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Cost Reduction by Fleet Planning for Parcel Delivery Service

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ABSTRACT

We consider the fleet planning problem for one of the leading Thai parcel delivery couriers, emphasizing the synchronization of fleet sizes with cyclical parcel volumes. The formulation of an integer programming problem aims to minimize fleet costs by leveraging historical parcel volumes. The model is applied to a single last-mile hub, resulting in a 19% reduction in the average monthly number of riders, a 22% decrease in the number of drivers, and an overall 19% reduction in fleet costs. Additionally, the model enhances fleet earnings, demonstrating a remarkable 36% increase in rider incentive payments and a 22% rise for drivers. In our model, we establish conditions that define the minimum number of fleets for each type of fleet on a daily basis. Furthermore, we guarantee that the total number of monthly shift fleets aligns with the daily count of shift fleets in each month. Encouraged by these positive outcomes, the recommendation is to extend the application of this model to all 95 last-mile hubs. The findings underscore the efficacy of strategic fleet planning in achieving cost reduction, operational optimization, and revenue increase across the organization.

Keywords: Integer programming; Mathematical programming; On-demand delivery; Workforce planning

1. Introduction

The surge in digital presence, notably in the realm of E-commerce, witnessed a notable uptick, as individuals turned to online avenues for their shopping needs. Moreover, a noteworthy trend emerged as some consumers transitioned into online selling, contributing significantly to the rapid growth of the E-commerce market. This upward trajectory in growth has remained consistent [1], underscoring a substantial expansion in the Thai parcel delivery market, as depicted in Fig 1.

The burgeoning E-commerce industry in Thailand is predominantly shaped by the pricing dynamics influencing customers' choices in parcel delivery services. Essentially, when a delivery company maintains low operating costs, it translates into reduced parcel delivery charges for

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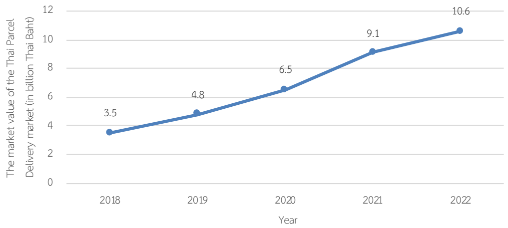

Fig. 1. The growth rate of the Thai Parcel Delivery market value.

customers. Of the various cost components associated with parcel delivery, the most significant, constituting 82%, is the fleet cost.

The parcel delivery fleet consists of two components: riders and drivers. A monthly comparison of parcel delivery volumes among these two categories reveals a consistent upward trend, forming a cyclical pattern. Specifically, every January witnesses the lowest parcel volume of the year, while December records the highest. Thus, towards the end of the year, the fleet scales up to accommodate the escalating parcel volume, necessitating the hiring of additional fleets to meet the rising demand.

However, at the beginning of the subsequent year, the previously hired fleet continues to operate as per their 6-month employment contracts. This results in a surplus of drivers at the beginning of the year, which clashes with the lower parcel volume during that period, as illustrated in Fig 2.

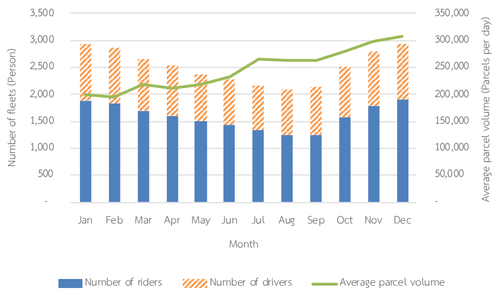

Fig. 2. Number of fleets not aligned with monthly parcel volume.

We consider the fleet planning problem to accommodate cyclical parcel volumes using mathematical programming to minimize fleet costs.

Thailand's diverse businesses experience seasonal product demand, requiring a dynamic workforce. Tailored workforce planning minimizes labor costs during low-demand periods, cutting management expenses. This paper provides insights for optimizing workforce planning in different industries, enhancing operational efficiency and cost-effectiveness.

The paper is organized as follows: Section 2 presents the literature review related to the study. Section 3 offers a comprehensive description of the problem. In Section 4, we introduce our mathematical model and elaborate on its application. Section 5 delves into a discussion of the results, while Section 6 provides an in-depth analysis and interpretation of the findings. Finally, Section 7 offers concluding remarks for the paper.

2. Literature Review

This section offers an overview of various studies in mathematical programming related to workforce planning. Hongyan and Peng [2] plan a workforce model for O2O logistics; they consider three employee types with varied compensation structures. The research focuses on reducing costs, determining each employee type's suitability, and optimizing task allocation based on demand, their result demonstrates the delivery capabilities' order, task reversal strategies, and substantial cost reduction benefits, from our approach, which focuses on workforce scheduling flexibility and cost reduction within our specific domain. The applicability extends to various delivery personnel, including riders and drivers, with adaptable cost reduction equations for exploring optimal workforce capabilities.

Addressing challenges in O2O (Online-to-Offline) on-demand services, Jiawei et al. [3] optimize order assignments, considering parameters such as orders per trip and detour proportion, influencing service capacities and profits in food/grocery delivery. Future research could explore models integrating future demand and custom incentives based on driver's capacities. The analysis of workload differences between experienced and inexperienced workers reveals a significant impact on efficiency. This knowledge is applicable to managing the distinct workloads of delivery personnel, with riders handling smaller parcels and having a higher workload compared to drivers.

Wicaksono and Ni [4] created a workforce planning tool by consolidating workforce requirements and calculating daily hours needed. Utilizing an Excel Pivot table, they determined the required number of employees, enabling streamlined production planning and anticipation of future workforce adjustments. The model also aids in recognizing potential redundancies in the production line. Given the unpredictable nature of parcel delivery businesses, marked by fluctuating daily volumes and irregular schedules of delivery personnel due to non-uniform work shifts, this research offers valuable insights for practical application.

Wathnakorn [5] investigated the challenges of managing workforce quantity to align with varying workloads. The study addressed issues arising from increased customer orders leading to higher production volumes. Urgent recruitment of new staff to meet production demands resulted in a mismatch of skills, hindering optimal performance. Workforce planning became imperative to address these issues, employing quantitative analysis and creating linear regression equations to model the relationship between production volumes and workforce quantity. The study aimed to benefit workforce optimization and future workforce planning in organizations dealing with varying monthly product quantities.

Lau et al. [6] developed models to enhance efficiency and operational practices for workforce allocation and scheduling issues. The results were obtained from a comparative analysis of algorithms, proposing high-quality solutions for workforce allocation and scheduling, particularly in semi-automated distribution centers. This paper can be beneficial by providing insights into workforce scheduling and allocation planning.

Goli et al. [7] investigated the challenges of multi-objective multi-period production planning (APP) under uncertain seasonal demand scenarios. The main objectives of this referenced research were to minimize overall costs, including in-house production, outsourcing, workforce hiring, raw material holding, material shortages, hiring costs, and idle times, while maximizing customer satisfaction levels to manage the uncertainty of demand. They applied efficiency-improving methods to a mixed-integer linear programming model, followed by the goal programming method to address diverse objectives and validate the efficiency of the model. The authors expressed interest in formulating "Subject to" equations, considering legal working hours without idle time and addressing uncertain customer demands in each season, expecting applicability in research.

3. Problem Description

A last-mile hub is responsible for receiving parcels from sorting centers and subsequently delivering them to customers within the hub's designated area. Monthly parcel volumes exhibit variation, reaching peaks at year-end due to festivities, promotional campaigns, and heightened order expenditures. Consequently, the early months of the year experience lower parcel volumes.

In addition to the fluctuation in monthly parcel volumes, daily parcel volumes also vary due to the closure of most sellers on weekends, resulting in the bulk dispatch of parcels to hubs on Mondays. After the sorting process based on delivery areas, parcels arrive to the hub, contributing to higher volumes on Tuesdays and Wednesdays, with Saturdays and Sundays marking the days.

with the lowest parcel volumes, as depicted in Fig 3.

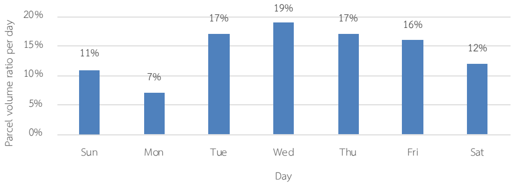

Fig. 3. Average parcel volume ratio per day.

The fleet consists of two parts: riders and drivers. Riders utilize motorcycles for small parcel delivery, while drivers operate pickup trucks for large packages. Each fleet is hired on a 6-month contract, working six days a week for seven hours per day. Monthly work schedules are determined by a hub supervisor, adhering to the required minimum fleet requirements. On weekdays (Monday to Friday), a hub is mandated to maintain a minimum of 3 riders and 2 drivers, while on weekends (Saturday and Sunday), the minimum requirement is 2 riders and 1 driver.

Compensation for the fleet consists of two components: base salary and incentive payments. The incentive payment is a product of the number of delivered parcels and the unit incentive payment for each hub. The criteria for incentive payments differ for each hub and each type of fleet.

In this paper, we focus on a single hub, and the aforementioned differences in the two types of fleets are summarized in Table 1. We list our model assumptions below:

1. The length of the delivery route, the distance between the hub and the destination delivery location, and the speed of movement and the transport time are not considered.

2. Each destination delivery location only receives deliveries from a single hub.

3. All scheduled riders and drivers do not get sick or absent.

Table 1. Fleet classification.

	Rider	**Driver**
Salary	11,000 THB per month	16,100 THB per month
Incentive fee	4.31 THB per parcel	11.39 THB per parcel
Workload	139 parcel per day	114 parcel per day
Weekdaymin	3 persons per day	2 persons per day
Weekendmin	2 persons per day	1 person per day
Proportion of parcels	0.68	0.32
Number of working days	24 days per month	24 days per month

4. Mathematical Models

We want to minimize fleet costs and ensure a sufficient number of fleets for daily parcel deliveries by formulating a linear integer programming problem as follows:

4.1 Index sets

$i=\{1,2,3,\ldots,12\}$, where i represents the monthly shift starting from month i to month $i+5$. for instance, $i=1$ corresponds to the shift from January to June, $j=\{1,2,3,\ldots,12\}$, representing months, where $j=1$ corresponds to January and $j=2$ to February, and so on, $k=\{1,2,3,\ldots,7\}$, representing daily shifts, where $k=1$ is the shift starting from Monday to Saturday, $k=2$ is the shift starting from Tuesday to Sunday, $k=3$is the shift starting from Wednesday to Monday, $k=4$ is the shift starting from Thursday to Tuesday, $k=5$ is the shift starting from Friday to Wednesday, $k=6$ is the shift starting from Saturday to Thursday, $k=7$ is the shift starting from Sunday to Friday,$q=\{1,2,3,\ldots,7\}$, representing days. For example, when $q=1$, it corresponds to Monday, $q=2$ to Tuesday, and so forth.

4.2 Parameters

m Monthly fleet planning indicator, considering each hub individually.

l Daily fleet planning indicator, considering each hub individually.

r Symbol for riders.

d Symbol for drivers.

P^l_{jq} Average parcel volume for month j, day q (parcels per day).

p^l_{rjq} Average small parcel volume for month j, day q (parcels per day).

p^l_{djq} Average large parcel volume for month j, day q (parcels per day).

ρ_r Proportion of small parcels, $0 \leq \rho_r \leq 1$.

ρ_d Proportion of large parcels, $0 \leq \rho_d \leq 1$.

W_r Maximum workload that a rider can deliver (parcels per day per person).

W_d Maximum workload that a driver can deliver (parcels per day per person).

w^l_{rjq} Workload of the rider for month j, day q (parcels per day per person).

w^l_{djq} Workload of the driver for month j, day q (parcels per day per person).

N^l_{rjq} Minimum required number for riders for month j, day q (person).

N^l_{djq} Minimum required number for drivers for month j, day q (person).

n^m_{rj} Monthly number of riders for month j (person).

n^m_{dj} Monthly number of drivers for month j (person).

n^l_{rjq} Daily number of riders for month j, day q (person).

n^l_{djq} Daily number of drivers for month j, day q (person).

S_r Monthly salary of riders (THB per month per person).

S_d Monthly salary of drivers (THB per month per person).

I_r Incentive fee of riders (THB per parcel).

I_d Incentive fee of drivers (THB per parcel).

$Weekdaymin_r$ Minimum number of riders required on weekday (person).

$Weekdaymin_d$ Minimum number of drivers required on weekday (person).

$Weekendmin_r$ Minimum number of riders required on weekend (person).

$Weekendmin_d$ Minimum number of drivers required on weekend (person).

4.3 Decision variables

R^m_j Number of riders for monthly in month j (persons).

D^m_j Number of drivers for monthly in month j (persons).

R^l_{kj} Number of riders for daily shift.

D^l_{kj} Number of drivers for daily shift k in month j (persons).

4.4 Objective Function

Minimize Annual Fleet Cost at hub

$$= \sum_{j=1}^{12}\left[\sum_{k=1}^{7} R^l_{kj} \times \left(S_r + 26 w^l_{rjq} \times I_r\right)\right] + \sum_{j=1}^{12}\left[\sum_{k=1}^{7} D^l_{kj} \times \left(S_d + 26 w^l_{djq} \times I_d\right)\right] \quad (4.1)$$

4.5 Constraints

$$n^l_{rjq} - N^l_{rjq} \geq 0 \; ; \forall j, \forall q \quad (4.2)$$

$$n^l_{rjq} - Weekdaymin_r \geq 0; \; \forall j, q \in \{1, 2, \ldots, 5\} \quad (4.3)$$

$$n^l_{rjq} - Weekendmin_r \geq 0; \; \forall j, q \in \{6, 7\} \quad (4.4)$$

$$n^l_{djq} - N^l_{djq} \geq 0; \; \forall j, \forall q \quad (4.5)$$

$$n^l_{djq} - Weekdaymin_d \geq 0 \; ; \forall j, \; q \in \{1, 2, \ldots, 5\} \quad (4.6)$$

$$n^l_{djq} - Weekendmin_r \geq 0 \; ; \forall j, q \in \{6, 7\} \quad (4.7)$$

$$\sum_{k=1}^{7} R_{kj}^{l} - n_{rj}^{m} = 0 \;;\forall j$$

$$\sum_{k=1}^{7} D_{kj}^{l} - n_{dj}^{m} = 0 \;;\forall j$$

$$R_j^m \geq 0, \text{ integer}; \forall j \tag{4.10}$$

$$D_j^m \geq 0, \text{ integer}; \forall j \tag{4.11}$$

$$R_{kj}^l \geq 0, \text{ integer}; \forall k, \forall j \tag{4.12}$$

$$D_{kj}^l \geq 0, \text{ integer}; \forall k, \forall j \tag{4.13}$$

4.5 Model description

The objective function (4.1) aims to minimize the fleet cost associated with parcel delivery. In this context, the coefficient of 26 represents the number of working days in a month. The annual fleet cost is calculated as the sum of fleet costs for both riders and drivers. This cost comprises salaries and incentive fees, where the latter is determined by multiplying the number of working days, the workload of delivery personnel, and the incentive fee per parcel.

Constraint (4.2) ensures that, for each month j, the number of riders is at least to the minimum required number necessary to handle the parcel volume for that specific day. Constraint (4.3) ensures that for each day q, the number of riders is at least the minimum required number for weekdays to handle the parcel volume for that day. Constraint (4.4) ensures that for each day q, the number of riders is at least the minimum required number for weekends to handle the parcel volume for that day. Constraint (4.5) ensures that, for each month j, the number of drivers is at least the minimum required number necessary to handle the parcel volume for that specific day. Constraint (4.6) ensures that for each day q, the number of drivers is at least the minimum required number for weekdays to handle the parcel volume for that day. Constraint (4.7) ensures that for each day q, the number of drivers is at least the minimum required number for weekends to handle the parcel volume for that day. Constraint (4.8) ensures that the daily number of riders in month j is equal to the monthly number of riders for that month. Constraint (4.9) ensures that the daily number of drivers in month j is equal to the monthly number of drivers for that month. Constraints (4.10) to (4.13) guarantee that the number of riders and drivers are non-negative integers, reflecting the impossibility of negative counts or fractional values for individuals.

The number of riders working on Sunday in month j is calculated as the sum of the number of daily shift riders from shift 2 to shift 7 as follows:

$$n_{rj1}^{l} = \sum_{k=2}^{7} R_{kj}^{l} \quad ;\forall j. \tag{4.14}$$

Number of riders working on Monday in month j is calculated as the sum of the number of daily shift riders for shift 1 and from shift 3 to shift 7 as follows:

$$n_{rj2}^{l} = R_{1j}^{l} + \sum_{k=3}^{7} R_{kj}^{l} \quad ;\forall j. \tag{4.15}$$

Number of riders working on Tuesday in month j is calculated as the sum of the number of daily shift riders from shift 1 to shift 2 and from shift 4 to shift 7 as follows:

$$n_{rj3}^{l} = \sum_{k=1}^{2} R_{kj}^{l} + \sum_{k=4}^{7} R_{kj}^{l} \quad ;\forall j. \tag{4.16}$$

Number of riders working on Wednesday in month j is calculated as the sum of the number of daily shift riders from shift 1 to shift 3 and from shift 5 to shift 7 as follows:

$$n_{rj4}^{l} = \sum_{k=1}^{3} R_{kj}^{l} + \sum_{k=5}^{7} R_{kj}^{l} \quad ;\forall j. \tag{4.17}$$

Number of riders working on Thursday in month j is calculated as the sum of the number of daily shift riders from shift 1 to shift 4 and from shift 6 to shift 7 as follows:

$$n_{rj5}^{l} = \sum_{k=1}^{4} R_{kj}^{l} + \sum_{k=6}^{7} R_{kj}^{l} \quad ;\forall j. \tag{4.18}$$

Number of riders working on Friday in month j is calculated as the sum of the number of daily shift riders from shift 1 to shift 5 and for shift 7 as follows:

$$n^{l}_{rj6} = \sum_{k=1}^{5} R^{l}_{kj} + R^{l}_{7j} \quad ;\forall j. \quad (4.19)$$

Number of riders working on Saturday in month j is calculated as the sum of the number of daily shift riders from shift 1 to shift 6 as follows:

$$n^{l}_{rj7} = \sum_{k=1}^{6} R^{l}_{kj} \quad ;\forall j. \quad (4.20)$$

Number of drivers working on Sunday in month j is calculated as the sum of the number of daily shift drivers from shift 2 to shift 7 as follows:

$$n^{l}_{dj1} = \sum_{k=2}^{7} D^{l}_{kj} \quad ;\forall j. \quad (4.21)$$

Number of drivers working on Monday in month j is calculated as the sum of the number of daily shift drivers for shift 1 and from shift 3 to shift 7 as follows:

$$n^{l}_{dj2} = D^{l}_{1j} + \sum_{k=3}^{7} D^{l}_{kj} \quad ;\forall j. \quad (4.22)$$

Number of drivers working on Tuesday in month j is calculated as the sum of the number of daily shift drivers from shift 1 to shift 2 and from shift 4 to shift 7 as follows:

$$n^{l}_{dj3} = \sum_{k=1}^{2} D^{l}_{kj} + \sum_{k=4}^{7} D^{l}_{kj} \quad ;\forall j. \quad (4.23)$$

Number of drivers working on Wednesday in month j is calculated as the sum of the number of daily shift drivers from shift 1 to shift 3 and from shift 5 to shift 7 as follows:

$$n^{l}_{dj4} = \sum_{k=1}^{3} D^{l}_{kj} + \sum_{k=5}^{7} D^{l}_{kj} \quad ;\forall j. \quad (4.24)$$

Number of drivers working on Thursday in month j is calculated as the sum of the number of daily shift drivers from shift 1 to shift 4 and from shift 6 to shift 7 as follows:

$$n^{l}_{dj5} = \sum_{k=1}^{4} D^{l}_{kj} + \sum_{k=6}^{7} D^{l}_{kj} \quad ;\forall j. \quad (4.25)$$

Number of drivers working on Friday in month j is calculated as the sum of the number of daily shift drivers from shift 1 to shift 5 and for shift 7 as follows:

$$n^{l}_{dj6} = \sum_{k=1}^{5} D^{l}_{kj} + D^{l}_{7,j} \quad ;\forall j. \quad (4.26)$$

Number of drivers working on Saturday in month j is calculated as the sum of the number of daily shift drivers from shift 1 to shift 6 as follows:

$$n^{l}_{dj7} = \sum_{k=1}^{6} D^{l}_{kj7} \quad ;\forall j. \quad (4.27)$$

The average volume of small parcels for day q is calculated based on the proportion of small parcels to the average parcel volume in that month. Since parcels cannot be fractional, rounding up is applied as follows:

$$p^{l}_{rjq} = Ceiling\left(\rho_{r} \times P^{l}_{jq}\right) \quad ;\forall j,\ \forall q. \quad (4.28)$$

The average volume of large parcels for day q is calculated by subtracting the average volume of small parcels for day q as follows:

$$p^{l}_{djq} = P^{l}_{jq} - p^{l}_{rjq} \quad ;\forall j,\ \forall q. \quad (4.29)$$

The minimum required number of riders for day q is calculated as the ceiling of the average quantity of small parcels divided by the workload that a rider can handle. Since riders cannot be fractional, rounding up is applied as follows:

$$N^{l}_{rjq} = Ceiling\left(\frac{p^{l}_{rjq}}{W_{r}}\right) \quad ;\forall j,\ \forall q. \quad (4.30)$$

The minimum required number of drivers for day q is calculated as the ceiling of the average quantity of large parcels divided by the workload that a driver can handle. Since drivers cannot be fractional, rounding up is applied as follows:

$$N^l_{djq} = Ceiling\left(\frac{p^l_{djq}}{W_d}\right) \quad ;\forall j,\ \forall q. \quad (4.31)$$

The workload for riders on day q is calculated as the ceiling of the average quantity of small parcels divided by the number of riders as follows:

$$w^l_{rjq} = Ceiling\left(\frac{p^l_{rjq}}{n^l_{rjq}}\right) \quad ;\forall j,\ \forall q. \quad (4.32)$$

The workload for drivers on day q is calculated as the ceiling of the average quantity of large parcels divided by the number of drivers as follows:

$$w^l_{djq} = Ceiling\left(\frac{p^l_{djq}}{n^l_{djq}}\right) \quad ;\forall j,\ \forall q. \quad (4.33)$$

For equations involving the ceiling function, we have rounded up the fractional part before integrating them into the model to ensure suitability for linear programming.

5. Results

We employ an integer programming approach to minimize fleet costs based on parcel volume in each time period. The Excel Solver is utilized to find solutions for the mathematical model, with data sourced from historical records over the past year and employee contractual agreements for each 6-month period.

The data entered for this scenario represents the average daily parcel quantity for each month. This is due to the business having seasonal variations both weekly and annually, as shown in Table 2.

Table 2. Input data of the average daily parcel volume for each month.

P^l_{jq}	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Jan	4,181	2,357	5,380	5,300	5,573	4,991	4,231
Feb	3,944	2,075	4,694	4,726	4,108	4,051	4,381
Mar	4,338	2,226	5,074	5,130	5,252	4,697	4,511
Apr	3,990	2,321	4,225	4,286	3,480	3,509	3,492
May	3,621	1,765	4,352	4,980	4,400	4,260	3,803
Jun	3,745	2,259	4,714	4,754	4,596	4,351	3,886
Jul	4,951	2,526	6,081	5,622	4,987	4,794	5,360
Aug	3,889	2,461	5,403	5,361	4,736	4,149	4,346
Sep	3,740	1,934	4,610	4,800	4,282	3,931	4,415
Oct	4,065	2,422	4,764	6,260	4,903	4,484	4,330
Nov	3,984	1,589	4,781	4,282	3,661	2,836	5,483
Dec	4,259	2,344	6,376	6,295	5,023	4,227	4,587

5.1 Main results

The results illustrate that aligning the fleet with parcel volumes leads to a 19% reduction in the number of riders and a 22% decrease in the number of drivers per month. This decrease stems from strategic fleet planning to synchronize with both daily and monthly parcel volumes. It's essential to emphasize that these findings are derived from the analysis of a single hub. As a result, the fleet is effectively tailored to meet delivery demands, minimizing the likelihood of fleet shortages or idle time.

When optimizing the number of fleets to better align with parcel volumes using mathematical modeling, the results indicate a reduction in fleet costs for parcel delivery. The fleet cost decreases by up to 19%, as depicted in Fig. 4.

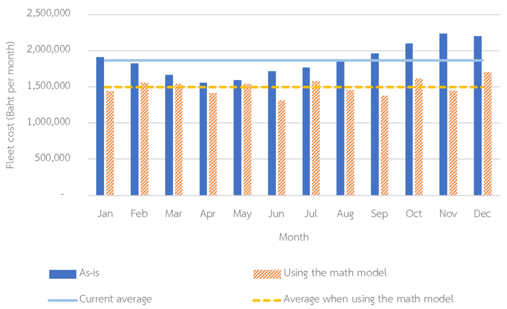

Fig. 4. Cost comparison results before and after implementing the model.

Moreover, the company can enhance the earnings of its fleets. Previously, fleets often received a similar volume of parcels entering the hub each day to ensure fair income distribution. However, this approach resulted in reduced income for fleets during months with low parcel volumes but excessive hiring. In this model, the number of fleets is adjusted to match parcel volumes, leading to increased income per fleet. The incentive pay for each fleet also increases, with riders experiencing a 36% boost and drivers seeing a 22% increase as well.

Our mathematical model is verified by walking through scheduling conditions with domain experts. The methods employed and the resulting outcomes were determined to be applicable in practice.

5.2 Sensitivity analysis

In this section, we examine the impact of altering input parameters on the annual fleet cost at the hub. The adjustments range from a reduction of 20% and 10% to an increase of 10% and 20%, showcasing the corresponding annual fleet cost at the hub values, as illustrated in Table 3.

Table 3. Impact on annual fleet cost at the hub on individual parameters.

Parameters	Annual fleet cost at the hub (THB)				
	20% Reduction	**10% Reduction**	**Current rate**	**10% Increase**	**20% Increase**
S_{rj}	17,220,434	17,603,234	17,986,034	18,368,834	18,751,634
S_{dj}	17,329,154	17,657,594	17,986,034	18,314,474	18,642,914
I_r	17,027,928	17,506,981	17,986,034	18,465,088	18,944,141
I_d	16,769,414	17,377,724	17,986,034	18,594,344	19,202,654
W_r	19,005,347	18,408,358	17,986,034	17,485,516	17,200,020
W_d	18,862,177	18,411,601	17,986,034	17,874,330	17,837,138
p^l_{rjq}	20,149,208	19,086,268	17,986,034	16,767,436	15,957,944
P^l_{jq}	14,210,826	16,402,357	17,986,034	19,646,591	21,532,898

From the analysis, it was found that Average parcel volume for month j, day q (P^l_{jq}) has the most significant impact on the annual fleet cost at the hub at 26%, as shown in Table 4. This implies that increasing the average daily parcel volume leads to a proportional increase in costs. Therefore, it is essential to accurately forecast the number of parcels entering each hub in the future to enhance overall management efficiency. Additionally, there is a need to develop delivery plans capable of coping with the uncertainty in volume and scheduling effectively. Implementing these strategies will help the logistics business adapt efficiently to increased parcel volumes without reducing the effectiveness of other operational aspects.

6. Discussion

We consider a single Last-Mile hub, but the company currently operates a total of 95 hubs. If the management decides to implement this mathematical model in every Last-Mile Hub, it will significantly contribute to cost reduction.

The fleet planning for parcel delivery is based on past data for comparison with the mathematical model. Directly using this historical data reveals the growing trend in the E-Commerce market. However, it is essential to note that relying solely on past data may introduce inaccuracies; hence, forecasting the parcel volume trend in the future using statistical methods is recommended.

Table 4. Percentage impact on annual fleet cost at the hub on individual parameters.

Parameters	Percentage change					
	20% Reduction	10% Reduction	Current rate	10% Increase	20% Increase	Total percentage change
S_{rj}	4%	2%	0%	2%	4%	13%
S_{dj}	4%	2%	0%	2%	4%	11%
I_r	6%	3%	0%	3%	5%	16%
I_d	7%	4%	0%	3%	6%	20%
W_r	5%	2%	0%	3%	5%	15%
W_d	5%	2%	0%	1%	1%	8%
p^t_{rjq}	11%	6%	0%	7%	13%	36%
P^t_{jq}	27%	10%	0%	8%	16%	61%

Analyzing this mathematical model within the context of multiple Last-Mile Hubs with distinct characteristics helps in understanding the efficiency and

benefits related to cost reduction in the company's parcel delivery operations. Implementing this model across all Last-Mile Hubs will support the company in enhancing the efficiency of its business activities, aligning with market demands, and preparing for future changes.

7. Conclusion

Using mathematical modeling to strategize the Last-Mile Hub's fleet, an illustrative example with a single hub showcases a reduction in fleet costs for parcel delivery. Presently, fleet costs average 22.39 million THB per year per hub, and with the implementation of the mathematical model, the costs are reduced to 17.99 million THB per year per hub, a reduction of 19%, approximately 4.41 million THB per year per hub.

Formulating a model for fleet planning is imperative, given its substantial impact on parcel delivery efficiency, cost minimization, and revenue increase for the company. Moreover, adept fleet planning can elevate the earnings of the fleets. Utilizing mathematical models enables the company to strategize and allocate budgets for hiring delivery drivers, optimizing the fleet in each hub to reflect parcel volumes during different time periods. The model calculates the optimal fleet size and delivery schedules, ensuring operations are efficient and responsive to customer needs.

The mathematical model is versatile and can adapt to future changes such as alterations in organizational objectives or modifications to facility schedules and job sequencing. Additionally, it can be applied to businesses with similar characteristics, enabling effective responses to changes in various situations, including human resource management or resource planning challenges.

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