Logistics Optimization: Loading Trends, Operational Hotspots and Performance Analysis

A Final Report for the Business Data Management Capstone Project

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Executive Summary

This project centers on Aakash Logistics, a small-scale logistics and transportation firm based in Bankura, West Bengal. The firm operates in a B2B context, primarily focusing on cement transportation, and is a transport partner of OCL-Dalmia, located in Medinipur, West Bengal.

The business is currently facing several operational challenges. These include difficulties in procuring third-party trucks during peak demand periods, effective coordination of backhaul trips, and maintaining a high driver retention rate. These issues are adversely affecting the firm's productivity and potentially leading to business losses.

To address these challenges, daily ledger entry data from 1st January to 20th November 2023 was collected and cleaned to focus on the headhaul trips from OCL. A series of analyses were conducted, including time series analysis, analysis of trend in loading, and an examination of the key activity areas of the firm. The coordination of backhaul trips across these areas, the performance of various trucks, and the driver retention rate were also analyzed.

The results and findings were graphically represented and interpreted with the assistance of the business owner. Based on these findings, a set of solutions to the identified problems were recommended for implementation to enhance the operational efficiency of the business.

Analysis Process/Method

Problem 1: Ensuring timely arrangement of third-party trucks during high demand periods.

1.1: Time Series Visualization of Daily Trip Count

In the mid-term report, a comprehensive time series analysis based on different weekdays and on a month-by-month and day-by-day basis was conducted.

A heatmap was utilized in this final report to visualize the time series data of trip count throughout January 1st to 20th November, 2023 with weekdays as rows and week numbers as columns (Figure 2). This heatmap was further demarcated on a monthly basis, providing a succinct visualization of the monthly, day-by-day, week-by-week trends and trend on different weekdays, thereby summarizing the findings of the mid-term report effectively.

1.2: Analysis of Weekly Trend in Trip Count

Now for further analysis of the data, the weekly trend was used. An entire week was deemed an appropriate reference period as there were high daily variations whereas subtle changes in the total trip count might be overlooked in the monthly aggregate. By reorganizing the daily trip count data, which contained the date, day, and total number of trips into sums of regular seven-day intervals, the total weekly trip counts with the week numbers were obtained. This was subsequently plotted in a line graph with a four-week moving average to capture the trend (Figure 1).

The moving average was used as a trend-following or lagging indicator that is based on the trip count of the past four weeks. The rationale behind this was to smooth out the weekly trip count data by creating a constantly updated average of trip count for every four weeks.

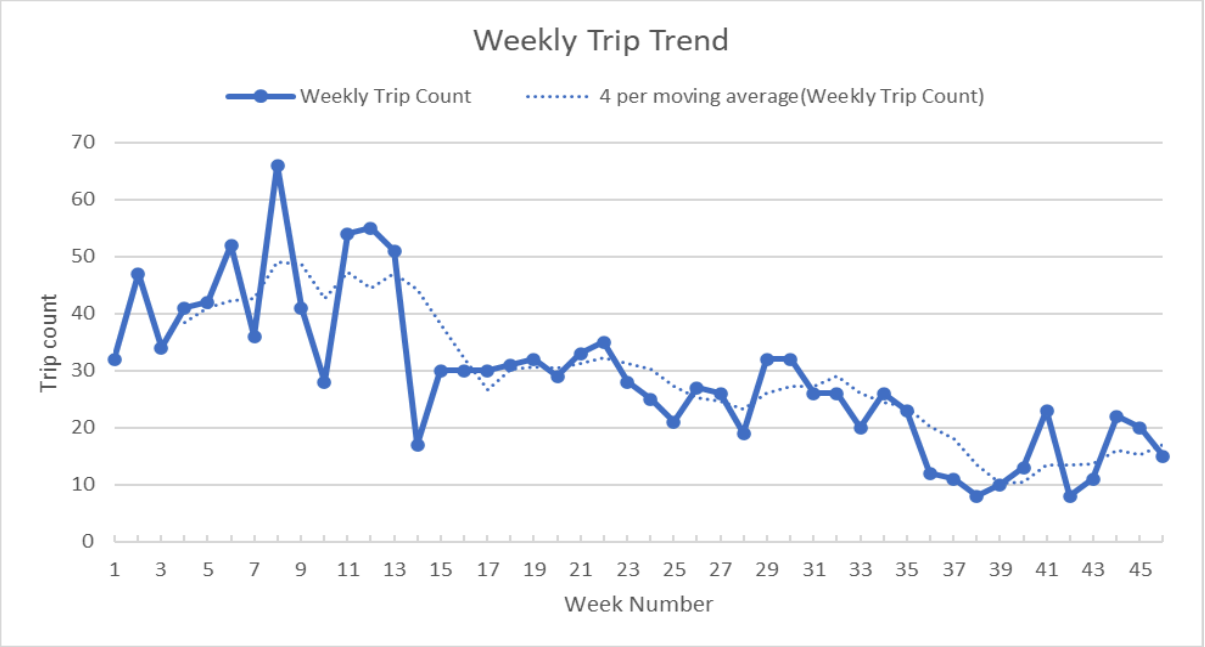

Figure 1: Line graph for the trend in weekly trips count

Note: Week 47, which only contains data for 2 days, is not considered in this analysis.

From Figure 1, it can be observed that the operational timeline of the firm can be segmented into three distinct periods:

- The initial phase (Week 1-13) represents a peak demand period.
- This is followed by a period of medium demand from Week 14-35.
- The final phase represents a low demand period for the remainder of the time.

The moving average remains relatively stable from Week 4-13, indicating a consistent demand during this period. It then experiences a decline until Week 17, after which it stabilizes again until Week 35. Following this, there is another decline until Week 39, after which it remains constant for the remaining period.

Given the limited number of data points, visualization techniques and the slope of the best fit line were used to examine the stationarity behavior of these three periods (as depicted in Figure 3). Furthermore, Descriptive statistics was used to characterize the behavior of each of these periods, as given in Table 1.

Week	Standard deviation	Total	Mean
1 to 13	10.41	579	44.54
14 to 35	4.74	598	27.18
36 to 46	5.16	153	13.91
1 to 46	13.12	1330	28.91

Table 1: The descriptive statistics of the different periods

Note: The standard deviation is calculated using the population formula.

From Table 1, it is evident that the trip count during the peak period (a 13-week period) is almost on par with that of the mid-season (spanning a 22-week period).

Furthermore, when comparing an identical duration of 11 weeks within these periods, the week 1-10 of the peak period witnessed 2.7 times more trips with a total of 419 than the dull period (Week 36-46) which had 153 trips.

The average trip count for Week 1-13 is more than 1.5 times and 3 times higher than that for Week 14-35 and Week 36-46, respectively. The average trip count for Week 14-35 is almost twice as high as that for Week 36-46.

Indeed, the analysis reveals that the peak period experiences a higher degree of variation compared to the other two periods. However, this variation is still less than the variation observed over the entire period. By segmenting the entire period into three distinct periods, the variation in the data has been effectively reduced.

Problem 2 : Improving the efficiency of backhaul trips coordination with the aim of increasing the proportion of roundtrip hauls.

2.1: Visualization of the Operational Hotspots of the Firm

A pivot table was utilized to aggregate the trip count, average revenue, and profit per ton for various places. The loading data for places with more than 10 trips from January 1st to November 20th, 2023, was then selected.

Profit per ton was done exclusively for headhaul trips, without considering any potential profit from backhaul trips as the dataset only contains information about the headhaul trips. Furthermore, the count for the headhaul trips that were also accompanied by backhaul were excluded from the calculation due to the absence of fuel cost data for those trips in the dataset.

After that, the final profit per ton of a place was calculated using the following formula:

$$\frac{(P_t \times T_t + P_o \times T_0)}{T}$$, where

P_t and P_o are the average profit per ton for third parties and the owner's trucks, respectively. T_t and T_o are the trip count for third parties and the owner's truck, respectively. T is the total trip count for that place.

The weighted average profit calculation considers truck ownership types, crucial due to a significant profit disparity, averaging around Rs 1,859, between the owner-owned and third party trucks. The unit for calculating average profit and revenue is 'per ton'. This is due to the revenue being provided by the company on a per ton basis for all the places.

A bubble chart was plotted using this data (refer to Figure 4), enabling a comparative analysis of the places based on trip count, average revenue, and profit per ton. This visualization highlights the top performing places and potential areas to focus on.

2.2: Analysis of the Key Activity Areas for Owner-Owned Trucks

A filter was then applied to the pivot table consisting of the place details to consider only the owner's trucks, resulting in place details specific to owner-owned trucks. This filter was necessary as the trip data is only relevant if the trip was done by the owner's truck. This is due to the fact that third-party trucks are exclusively utilized for headhaul trips from OCL, due to the existing cement partnership. The lack of additional partnerships consequently restricts the engagement of third-party trucks. Hence, those entries were excluded to identify the key operational areas solely for the trucks owned by the Owner.

Table 2 presents the performance data of the owner-owned trucks in the places with more than 25 trips. This threshold was set considering the feasibility of investing in a backhaul partnership if the place is not visited frequently enough. These selected places account for 90% of all the 974 trips undertaken by the owner trucks.

Places	Trip Count	Average Profit Per Ton (in rs)	Average Revenue Per Ton (in rs)
Asansol	380	318.43	735.31
Bankura	295	130.38	596.07
Durgapur	107	175.80	670.08
Bishnupur	95	125.07	548.16

Table 2: The performance data of the owner-owned trucks in different places

Note: The profit and revenue were calculated exclusively for trips that were headhaul-only due to the reason described in point 2.1.

From Table 2, it can be seen that Asansol emerges as a significant location for the business, registering the highest trip count and average profit per ton. Notably, its average profit per ton surpasses that of Bankura, the second most frequented place, by a factor of 2.4.

2.3: Analysis of the Backhaul Trip Coordination in the Key Activity Areas for Owner-Owned Trucks

To further understand how these places are performing with respect to backhaul trip coordination, the total trip count was broken down into 'Headhaul only' trip count and 'Round haul' trip count. This was achieved by utilizing a pivot table and applying filters for the respective trip types, resulting in Table 3.

Place	Headhaul only trip count	Round haul trip count	Percentage of roundhaul Trip
Asansol	38	342	90%
Bankura	150	145	49%
Durgapur	22	85	79%
Bishnupur	63	32	34%

Table 3: The total trip breakdown for various places

The percentage of round haul trips was computed using the following formula:

$$\frac{Round\ haul\ trip\ count}{Round\ haul\ trip\ count + Headhaul\ only\ trip\ count} \times 100\ \%$$

From the analysis, it is evident that Asansol and Durgapur are performing well in terms of backhaul trips coordination. However, the performance in the other two locations appears to be less satisfactory.

Problem 3: Increasing the driver retention rate, with the intention to reduce the number of idle trucks.

3.1: Actual vs Expected Performance Analysis of Owner's Trucks

Given that the travel distance is relatively short, with a maximum of 400 km from OCL to the destination and back, a truck ideally should take 1 day without a backhaul trip and a

maximum of 2 days with a backhaul trip, as per the owner's input. This implies that there should be at least 10 trips conducted a month most of the time, assuming optimal conditions. However, this target was often not met, even during the peak season.

The table 4 illustrates the number of times this target was achieved by the trucks. This was calculated using a pivot table with entries of months as rows and truck numbers as columns, and trip count as values. The 'countif' function with the conditions of ">=10" and "<10" were then applied to obtain these frequencies.

Number of trips done by the trucks in a month	Frequency	Frequency in percentage
< 10 trips	79	70%
>= 10 trips	34	30%

Table 4: The frequency distribution of the number of trips done by the trucks in a month

Note: 3 trucks were sold during the data period in the middle of the month, so the month they were sold has been excluded from the calculation. November has also been excluded from the calculation as the data for the entire month was not available.

From Table 4, it is observed that in 70% of the total instances, the trucks were idle for more than a third of a month. Furthermore, it was noted that on 17 instances, which constitute 15% of the total, the monthly trip count was less than 5. A significant finding from the data is that out of the 12 trucks in operation, 3 never achieved the monthly target of 10 trips.

3.2: Examination of Trucks' Idle Periods Resulting from Driver Transitions

In order to analyze the frequency of driver changes in the truck fleet, and thereby gauge the owner's ability to promptly find replacement drivers for idle trucks, a pivot table was utilized. This pivot table was filtered based on the owner's truck, with dates represented as rows, truck number and driver name as columns and trip count as values.

Whenever a change in truck driver occurred, the last trip count for the outgoing driver and the first trip count for the incoming driver, along with the intervening blank entries were recorded in an Excel column. The blank entries represent the gap in days between driver changes. The 'COUNTBLANK' function in Excel was then employed to calculate the gap days. The summarized findings of this analysis are presented in Table 5.

Days	Frequency	Frequency in percentage
<3	15	28%
3-6	16	30%
7-10	7	13%
>10	15	28%

Table 5: The frequency distribution of the number of days gap between the driver changes

A total of 53 instances were recorded where a change in drivers was necessitated. It was found that approximately 41% of these instances resulted in a transition period of a week or more before a replacement driver could be secured.

It was also observed that the majority of the replacement drivers were not new hires, but were regularly operating other trucks within the fleet.

3.3: Driver Retention Rate Analysis

Now, in order to analyze the firm's ability to retain the drivers, the starting and ending trip dates for each driver were calculated by utilizing the "min" and "max" options under the "Summarize value field by" feature in Excel's Pivot Table on the trip dates. The remaining calculations were performed using the 'COUNTIFS' function in Excel.

The driver retention rate was computed using the following formula [source]:

$$\frac{number\ of\ people\ employed\ during\ the\ entire\ period}{number\ of\ people\ employed\ at\ the\ start\ of\ the\ period}\ x\ 100\% = \frac{6}{12}\ x\ 100\% = 50\%$$

The period was defined from 7th January 2023 to 17th November 2023. This specific timeframe was chosen as it was observed that not all trucks were necessarily loaded on 1st January or 20th November, resulting in a lack of data corresponding to drivers on these dates. Therefore, the nearest available dates were selected.

The ‘Number of people employed during the entire period’ refers to drivers who were engaged from the beginning date to the end date of the period under consideration. It does not account for those who were hired midway through the period.

It was observed that after 7th January 2023, a total of 9 new drivers were appointed. Out of these, 6 were temporary drivers, indicating they were employed for short durations when a regular driver was on leave or had left. The remaining three were permanent appointments.

Results and Findings

Problem 1: Ensuring timely arrangement of third-party trucks during high demand periods.

1.1: Time Series Visualization of Daily Trip Count

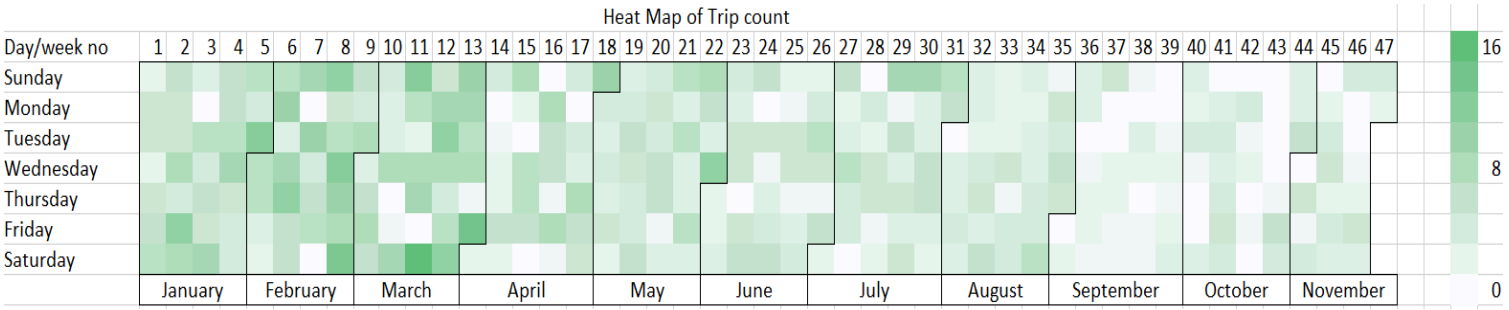

Figure 2: Heat map representing daily trips count from week 1 - 47, 2023

The annual operational cycle of the firm, as depicted in Figure 2, can be segmented into three distinct phases based on the observed loading trends:

1. **Peak-Season (January to March, weeks 1-13)**: This period exhibited a high loading trend. The surge can be attributed to OCL's need to meet its annual targets, leading to an increase in shipment orders.
2. **Mid-Season (April to August, weeks 14-35)**: Characterized by extreme summer heat and monsoon conditions, this phase led to a decrease in construction work, hence a reduced demand for cement.
3. **Dull-Season (September - November, weeks 36-47)**: Contrary to expectations of a rebound in trip count post-monsoon, this period witnessed a decline in trips, even lower than during the monsoon period. This downturn can be attributed to drivers taking time off during the festive season, which impacted the availability of owner-operated trucks. The firm's high dependency on the owner's trucks led to a shortfall in output during periods of existing demand.

An interesting monthly pattern was observed in Figure 2 where the **ending of each month showed a higher loading trend compared to the rest of the month**, while the beginning of the month exhibited a slowed-down trend. This pattern can be linked to the

operational dynamics of OCL, where orders typically increase towards the month-end due to its target fulfillment requirements.

Figure 2 shows a **higher trip count during weekends**. This could be due to less congested roads during those days. Wednesdays also showed a high trip count, likely due to the backhaul trips being scheduled for alternate days, considering that a truck takes an average of 1-2 days to return to the factory. This leads to fluctuations in the loading by the owner's trucks at OCL.

1.2: Result of Analyzing the Weekly Trend in Trip Count

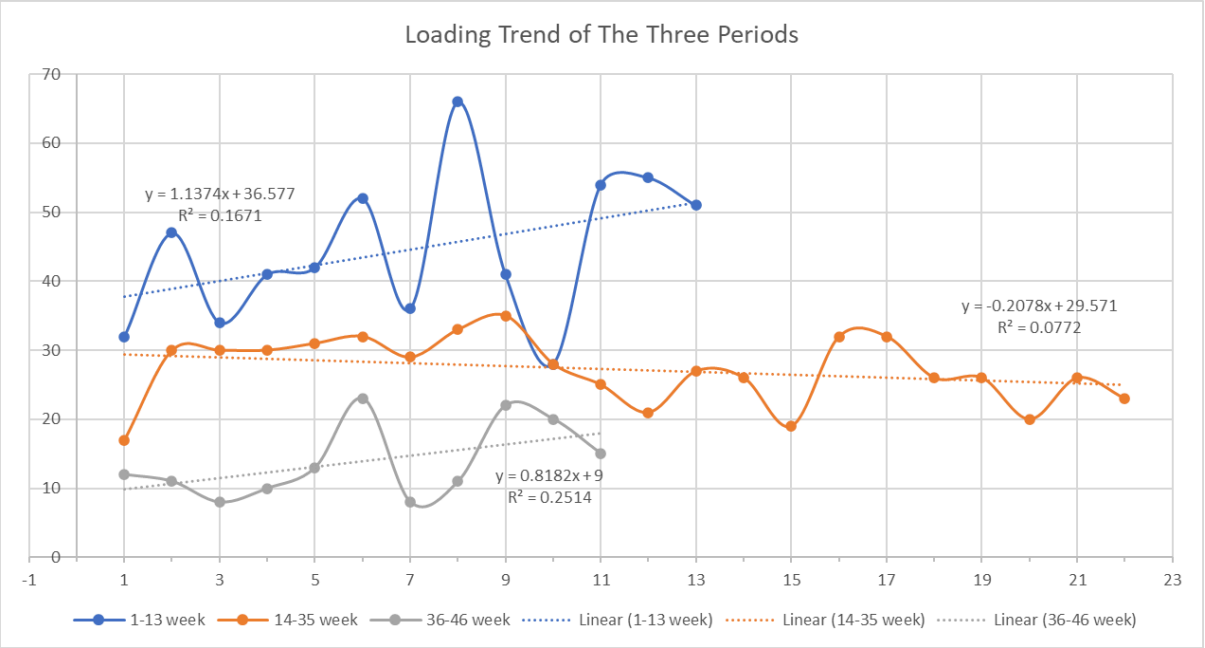

Figure 3: Line graphs for the weekly trend in trip count for the three different periods

Figure 3 shows the three phases of the firm's annual operational cycle in cross section. It reveals that the trip count for the first phase predominantly remained above the corresponding weeks in the second phase, which in turn stayed above the third phase.

The slope of the second phase is nearly zero, indicating a relatively stable trend. In contrast, the slopes of the third and first phases exhibited a more positive trend. This can be attributed to higher than average loading during the last three weeks of the first phase and week 9 and 10 of third phase.

However, it is important to note that the R-squared values of the best fit line for all three phases are approaching zero. This suggests that there is no linear correlation between time

and trip count. In other words, **the trip count remains almost constant during these individual periods**, assuming there is no other relationship between the trip count and time.

Problem 2 : Improving the efficiency of backhaul trips coordination with the aim of increasing the proportion of roundtrip hauls.

2.1: Visualization of the Operational Hotspots of the Firm

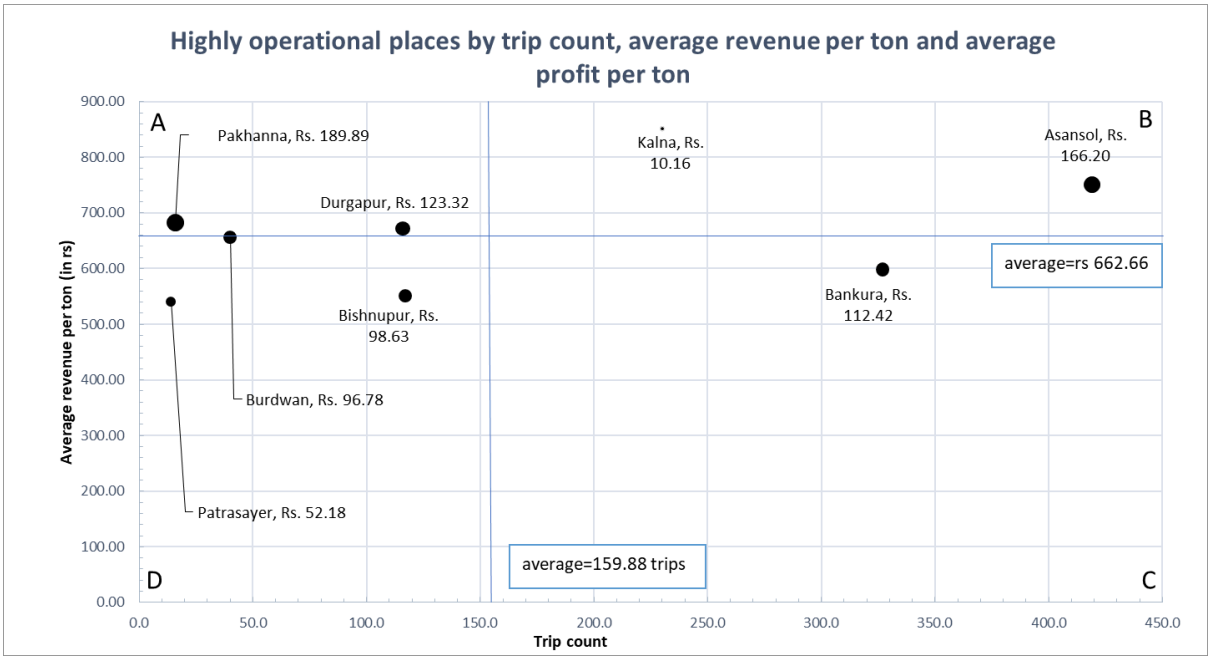

Figure 4: Bubble chart representing the highly operational places

Figure 4 offers a comprehensive analysis of the firm's operational areas, encompassing both owner-owned and third-party trucks' trip data. The profit, represented by the area of the bubble and the data labels, pertains only to the headhaul-only trips. Profits are calculated as a weighted average, as outlined in Section 2.1 of the analysis.

The chart area is segmented into four quadrants based on the average trip count and the average revenue per ton:

- Group A: High revenue and low trip count - Pakhanna and Durgapur
- Group B: High revenue and high trip count - Kalna and Asansol
- Group C: Low revenue and high trip count - Bankura
- Group D: Low revenue and low trip count - Patrasayer, Bishnupur, and Burdwan

Kalna, categorized under Group B, is an anomaly because it registered the lowest profit among all locations, despite having the highest revenue and higher trip count. This happened due to the fact that all trips to Kalna were exclusively performed by third-party trucks, which yield significantly lower profits than owner-owned trucks. The owner's trucks do not operate in the Purba Barddhaman district, where Kalna is located, and instead restrict operations within the Bankura, Medinipur, and Paschmi Burdwan districts. This decision is primarily driven by the drivers' familiarity with these areas and the short-distance nature of the trips, which can be completed within 1-2 days. This strategy explains the high trip count observed in Bankura and Asansol.

The revenue for each location is predetermined by OCL, and the firm has no control over it. OCL assigns the responsibility of shipment loading to different transporters based on the area. However, the firm can negotiate with OCL to load in areas other than the transporter's designated area.

2.2: Result of Analyzing the Key Activity Areas for Owner-Owned Trucks

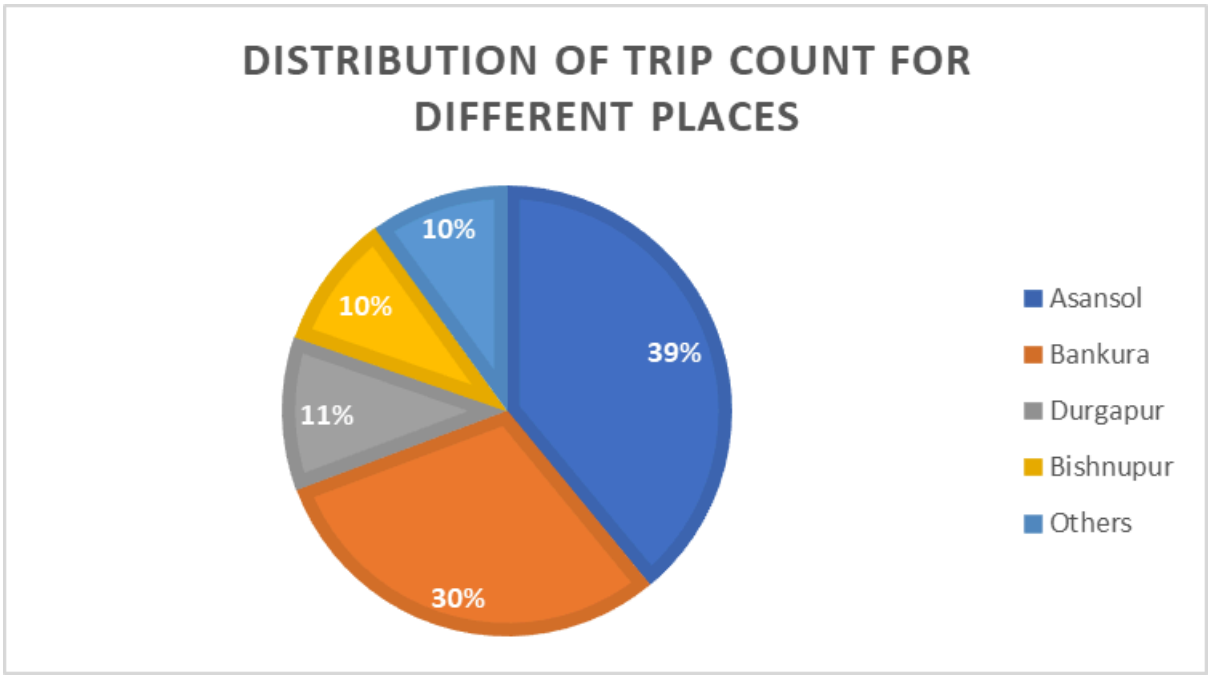

Figure 5: Pie chart displaying the distribution in trip count with respect to various places

Figure 5 provides a detailed distribution of trip counts for key operational areas involving owner-owned trucks. The chart reveals that **Asansol registers the highest proportion of trip count, followed closely by Bankura**. Durgapur, which ranks third, is geographically

close to Asansol, while Bishnupur is close to Bankura. This indicates that owner-owned trucks predominantly operate in the districts of Bankura, Medinipur, and Paschmi Burdwan, as mentioned in Section 2.1 of results.

It is noteworthy that OCL places a substantial number of shipment orders for Bankura and Asansol, surpassing the orders placed for other two locations. As a result, Bankura and Asansol have emerged as the firm's niche areas.

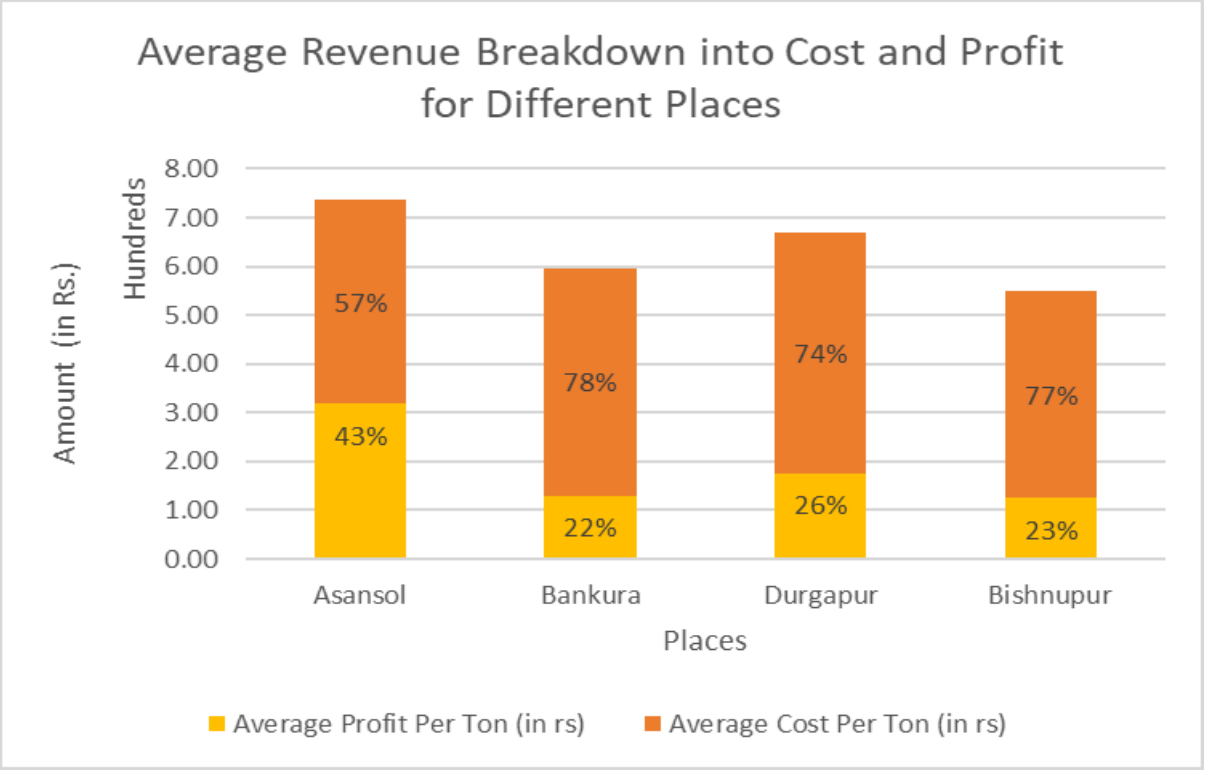

Figure 6: Stacked column chart representing the revenue breakdown for different places

Figure 6 provides a detailed breakdown of revenue into cost and profit. Among the most frequented locations, **Asansol exhibits the highest profit-to-revenue ratio**. Bankura and Bishnupur, both located in close proximity to OCL, exhibit similar revenue patterns which are relatively lower. However, each trip incurs fixed costs such as driver salaries and toll fees. Consequently, despite a substantial trip count, these locations yield reduced profits.

The firm thus prioritizes unloading in Asansol most of the time, driven by its higher profit margin and the highest revenue per ton. Bankura serves as the second option for unloading.

2.3: Result of Analyzing the Backhaul Trip Coordination in the Key Activity Areas for Owner-Owned Trucks

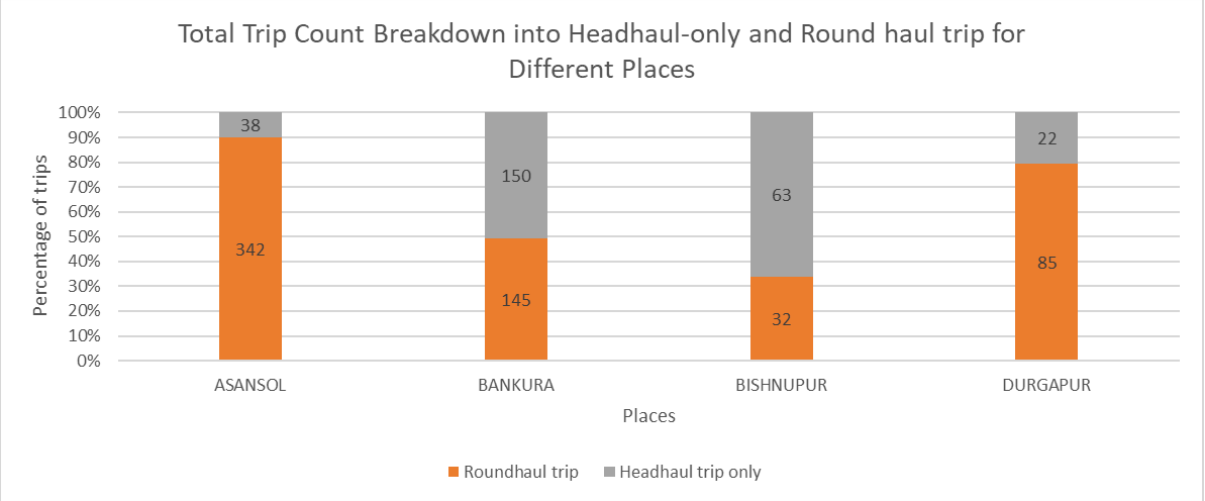

Figure 7: 100% stack column chart representing the total trip count breakdown for different places

As depicted in Figure 7, it is evident that **Asansol and Durgapur are performing exceptionally well in terms of backhaul trip coordination**. This can be attributed to the readily available shipment orders originating from brick, rod, and cement industries in these areas, coupled with the well-connected network of the owner.

However, **the performance is less optimal for Bankura and Bishnupur**. The primary factor contributing to this suboptimal performance is the lack of readily available industrial orders for trucks not affiliated with local transporters in these regions. As a result, a significant portion of the backhaul trips from these locations are actually rerouted to Asansol.

Problem 3: Increasing the driver retention rate, with the intention to reduce the number of idle trucks.

3.1: Result of analyzing the Actual vs Expected Performance of Owner's Trucks

During the period from January to October 2023, three trucks, identified by the numbers 2793, 2962, and 3761, were sold. That is why these trucks have a lower expected trip count. The expected trip count depicted in Figure 8 does not include data from November, as the data for the entire month was not available.

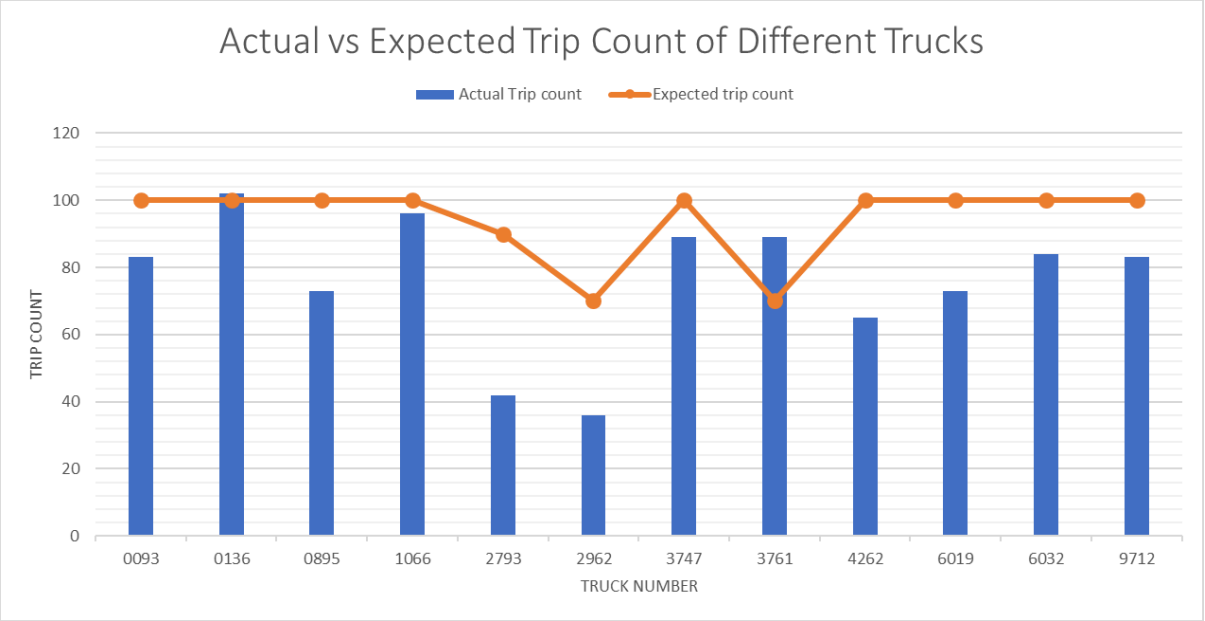

Figure 8: Combo chart displaying the actual and expected trip count disparity for different trucks

As per Figure 8, trucks numbered 3761 and 0136 successfully met their respective targets for the period under consideration. Trucks 1066 and 3747 were notably close to achieving their targets. In contrast, trucks 2793 and 2962 exhibited the lowest trip count. This data suggests that while the number of trips is largely dependent on demand, it is also influenced by factors such as the driver's efficiency and the idling time of the truck.

3.2: Result of the examining the Trucks' Idle Periods Resulting from Driver Transitions

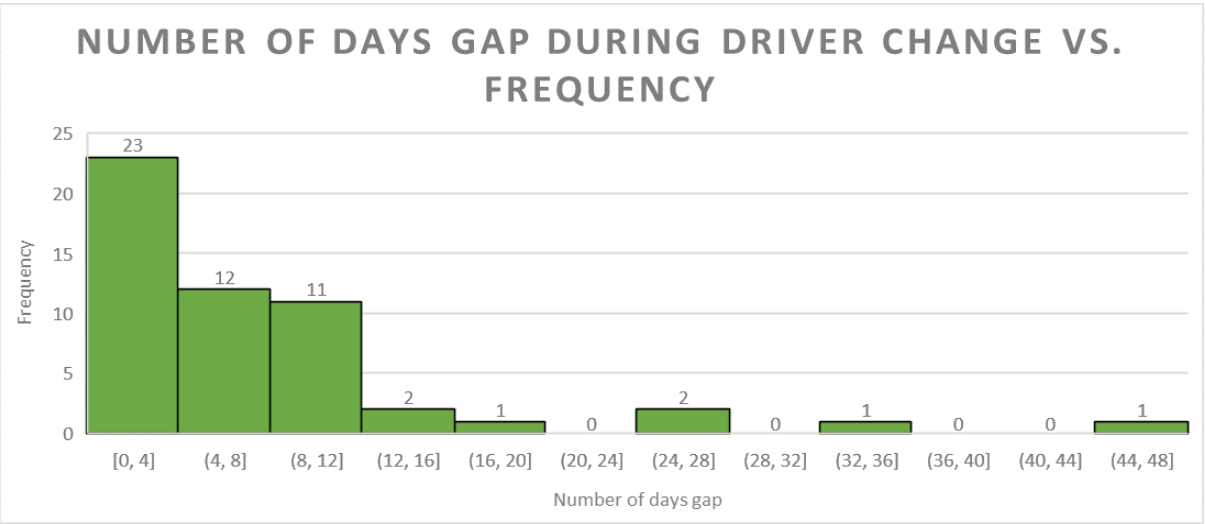

Figure 9: Histogram representing the frequency distribution of number of days gap during driver change

As depicted in Figure 9, approximately 43% of the time, the duration for driver replacement was a reasonable 0-4 days. However, for the remaining **57% of the instances, the replacement process extended to 5 days or more**. Notably, there were 2 instances where the replacement process exceeded 30 days.

The majority of the replacement drivers were not new hires, but were instead existing drivers who were regularly operating other trucks within the fleet. This pattern can be attributed to the challenges associated with finding suitable drivers. The process of securing a permanent replacement for a truck can be time-consuming, during which the truck remains idle.

3.3: Result of Driver Retention Rate Analysis

As revealed in Section 3.3 of the analysis, the firm's **driver retention rate is currently at 50%**. This figure is significantly impacted by two primary factors as identified by the owner. The first factor is the competitive salary packages offered by other firms, which are reportedly more lucrative and thus, attract drivers away. The second factor is related to performance standards. Some drivers are not meeting the expected performance benchmarks, leading to a substantial reduction in the number of trips. This underperformance often results in their termination.

Interpretation of Results and Recommendations

Problem 1: Ensuring timely arrangement of third-party trucks during high demand periods.

The strategic engagement of third-party trucks can be effectively planned to cater to the fluctuating demand patterns throughout the year. The following provides a detailed approach:

1. **Annual Planning:** During the peak demand period, specifically January to March(1st to 13th week of the year), advanced planning is crucial. The procurement of third-party trucks during this period can ensure that the high demand is adequately met, thereby maintaining service levels. This planning can ideally be initiated in December. The rationale behind this is to allow sufficient

lead time for negotiations with third-party providers, ensuring availability of trucks and avoiding last-minute price surges.

2. **Monthly Planning:** The end of each month (26th - 31st) typically witnesses a surge in demand. To cater to this increased demand, the engagement of third-party trucks can be strategically planned a week in advance. This planning should be aligned with the average monthly demand.

Problem 2 : Improving the efficiency of backhaul trips coordination with the aim of increasing the proportion of roundtrip hauls.

The efficiency of backhaul trip coordination varies across different locations, impacting the proportion of roundtrip hauls. Here are some recommendations:

1. **Preservation of Asansol's backhaul trip coordination:** Asansol, a crucial location for the firm, has demonstrated success in coordinating backhaul trips without any established backhaul transport partnerships. This effective strategy should be sustained, with Asansol continuing as a primary focus in the firm's operations.
2. **Improvements for Bankura and Bishnupur:** Bankura and Bishnupur have shown less success in coordinating backhaul trips. To enhance this, the owner should consider expanding the network in these areas or establishing backhaul transport partnerships with the local industries in Bankura. Given the proximity of these locations (approximately 40 km apart), there is potential for synergistic operations of backhaul trips between these two places that could improve the overall efficiency of the firm.

Problem 3: Increasing the driver retention rate, with the intention to reduce the number of idle trucks.

To mitigate the financial losses associated with idle trucks and improve driver retention, the following strategies can be adopted:

1. **Rotational Standby System and Fixed Holidays:** Given the typically lower demand at the beginning of each month, the firm could maintain a standby fleet of 3-4 trucks. The remaining drivers could then be provided with a rotational holiday

schedule. Additionally, implementing a system of fixed holidays for drivers can ensure regular rest periods and contribute to driver satisfaction and hence lessen the number of idle trucks.

2. **Performance-based Incentives:** The firm could introduce yearly incentives and recognition for the highest-performing drivers, particularly those who complete the most trips. This strategy can serve as a powerful motivator, encouraging all drivers to enhance their performance.
3. **Formal Leave Process:** Establishing a formal process for leave applications can ensure smooth operations during driver absences. If a driver takes leave, they could be asked to provide a temporary replacement driver.

Additional Recommendations:

1. **Demand Fulfillment using Third party trucks:** During the downtime in September, which is caused by driver unavailability, the demand can be met by utilizing third-party trucks. This strategy can help maintain service levels during periods of internal resource constraints.
2. **Diversification during Low Demand Periods:** During the Monsoon season, when demand is typically low, it may be beneficial to explore other areas of operation, like the agricultural and consumer staple sectors to supplement income. These sectors are often less affected by the monsoon and could provide stable income during this period.
3. **Business Expansion in High Revenue Areas:** The firm can consider expanding the business in areas like Kalna, which have shown high revenue potential. By leveraging the high revenue in these areas, the firm can enhance its profitability.