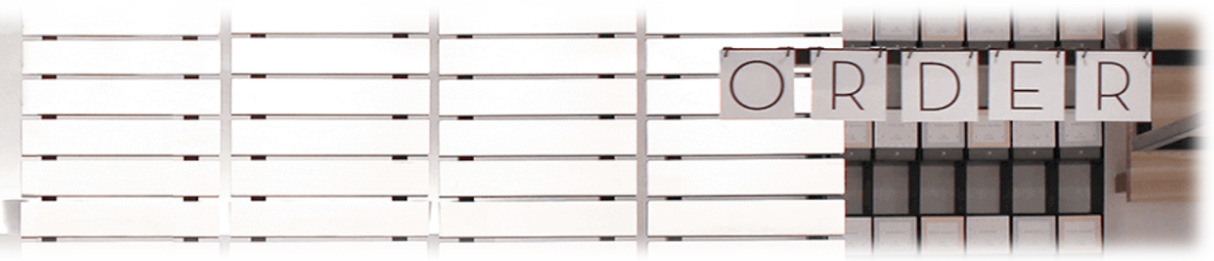
| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| 0.01 | 29322.15 | 309.81 | 29261.43 | 29382.87 | 121.44 |
| 0.1 | 29322.15 | 309.81 | 29261.43 | 29382.87 | 121.44 |
| 0.2 | 29317.19 | 309.25 | 29256.58 | 29377.80 | 121.22 |
| 0.4 | 29306.72 | 310.43 | 29245.87 | 29367.56 | 121.69 |
| 0.6 | 29316.10 | 288.97 | 29259.46 | 29372.74 | 113.27 |
| 0.8 | 29333.40 | 315.01 | 29271.66 | 29395.14 | 123.48 |
| 1.0 | 29362.25 | 362.80 | 29291.15 | 29433.36 | 142.21 |
| 2.0 | 28175.26 | 310.21 | 28114.46 | 28236.06 | 121.60 |
| 4.0 | 27426.88 | 301.86 | 27367.72 | 27486.05 | 118.33 |
| 6.0 | 27437.89 | 303.50 | 27378.41 | 27497.38 | 118.97 |
| 8.0 | 27429.27 | 306.06 | 27369.29 | 27489.26 | 119.97 |
| 10.0 | 27431.43 | 303.44 | 27371.96 | 27490.91 | 118.94 |
| 100.0 | 27430.14 | 303.96 | 27370.56 | 27489.71 | 119.15 |

*Panel B: STRATEGY 1 (Benchmark)*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| - | 27437.98 | 303.64 | 27378.46 | 27497.48 | 119.03 |

- *The total revenue reaches to its maximum of 29362.25 with $\theta$ being 1, which is reasonable, because the value of offline orders is larger than the online order.*
- *Compared with the benchmark strategy, the revenue improves by 7%, which shows a significant improvement of profitability.*
- *The CI width is significantly small compared with the mean of total revenue, which shows the robust of our result.*

## III. Results & analysis




### ➢ Goal 2: Average waiting time

Table 3: Output of Goal 2

*Panel A: STRATEGY 2*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| 0.01 | 0.694 | 0.018 | 0.691 | 0.698 | 0.007 |
| 0.1 | 0.694 | 0.018 | 0.691 | 0.698 | 0.007 |
| 0.2 | 0.694 | 0.018 | 0.691 | 0.698 | 0.007 |
| 0.4 | 0.695 | 0.018 | 0.691 | 0.698 | 0.007 |
| 0.6 | 0.695 | 0.018 | 0.691 | 0.698 | 0.007 |
| 0.8 | 0.701 | 0.021 | 0.697 | 0.706 | 0.008 |
| 1.0 | 0.728 | 0.024 | 0.723 | 0.733 | 0.010 |
| 2.0 | 0.751 | 0.023 | 0.746 | 0.755 | 0.009 |
| 4.0 | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |
| 6.0 | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |
| 8.0 | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |
| 10.0 | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |
| 100.0 | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |

*Panel B: STRATEGY 1 (Benchmark)*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| - | 0.757 | 0.025 | 0.752 | 0.762 | 0.010 |

- *Both the mean and standard deviation is decreased compared with the benchmark result.*
- *When $\theta$ equals to 0.4 and 0.6, the average waiting time reaches 0.695, decreased by 10.8% compared with the FIFO strategy.*

## III. Results & analysis

### ➢ Goal 3: Total revenue with waiting time penalty

Table 4: Output of Goal 3

*Panel A: STRATEGY 2*

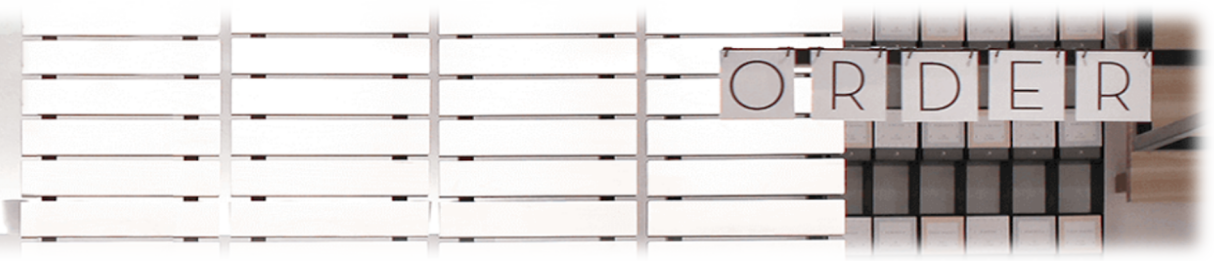
| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| 0.01 | 24621.87 | 351.73 | 24552.93 | 24690.81 | 137.88 |
| 0.1 | 24621.87 | 351.73 | 24552.93 | 24690.81 | 137.88 |
| 0.2 | 24616.04 | 347.99 | 24547.84 | 24684.25 | 136.41 |
| 0.4 | 24607.49 | 346.88 | 24539.50 | 24675.48 | 135.97 |
| 0.6 | 24611.70 | 336.19 | 24545.81 | 24677.59 | 131.78 |
| 0.8 | 24575.21 | 352.56 | 24506.11 | 24644.31 | 138.20 |
| 1.0 | 24368.09 | 418.45 | 24286.08 | 24450.11 | 164.03 |
| 2.0 | 23038.71 | 369.17 | 22966.35 | 23111.06 | 144.71 |
| 4.0 | 22296.92 | 372.44 | 22223.92 | 22369.92 | 145.99 |
| 6.0 | 22304.95 | 373.76 | 22231.70 | 22378.21 | 146.51 |
| 8.0 | 22299.28 | 377.32 | 22225.33 | 22373.24 | 147.91 |
| 10.0 | 22300.52 | 374.68 | 22227.09 | 22373.96 | 146.87 |
| 100.0 | 22299.52 | 375.79 | 22225.87 | 22373.18 | 147.31 |

*Panel B: STRATEGY 1 (Benchmark)*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| - | 22304.58 | 378.07 | 22230.48 | 22378.68 | 148.20 |

- ***This goal is the mixed to reach the balance between maximizing revenue and the minimizing the average time at the same time.***
- *The objectives reaches the highest when $\theta$ is 0.1.*
- *The best result of 24622 is significantly better than the benchmark result of 22305, increased by 10.4%.*
- *Our result is robust because both the CI width and standard deviation is significantly small compared with the mean of the objective*

## III. Results & analysis




### ➢ Further exploration: Total order

Table 5: Output of Total order

*Panel A: STRATEGY 2*

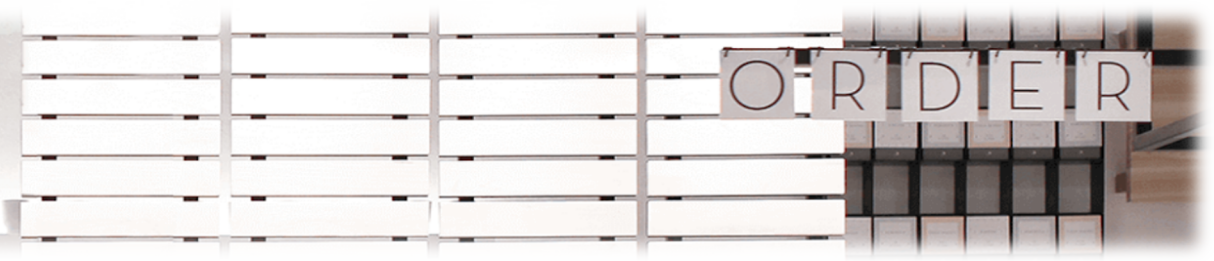
| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| 0.01 | 1111.40 | 16.22 | 1108.22 | 1114.57 | 6.36 |
| 0.1 | 1111.40 | 16.22 | 1108.22 | 1114.57 | 6.36 |
| 0.2 | 1111.12 | 16.09 | 1107.97 | 1114.27 | 6.31 |
| 0.4 | 1110.73 | 16.12 | 1107.57 | 1113.89 | 6.32 |
| 0.6 | 1111.13 | 15.60 | 1108.07 | 1114.18 | 6.11 |
| 0.8 | 1112.68 | 15.04 | 1109.73 | 1115.62 | 5.90 |
| 1.0 | 1117.13 | 17.06 | 1113.78 | 1120.47 | 6.69 |
| 2.0 | 1096.92 | 16.13 | 1093.76 | 1100.08 | 6.32 |
| 4.0 | 1082.09 | 16.13 | 1078.93 | 1085.25 | 6.32 |
| 6.0 | 1082.37 | 16.42 | 1079.15 | 1085.58 | 6.44 |
| 8.0 | 1082.29 | 16.48 | 1079.06 | 1085.51 | 6.46 |
| 10.0 | 1082.29 | 16.52 | 1079.05 | 1085.52 | 6.48 |
| 100.0 | 1082.25 | 16.56 | 1079.00 | 1085.49 | 6.49 |

*Panel B: STRATEGY 1 (Benchmark)*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| - | 1082.27 | 16.59 | 1079.02 | 1085.52 | 6.502 |

- *The total order reaches the maximum value at 1117.13 at $\theta$ is 1, still grabbing 35 orders more than the benchmark. The improvement may not be that significant.*
- *However, we still see a better result by our strategy .*

## III. Results & analysis




### ➢ Further exploration: Total lost order

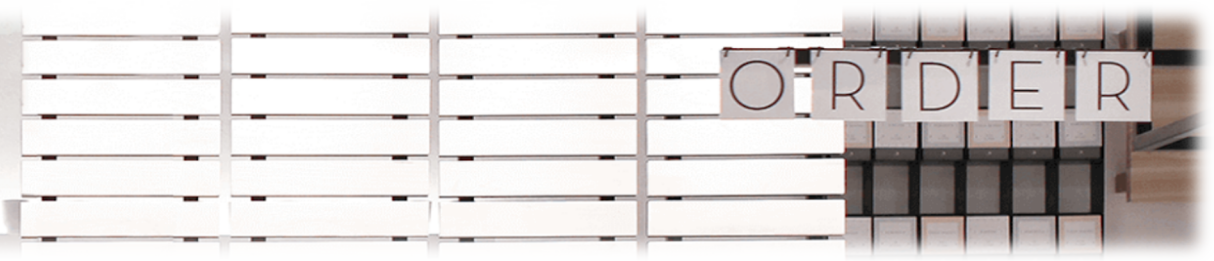
Table 6: Output of Total lost order

| *Panel A: STRATEGY 2* | | | | | |
|---|---|---|---|---|---|
| **$\theta$** | **Mean** | **Std. Dev.** | **CI lower** | **CI upper** | **CI Width** |
| 0.01 | 327.63 | 21.64 | 323.39 | 331.87 | 8.48 |
| 0.1 | 327.63 | 21.64 | 323.39 | 331.87 | 8.48 |
| 0.2 | 327.91 | 21.61 | 323.67 | 332.14 | 8.47 |
| 0.4 | 328.30 | 21.70 | 324.04 | 332.55 | 8.51 |
| 0.6 | 327.90 | 21.74 | 323.64 | 332.16 | 8.52 |
| 0.8 | 326.35 | 20.76 | 322.28 | 330.42 | 8.14 |
| 1.0 | 321.90 | 21.41 | 317.70 | 326.10 | 8.39 |
| 2.0 | 342.11 | 22.43 | 337.71 | 346.50 | 8.79 |
| 4.0 | 356.94 | 22.73 | 352.48 | 361.39 | 8.91 |
| 6.0 | 356.66 | 22.74 | 352.20 | 361.12 | 8.92 |
| 8.0 | 356.74 | 22.88 | 352.25 | 361.23 | 8.97 |
| 10.0 | 356.74 | 22.93 | 352.25 | 361.23 | 8.99 |
| 100.0 | 356.78 | 22.99 | 352.27 | 361.29 | 9.01 |

| *Panel B: STRATEGY 1 (Benchmark)* | | | | | |
|---|---|---|---|---|---|
| **$\theta$** | **Mean** | **Std. Dev.** | **CI lower** | **CI upper** | **CI Width** |
| - | 356.76 | 23.22 | 352.21 | 361.31 | 9.10 |

- *We are supposed to minimize the total lost order. The result is symmetrical to the total order we grab listed above.*
- *We get the best result at $\theta$ equals to 1.*

## III. Results & analysis




- **Further exploration: Total lost revenue**

Table 7: Output of Total lost revenue

*Panel A: STRATEGY 2*

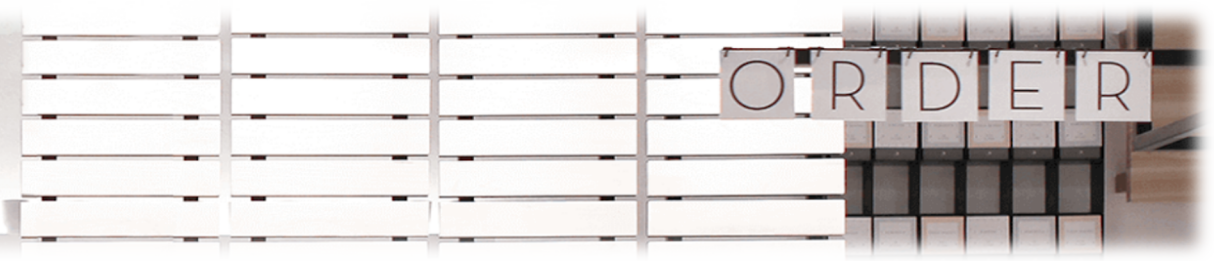
| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| 0.01 | 11010.73 | 775.91 | 10858.65 | 11162.80 | 304.15 |
| 0.1 | 11010.73 | 775.91 | 10858.65 | 11162.80 | 304.15 |
| 0.2 | 11017.59 | 775.91 | 10865.52 | 11169.67 | 304.15 |
| 0.4 | 11032.10 | 778.43 | 10879.53 | 11184.67 | 305.14 |
| 0.6 | 11018.10 | 771.83 | 10866.83 | 11169.38 | 302.55 |
| 0.8 | 10970.47 | 742.88 | 10824.87 | 11116.07 | 291.20 |
| 1.0 | 10651.19 | 761.40 | 10501.95 | 10800.42 | 298.46 |
| 2.0 | 10258.31 | 743.48 | 10112.59 | 10404.03 | 291.44 |
| 4.0 | 10160.93 | 758.78 | 10012.22 | 10309.65 | 297.43 |
| 6.0 | 10147.73 | 756.86 | 9999.39 | 10296.07 | 296.68 |
| 8.0 | 10157.44 | 766.36 | 10007.23 | 10307.64 | 300.41 |
| 10.0 | 10155.01 | 758.79 | 10006.29 | 10303.73 | 297.44 |
| 100.0 | 10156.57 | 761.00 | 10007.41 | 10305.72 | 298.31 |

*Panel B: STRATEGY 1 (Benchmark)*

| $\theta$ | Mean | Std. Dev. | CI lower | CI upper | CI Width |
|---|---|---|---|---|---|
| - | 10146.48 | 761.50 | 9997.23 | 10295.73 | 298.50 |

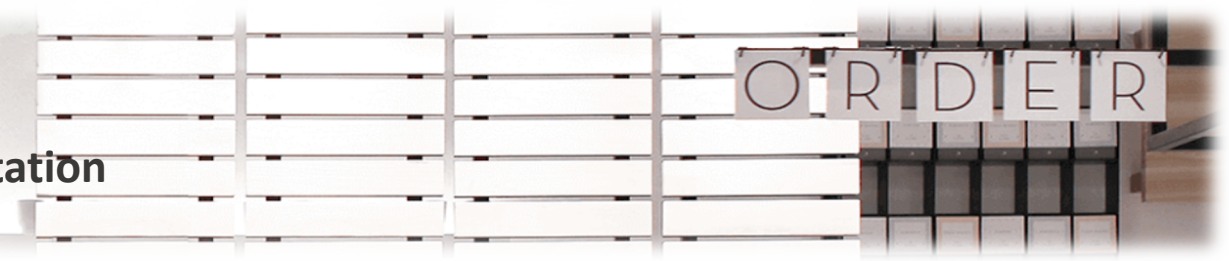
- *When $\theta$ increases from 0.4 to 4.0, the total revenue lost decreases from 11032 to 10147. It does not achieve our benchmark of 10146, because our goal is not only to maximize the revenue, but also to improve the satisfaction of our customers. .*

## IV. Conclusion & value proposition: Policy recommendation




- We use **Antithetic Method** on both the service time and the inter arrival time. The result achieved above is after the antithetic method. It leads to a robust result with relatively small CI.
- When **simply maximizing revenue**, $\theta$ is 1.
- When **minimizing average waiting time**, the range from 0.4 to 0.6 is the optimal.
- When **synthesize these two objectives, which is the total revenue with waiting time penalty,** the optimization is achieved when $\theta$ reaches 0.8.

- At **$\theta$ is 0.8**, the total revenue, the average waiting time and total revenue with waiting time penalty are 29333, 0.701 and 24575.21, **all of which are significantly better off than our benchmark, FIFO**. In addition, the three other objectives, total order, total lost order are all in acceptable range.
- When the historical proportion of online and offline orders is different from our target proportion, in the future, we will change the service priority and go to manual intervention to maintain this proportion.




## IV. Conclusion & value proposition: our contribution and limitation

***Contribution:***

- Parameter setting
- Strategy selection
- The results show that the objective function of our recommendation strategy is **improved by more than 10%** compared with the basic strategy, which **has a very positive impact on the overall development of enterprises.**

***Limitation and future work:***

- Parameter setting
- Model setting
- Method recommendation


# Thank you & Merry Christmas!

**Group 2**
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