

Room Allocation Planning in Room Rental Business Using Integer Linear Programming

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Abstract

This study develops a mathematical model for room allocation in a small-scale accommodation business by simultaneously considering

daily and monthly stays under capacity constraints. The model incorporates time-varying demand, fixed and variable costs, and opportunity costs arising from inefficient resource utilization. Framed within revenue management and operations research, the proposed approach is formulated as a pure integer linear programming model and solved using LINGO. The empirical analysis is based on real operational data from an accommodation facility consisting of 35 rooms classified into six room types, offering both short-term and long-term stays. Historical demand data over a one-year period are integrated into the model. The results demonstrate that the proposed model achieves a global optimal solution and significantly improves total profit compared to the existing allocation policy. Furthermore, the findings emphasize the importance of opportunity cost in room allocation decisions and show that a time-dependent mixed allocation strategy between daily and monthly stays enhances capacity utilization while systematically reducing revenue loss from unsold rooms.

Keywords

Integer Linear Programming, Revenue Optimization, Accommodation Management

1. Introduction

The hotel and accommodation industry plays a vital role in the Thai economy, as it significantly contributes to employment generation and tourism-driven revenue. The sector supports more than 1.5 million jobs nationwide, while Thailand welcomes an average of over 40 million tourists annually. Despite this strong demand, the rapid expansion of accommodation facilities in recent years has intensified competition and led to an oversupply of rooms in many areas, placing substantial financial pressure on hotel and accommodation operators.

Empirical evidence suggests that oversupply is more prevalent in provincial areas than in major tourist destinations or economic centers. In these regions, accommodation businesses often experience low occupancy rates, resulting in many vacant rooms. Such conditions increase the burden of fixed operating costs and generate opportunity costs from underutilized resources, ultimately reducing overall profitability and threatening business sustainability.

Given these challenges, there is a growing need for effective strategies to support the recovery and long-term viability of accommodation businesses facing persistent vacancy issues. Revenue management has been widely recognized as a systematic approach for improving profitability through optimal capacity allocation and demand-based decision-making. However, traditional managerial practices often rely on intuition rather than quantitative analysis and may fail to account for opportunity costs associated with unused room capacity.

To address this gap, this study applies revenue management concepts in combination with operations research techniques to develop a decision-support framework for accommodation allocation. Mathematical optimization is employed to identify allocation strategies that maximize profit under capacity and demand constraints. The proposed model is implemented using the LINGO optimization software to solve the problem efficiently and obtain optimal solutions. By integrating economic considerations with quantitative modeling, this research aims to provide practical insights for accommodation operators seeking to improve resource utilization and financial performance under conditions of oversupply.

2. Literature Review

2.1 Revenue Management in the Accommodation Industry

Revenue management has been widely recognized as an effective approach for maximizing revenue through demand-driven pricing and capacity allocation under uncertainty. Kimes (1989) laid the foundational principles of revenue management by characterizing hotel rooms as perishable assets whose value is lost if unsold within a given time period. Subsequent studies expanded these concepts to the hospitality sector by emphasizing the integration of demand forecasting, pricing strategies, and capacity control in improving financial performance (Weatherford and Bodily 1992; Hayes and Ninemeier 2009). More recent research confirms that revenue management techniques remain highly relevant in accommodation businesses operating under fluctuating demand and competitive market conditions (Guillet 2020).

2.2 Room Allocation and Capacity Management

Room allocation is a critical operational decision that directly affects occupancy rates and revenue outcomes in accommodation businesses. Zhang and Weatherford (2012) proposed a room allocation framework that balances demand across multiple room types while accounting for capacity constraints. Cross et al. (2011) demonstrated that inappropriate allocation decisions, particularly those prioritizing short-term gains, may result in capacity misutilization and long-term revenue loss. These findings highlight the importance of systematic allocation strategies that align room availability with heterogeneous demand patterns.

2.3 Mathematical Optimization and Integer Programming Approaches

Mathematical optimization has been extensively applied to support decision-making in revenue and capacity management problems. Talluri and Ryzin (2004) developed optimization-based revenue management models that explicitly incorporate capacity and demand uncertainty. In hospitality applications, integer linear programming has proven particularly effective due to the discrete nature of room inventory and booking decisions (Kimes, 1989; Ivanov and Zhechev 2012). These models provide globally optimal solutions and transparent decision rules that can be directly implemented in managerial practice.

2.4 Opportunity Cost and Resource Utilization

Opportunity cost has been increasingly recognized as a critical factor in capacity allocation decisions. Weatherford and Kimes (2003) argued that ignoring opportunity cost may lead to suboptimal acceptance and rejection decisions in revenue management systems. In the accommodation context, opportunity cost typically arises when rooms are allocated to lower-yield stays while higher-yield demand is displaced or unmet. Ara et al. (2022) demonstrated that explicitly incorporating opportunity cost into optimization models can significantly reduce revenue loss from idle or inefficiently allocated capacity.

2.5 Length of Stay and Time-Dependent Allocation Decisions

Several studies emphasize the importance of considering length-of-stay characteristics in accommodation revenue management. Weatherford and Bodily (1992) introduced a conceptual framework showing that accepting bookings at one point in time affects future revenue opportunities. Chiang et al. (2007) further highlighted that time-dependent demand and varying lengths of stay introduce dynamic trade-offs in allocation decisions. Talluri and Ryzin (2004) showed that neglecting these temporal interactions may result in biased revenue estimates and inefficient capacity utilization.

2.6 Decision Support Systems and the Use of LINGO

Operations research provides a structured framework for developing decision-support tools through mathematical modeling. Russell and Taylor (2010) described the fundamental components of optimization models, including decision variables, objective functions, and constraints. LINGO has been widely used to solve linear, integer, and

mixed-integer programming problems due to its ability to efficiently handle complex constraint structures. Boonmee (2021) and Likasiri (2021) demonstrated the applicability of optimization software for solving resource allocation problems in management and engineering contexts. Garza (2017) further confirmed that mixed-integer linear programming models can effectively capture the interaction between demand, pricing, and limited capacity.

2.7 Recent Developments in Revenue Management Decisions

Recent research in revenue management increasingly integrates analytical optimization with a deeper understanding of customer behavior. Qi et al. (2024) emphasized that the effectiveness of dynamic pricing depends not only on revenue maximization but also on how customers perceive fairness and transparency. Their results suggest that managerial decisions must consider behavioral responses alongside mathematical optimality. Extending this perspective, Moula et al. (2024) demonstrated how data mining techniques can uncover heterogeneous customer segments, enabling more tailored strategies and refined decision rules. By identifying distinct patterns in booking behavior, analytics can better align operational policies with market characteristics. Together, these studies illustrate a broader movement toward customer aware and data driven decision support, where optimization models are expected to reflect both quantitative efficiency and behavioral realities.

The literature review reveals that most existing studies focus on large-scale hotels or consider a single type of stay, typically daily bookings. Limited attention has been given to small-scale accommodation businesses that simultaneously serve daily and monthly stays, particularly under conditions of oversupply in non-tourist regions. Moreover, opportunity cost is often discussed conceptually but rarely integrated explicitly into mathematical room allocation models. To address these gaps, this study develops an integer linear programming model that incorporates time-varying demand, multiple room types, fixed and variable costs, and opportunity cost to support optimal room allocation decisions for small-scale accommodation businesses.

3. Research Methodology

3.1 Case Study Description

The case study focuses on a small-scale accommodation business operating at a semi-resort hotel standard in a provincial area of Thailand. The business primarily serves long-term (monthly) customers, most of whom are health science students undertaking internships, medical personnel, and relatives of patients receiving treatment at nearby hospitals. In addition, the accommodation also serves short-term (daily) customers, including general tourists. The facility consists of three accommodation buildings with a total of 35 rooms, categorized into six different room types. Two types of stays are offered: short-term (daily) and long-term (monthly). For long-term stays, customers are required to sign a minimum contract period of three months.

3.2 Data Collection and Data Management

The data used in this study are divided into two main categories: (1) basic room-related data and (2) historical customer demand data. These datasets provide the necessary input parameters for model formulation and analysis.

Basic information related to the six room types was collected to calculate fixed and variable costs. Fixed costs include business licensing fees, employee wages, waste management fees, air-conditioning maintenance costs, and internet service expenses. These costs were calculated on an annual basis and then allocated proportionally to each room type according to room size, as room areas differ across categories. The allocated fixed costs were subsequently converted into daily and monthly fixed costs per room.

Variable costs were calculated based on service activities associated with each stay type. For monthly stays, variable costs include bedding replacement and room cleaning services conducted once per month. For daily stays, additional variable costs were incurred, including amenities provided to guests such as bottled water, soap, shampoo, instant coffee, as well as electricity and water consumption. Based on the calculated fixed and variable costs and the corresponding room prices, the daily and monthly profits for each room type were determined. Costs were distributed proportionally by room size since financial records and expense structures are organized according to physical room characteristics. Table 1 summarizes the cost structure and profit information for all six room types.

Room demand data were collected from historical records covering a one-year period, from January 1, 2023, to December 31, 2023. Demand values were expressed in integer units because room availability and reservations are recorded and managed on a per room basis. Fractional results obtained from averaging therefore required conversion to whole numbers. Daily occupancy data for each room were recorded and organized in Microsoft Excel on a monthly

basis. Each room and room type was tracked individually, with different colors used to distinguish stay durations. Daily stays were recorded without color coding, while monthly stays were highlighted in grey to facilitate data classification and analysis.

Table 1. Cost and Profit Data for Each Room Type

Room Type	Number of Rooms	Daily Rental Price (Including Monthly Equivalent)	Daily Cost (Including Monthly Equivalent)	Daily Profit (Including Monthly Equivalent)	Monthly Rental Price	Monthly Cost	Monthly Profit	Fixed Profit per Room per Month
1	2	13500	2630	10870	4500	980.92	3519.08	952.16
2	15	18000	2954	15046	6500	1314.18	5185.82	1285.42
3	2	18000	2954	15046	6500	1314.18	5185.82	1285.42
4	11	21000	3179	17821	7000	1382.74	5617.26	1338.98
5	4	21000	4667	16333	7500	1457.25	6042.75	1398.49
6	1	24000	5705	18295	7500	1495.81	6004.19	1452.05

(All monetary values are in Thai Baht)

On days when a room was occupied, a value of one (1) was recorded in the dataset, whereas unoccupied days were left blank, as illustrated in Figure 1. To transform daily demand data into monthly demand figures suitable for model input, daily usage counts were averaged over the number of days in each month. For example, if Room Type 2 recorded a total of 78 occupied days in January, the average daily demand for that month was calculated as 78 divided by 31, resulting in 2.5 rooms per day. Because room demand must be expressed as an integer, the value was rounded up to 3 rooms per day. This rounding method introduces a conservative bias, which may slightly overestimate the profit. This procedure was applied to all room types and all months, resulting in monthly average demand values for both daily and monthly stays throughout the year 2023.

Room no.	Jan-23																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
33	1		1	1					1	1					1	1				1	1	1					1				1	
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
101			1					1	1			1									1			1							1	
102	1									1			1				1					1				1		1	1			
201	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
202	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
203			1								1				1	1					1				1			1	1		1	
204	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
205	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
301	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
302	1		1		1				1			1			1	1					1			1				1				
303	1	1				1				1					1	1						1		1	1						1	
304			1				1			1		1	1			1			1			1					1		1			
305	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
111	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
112	1	1		1				1	1	1					1		1							1								
113	1				1			1				1						1				1	1				1		1			
114			1				1				1	1			1							1	1									
115	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
211	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
212			1		1			1		1		1				1	1	1				1			1			1	1		1	
213	1	1		1			1					1								1				1		1					1	
214	1	1		1				1	1			1			1				1		1										1	
215		1		1					1										1			1	1				1	1				
311	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
312	1			1		1	1	1	1				1							1		1						1			1	
313	1			1	1					1	1	1				1	1				1		1				1		1			
314	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
315	1	1			1		1		1				1				1	1			1				1	1						

Figure 1. Example of Room Demand Data Collection

3.3 Mathematical Model Formulation

Based on the data collected in Section 3.2, the information is transformed into parameters for the mathematical optimization model. The model is formulated as follows.

Indices

i : Type of room ($i = 1, 2, 3, 4, 5, 6$)

t : Months ($t = 1, 2, \dots, 12$)

Parameters

Room_{i}	: Total number of rooms of type i
Price_{dm_i}	: Daily rental price (aggregated to monthly value) for room type i
Price_{m_i}	: Monthly rental price for room type i
Cost_{dm_i}	: Total monthly cost of daily rental rooms of type i
Cost_{m_i}	: Monthly cost of monthly rental rooms of type i
Fixed_{$cost_{dm_i}$}	: Fixed cost of daily rental rooms of type i
Demand_{dm_i}	: Average monthly demand for daily rental rooms of type i in month t
Demand_{m_i}	: Monthly demand for monthly rental rooms of type i in month t
Min_{monthlylimit}	: Minimum number of rooms allocated to monthly rentals per month

Decision Variables

$X_{i,t}$	Number of nights sold under daily rental for room type i in month t (unit: nights/room)
$Y_{i,t}$	Number of rooms rented under monthly contracts for room type i in month t (unit: rooms)
$Z_{i,t}$	Number of rooms of type i that start a new monthly contract in month t (minimum contract length: 3 months)

Deviation Variables

$D^-_{i,t}$	Lost sales of daily rental rooms of type i in month t
$D^+_{i,t}$	Excess capacity of daily rental rooms of type i in month t
$M^-_{i,t}$	Lost sales of monthly rental rooms of type i in month t
$M^+_{i,t}$	Excess capacity of monthly rental rooms of type i in month t

Objective Function

The objective of the model is to **maximize total annual profit**, defined as:

$$\begin{aligned} \max Z = \sum_{i=1}^6 \sum_{t=1}^{12} [& x_{i,t}(Price_dm_i - Cost_dm_i) + y_{i,t}(Price_m_i - Cost_m_i) \\ & - D^-_{i,t}(Price_dm_i - Cost_dm_i) - M^-_{i,t}(Price_m_i - Cost_m_i) \\ & - D^+_{i,t}(Fixed_cost_dm_i) - M^+_{i,t}(Fixed_cost_dm_i)] \end{aligned}$$

This objective function accounts for revenue from daily and monthly rentals while subtracting opportunity costs from lost sales and excess capacity.

Constraints

1. Room Capacity Constraint

The total number of rooms allocated to daily and monthly rentals must not exceed the available number of rooms:

$$x_{i,t} + y_{i,t} \leq Room_i \quad \forall i, t$$

2. Minimum Monthly Rental Requirement

The total number of monthly rental rooms must not be less than the minimum required level:

$$\sum_{i=1}^6 y_{i,t} \geq Min_{monthlylimit} \quad \forall t$$

3. Minimum Contract Duration Constraint

Monthly rental contracts must last for at least three months. If a new contract starts in month t , it must remain active through month $t + 2$:

$$y_{i,t} \geq z_{i,t} + I(t > 1)z_{i,t-1} + I(t > 2)z_{i,t-2} \quad \forall i, t$$

where $I(\cdot)$ is an indicator function equal to 1 if the condition inside the parentheses is satisfied, and 0 otherwise.

4. Monthly Rental Continuity Constraint

The number of monthly rental rooms in each month cannot exceed the total of existing contracts from the previous month plus new contracts initiated in the current month:

$$y_{i,t} \leq y_{i,t-1} + z_{i,t} \quad \forall i, t > 1$$

5. Demand Soft Constraints

Sales are restricted by demand levels. Any deviation from demand is captured using deviational variables and penalized as opportunity costs in the objective function.

Daily rental demand constraint:

$$x_{i,t} + D_{i,t}^- - D_{i,t}^+ = Demand_dm_{i,t} \quad \forall i, t$$

Monthly rental demand constraint:

$$y_{i,t} + M_{i,t}^- - M_{i,t}^+ = Demand_m_{i,t} \quad \forall i, t$$

6. Non-Negativity and Integer Constraints

$$x_{i,t}, y_{i,t}, z_{i,t}, D_{i,t}^-, D_{i,t}^+, M_{i,t}^-, M_{i,t}^+ \in \mathbb{Z}^+, \mathbb{Z}^0$$

3.4 Optimization Analysis Using LINGO Version 21

After defining the parameters, decision variables, objective function, and constraints as described in Section 3.3, the proposed mathematical model is implemented in the LINGO optimization software (Version 21) to obtain the optimal solution. Historical demand data for both daily and monthly stays over the year 2023, as presented in Section 3.2, are incorporated into the model as demand parameters to evaluate the maximum achievable profit.

The mathematical model is coded and solved in LINGO following three main steps, as illustrated in Figure 2.

- **Step 1:** Definition of index sets In this step, the index sets are specified to establish the relationships among parameters and decision variables, including room types and time periods.
- **Step 2:** Parameter specification The second step involves assigning parameter values based on the operational data of the accommodation facility. These parameters represent fixed numerical values derived from the cost and revenue information summarized in Table 1.
- **Step 3:** Model formulation and optimization In the final step, the objective function and all relevant constraints are defined. The LINGO solver is then used to perform the optimization process and determine the optimal allocation strategy that maximizes total profit under the given constraints.

```

MODEL:
SETS:
    ROOMTYPE /1..6/: room, price_dm, price_m, cost_dm, cost_m, fixedcost_m;
    MONTHS /1..12/:
        RT(ROOMTYPE, MONTHS): x, y, z, demand_d, demand_m,
                                Lost_D, Over_D, Lost_M, Over_M;
ENDSETS

DATA:
    room = 2 15 2 11 4 1;
    price_dm = 13500 18000 18000 21000 21000 24000;
    cost_dm = 2630 2954 2954 3179 4667 5705;
    price_m = 4500 6500 6500 7000 7500 7500;
    cost_m = 980.92 1314.18 1314.18 1382.74 1457.25 1495.81;
    fixedcost_m = 952.16 1285.42 1285.42 1338.98 1398.49 1452.05;

    demand_d =
    0 1 1 1 1 1 1 1 1 1 1 1
    3 2 3 3 3 2 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 0 0 0
    3 2 2 3 3 2 2 3 4 3 3 3
    0 0 0 0 0 0 0 0 0 0 0 0
    0 0 0 0 0 0 0 0 0 0 0 0;

    demand_m =
    2 1 1 1 1 1 1 1 1 1 1 1
    7 7 6 9 9 9 12 13 13 13 13 13
    1 1 1 1 1 1 1 1 1 2 2 2
    3 3 3 3 4 4 5 5 5 6 6 6
    4 4 4 4 4 4 4 4 4 4 4 4
    1 1 1 1 1 1 1 1 1 1 1 1;

    min_monthly_limit = 15;
ENDDATA

! --- OBJECTIVE FUNCTION --- ;
MAX = @SUM(RT(i, t):
    (x(i, t) * (price_dm(i) - cost_dm(i))) +
    (y(i, t) * (price_m(i) - cost_m(i))) -
    (Lost_D(i, t) * (price_dm(i) - cost_dm(i))) -
    (Lost_M(i, t) * (price_m(i) - cost_m(i))) -
    (Over_D(i, t) * fixedcost_m(i)) -
    (Over_M(i, t) * fixedcost_m(i))
);

! --- CONSTRAINTS --- ;
1. Capacity:
@FOR(RT(i, t):
    x(i, t) + y(i, t) <= room(i);
);

2. Monthly Limit:
@FOR(MONTHS(t):
    @SUM(ROOMTYPE(i): y(i, t)) >= min_monthly_limit;
);

3. Contract 3 Months Logic:
@FOR(RT(i, t):
    y(i, t) >= z(i, t) + @IF(t #GT# 1, z(i, t-1), 0) + @IF(t #GT# 2, z(i, t-2), 0);
    y(i, t) <= @IF(t #GT# 1, y(i, t-1), 0) + z(i, t);
);

4. Demand Soft Constraints:
x(i, t) + Lost_D(i, t) - Over_D(i, t) = demand_d(i, t);
y(i, t) + Lost_M(i, t) - Over_M(i, t) = demand_m(i, t);
);

5. Integer Variables:
@FOR(RT(i, t):
    @GIN(x(i, t)); @GIN(y(i, t)); @GIN(z(i, t));
    @GIN(Lost_D(i, t)); @GIN(Over_D(i, t));
    @GIN(Lost_M(i, t)); @GIN(Over_M(i, t));
);
END
    
```

Figure 2 The mathematical model implemented using LINGO.

Lingo 21.0.38 Solver Status [Lingo_model_24Jan2026_Newwww]	
Solver Status:	
Model Class:	PIIP
State:	Global Opt
Objective:	4.21443e+06
Infeasibility:	0
Iterations:	130
Extended Solver Status:	
Solver Type:	B-and-B
Best Obj:	4.21443e+06
Obj Bound:	4.21443e+06
Steps:	0
Active:	0
Variables:	
Total:	504
Nonlinear:	0
Integers:	504
Constraints:	
Total:	373
Nonlinear:	0
Nonzeros:	
Total:	1560
Nonlinear:	0
Generator Memory Used (K):	115
Elapsed Runtime (hh:mm:ss)	00:00:00
Update Interval: 2	Interrupt Solver
Close	

Figure 3 Results generated by LINGO.

As shown in Figure 3, the solver status from LINGO after solving the Pure Integer Linear Programming (PILP) model and successfully obtained the global optimal solution without infeasibility using the Branch-and-Bound algorithm.

4. Results and Discussion

4.1 Validation of the Mathematical Model Using Real Data

The purpose of this validation experiment is to verify the correctness of parameter input and ensure that the optimization calculations performed by the LINGO software are accurate. In this test, the decision variables for both daily and monthly rentals are fixed to equal the corresponding demand parameters, without considering any of the constraints defined in Section 3.3.

Under this setting, the model represents a direct profit calculation based solely on demand fulfillment. The results obtained from the LINGO software, as shown in Figure 4, are then compared with profit calculations performed independently using Microsoft Excel, as presented in Table 2.

The comparison indicates that the total profit calculated by both software tools is identical, with a value of 2,427,044.48 THB (approximately 77,232.91 USD) . This consistency confirms that the parameters are correctly specified and that the mathematical model has been properly implemented in the LINGO environment.

```

LINGO/WIN64 21.0.38 (22 Apr 2025), LINDO API 15.0.6099.233

Licensee info: watchara_sattha@cmu.ac.th
License expires: 9 JUL 2026

Global optimal solution found.
Objective value:                2427044.
Objective bound:                2427044.
Infeasibilities:                0.000000
Extended solver steps:          0
Total solver iterations:        0
Elapsed runtime seconds:        0.23
    
```

Figure 4. Validation Results Obtained from LINGO

Table 2. Results of Model Validation Using Microsoft Excel

Month	Profit from Daily Stays (THB)	Profit from Monthly Stays (THB)	Total Profit (THB)
1	94129.1	95551.69	189680.79
2	78633.5	92032.61	170666.11
3	93672.35	86846.79	180519.14
4	101680.15	102404.25	204084.4
5	98670.85	108021.51	206692.36
6	82460.9	108021.51	190482.41
7	70006.1	129196.23	199202.33
8	85342.7	134382.05	219724.75
9	98071.4	134382.05	232453.45
10	62026.2	145185.13	207211.33
11	63670.05	145185.13	208855.18
12	72287.1	145185.13	217472.23
			2427044.48

4.2 Optimization Results for the Case Study

After validating the mathematical model, all constraints defined in Section 3.3 are incorporated into the optimization process, allowing the decision variables to function fully in determining the optimal room allocation strategy. The results indicate that the proposed model successfully identifies an optimal solution. The LINGO software reports a

global optimal solution, confirming that the model is stable and free from conflicting constraints within the system. The optimal value of the objective function, representing the maximum achievable profit, is 4,214,429 THB or approximately 134,138.45 USD. In addition, the objective bound is equal to the objective function value, indicating that the solution is truly optimal with no optimality gap. The model reports zero infeasibilities, demonstrating that all constraints are satisfied simultaneously and that the solution is feasible under real operational conditions. The optimization results obtained from the LINGO software are illustrated in Figure 5.

```

LINGO/WIN64 21.0.38 (22 Apr 2025), LINDO API 15.0.6099.23

Licensee info: watchara_sattha@cmu.ac.th
License expires:  9 JUL 2026

Global optimal solution found.
Objective value:           4214429.
Objective bound:           4214429.
Infeasibilities:            0.000000
Extended solver steps:      0
Total solver iterations:    130
Elapsed runtime seconds:    0.22

Model Class:                PILP

Total variables:             504
Nonlinear variables:         0
Integer variables:           504

Total constraints:           373
Nonlinear constraints:        0

Total nonzeros:             1560
Nonlinear nonzeros:          0

```

Figure 5. Optimization Results of The Case Study

From a computational perspective, the model requires a total of 130 solver iterations to reach the optimal solution. The problem is classified as a Pure Integer Linear Programming (PILP) model. It consists of 504 decision variables, all of which are integer variables, and 373 constraints.

Based on these results, it can be concluded that the proposed mathematical model is appropriate and effective in solving the room allocation problem. The model produces a feasible and globally optimal solution and can be reliably applied for economic analysis and managerial decision-making in room allocation and revenue management. The findings demonstrate the model's potential to support strategic decisions aimed at improving resource utilization and maximizing profitability in small-scale accommodation businesses.

4.3 Results Interpreting

The results of the room allocation analysis, separated into daily and monthly stay formats over the 12-month planning horizon, indicate distinct allocation patterns across room types. For daily stays, room types 2 and 4 are allocated in relatively high proportions throughout the year. However, the allocation of room type 2 decreases starting from April, while the allocation of room type 4 increases steadily toward the end of the year. This pattern reflects seasonal changes in profit suitability across room types. In contrast, room type 5 is not allocated to daily stays at any time during the year, as shown in Table 3.

For monthly stays, room type 5 is consistently allocated throughout the year, indicating stable long-term demand. Room type 2 shows an increase in allocation beginning in the middle of the year, whereas room types 4 and 6 are suitable for monthly stays only during the early months of the year, as presented in Table 4.

Overall, the model suggests that accommodation management should adopt a time-dependent mixed strategy between daily and monthly stays in order to reduce opportunity costs and enhance room utilization efficiency.

Table 3. Daily Room Allocation Results for Each Room Type

Room Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	1	1	1	1	1	1	1	1	1	1
2	9	9	9	6	6	6	6	6	6	6	6	6
3	1	1	1	1	1	1	1	1	1	1	1	1
4	9	9	9	11	11	11	11	11	11	11	11	11
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	1	1	1	1	1	1	1	1

Table 4. Monthly Room Allocation Results for Each Room Type

Room Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	1	1	1	1	1	1	1	1	1	1
2	6	6	6	9	9	9	9	9	9	9	9	9
3	1	1	1	1	1	1	1	1	1	1	1	1
4	2	2	2	0	0	0	0	0	0	0	0	0
5	4	4	4	4	4	4	4	4	4	4	4	4
6	1	1	1	0	0	0	0	0	0	0	0	0

4.4 Opportunity Cost Analysis

The opportunity cost analysis reveals that excess capacity (*Over*) occurs exclusively in daily stays (*Over_D*), while lost sales (*Lost*) occur only in monthly stays (*Lost_M*). No occurrences of lost daily sales (*Lost_D*) or excess monthly capacity (*Over_M*) are observed throughout the year. This finding highlights a clear structural difference in allocation behavior between the two stay formats.

As shown in Table 5, *Over_D* values are consistently high for room types 2 and 4 across most months, particularly during the middle to late parts of the year. This indicates that excessive capacity is reserved for daily stays beyond actual demand, leading to inefficient utilization of room resources.

Conversely, *Lost_M* values, as presented in Table 6, are also most prominent in room types 2 and 4 and tend to increase during the second half of the year. This pattern suggests that demand for monthly stays exceeds system capacity, resulting in missed opportunities for long-term revenue generation.

In summary, adjustments in room allocation during certain periods, such as reducing daily stay allocations for specific room types and increasing the proportion of monthly stays, highlight the critical role of opportunity cost in the model's decision-making process. Allocating rooms to suboptimal stay formats leads to profit loss, which is consistent with the interpretation of **reduced cost** in optimization theory. Specifically, allocating excessive capacity to daily stays results in forgone opportunities to accommodate monthly tenants who offer more stable long-term revenue. Therefore, increasing the allocation of monthly stays for selected room types can effectively reduce opportunity costs and improve the overall revenue performance of the accommodation business.

Table 5. Excess Capacity of Daily Rooms

Room Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	0	0	0	0	0	0	0	0	0	0	0
2	6	7	6	3	3	4	5	5	5	5	5	5
3	0	0	0	0	0	0	0	0	0	1	1	1
4	6	7	7	8	8	9	9	8	7	8	8	8
5	0	0	0	0	0	0	0	0	0	0	0	0
6	1	1	1	1	1	1	1	1	1	1	1	1

Table 6. Lost Sales of Monthly Rooms

Room Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	0	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	3	4	4	4	4	4
3	0	0	0	0	0	0	0	0	0	1	1	1
4	1	1	1	3	4	4	5	5	5	6	6	6
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	1	1	1	1	1	1	1	1

5. Conclusion

The analysis results indicate that the proposed model dynamically adjusts the allocation proportions between daily and monthly stays over time. This behavior clearly reflects differences in economic efficiency between the two accommodation formats. Certain room types generate higher returns when allocated to daily stays, while others are more suitable for monthly stays, depending on demand conditions and profitability structures.

Overall, the results demonstrate that the proposed model can serve as a strategic decision-support tool for room allocation management. Accommodation operators should maintain flexibility in adjusting the balance between daily and monthly stays in response to changing market conditions to maximize total revenue and reduce opportunity costs associated with underutilized room resources.

6. Discussion

The empirical study relies on data from a single small-scale property. Although the modeling logic can be transferred to other settings, applying the same parameters to larger hotels or highly competitive urban environments may require further adjustment.

Future research could relax some of the underlying assumptions by incorporating demand uncertainty, adaptive pricing strategies, or more refined customer segmentation. Extensions toward multi-property coordination or integration with real-time booking systems may further narrow the gap between analytical modeling and practical operations.

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Biographies

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