Masters Programmes: Assignment Cover Sheet

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Have you used Artificial Intelligence (AI) in any part of this assignment?	No.

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- I declare that this work is being submitted on behalf of my group and is all our own, except where I have stated otherwise.
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Upon electronic submission of your assessment, you will be required to agree to the statements above

1. **Question 1**

BuildMax Rentals is considering implementing a Revenue Management (RM) strategy to optimise its revenue and fleet utilisation. We have assessed and compared its business conditions with other industries which focuses on RM such as airline, hotel, and car rentals. The comparison is shown in Table 1.

Table 1: Condition of Revenue Management of BuildMax vs Airlines, Hotels, Car Rentals

Conditions of RM	BuildMax	Airlines	Hotels	Car Rentals
Fixed Capacity	Fixed fleet availability, and each branch has a fixed availability of machine, which require optimal allocation.	Largely fixed in the short term, however, flexible via fleet management, scheduling and leasing.	Fixed number of rooms to be sold.	Car rentals can relocate vehicles between branches based on demand. Therefore, capacity is dynamic rather than strictly fixed.
Perishable Resources	Idle machines do not generate revenue and depreciates over time.	Unsold seats expire after the plane takes off.	Unoccupied rooms expire at the end of the day.	Unused cars expire at the end of the day and depreciates overtime.
Low Variable Cost	Cost of letting an additional machine is low compared to initial fixed cost for fleet.	Maintenance and crew costs are low compared to buying a new aircraft	Room maintenance costs less than hotel construction.	Vehicle maintenance costs less than fleet purchase.
Variable Demand	Seasonal demand for machine rental. Higher demand during	Seasonal travel period. e.g. high travel demand for Christmas, and	Holidays and business seasons influence demand.	Geographical and seasonal demand.

	spring and summer.	winter vacations.		
Price Sensitivity	Distinct rental segments: short-term rentals (1 week) and long-term rentals (4, 8 or 16 weeks).	Business, Leisure, Grouped, Negotiated, Students, Children, Seniors, Military.	Leisure, Conventions, Meetings, Contract accounts, Groups.	Business, Leisure, Grouped, Students.

Table 1 shows that BuildMax meets all conditions for implementing RM strategy but faces key challenges. Firstly, fleet constraints at each branch limit expansion in the short term, preventing the company from meeting excess demand. Besides that, machines require servicing between rentals, reducing flexibility in fulfilling demand.

Additionally, BuildMax must ensure that machines are allocated to the right locations to avoid shortages in high-demand areas and underutilisation in low-demand ones. Furthermore, one-way rentals increase transportation costs which disrupts the revenue management model, complicating optimisation.

Moreover, BuildMax serves multiple customer segments, making price differentiation challenging. Defining segments with distinct willingness to pay (WTP) adds further operational complexity. Lastly, government projects require fixed pricing, limiting BuildMax's pricing flexibility in RM. For corporate bulk discounts, BuildMax must balance reduced revenue per unit with utilisation rates. These challenges require BuildMax to balance pricing constraints, utilisation, and revenue impact when accepting rentals

2. Question 2

2.1. LP Model Formulation

An LP model was developed to optimise BuildMax's rental revenue, assuming fixed prices and demand for a clear optimisation framework.

Decision variables:

$x_{i,j,k}$: Approved rentals in week i, for equipment j, for duration k.

$R_{i,j}$: Units of equipment j returned in week i.

$I_{i,j}$: Available inventory at the start of week i for equipment type j.

Where:

$i \in W,\ W = \{1, 2, 3, \ldots, 51, 52\}$ represent the number of weeks.

$A \subseteq E,\ E = \{\text{Excavator, Crane, Bulldozer}\}$ is the type of equipment available for rental.

$k \subseteq D,\ D = \{1, 4, 8, 16\}$ are the week(s) durations for which rental services are provided.

Objective Function:

$$\text{Maximise} \quad \text{Z} = \sum_{\text{i}\in\text{W}} \sum_{\text{j}\in\text{E}} \sum_{\text{k}\in\text{D}} \text{p}_{\text{i,j,k}} \cdot \text{x}_{\text{i,j,k}} \cdot (\text{k} \times 7)$$

Where:

$p_{i,j,k}$ is the rental price per day for renting equipment j in week i for duration k.

$k \times 7$ represent the total duration in days (since k is in weeks)

Constraints:

i. Demand Constraints:

The number of approved rentals for any given week, equipment type and rental duration should not exceed their demand.

$$X_{i,j,k} \leq Demand_{i,j,k} \quad \forall i, j, k$$

ii. Inventory Update Constraints:

To ensure that available inventory $I_{i,j}$ is correctly updated over time.

For the first week,

$$I_{1,j} = Initial\ Inventory_j \quad \forall i, j$$

For subsequent weeks $(i > 1)$,

$$I_{i.j} = I_{i-1,j} + R_{i,j} - \sum_{k\in D} X_{i-1.j.k} \quad \forall i, j$$

iii. Returns Constraints:

This track returns based on previous week rentals. For first week, $R_{i,j} = 0$ and for subsequent weeks $(i > 1)$,

$$R_{i,j} = \sum_{k \in D} X_{i-k,j,k} \quad \text{if} \quad (i-k) \in W \quad \forall i,j$$

iv. Inventory-Based Allocation Constraint:

At any point in time, rentals cannot exceed available inventory.

$$\sum_{k \in D} X_{i.j.k} \leq I_{i,j} \quad \forall i,j$$

v. Non-negativity Constraints:

$X_{i,j,k}$, $R_{i,j}$, $I_{i,j} \in Z^+$

2.2. **Acceptance Comparison**

Unsatisfied demand rate is evaluated to compare and analyse the acceptance strategy of LP. An unsatisfied demand rate of 0 implies that all demand under the category is satisfied for given week, and vice versa.

$$Unsatisfied\ demand\ rate = \left(Demand_{i,j,k} - X_{i,j,k}\right)/Demand_{i,j,k}$$

As observed in Figures 1-3, the LP has prioritised customer demand for 16-week and 8-week rentals. With at most only 2 weeks in a year when demand for these durations was not met. The LP compensates for this demand by sacrificing on demand for 1-week duration, mostly between weeks 13 and 37 (i.e. middle of spring to the end of summer).

Figure 1: Excavator Unsatisfied Demand Trend

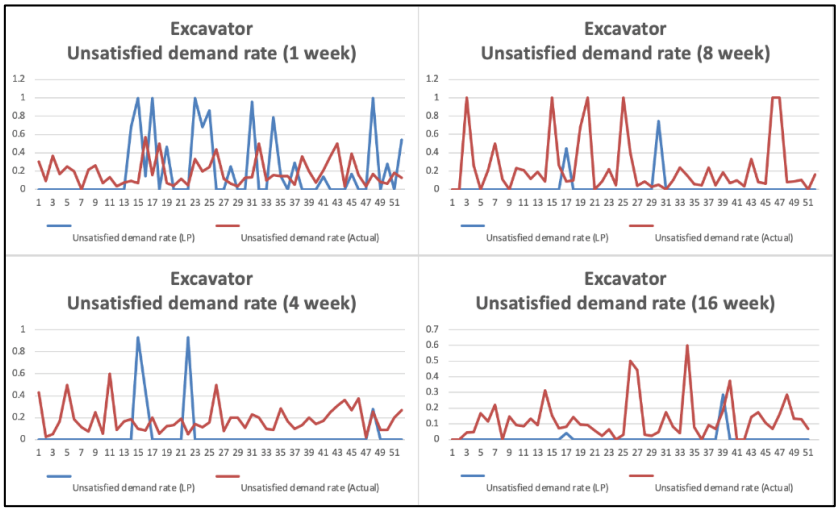


Figure 2: Crane Unsatisfied Demand Trend

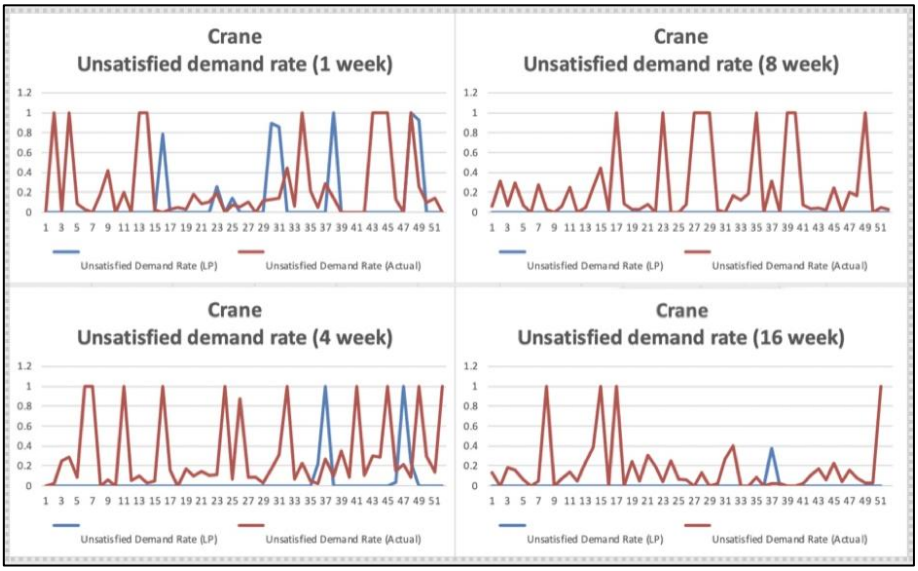
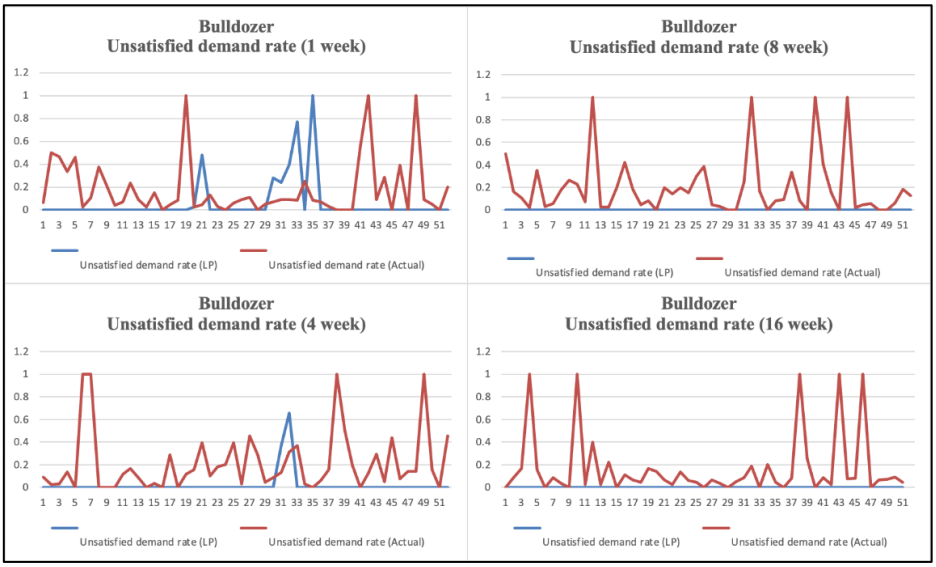


Figure 3: Bulldozer Unsatisfied Demand Trend



2.3. **Revenue Comparison**

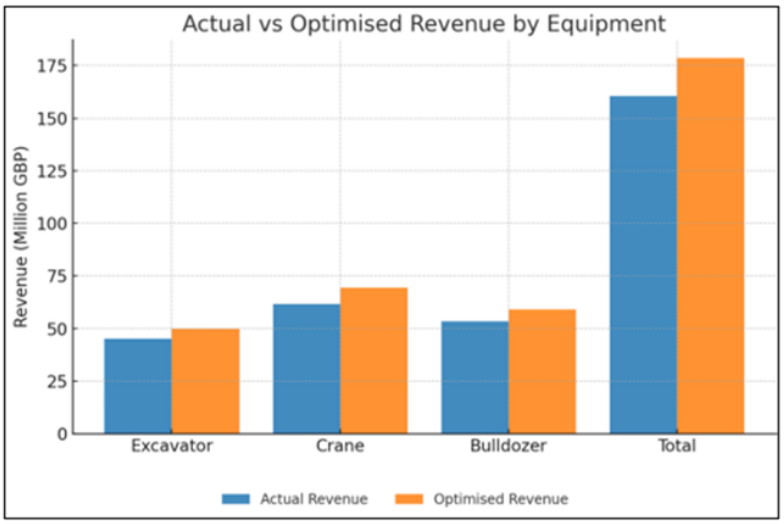
As shown in Table 2, the optimised revenue structure closely aligns with the actual revenue structure (Appendix 1). Notably, long-term rentals (8 and 16 weeks combined) contributed to approximately 80% of the total annual revenue for each equipment type.

Table 2: Revenue Structure by Duration and Equipment

Equipment	Duration	Optimised Revenue (%)	Actual Revenue (%)
Excavator	1	3.60%	4.23%
Excavator	4	14.31%	14.20%
Excavator	8	31.42%	30.17%
Excavator	16	50.68%	51.40%
Crane	1	3.46%	3.82%
Crane	4	14.03%	13.94%
Crane	8	29.75%	28.60%
Crane	16	52.77%	53.65%
Bulldozer	1	4.47%	4.72%
Bulldozer	4	16.44%	15.87%
Bulldozer	8	27.88%	27.05%
Bulldozer	16	51.22%	52.36%

As demonstrated in Figure 4, the LP model resulted in an 11.22% increase in overall revenue for BuildMax, indicating that the long-term strategy effectively boosts revenue. Among the three equipment types, Crane achieved the highest revenue and the highest growth rate at 12.44%, highlighting its significant potential for profitability, while Excavators showed the smallest growth at 10.14%.

Figure 4: Actual v/s Optimised Revenue across Equipment

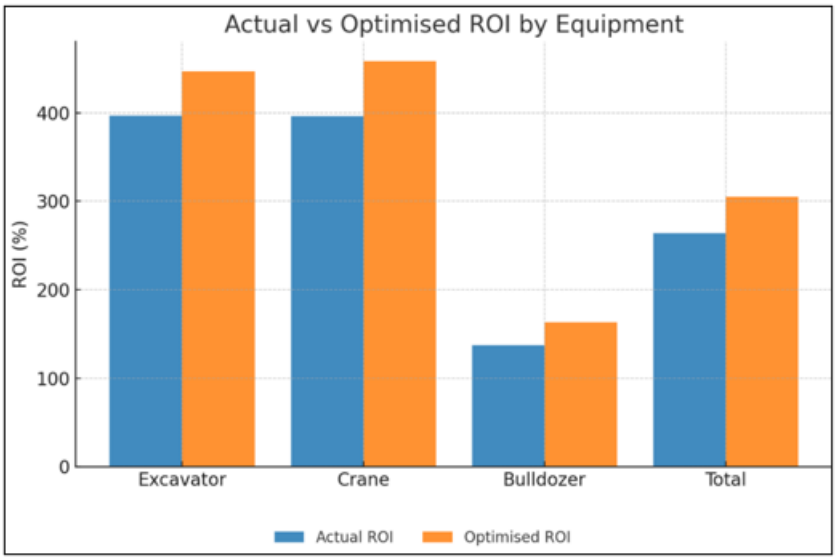


Equipment	Actual Revenue (GBP)	Optimised Revenue (GBP)	Revenue Increase (%)
Excavator	45,274,005.00	49,866,264.00	10.14
Crane	61,785,689.00	69,471,738.00	12.44
Bulldozer	53,413,920.00	59,140,634.00	10.72
Total	160,473,614.00	178,478,636.00	11.22

2.4. **ROI Comparison**

Figure 5 below shows a 15.47% increase in ROI due to optimised revenue. Bulldozers saw the highest relative ROI increase at 18.52%, suggesting untapped revenue potential. In terms of absolute ROI, Excavators and Cranes remained the top performers.

Figure 5: ROI Comparison across Equipment



Equipment	Actual ROI (%)	Optimised ROI (%)	ROI Change (%)
Excavator	396.43	446.78	12.70
Crane	396.27	458.01	15.58
Bulldozer	137.4	162.85	18.52
Total	264.1	304.99	15.47

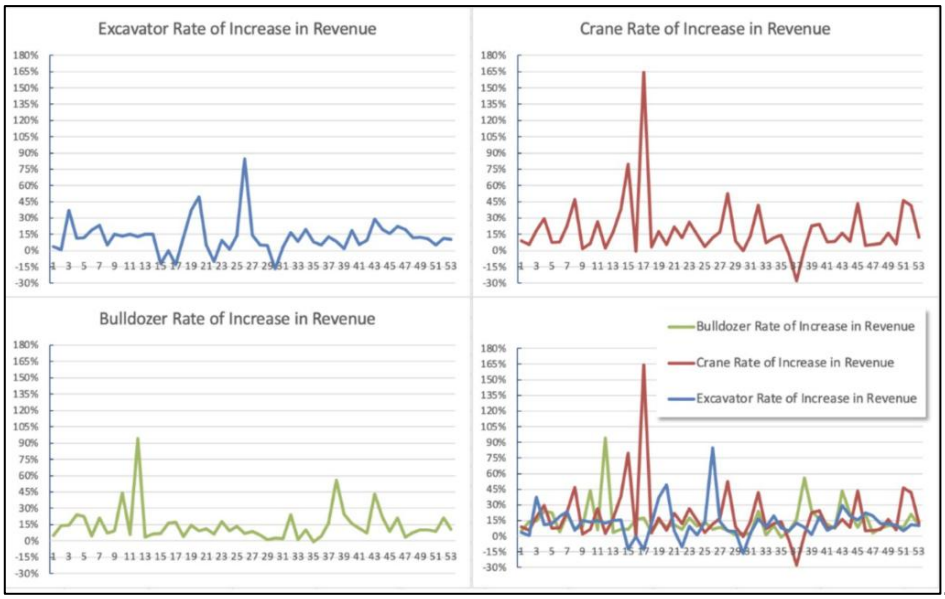
3. **Question 3**

To effectively implement the new RM system and translate the findings in section 2.2-2.4 into tangible ROI improvements, BuildMax should consider adopting the following strategies:

i. Prioritise long-term rentals (e.g. from mining and oil companies) which maximises around 80% of its revenue. If inventory falls short during weeks 13 and 37, short-term orders could be sacrificed to fulfil long-term demand.

ii. Focus on important high potential periods: As shown in Figure 6, profit potential is high during these periods: Excavators (weeks 18-20), Cranes (weeks 7-17), and Bulldozers (weeks 8-13)

Figure 6: Rate of Increase in Revenue



iii. Change the pricing strategy from solely based on Bulldozers' inventory (Appendix 2), to a dynamic pricing strategy based on demand fluctuations, seasonality and rental duration.

iv. For government and municipal projects and bulk corporate bookings, fixed contract price could be set such that the ROI of the contract exceeds 265% (total actual ROI currently). This will ensure contracts remain profitable, preventing under-pricing.

v. Allow flexible return for long-term rentals contract with penalty. Liquidated damages are X% of the remaining lease term, where X is calculated based on the project ROI.

While LP offers a solid solution, it has several limitations in terms of addressing the challenges faced. The following, highlights these limitations along with key insights regarding potential improvements:

i. Prioritisation of long-term rentals: The model as inferred from section 2.3 tends to prioritise long-term rental. However, short-term rentals are often more profitable and flexible. Incorporating constraints allocating a defined weight to short-term rentals during the approval process could benefit equipment utilisation and drive larger profits.

ii. Maintenance bandwidth considerations: The current model reallocates equipment immediately after returns, leaving exceptionally tight bandwidth for maintenance requirements. This could lead to unavailability during breakdowns, disrupting the optimised plan. A potential improvement is to use daily demand data instead of weekly to set precise maintenance thresholds, prioritising long-term rentals and ensuring a more faut-tolerant revenue system.

iii. Limited Granularity in Demand data: The current model uses weekly demand data restricting its ability to respond to fluctuating demands within a week. Incorporating day level data would allow more accurate, real-time equipment allocation.

iv. Misaligned Pricing Strategy: The current pricing strategy used by the model is based upon the existing RMS. This strategy correlates the daily rental price of all equipment across all duration with Bulldozer’s inventory. Pricing strategies could be improved by dynamically adjusting them as per each equipment’s demand ensuring more alignment with market conditions.

v. Absence of Sector-Specific Demand Optimisation: The current model pools together different sections, ignoring differences in rental behaviours, WTP and seasonal trends. Sector-specific demand forecasting and allocation could help BuildMax maximise profits by targeting high-margin sectors while optimising equipment utilisation.

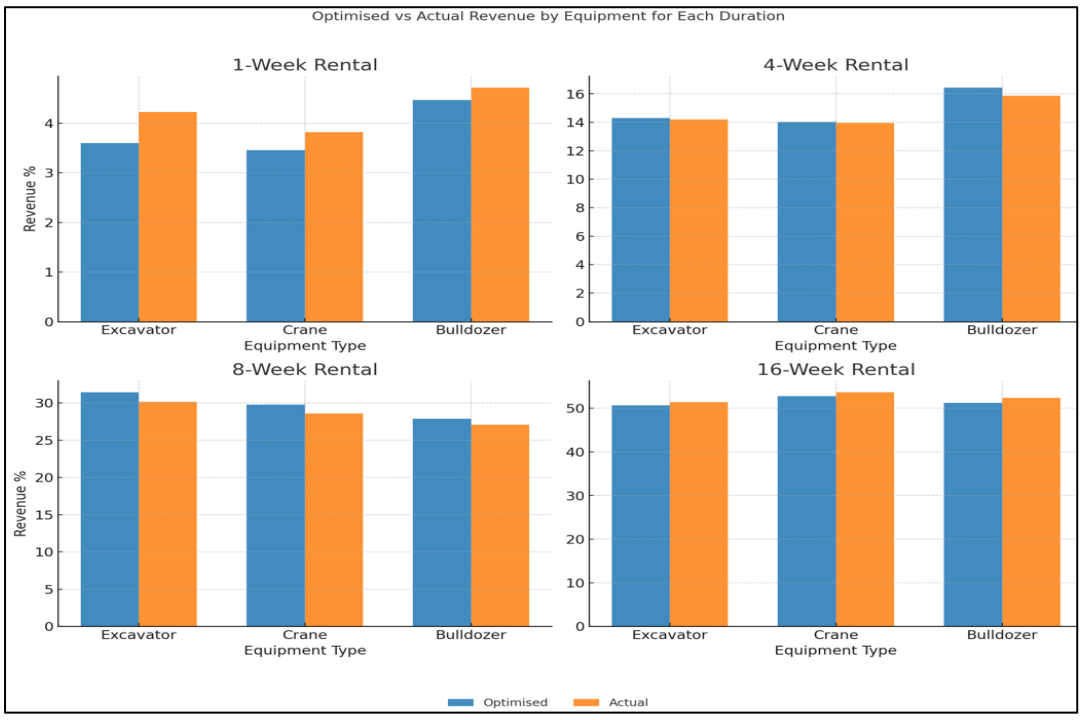
vi. Redistribution of rentals across branches**:** The current model does not consider returns coming from and rolling to other branches, incorporating inter-branch transfers and demand driven reallocation across branches could mitigate this issue and further reinforce operational flexibility.

By addressing these limitations BuildMax can further drive their revenue and profits, while ensuring more operational efficiency and fault tolerance.

Appendices

Appendix 1: Revenue Optimisation by Rental Duration and Equipment

Figure 1: Optimised Vs Actual Revenue by Equipment for Each Duration



Appendix 2: Correlation Matrix

Figure 2: Correlation Matrix between Equipment Prices and Bulldozer Inventory