OPTIMIZING FINANCIAL STABILITY, WORKFORCE PRODUCTIVITY, AND SUPPLY CHAIN RESILIENCE OF A MANUFACTURER/SERVICE PROVIDER.

A Proposal report for the BDM capstone Project

Submitted by

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EXECUTIVE SUMMARY AND TITLE- Patna Calibrators is a family business, B2B manufacturing and service provider located in Gulzarbagh, Patna, Bihar. It was established in 1982 and works in manufacturing petroleum storage solutions. This includes diesel tankers, oil tankers, water storage tanks, petrol pump canopies, and structural fabrication services. The company serves major clients like Indian Oil Corporation, Hindustan Petroleum, and Bharat Petroleum.

The total workforce is of 20 to 40employees, the firm is facing several operational and financial challenges including delayed payments from clients, which affect cash flow and force the company to take out loans. Seasonal disruptions during rain and winter reduce workforce availability and slow down production. Supply chain delays occur due to the lack of raw materials in Patna. Additionally, increased labour costs arise from frequently hiring daily wage workers. Together, these issues hinder workflow, raise operational costs, and lower overall profitability.

The data was given by Patna Calibrators. The main source of this data is the BANK.xlsx file. It contains various sheets that cover various financial and operational activities. Important datasets are records of client transactions (sales and payments), office expenses, cash payments for labour & transportation, attendance sheet, order fulfilment sheet etc. These variables are chosen because they help track customer payment patterns and study spending on workforce-related costs. We calculated descriptive statistics like mean, median, standard deviation, and total amounts for debit and credit entries. This calculation helps measure cash inflows and outflows. The summary tells average payment amounts, spending trends on daily labour, and changes in cash flow during the two-month period. These datasets form the basis for spotting financial issues and informing resource allocation decisions.

PROOF OF DATA ORIGINALITY

Dataset Link- https://docs.google.com/spreadsheets/d/1X3tfPZZ2KCEOX0dyTjI5k0tUnfMr0739/edit?usp=sharing&ouid=105733453307777656845&rtpof=true&sd=true

Letter From Organization- https://drive.google.com/file/d/1XMjX6gvp4NcpW4d59CTeo5ILpL8OOo8q/view?usp=sharing

Images- https://drive.google.com/file/d/1wsjQMSZwo6i2IFHWK-QVqtG_F2xNM_1G/view?usp=sharing

Short Video- https://drive.google.com/file/d/1ijsxrcRdXblKSfz6Cn2i0JZauFW1aR9s/view?usp=drive_link

METADATA-These were the problem statements:

Problem statement 1: Delay Payment of the orders by the customer/companies causes workflow disbalance causing, delays in procurement and production schedules resulting in taking loans from banks, paying interest and decrease in the profitability. Problem statement 2: Seasonal conditions like rain and winter weather causes significant decrease in workforce, disruptions in the supply chain and delay in orders completion resulting in potential loss and decrease in production pace. Problem statement 3: Unavailability of raw materials in Patna and transporting them from Kolkata causes delay in completion of order and customer unsatisfaction. Problem statement 4: Decrease in the workforce results in the hiring of daily wage worker causes extra workforce expense.

SHEET 1 – DEBIT CREDIT OF LARGE CASH FLOW **Table 1**

Variable Name	Data Type	Description/Importance	Relevance to Problem
Date	Date	Date on which the transaction happened	Identifies timing of expenses/income to check delays or seasonal impacts

Variable Name	Data Type	Description/Importance	Relevance to Problem
Particulars	Text	Details of who paid or who received the money	Helps identify vendor, employee, or customer involved in a transaction
Vch Type	Text	Voucher type – two categories are there "Payment" or "Receipt" is mentioned in the data	Shows whether cash is going out or coming in
Vch No.	Numbers	Voucher number – unique ID or number for tracking transactions so that no one can take unnecessary money or stealing	For reference in detailed analysis
Debit	Numbers	Amount of money paid	Shows operational costs (e.g., wages, purchases)
Credit	Numbers	Amount of money received by the Business	Tracks payments received
Invoice date	Date	Date when an invoice is created and issued by the seller to the buyer.	Helps in checking delay of date by checking the date of payment

This sheet is essential for analysing Problem 1: With credit column, we can see who pay late and how that affects available balance for workflow, Debit column shows money outflow, which will still happen if the cash is delays or the payment is delayed – showing cash flow tension. Dates can be used to check seasonal impacts (Problem 2), like if more payments or wage payments are done during which months.

SHEET 2 - CONVEYANCE LEDGER ACCOUNT **Table 2**

Variable Name	Data Type	Description/Importance	Relevance to Problem
Date	Date	Date of the cash expense	Keeps track of frequency and consistency of daily travel/work movement
Particulars	Text	To Cash - indicating a payout	Identifies this as a cash transaction from company to employee
Vch Type	Text	Type of transaction — mostly Payment	Specifies nature of transaction
Vch No.	Numeric	Voucher number for office reference	Used for tracking and auditing
Debit	Numeric	Expense amount (daily allowances or daily work payments)	Indicates operational expense tied to employee activity or service delivery

Relates to Problem 2: This sheet can identify monthly patterns in conveyance expenses for months having higher cash flow it might reflect seasonal field work. calculates per-day average conveyance. Helps in cost control analysis: are these expenses within budget or increasing in a weird pattern.

SHEET 3- GST SALE **Table 3**

Variable Name	Data Type	Description/Importance	Relevance to Problem
Date	Date	Date of transaction	identifies revenue patterns and compare month-wise sales
Particulars	Text	Names of companies (IOCL, BPCL, HPCL)	Indicates client diversity and concentration — helpful for dependency/risk analysis

Variable Name	Data Type	Description/Importance	Relevance to Problem
Vch Type	Text	Type of entry like Sales	Confirms the nature of the ledger and filters relevant entries
Vch No.	Text	Unique number for office reference	Internal referencing; supports traceability and auditing
Credit	Numeric	Sale value — revenue earned	Key to understanding sales trends and peak periods

Relates to Problem 1: The "Particulars" column can calculate how much each client contributes to total revenue. Also relates to Problem 2: Comparing this with Sheet2 (expenses) allows profitability analysis month-by-month.

High-value sales and frequent entries can indicate major revenue contributors and cash flow cycles.

SHEET 4 - LEDGER ACCOUNT BIHAR STATE OFF **Table 4**

Variable Name	Data Type	Description/Importance	Relevance to Problem
Date	Date	Date of transaction (sale or payment)	Helps in tracking payment delays or patterns
Particulars	Text	Transaction details — GST SALE or payment from STATE BANK OF INDIA	Identifies whether it's a sale (debit) or a payment (credit)
Vch Type	Text	Type of voucher — "Sales" or "Receipt"	Categorizes the transaction
Vch No.	Text	Voucher or receipt number	Useful for internal recordkeeping and cross-verification
Debit	Numeric	Amount invoiced (sale made to client)	Revenue generated from the client
Credit	Numeric	Amount received from the client (payment)	Indicates payment collection and timing

Key to Problem 3: Match each sale (debit) to its corresponding payment (credit). Calculate the delay between invoice and payment dates. Important for Cash Flow Analysis:
If large receivables stay unpaid it affects cashflow which causes problems in operation of the business (like delays in vendor payments).

SHEET 5- OFFICE EXP. LEDGER ACCOUNT **Table 5**

Variable Name	Data Type	Description/Importance	Relevance to Problem
Date	Date	Date when the cash expense was recorded	Helps analyze daily/weekly/monthly expense trends
Particulars	Text	Always "To Cash" — meaning cash expense	Indicates it's a cash payment
Vch Type	Text	Type of voucher — here it's always "Payment"	Confirms it's an outgoing transaction
Vch No.	Text	Voucher number — internal bookkeeping ID	Useful for accounting accuracy and tracking
Debit	Numeric	Amount of cash spent	Reflects office running expenses

Linked to Problem 2:Calculate total expenses over the period. Spot trends or spikes on certain days or weeks. See if certain periods have higher outflows.

SHEET 6 -ATTENDANCE **Table 6**

Variable Name	Data Type	Description	Relevance to Problem 4
Date	Date	The calendar date of observation.	Helps analyze absenteeism trends over time.
Day	Text/String	The day of the week (e.g., Monday, Tuesday).	Useful to check if absenteeism increases on weekends.
Employee Columns	Categorical	Marked as **P (Present)** or **A (Absent)** for each worker per day.	Central to identifying labor shortages.
Total Present	Numeric	Calculated: number of present employees per day.	Determines if backup labor is needed that day.
Total Absent	Numeric	Calculated: number of absent employees per day.	Reflects absenteeism level.
Extra Workers Needed	Numeric	Derived: Present < Threshold → extra workers hired.	Used to estimate added workforce costs.

This dataset is directly related to Problem 4, which is employee absenteeism and its impact on extra workforce expenses. Tracking employee presence helps determine: Which days fall short of labour needs How often and how many workers are hired as backup. What cost is for daily wage labourers due to absenteeism. By transforming categorical presence data into counts and identifying thresholds, we quantify the financial impact of inconsistent attendance.

SHEET 7 -FULFILMENT DETAILS OF THE ORDERS **Table 7**

Variable Name	Data Type	Description / Importance
Order ID	Text	Unique identifier for each order - tracking and referencing individual transactions across datasets.
Order Date	Date	date of order - track customer ordering patterns and calculate lead times.
Order Deadline	Date	expected delivery date - compute delivery delays.
Fulfillment Source	Categorical (Text)	location from which the order was fulfilled: Patna (local) or Kolkata (external).
Transport Start Date	Date	shipment was dispatched - identifying delays in processing or dispatching.
Delivery Date	Date	order was delivered - Order Deadline to calculate delay.
Delay (in Days)	Numeric	Calculated difference between Delivery Date and Order Deadline. Indicator of fulfillment performance.
Stock Available in Patna	Categorical (Yes/No)	Indicates if inventory was locally available. “No” implies sourcing delays from Kolkata.
Customer Satisfaction Rating	Numeric (1–5)	customer’s satisfaction- business impact of delays.
Order Quantity	Numeric	Quantity ordered. We can see if large order volumes cause delays or operational strain.
Delay Reason	Text	explanation of cause for delay

Justification: Link to Problem Statements Each variable contributes directly to Problem Statement 3: Fulfilment Source & Stock Availability in Patna: Directly show whether delays are due to non-availability of materials locally. Delay (in Days): Quantifies fulfillment delays. Customer Satisfaction Rating: Measures customer impact and links operational inefficiencies to business consequences. Delay Reason: Helps classify types of issues — logistical, inventory-related, or others. Order Quantity: correlate workload with fulfilment performance. Transport Start Date & Delivery Date: Show timeline of action post-ordering.

DESCRIPTIVE STATISTICS- SHEET 1

CREDIT	
Mean	91513.27077
Standard Error	17381.38497
Median	24485
Mode	100000
Standard Deviation	165807.8449
Sample Variance	27492241441
Kurtosis	13.34382482
Skewness	3.290961064
Range	1036163
Minimum	30
Maximum	1036193
Sum	8327707.64
Count	91

Table 8

Mean >>median - few very large credit amounts cross the mean. High standard deviation and skewness show a wide, uneven distribution – some customers pay very high amounts for delays as bulk. Long right tail shows delay of large payments/bulk payments.

Justification Problem 1: Very high mean (₹91,513), low median (₹24,485) and skewness (3.29) large payment were made at end. Kurtosis (13.34) shows frequent extreme large payments– delayed bulk payments from some customers. The delay supports the problem of disrupted cash flow and loan needs.

DEBIT	
Mean	290188.0177
Standard Error	39018.0948
Median	279800
Mode	300000
Standard Deviation	198954.0268
Sample Variance	39582704772
Kurtosis	-0.659039206
Skewness	0.421059801
Range	719094.22
Minimum	1420
Maximum	720514.22
Sum	7544888.46
Count	26

Table 9

Statistic	Value
Mean	32.11
Standard Error	2.53
Median	26
Mode	13
Standard Deviation	24.18
Sample Variance	584.57
Kurtosis	-0.57
Skewness	0.63
Range	100
Minimum	1
Maximum	101
Sum	2922
Count	91

Table 10

Mean, median and mode are close showing consistent debit. Small skewness & moderate range compared to credit show more controlled expense patterns. But high values still show financial outflows for raw material.

The average delivery delay of 32 days, with a median of 26 and mode of 13, indicates frequent 2–4 week delays, while some orders face extreme delays up to 101 days, raising the overall average. High variability (SD 24.18, range 100) and positive skew (0.63) show inconsistent and unpredictable delivery timelines. The flat distribution (kurtosis -0.57) further confirms widespread delays. This aligns with Problem Statement 3, highlighting systemic issues like stock unavailability in Patna and transport reliance on Kolkata — affecting cash flow, client trust, and productivity.

SHEET 2

DEBIT	
Mean	183.537
Standard Error	7.577953
Median	172
Mode	110
Standard Deviation	55.68636
Sample Variance	3100.97
Kurtosis	1.111677
Skewness	0.912382
Range	267
Minimum	110
Maximum	377
Sum	9911
Count	54

Table 11

Mean and Median are close showing relatively symmetrical spending behaviour. Low standard deviation (₹55.69) shows controlled and predictable spending on conveyance. Skewness (0.91) and kurtosis (1.11) shows a few high values but not highly irregular .

Justification Problem 4: Workforce decrease leads to extra expense -- Although this ledger isn't direct labour cost, it reflects operational support costs that increase when permanent staff are unavailable. Daily wage workers require travel charges and supervisors need to travel for that.

SHEET 3 **Table 12**

GST SALE CREDIT	
Mean	302780.7
Standard Error	32017.39
Median	225500.4
Mode	171929.5
Standard Deviation	150174.8
Sample Variance	2.26E+10
Kurtosis	-0.66589
Skewness	0.848937
Range	458169.3
Minimum	156779.7
Maximum	614948.9
Sum	6661176
Count	22

The mean (₹3.02 lakh) is higher than the median (₹2.25 lakh), indicating some larger sale credits pull up the average. A standard deviation of ₹1.5 lakh and range over ₹4.5 lakh show substantial variation in GST credits, possibly due to Bulk seasonal orders, Irregular customer payments, Or dependence on specific clients. Skewness (0.85) suggests occasional high-value sales inflating totals. Kurtosis (-0.67) shows a slightly flatter distribution (fewer extreme spikes, but broader spread).

Justification Problem 1: The wide fluctuations in GST credit (Range: ₹4.58 lakh, Std Dev: ₹1.5 lakh) indicate inconsistent payment inflows, disrupting cash flow and forcing reliance on loans or overdrafts, which reduces profit margins. These irregularities support **Problem 2**, as seasonal dips likely lower sales volumes and production, while surges strain logistics. Simultaneously, they confirm **Problem 3**, where supply delays from stock shortages or production lags result in missed or late sales, driving customer dissatisfaction. The credit variations clearly reflect deeper systemic and seasonal issues affecting both operations and customer trust.

SHEET 5 **Table 13**

Mean	150.6037736
Standard Error	4.427724668
Median	150
Mode	185
Standard Deviation	32.23432214
Sample Variance	1039.051524
Kurtosis	-0.543651075
Skewness	-0.060868393
Range	143
Minimum	80
Maximum	223
Sum	7982
Count	53

Mean, median and mode are very close showing stable office expenses. Low standard deviation and low range (₹143) make the costs predictable. Nearly zero skewness (-0.06) shows balanced expense distribution. Flatter kurtosis (-0.54) no spikes in expenses.

Justification Problem 2: Seasonal Labor Disruption and **Problem 4:** Hiring Daily Wage Workers Increases Costs **-** These are the payments for daily wage workers when the labours is not enough which causes a increase in cost and decrease in productivity in seasonal weather like rain**.**

SHEET 6 ATTENDANCE **Table 14**

Mean	15.83333333
Standard Error	0.285290784
Median	16
Mode	16
Standard Deviation	2.519619981
Sample Variance	6.348484848
Kurtosis	0.250104404
Skewness	-0.611804517
Range	11
Minimum	9

Maximum	20
Sum	1235
Count	78

Interpretation: Attendance of labours for 53 days (April +may excluding Sundays) can be used to check important insights for the availability of workers/labours and the operational requirements fulfilled or not based on that. Mean (15.83)- 16 workers - average, relatively stable labour force size in normal conditions. Median (16)- half the days at least 16 workers. Mode (16)- Most frequent 17 workers - most common workforce strength. Standard Deviation (2.51)- Moderate spread - variability in workforce availability - may cause less productivity on low count of workers. Range (11) - highest (20) - lowest (9) =13: significant fluctuation due to absent worker because of seasonal factor like rain. Minimum (9 workers)- causes operational disruption -leads to temporary hiring of daily wage workers. Skewness (-0.611)- slightly negative skew shows there are more number of high attendance days but some very low attendance days makes the average very low. Kurtosis (0.25)- distribution is very slightly peaked meaning values are a bit concentrated near the average but has some occasional deviations.

Justification (Problem Statement 4) Minimum Value (9 Workers): lowest attendance was 7 (<50% of full strength) which causes hiring of daily wage workers (extra expenses)**.** Moderate Standard Deviation (2.51): shows fluctuations in daily attendance showing inconsistency. Work/operational planning is affected by variability, causing stress on schedule and increases cost. Negative Skewness (-0.611): most days have high attendance but there are significant drops as well resulting to temporary hiring needs. Range =11 (9 to 20): workforce attendance is not stable disrupting production. Slightly Peaked Kurtosis (0.25): slight concentration around the mean but with some extreme low values showing irregular workforce.

SHEET 7

Table 15

Fulfilment Source	Average delay
Kolkata	3.101
Patna	1.444

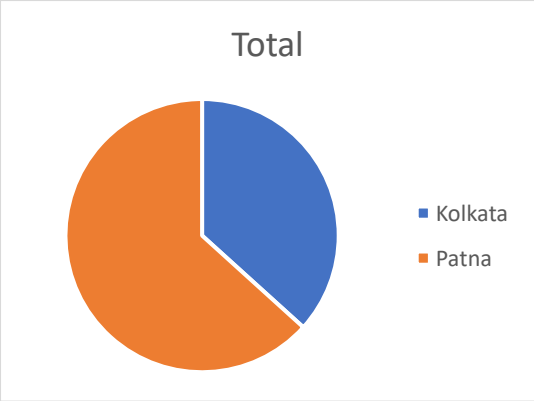


Chart 1

Table 16

Row Labels	Count of Order ID
Kolkata	58
Patna	100
Grand Total	**158**

DELAY IN DELIVERY	
Mean	2.151898734
Standard Error	0.137700098
Median	2
Mode	2
Standard Deviation	1.730863395
Sample Variance	2.995888092
Kurtosis	-0.391141691
Skewness	0.531351204
Range	6
Minimum	0
Maximum	6
Sum	340
Count	158

Table 17

The average delay across all 158 orders is just over 2 days, with both the median and mode also at 2, indicating a fairly stable delay trend for most orders. This means that for a majority of customers, deliveries were either on time or delayed by a very short period. The standard deviation is 1.73, which tells us that the delay durations are generally clustered around the mean, with only a few cases stretching further out. The range is 6 days, meaning the longest recorded delay in the dataset was 6 days — which, in the context of B2B manufacturing, is noticeable but not extreme. The skewness of 0.53 shows a slight right skew, meaning while most deliveries are close to the expected deadline, a few orders experience longer delays. The negative kurtosis (-0.39) indicates a relatively flat distribution, so the delays are spread somewhat evenly rather than clustered around one single value. While a 2-day average delay might seem small in isolation, in a competitive industrial market, even short delays can lead to customer dissatisfaction, especially when it becomes a pattern. The fact that there is some consistency (low variance) is encouraging, but the business still needs to address the underlying causes — such as supply chain lag, stock unavailability, or weather-based disruptions. This analysis supports the findings in Problem Statement 3, where orders fulfilled from Kolkata due to Patna stockouts tend to be more delayed, affecting not just timelines but also customer satisfaction ratings.

DETAILED EXPLANATION OF ANALYSIS PROCESS/METHOD

DATA CLEANING AND PREPROCESSING

1.Explanation: First step before doing any analysis is to clean and preprocess the data so that it is accurate for further analysis. Following steps were caried out:

a. Checking of blank cells /Null Values Blank cells/NULL values cause incorrect calculations so were replaced (by using mean or median). Missing values were removed (if minimal & non critical)

b. Outliers Outliers were checked using boxplots and standard deviation data. Outliers were reviewed for Attendance sheet, very low workforce reflects seasonal issues not an error. So it was not removed**.**

c. Data Formatting Numerical values were formatted to a proper format (e.g., two decimal places). Dates were uniformly formatted (example: DD/MM/YYYY).

d. Column renaming and Data Labelling Unnamed columns were named based on context (e.g Credit Amount, Attendance Count) for clarity. Labels were added to see difference between credit, debit and other categories.

2. Importance:

a. Avoids Misleading Results If the data contains errors like duplicates or missing values it can give incorrect results for important calculations like averages or trends. Cleaning the data helps in making the results correct and able to reflect and show what is really going on in the company/business.

b. Makes Statistics More Trustworthy When the data is clean, the numbers you get like the average or most common value are more accurate. This helps us spot real patterns, such as seasonal extremes in staffing or regular payment delays.

c. Helps Identify Real Problems Clean data can make it easier to view how several issues are interconnected. For example, if customers are paying late, clean data can help trace the root cause, like billing errors or credit problems.

d. Improves Graphs and Reports When the data is clean and preprocessed, it's much easier to create clear charts. This makes it simpler for teams to understand the situation and take action.

e. Boosts Prediction Accuracy We can use forecasting tools or predictive models on clean data if neeed. It give accurate results using these tools in machine learning models.

ANALYSIS PROCESS/METHOD

PROBLEM 1: DELAY IN PAYMENT BY CUSTOMERS: Relevant Sheet(s): Debit credit of large cash flow and GST SALE**---Identify Delayed Payments:** Compare the "Invoice Date" and "Payment Date" from both the sheets. Calculate Delay = Payment Date - Invoice Date. These two fields are essential to calculate how long the payment was delayed **---Quantify Delay Using Mean:** Let Di be the delay for order i. Di=Payment Date of i −Invoice Date of i. This helps quantify the delay in payment for every transaction.

- $\bar{D} = \frac{1}{n}\sum_{i=1}^{n} D_i$ Mean Delay =32.10989011**---Flag Long Delays:** Set a threshold T, like T=15 days and ET=50 days. If Di<T, Ontime. If ET>Di>T, Moderate delay. If Di>ET, Critical Delay

On-Time	31
Moderate delay	36
critical delay	24

Table 18

Monthly/quarterly delay trends using line graphs or heatmaps. estimate financial impact: where R= annual interest rate, A = delayed amount. $$\text{Interest Cost} = \frac{R}{365} \times D \times A$$ **---Cash Flow Disruption Insight:** Check delays with bank loans**---Justification:** Time-difference is the most direct method for delay**---Rationale:** Directly measures problems in internal finances.

PROBLEM 3---1. Clarity: Step-by-Step Analysis Data Columns Used: Order ID, Order Date, Order Deadline, Fulfilment Source, Transport Start Date, Delivery Date, Delay (in Days), Customer Satisfaction Rating, Stock Available in Patna(yes/no)

Observation: All selected rows which have **Stock Available in Patna = No** means Patna didn't have stock so Kolkata finished the orders.

Delay Calculation: Delay=Delivery Date−Order Deadline. Positive values-a late delivery. Negative values are replaced with 0 to show no delay.

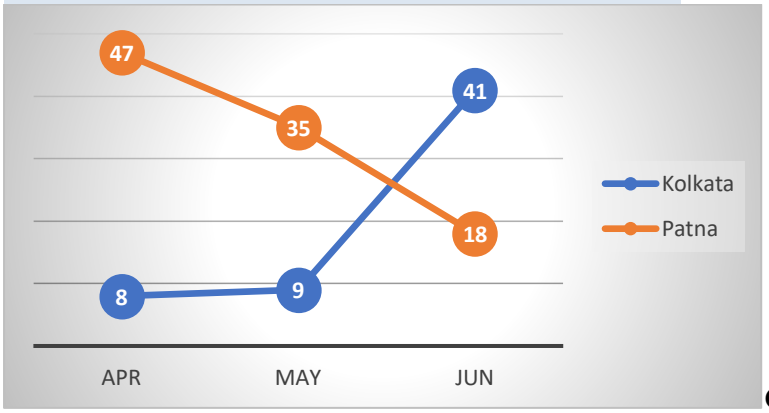
Satisfaction Trend: Most orders with delay ≥ 3 days have **Customer Satisfaction ≤ 3** **Table 19**

Count of Customer Satisfaction Rating	**Column Labels**					
Row Labels	**1**	**2**	**3**	**4**	**5**	**Grand Total**
0		1	8	12	17	38
1		1	2	6	7	16
2	1	8	12	15	10	46
3	2	11	8	4	3	28
4	5	3	2	1		11
5	4	4	2			10
more than 5	3	3	2	1		9
Grand Total	**15**	**31**	**36**	**39**	**37**	**158**

2. Abstraction: Mathematical View Di be the delay in days for order i**.** Si be the satisfaction rating for order i. Fi be the fulfilment source (Patna/Kolkata)**.** Ai∈ {0,1} be the availability of stock in Patna (1 = Yes, 0 = No)**.** We observe: For all i , if Ai=0⇒Fi=Kolkata and for majority Di≥2⇒Si≤3**.** This shows a **negative correlation** between delay and satisfaction.

3. Justification of Methods Used: Scatter Plot (Delay vs Satisfaction by Fulfillment Source): Shows direct correlation of delay with satisfaction and separates Patna vs Kolkata impact. **Pivot Table**: Summarizes total delays and average satisfaction by fulfilment center. **Line Graph**: **Table 20** Identifies if Patna stock-outs cause spikes in Kolkata orders.

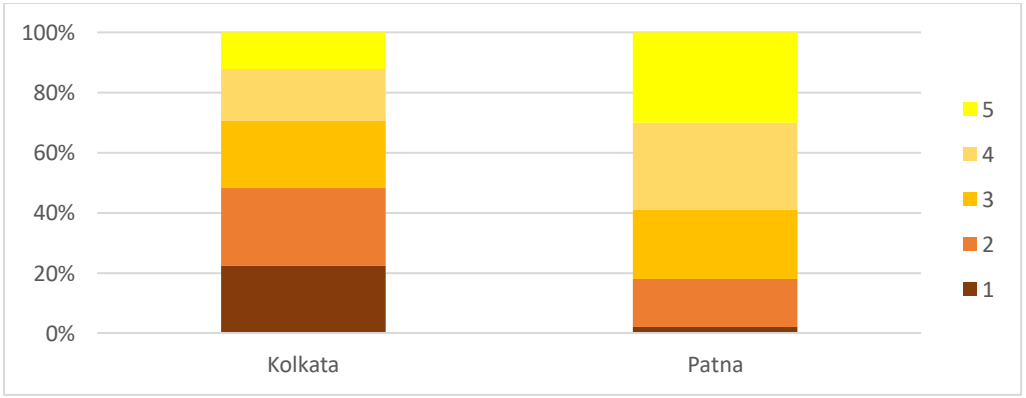
Count of Order ID MONTHS	FULLFULLMENT CENTRE Kolkata	Patna	Grand Total
Apr	8	47	55
May	9	35	44
Jun	41	18	59
Grand Total	58	100	158



Graph 1

- **100% Stacked Column:**
  Shows the spread of satisfaction values for Kolkata vs Patna. **Table 21**

Count of Customer Satisfaction Rating Row Labels	Column Labels 1	2	3	4	5	Grand Total
Kolkata	13	15	13	10	7	58
Patna	2	16	23	29	30	100
Grand Total	**15**	**31**	**36**	**39**	**37**	**158**



Graph 2

Compared to simpler summary statistics, these **visual tools highlight patterns and outliers**, which are crucial in this type of operations analysis.

4. Rationale: Connecting Method to Problem-The **core issue** is stock unavailability in Patna leading to sourcing from Kolkata, causing delay → reducing satisfaction. The chosen methods: Validate that **Kolkata orders are linked with delays.** Confirm that **delays negatively affect satisfaction.** Reveal how often this occurs and to what extent. **Table 22**

Fulfillment Source	Average delay
Kolkata	3.101
Patna	1.444

5. Logical Flow of Analysis Identified fulfillment location per order. Filtered for Stock Available in Patna = No → All fulfilled by Kolkata. Checked delays and mapped them with satisfaction scores. Used pivot tables and charts (scatter, box plot) for trend visualization. Interpreted correlation and frequency to support the conclusion. Whenever Patna lacks stock, orders are fulfilled from Kolkata, leading to transportation delays, and customer satisfaction drops to 1–3 in most cases. This confirms a **systematic problem** caused by **supply chain dependency** on Kolkata.

PROBLEM 4- DECREASE IN THE WORKFORCE RESULTS IN THE HIRING OF DAILY WAGE WORKER CAUSES EXTRA WORKFORCE EXPENSE.

1. Extract Workforce Attendance Data - Use attendance per day from the dataset.

2. Set Required Workforce Threshold- standard daily required workforce=16 **.**For each day, if the actual number is **less than the threshold**, the **shortage is calculated**. This shortage is assumed to be filled by **daily wage workers**.

3. Identify Workforce Shortage- Calculate shortage: Shortage = (Required Workforce−Actual Present)

4. Estimate Daily Wage Hiring- Multiply daily shortage by daily wage rate to calculate.
Daily Wage Expense=Shortage× Wage Rate. By assigning a fixed **daily wage rate** (e.g., ₹480 per worker/day), the **extra cost** is estimated. Total shortage of labour in 2 months. 77 workers *480(as per Bihar rules) = 36960 Rs more needed for productive results everyday.

5. Summarize Over Time- Group by month to track trend of extra expenses due to hiring. Because of rainy conditions in June workforce was less **Table 23**

	TOTAL		APRIL		MAY		JUNE
Adequate	52	Adequate	23	Adequate	19	Adequate	10
Mild Shortage	19	Mild Shortage	3	Mild Shortage	7	Mild Shortage	9
Severe Shortage	7	Severe Shortage	0	Severe Shortage	1	Severe Shortage	6

Visualization - Create line chart: Date vs Extra Daily Wage Expense/shortage of number of workers**.**This shows that in june workers were less in number and more workers were needed and extra money was spend in hiring. Visualization helps identify peak periods and recurring shortages, supporting corrective planning.

Use of Abstraction (Mathematical Equations): R = Required workforce per day**.** Ad= Actual workforce present on day d**.** W = Wage rate per day per worker**.** Sd=R-Ad (shortage)**.** Cd= Sd×W (daily wage cost)

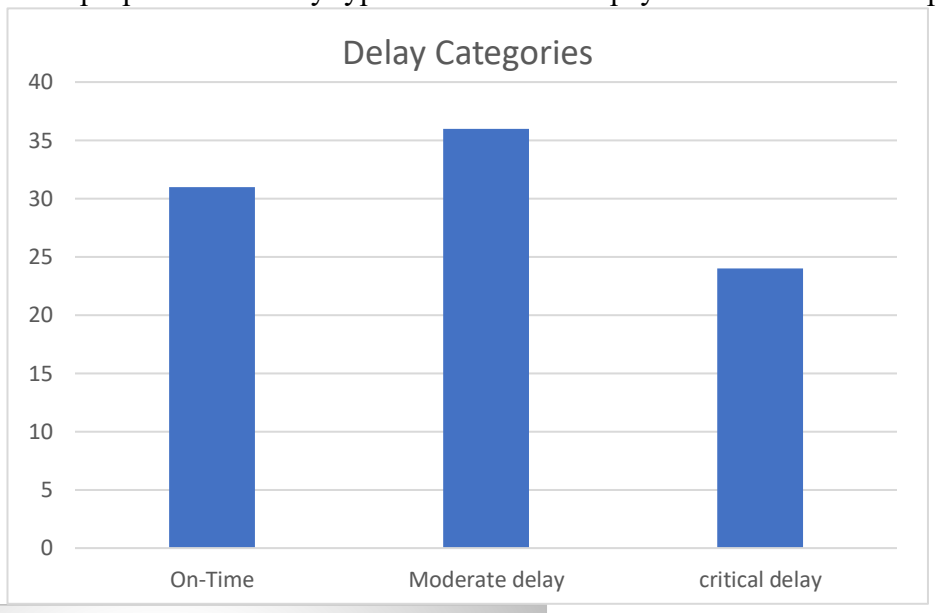
Justification of Chosen Methods: Shortage Calculation is a direct method based on daily headcount difference — simple, accurate, and practical. Cost Estimation using multiplication is more transparent than advanced forecasting or regression, which are unnecessary for this scenario. Weekly/monthly aggregation gives insights into patterns and budget planning. Visualization through bar charts or line graphs is intuitive for management use. Compared to machine learning or complex modeling, this method is sufficient, scalable, and easily explainable for workforce planning and cost management.

Rationale: Connection to Problem---The problem directly concerns extra costs due to workforce shortage. This method quantifies the exact number of workers missing, and the cost incurred daily. It helps in:

Identifying high-risk dates, understanding recurring patterns, making decisions on permanent vs temporary hiring, or offering incentives for regular attendance

RESULTS AND FINDINGS PROBLEM 1

Presentation--To effectively represent the delay patterns in customer payments, the following charts are there: Bar Chart: To show the count of transactions in each delay category (On-Time, Moderate, Critical). Pie Chart: visualize the proportion of delay types across the total payments. Bar Chart: Top 10 Critical Delay Vendors.



Graph 3

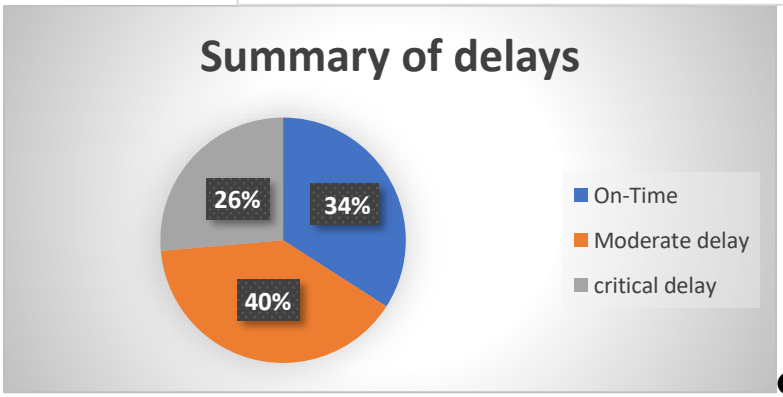
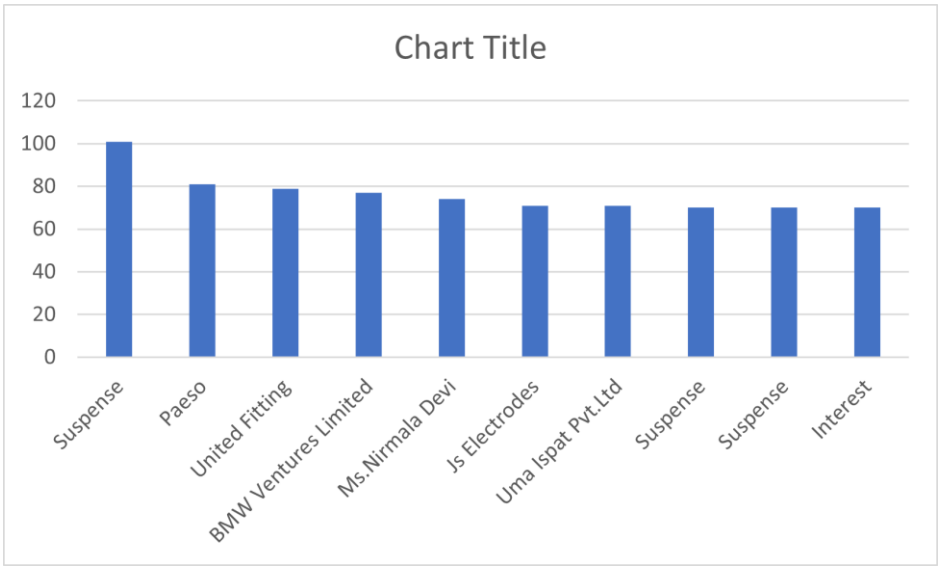
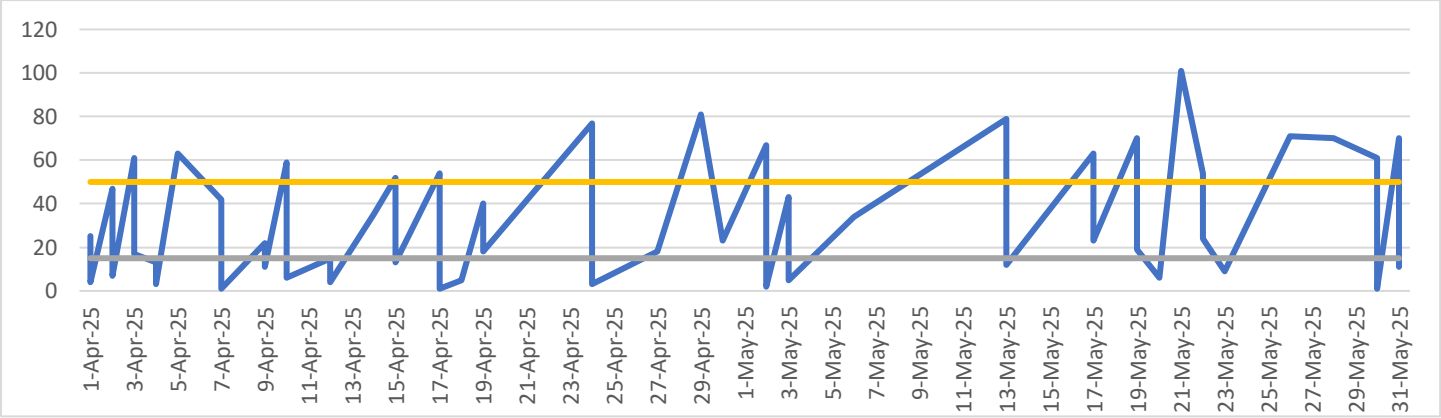


Chart 2



Graph 4

Graph 5



The trend analysis proves that payment delays are not only frequent but also fluctuate unpredictably. This uncertainty stresses procurement planning, affects vendor trust, and may cause loan dependency to maintain cash flow — directly impacting profitability

Trends and Patterns---Majority of payments (66%) are delayed, with Moderate Delay being the most common. Critical delays (24 out of 91) show a worrying number of severely late payments, possibly affecting cash flow. The average delay is 32 days, and the data is right-skewed, indicating a few extremely delayed payments. Delay values show high variability (standard deviation ~24 days), reflecting inconsistent customer behaviour.

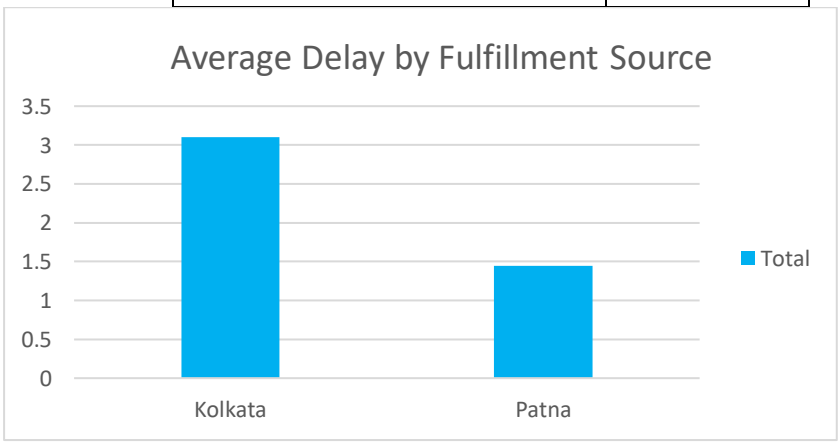
Preliminary Insights---Cash flow is strained due to inconsistent and late payments, especially critical ones. Customers likely need incentives for early payment or penalties for long delays. Patterns suggest the business should monitor high-delay clients more closely or adjust credit policies. Potential interest losses due to delayed payments justify urgent workflow optimization.

PROBLEM 3--Presentation of Findings- To analyse the delays caused by unavailability of raw materials in Patna we examined 158 orders. The dataset was visualized using bar charts, pie charts, and box plots for effective insight extraction.

1. Trends and Patterns – a) Fulfillment Source vs. Delay-Orders -- b). Stock Unavailability Impact

Table 24

Fulfillment Source	Average delay
Kolkata	3.101
Patna	1.444



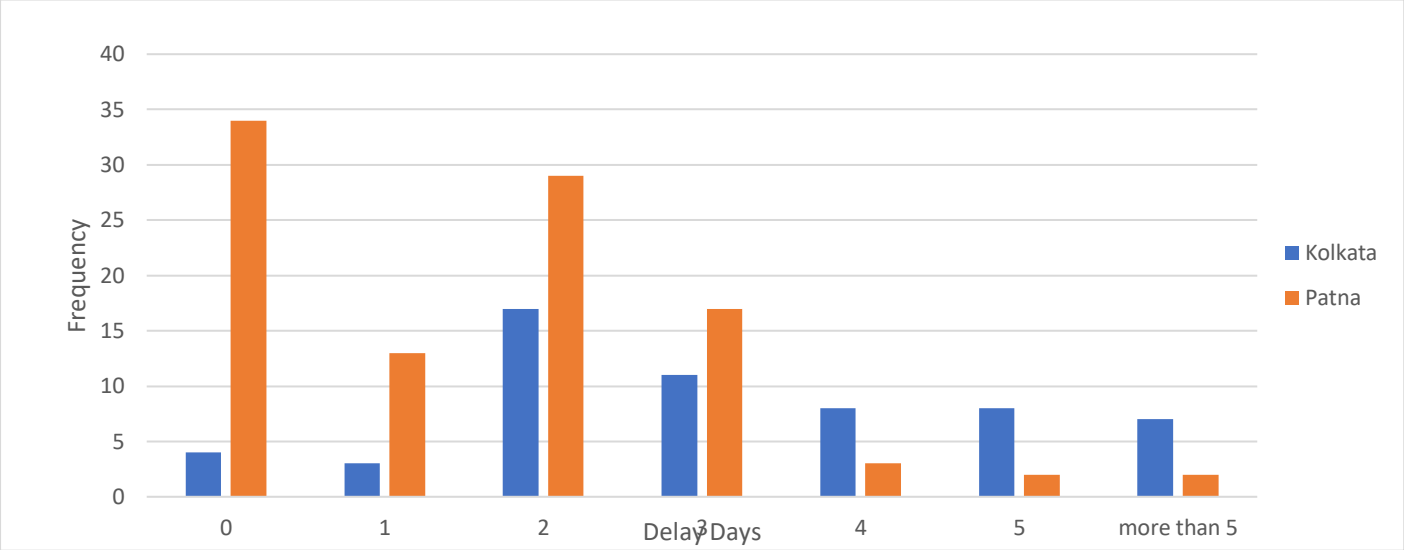
Graph 6

b). Stock Unavailability Impact **table 25**

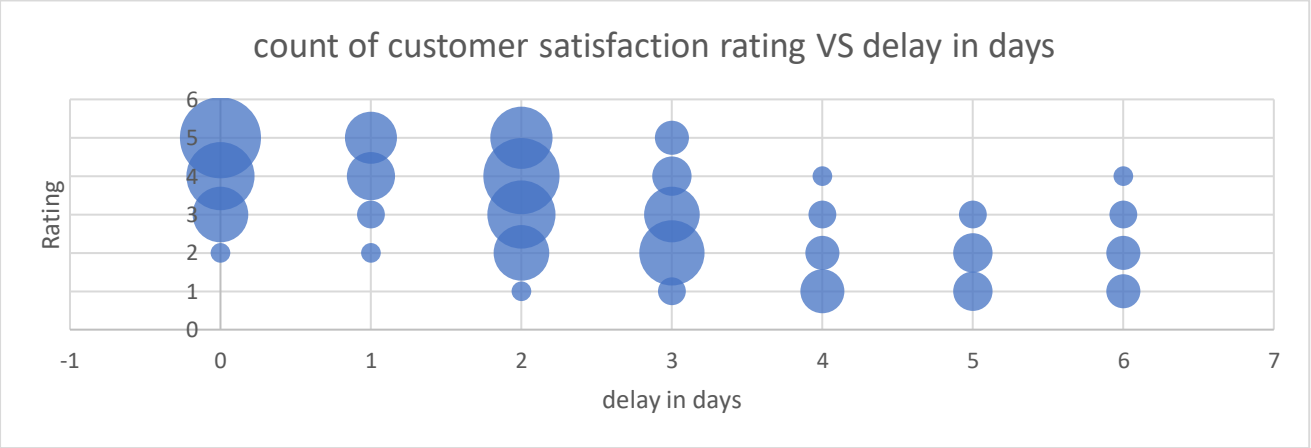
Count of Delay (in DAYS)	Column Labels

Row Labels	Kolkata	Patna	Grand Total
0	4	34	38
1	3	13	16
2	17	29	46
3	11	17	28
4	8	3	11
5	8	2	10
more than 5	7	2	9
Grand Total	**58**	**100**	**158**

Graph 7



- Among the orders where Patna stock was unavailable, very huge numbers had delays >=2. These orders also correlated with lower customer satisfaction, often rating 3 or 4 out of 5, versus 5/5 for in-time deliveries. **Graph 8**

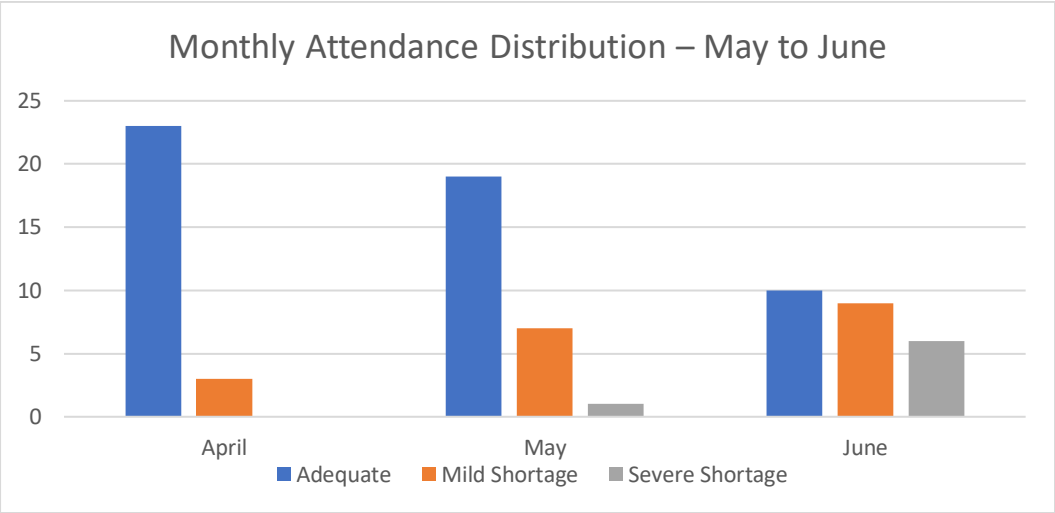


d. Customer Satisfaction vs. Delay - A clear inverse correlation was observed: Orders delayed by ≥2 days had an average satisfaction rating of low. Orders delivered on or before deadline had an average rating of high.

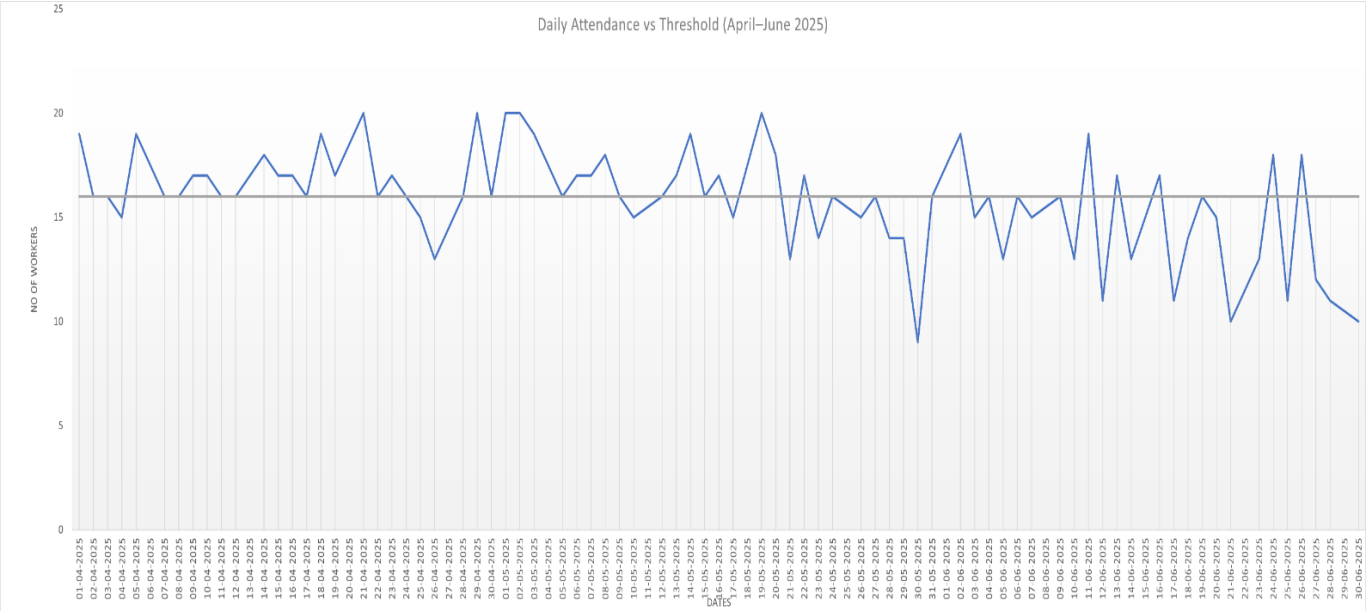
2. Preliminary Insights---Transport Dependency: Orders sourced from Kolkata (due to raw material shortage in Patna) caused the majority of critical delays, emphasizing Patna's stock readiness as a key bottleneck. Customer Experience Risk: Every additional day of delay led to a drop in average satisfaction, highlighting the direct customer impact of sourcing decisions. Actionable Insight:

Establishing a buffer stock in Patna and predicting stock-outs earlier can drastically reduce delays and improve service quality.

PROBLEM 4- Presentation **Graph 9**



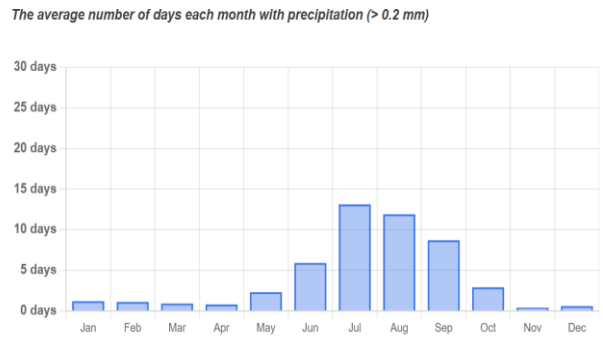
Graph 10



1. Bar Chart: "Monthly Attendance Distribution – April to June"- categorizes each working day into: Adequate (≥16), Mild Shortage (12–15), Severe Shortage (<12)
2. Line Graph: "Daily Attendance with Shortage Threshold"- shows the daily attendance trend with a horizontal line at 16 representing the shortage threshold. It clearly shows the frequency and severity of attendance drops over time. Trends and Patterns---April 2025: Most days have adequate attendance and only a few days falling into mild shortage. May 2025: A visible rise in mild and severe shortages begins to appear. Few days are below the 16 threshold which shows some inconsistent workforce. June 2025: A significant drop is seen, with the no. of severe shortage days increasing and shows a serious disruption in regular workforce. The line graph supports this trend — attendance in April and early May remains mostly above the threshold, but from end- May to July, frequent dips below 16 are observed. Preliminary Insights---Increased absenteeism in June directly relates with periods of rainfall. This decrease affects order completion timelines aligning with customer dissatisfaction mentioned in the problem statement. The charts demonstrate a clear pattern

of attendance degradation, especially in June confirming that labour shortage is a significant issue affecting operations. These below graphs are taken from weather-and-climate.com.

Graph 11



Graph 12