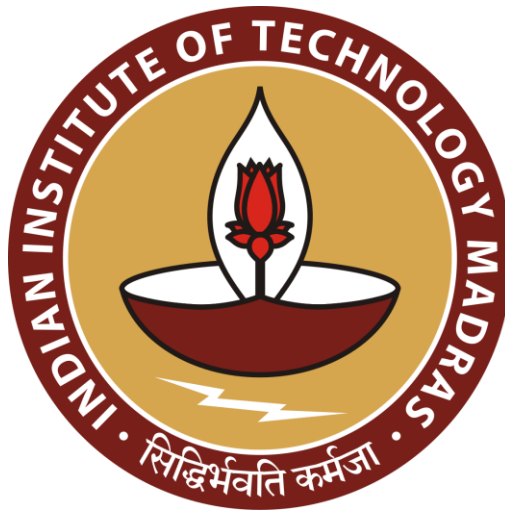


Enhancing Business Dynamics through Data-Driven Solutions at King Pipes



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18th December 2023

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Declaration Statement

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18th December 2023,

BDM Project Evaluation Team,

IIT Madras,

Tamil Nadu, India

Subject: Acknowledgment of Data Source and Capstone Project

Dear Sir/ma'am,

As a student at the Indian Institute of Technology, Madras pursuing a BS in Data Science and Applications, I, Suyamoon Pathak, hereby acknowledge using Samrat Plastic Industries' data for my business data management capstone project.

I affirm that the information I received from Samrat Plastic Industries was used truthfully and only for the capstone project's scholarly purposes. The IITM principles and the highest ethical standards have been followed in the formulation of any representations, analyses, or conclusions derived from this data.

I appreciate your cooperation and understanding.

Sincerely,



Suyamoon Pathak

1. Executive Summary

This extensive study digs deeply into the statistical analysis that was carried out for Samrat Plastic Industries, revealing crucial information on a range of operational aspects. Quality assurance, supplier performance, time series analysis for marketing spend, the relationship between engagement metrics and ad spend, supplier geographic distribution, physical characteristics of different material types, advertising trends and expenditure, event participation, and engagement metrics were all carefully examined.

The identification of fluctuations in product quantity and supplier efficiency was made possible by the application of statistical methods, particularly control charts. These methods made it clear how important it is to uphold constant quality standards and effective inventory control. By identifying process variations, control charts allowed for targeted interventions for quality improvements that improved customer satisfaction and operational effectiveness.

Indirect gains in demand trend estimates were made possible by the use of time series forecasting techniques. This has a big impact on financial choices, making resource allocation more precise. Through resource allocation, correlation studies between engagement metrics and ad spending yielded crucial insights for strategic decision-making aimed at optimizing engagement.

Process control was demonstrated by suppliers' uniform pricing for certain items and their adherence to control limitations. Furthermore, new market development regions were discovered through insights into regional supplier distributions, providing chances for growth and well-informed business decisions.

High as well as low density supplier locations were identified using geographic insights, which also suggested existing industrial zones or possible high-demand places. In order to guarantee product reliability and competitiveness, physical attribute assessments conducted across material types revealed areas that needed standardization and improvement.

Different trends in the amount spent on advertising exposed a calculated approach that favored focused spending on sites such as Facebook, suggesting a high level of confidence in its efficacy. While in-person event interactions showed limited increase, engagement metrics preferred social media platforms, particularly Facebook and Instagram, indicating the need for enhanced offline engagement techniques.

The findings demonstrated a favorable relationship between greater lead generation and sales conversion rates on different platforms and higher ad spending. This emphasizes how important it is to have a well-rounded, focused advertising plan for increased marketing effectiveness.

The whole plan places a strong emphasis on online interaction optimization, supplier diversity, data-driven advertising, and ongoing quality improvement. The goal of integrating digital and physical touchpoints is to improve audience connection and retention while delivering a smooth consumer experience. Other suggestions include value-based content production, targeted segmentation, staff training, and adaptable CTAs.

Samrat Plastic Industries will be able to cultivate a culture of continuous improvement, use data-driven insights for strategic decision-making, and coordinate a well-balanced combination of digital and physical engagement strategies for long-term growth and competitive advantage thanks to this thorough analysis and the recommendations that follow.

2. Analysis Process

2.1. Analysis of Quality Control

Methodology:

Statistical tools were essential in the effort to improve product quality. To carefully track and examine the variations in product quality among several batches or suppliers, control charts—more especially, the X-bar and R charts—were used.

Justification:

- **Problem Alignment:** This technique addressed the problem statement's main concern, which was the inconsistent product quality. The analysis sought to remedy and lessen the impact of differing quality standards by explicitly addressing this difficulty.
- **Method Suitability:** In this case, using control charts and statistical process control was appropriate. It made it possible to identify variations in the quality of the product, which made it possible to implement focused interventions meant to enhance quality.
- **Impact:** The maintenance of uniform quality standards was significantly impacted by the root cause of variability detection made possible by these control charts. Maintaining a competitive edge in the market requires high levels of customer happiness and loyalty, which were strongly correlated with this consistency.

Techniques:

The particular tools employed in this investigation included control charts, specifically the R and X-bar charts. With the use of these statistical methods, it was possible to evaluate differences in product quality between batches or suppliers methodically and quantitatively, which laid a solid foundation for further efforts to improve quality.

2.2. Analysis of Supplier Performance

Methodology:

The analysis of supplier performance comprised a thorough examination based on important indicators such as lead times, price information, and the regularity of undamaged product deliveries.

Justification:

- **Problem Alignment:** This technique addressed supplier efficiency in particular, which immediately addressed problems related to inefficient inventory management. The

goal was to address inefficiencies that led to inventory problems by focusing on the performance of suppliers.

- **Data Leverage:** Utilizing the price, lead time, and quantity data that was provided allowed for a thorough assessment of the efficacy of the suppliers. This data-driven strategy made sure that every supplier's contribution to the inventory management process was thoroughly and accurately evaluated.
- **Impact:** Inventory optimization was immediately impacted by the improved analysis and ensuing improvement in supplier selection. This optimization in turn promoted a more effective operating framework by lowering stockouts, streamlining inventory levels, and saving money.

Techniques:

The evaluation process encompassed the creation and application of supplier scorecards. These scorecards analyzed indicators including lead times, delivery performance, and price consistency, acting as organized assessment tools. Libraries like `geopandas` were also used to identify the dense and sparse supplier locations around the country.

2.3. Time Series Analysis for Marketing Expenditure

Methodology:

The study employed time series methodologies to investigate the patterns linked to marketing spend.

Justification:

- **Problem Alignment:** The emphasis on time series analysis was intended to address the difficulties involved in precisely projecting consumer demand. This technique aimed to help forecast demand trends indirectly by examining and interpreting patterns seen in marketing expenditure data.
- **Data Suitability:** Finding subtle, and enduring trends in advertising spending required the use of weekly data. The data allowed for a more thorough comprehension of variations and trends throughout various time periods.
- **Impact:** Using time series techniques improved financial decisions in a noticeable way. Through the application of previous expenditures, this study facilitated a more accurate and well-informed resource allocation.

Techniques:

Graphing techniques were used in the investigation as they have the power to reveal patterns in time series data, offering perceptions into patterns, fluctuations, and possible future paths for marketing spending.

2.4. Analysis of the Correlation Between Engagement Metrics and Ad Spend:

Methodology:

Correlation analysis was used.

Justification:

- **Problem Alignment:** The principal aim was to decipher the correlation between advertising expenditure and the ensuing consumer engagement indicators. This was done to clarify how the costs of various platforms affect user involvement.
- **Strategic Decision-Making:** The purpose of the research was to determine the most influential areas of involvement in order to support strategic decision-making. Gaining insight into the relationship between engagement metrics and ad budget allowed for more efficient use of available resources.
- **Data-Driven Insights:** Through the use of correlation analysis, the method produced mathematical relationships and empirical proof of the ways that differences in ad expenditure affect engagement metrics on different platforms.

Techniques:

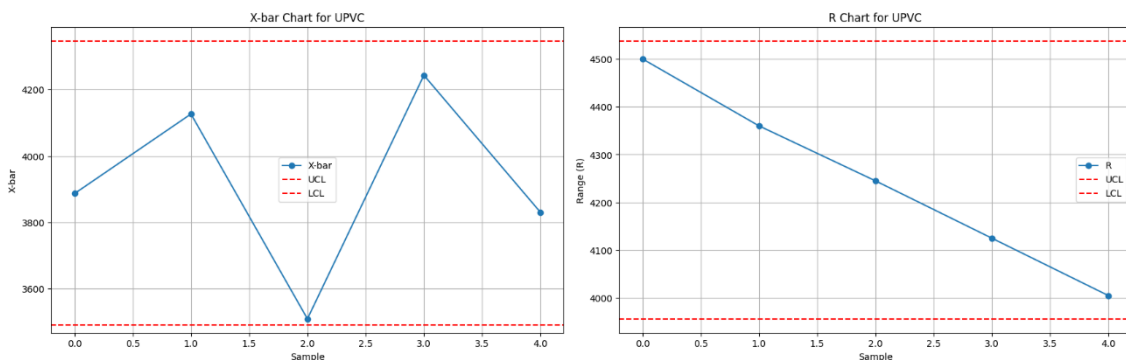
The study utilized statistical methods such as Pearson's correlation coefficient to measure the correlations between advertising expenditures on various platforms and engagement indicators, including click-through rates, attendance, and leads produced. These techniques made it possible to comprehend the intricacies of the link between ad spend and engagement metrics methodically and quantitatively.

3. Results and Findings

3.1 Product Quantity

For all graphs, the Upper Control Limit (UCL) and Lower Control Unit (LCL) were taken as ± 1.5 standard deviations from the mean consulting with the Production manager.

3.1.1. UPVC

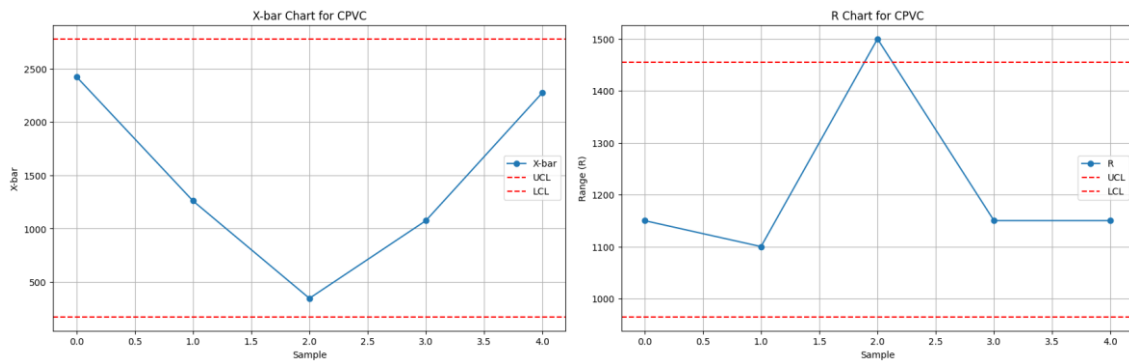


X-bar chart: Variations in the average number of UPVC goods are suggested by the zigzag pattern. The average UPVC amount is within an acceptable range, which is defined by UCL

at 4300 and LCL at 3500. The line indicates changes but typically stays within allowable limitations as it swings within the regulatory limits.

R chart: Variability within UPVC sample numbers is represented by a straight line with a negative slope. The allowable range for fluctuation in UPVC amount is defined by UCL at 4550 and LCL at 3950. Stable variability in UPVC amount produced is indicated by the line staying within the regulated boundaries.

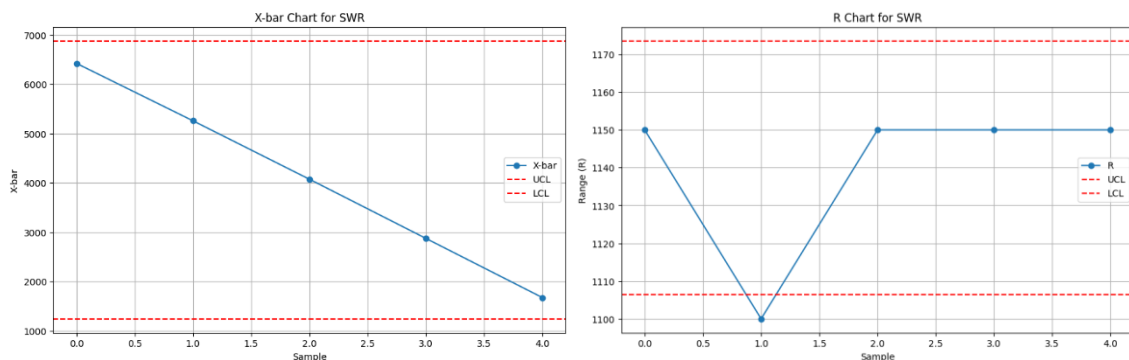
3.1.2. CPVC



X-bar chart: A U-shaped pattern indicates significant variation in the average number of CPVC products between samples. The permissible range for the average CPVC amount is defined by the LCL at 250 and the UCL at 2750. Significant differences in the procedure might point to discrepancies or modifications in the CPVC production process.

R chart: The CPVC sample amounts' variability is depicted by the hill-shaped pattern. The permissible range for CPVC amount variations is defined by UCL at 1455 and LCL at 950. The variability in CPVC amount is largely contained within the regulatory limits, despite occasional swings. However, because sample 2.0's range is greater than the UCL, further research may be necessary.

3.1.3. SWR



X-bar chart: The average number of SWR products is represented by a straight line with a negative slope. For average SWR amount, the allowable range is defined by UCL at 6900 and LCL at 1200. The average quantity produced for SWR is rather steady and consistent, since the line remains within the control boundaries.

R chart: This plough-shaped plot shows the extent of variability in the SWR sample amounts. UCL at 1175, LCL at 1108. When compared to other samples within the control limits, Sample 1.0 shows a large variance in range or is an outlier as it dips below the LCL at 1100.

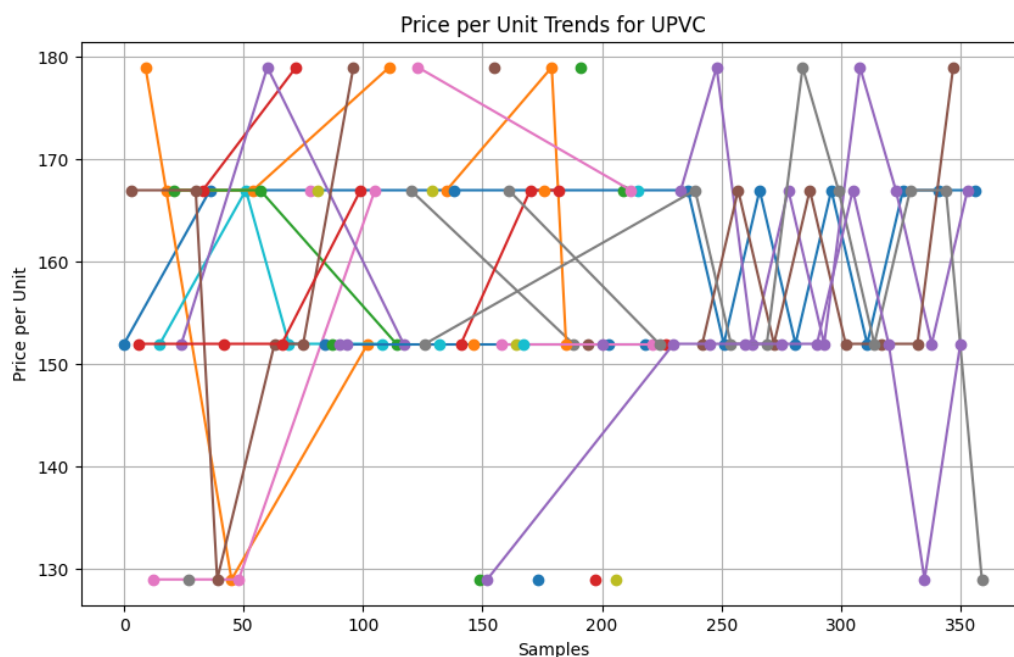
Overall Analysis:

- **Control Limits Adherence:** A mainly regulated manufacturing process is shown by the majority of data points falling inside the designated control limits.
- **Outliers and Trend Analysis:** For consistent and ideal output, observations that go outside of control boundaries or that reveal particular patterns may need more investigation and possible process changes.

3.2. Trends in Price per Unit

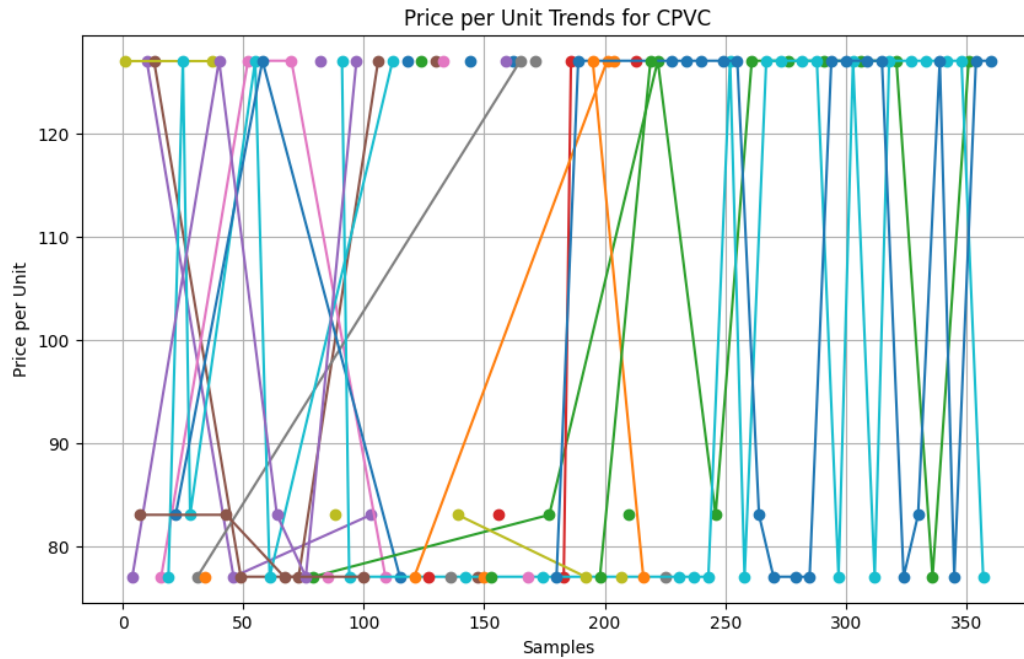
The price trend is uniform across all the sizes of pipes. It seems Samrat Plastic Industries has been putting the same price for all the suppliers for a specific product. The suppliers buying different sizes of products have been connected with same coloured lines.

3.1.1. UPVC:



In the graph above, it can be seen that UPVC_001 (INR 152), UPVC_002 (INR 167), UPVC_003 (INR 129), and UPVC_004 (INR 179) all have uniform price per unit values across all suppliers.

3.1.2. CPVC:



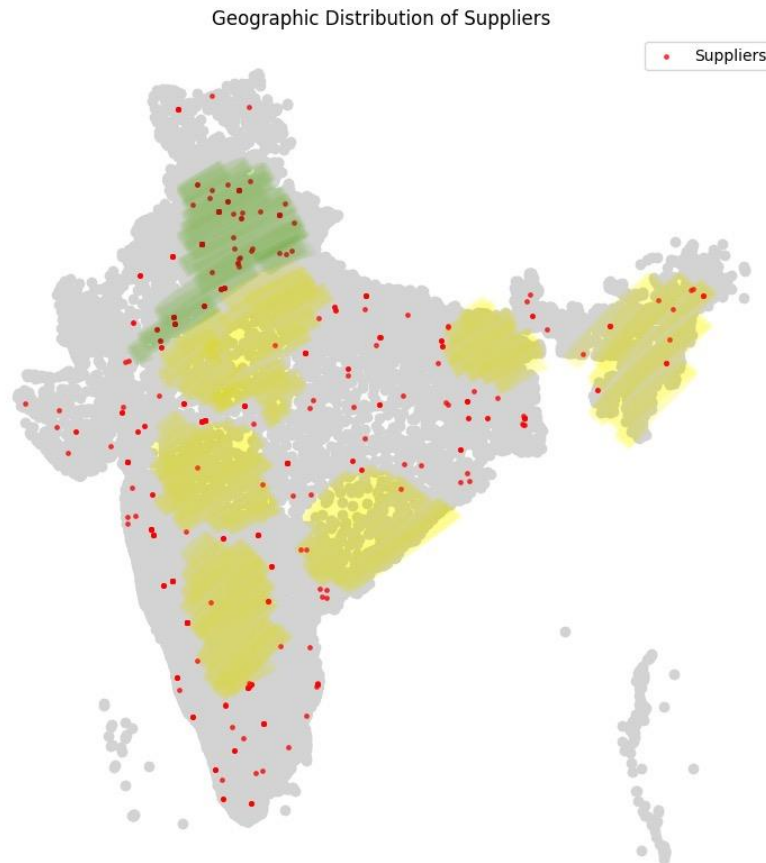
In the graph above, it can be seen that CPVC_001 (INR 77), CPVC_002 (INR 127), and UPVC_003 (INR 83) all have uniform price per unit values across all suppliers.

3.1.3. SWR:



In the graph above, it can be seen that SWR_001 (INR 49), SWR_002 (INR 51), and SWR_003 (INR 44) all have uniform price per unit values across all suppliers.

3.3 Geographic Distribution and Supplier



Considering the geographic dispersion of suppliers:

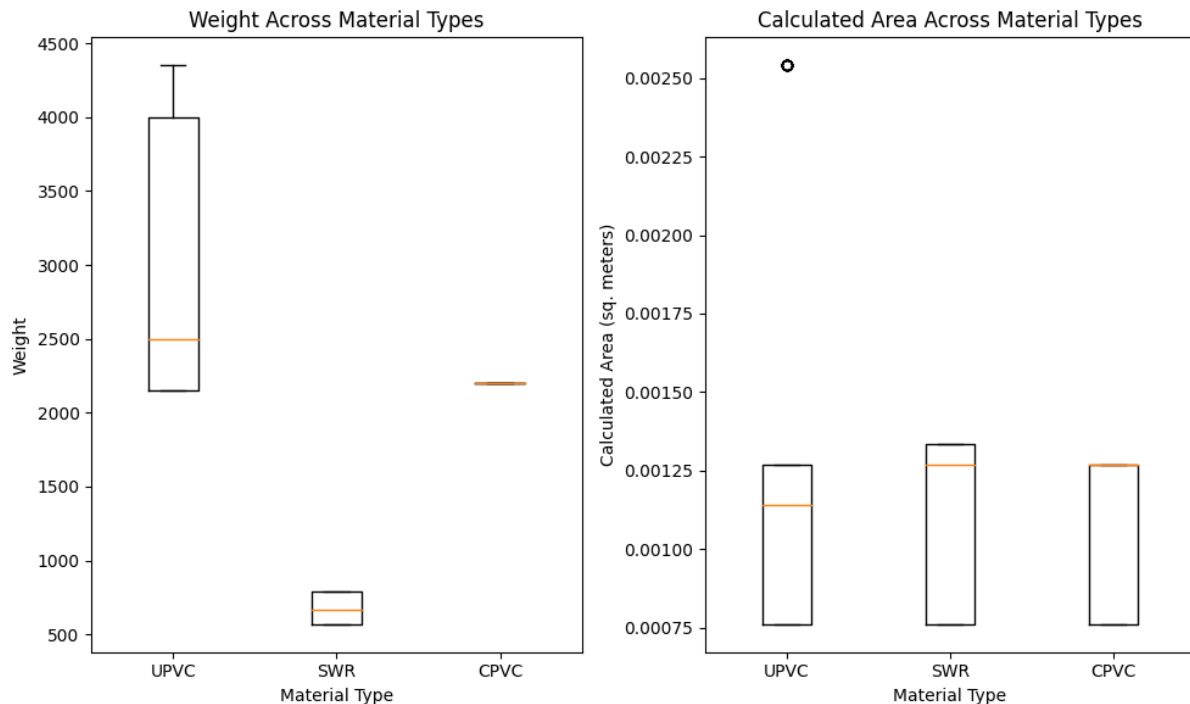
Density of Regional Suppliers:

- **High Density:** Notably, high supplier densities are seen in places like Haryana, Delhi, and surrounding cities. This could refer to developed industrial zones, perhaps with improved facilities or financial incentives for suppliers.
- **Sparse Areas:** The northeastern Seven Sister states, Bihar, Madhya Pradesh, and Andhra Pradesh have reduced supplier densities. This might point to unexplored markets or areas that the pipe business hasn't looked at as much.

Economic Operations and Market Share:

- **Economic Hubs:** Areas with a high population density may be associated with increased industrial activity. These regions may have pipe product opportunities or have a high demand for pipe-related materials.
- **Possibilities in Sparse Regions:** Untapped markets may exist in areas where there are few suppliers. Investigating these areas for possible growth or market penetration plans might be advantageous for the pipe sector.

3.4. Physical Characteristics Among Material Kinds:



3.4.1. UPVC:

The graph above shows a wide range of UPVC pipe weights, from 4000 to 4300 grams. This variance suggests that there may be a problem with standards since it might indicate that different densities or materials are utilized within the UPVC category. These differences may have an impact on cost-effectiveness or structural integrity, therefore manufacturers should evaluate them. Furthermore, the anomaly detected in the computed area (square meters) at 0.00255 raises the possibility of anomalies in particular UPVC goods. This suggests that in order to guarantee constant product quality throughout the UPVC range, quality control inspections and close examination of production procedures are required. The sector ought to concentrate on streamlining manufacturing processes to standardize UPVC pipe characteristics, boosting dependability and competitiveness.

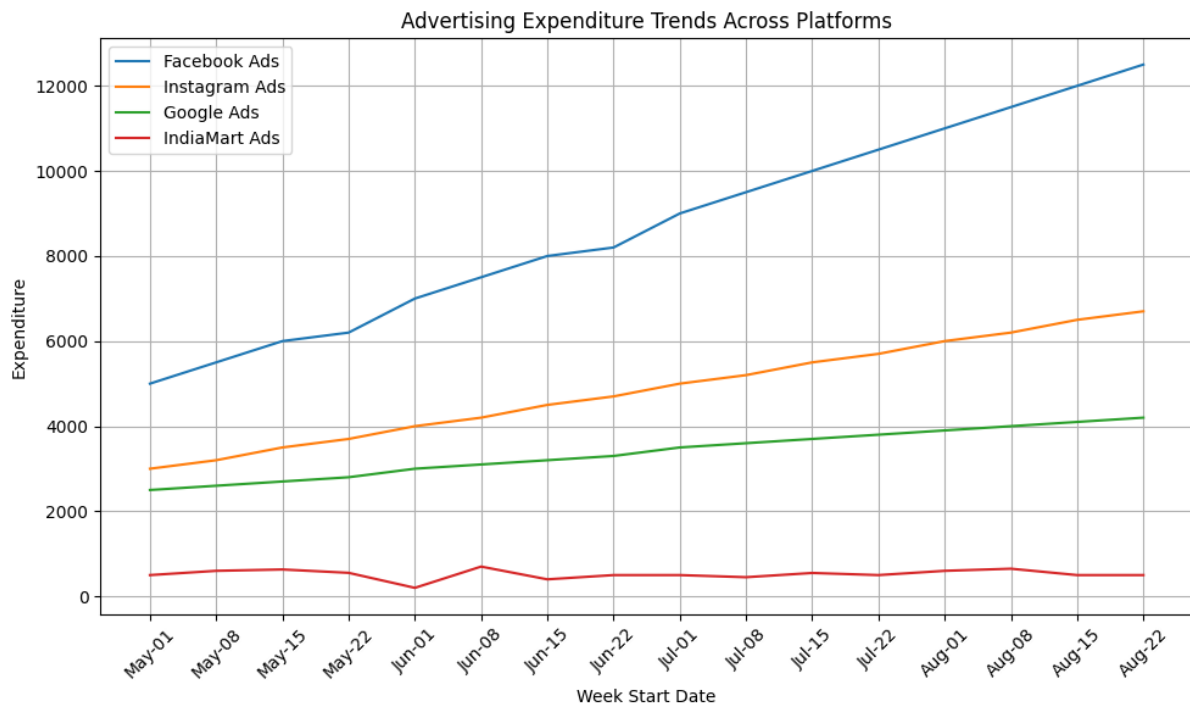
3.4.2. CPVC:

CPVC pipes, as opposed to UPVC, have a weight distribution that is surprisingly constant, with all quartiles focusing on 2200 units. This consistency points to a closely monitored production process, which is good for preserving the dependability and consistency of the final product. The weight graph's lack of whiskers highlights the CPVC pipes' low degree of fluctuation and shows that the weight range is strictly regulated. This constancy can be advantageous from a strategic standpoint, particularly in situations where reliable material qualities and constant performance are essential. Because of its consistency, CPVC pipes may be marketed by the industry as dependable, consistent, and appropriate for particular applications that call for standardized features.

3.4.3. SWR:

The weight distribution of SWR pipes has a modest range from 600 to 780 grams, falling between UPVC and CPVC. This distribution suggests a somewhat wider weight range in comparison to CPVC, even if it is less variable than UPVC. But the lack of whiskers points to a steady weight profile in this area. In order to optimize manufacturing procedures and maintain a more regular weight range, manufacturers have to look into the cause of this fluctuation. Furthermore, a degree of consistency in the material's area is shown by the lack of outliers in the computed area for SWR pipes. The industry is able to promote SWR pipes as a dependable option for certain building or infrastructure projects requiring constant material qualities because of this consistency, which can be helpful in situations where standardization is essential.

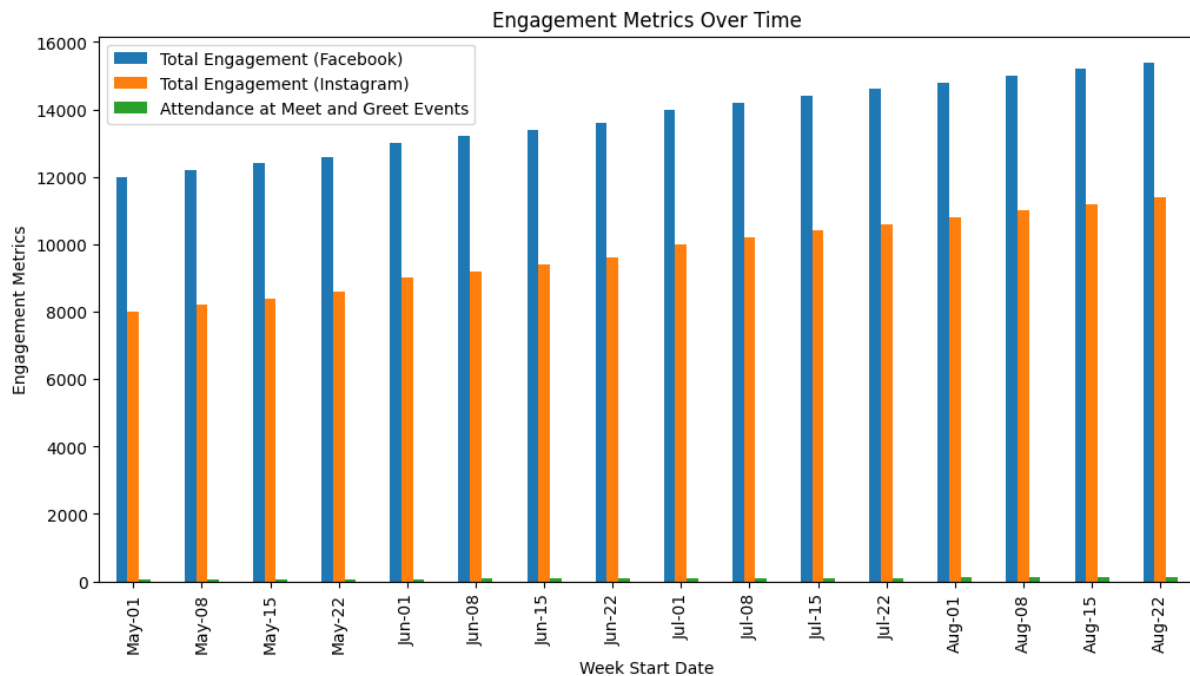
3.5. Expenditure and Advertising Trends:



Plotted trends derived from the data on advertising expenditures show unique patterns on different platforms. Over the course of the observed weeks, the expenditure on Facebook, Instagram, and Google advertisements has shown a continuous rising trajectory, suggesting a continued investment in these channels. The expenditure on Facebook advertisements has increased the highest, with a steeper slope than that of Instagram and Google ads. This pattern suggests a calculated faith in Facebook advertising's efficacy, which has resulted in a significant increase in its budget. On the other hand, although Instagram and Google advertisements show increasing costs, their curves indicate a more modest growth rate when compared to Facebook. On the other hand, during the course of the observation period, IndiaMart advertisements show a steady and prudent investment.

This disparity in spending patterns points to a more deliberate strategy that is more focused on Facebook advertisements that show increasing efficacy and prospective returns while keeping other channels stable.

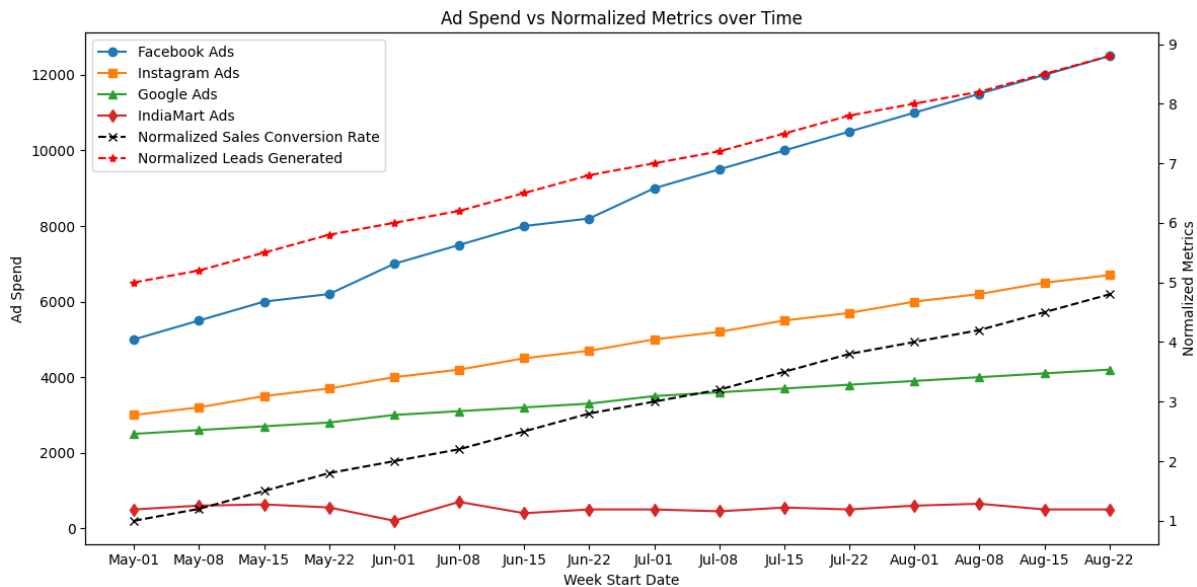
3.6. Event Participation and Engagement Metrics:



The dynamic response of various platforms to audience involvement is eloquently illustrated by the depiction of engagement numbers across time. Facebook advertisements had the most interaction over the course of the weeks, with a respectable increase from around 12,000 engagements to about 15,400. In the meantime, engagement from Instagram advertisements rises in a comparable manner, but at a slower rate—from 8,000 to 11,400 interactions. It's interesting to note that, in contrast to the widespread reach of social media platforms, in-person engagement—which is measured by the attendance at meet and greet events—remains very low over the course of the studied time, varying just slightly between 50 and 125.

This illustration highlights how social media—especially Facebook and Instagram—dominates in attracting and keeping the target audience over time. The consistent increase in interactions on these channels points to a strong reaction to the advertisements or material that is shared there. On the other hand, the noticeably reduced attendance at in-person events suggests that the approach for in-person engagements needs to be reevaluated or improved. When compared to traditional event-based tactics, the significant difference in engagement levels between online and offline channels highlights the unmatched reach and effect of social media in engaging and enthralling the audience. This realization emphasizes how crucial it is to have a multifaceted marketing plan that uses physical and digital media to engage audiences fully and increase brand awareness.

3.7. Sales Conversion and Generated Leads:



The graph above illustrates a convincing relationship between higher ad expenditure and the ensuing increases in "Normalized Leads Generated" and "Normalized Sales Conversion Rate." The normalized indicators show a discernible, steady growth as the expenditure in advertising across many platforms—Facebook, Instagram, Google Ads, and IndiaMart—increases over time. This trend suggests that there is a favorable correlation between advertising spending and the results of lead generation and sales conversion rates. This trend provides useful information for businesses looking to maximize Samrat Plastic Industries' marketing efforts for better results by highlighting the significance of a well-balanced and well-targeted advertising plan in generating increased conversions and lead acquisition.

4. Interpretation of Results and Recommendations

4.1. Synthesis of Key Findings

The thorough examination on the data provided by Samrat Plastic Industries across several areas yielded crucial insights that addressed the difficulties that were found. The main conclusions are summarized as follows:

4.1.1. Control of Quality and Performance of Suppliers:

- The utilization of control charts enabled the identification of changes in product quantity and supplier efficiency. This was in perfect harmony with the company's goals of constant quality and efficient inventory control.
- Control charts helped with focused interventions for quality enhancements by identifying process differences. Both operational effectiveness and customer happiness will improve as a result.

4.1.2. Correlation studies and time series analysis:

- Through patterns of marketing spend, time series forecasting approaches allowed for an indirect improvement in the accuracy of demand trend projections. This substantially influenced financial and resource allocation decisions.

- Analyses of correlations between ad expenditure and engagement indicators across many platforms provided critical information for strategic decision-making, maximizing engagement through resource optimization.

4.1.3. Trends in Product Quantity and Price:

- Control within manufacturing processes was demonstrated by adherence to control limits and uniform pricing among suppliers for certain items, according to evaluations of product quantity and price patterns.
- Potential market development locations and economic centers were identified by insights into the regional supplier distributions, providing chances for expansion and wise business judgments.

4.1.4. Physical attributes and current advertising trends:

- Differences in the physical properties of various materials suggested areas for standardization and optimization that may improve product offers' dependability and competitiveness.
- The advertising landscape demonstrated a purposeful approach that prioritizes Facebook advertisements over other platforms, with a focus on concentrated investment in the most popular digital interaction channels.

4.1.5. Leads, Sales Conversion, and Engagement Metrics:

- Social media platform interaction online greatly surpassed in-person engagements, highlighting the need for a well-rounded strategy utilizing both digital and physical media.
- Increased ad spending was strongly correlated with higher lead generation and sales conversion rates, underscoring the need for a focused and well-balanced advertising strategy for marketing efficiency.

4.2. Implications for Quality Control Enhancement

The control charts and pricing consistency across suppliers for certain commodities reveal variations in product quantity that may be due to intrinsic differences in manufacturing processes. The differences might be caused by differences in material composition, production methods, or operating protocols. Variations of this kind may have an immediate negative effect on the end product's consistency and quality, which might result in unhappy customers and inefficient operations.

The observed variances in product quantity necessitate a focused strategy for improving production processes in order to guarantee constant quality standards. This might include optimizing the sourcing of materials, recalibration of equipment, and strict adherence to established production procedures. By putting in place strong quality control checkpoints at crucial production phases, disparities may be identified early and mitigated more easily, leading to a more consistent final product.

4.3. Optimal Advertising Strategies

The patterns in advertising spending that have been noted for various platforms show unique trajectories. Over the course of the monitoring period, Facebook, Instagram, and Google all show increased expenditure. In particular, Facebook has a much steeper slope than the other platforms, suggesting a strong belief in its effectiveness. IndiaMart, on the other hand, has a consistent and reasonable spending trend.

Facebook leads when it comes to engagement metrics, particularly interactions, since it shows a steady and significant rise in involvement. Though its growth rate is slower, Instagram is following a similar pattern. On the other hand, interactions at in-person events are almost unchanged, indicating a need for better offline engagement tactics.

4.4. Leveraging Online Engagement for Conversions

A strong relationship has been found in the observed data between rising advertising costs and ensuing increases in the number of leads and Sales Conversion Rate. These metrics show a steady and discernible increase as the amount spent on advertising across several platforms—Facebook, Instagram, Google Ads, and IndiaMart—increases over time.

4.5. Effectiveness of Online vs. Offline Engagement Strategies:

There is a clear difference between online and offline engagement techniques in terms of efficacy, according to the research. Throughout the observation period, online platforms—particularly Facebook and Instagram advertisements—showed much greater levels of audience involvement. Attendance at in-person events fluctuated somewhat, but engagement metrics remained low.

4.6. Long-term Strategic Directions

The long-term strategy directions center on standardizing processes and encouraging a culture of continual improvement in quality control, with a special emphasis on UPVC standardization. Creating strategic alliances and broadening the pool of suppliers will guarantee dependability and reduce the risks brought on by regional dependence. Data-driven and flexible advertising tactics will focus on Facebook and Instagram while experimenting with new types of content. Maximizing online engagement will also depend on lead nurturing and online conversion funnel optimization. By merging physical and digital touchpoints, the overall objective is to create a smooth and unified consumer experience. This will ensure a holistic strategy that matches message and engagement tactics for improved audience connection and retention.

4.7. Other recommendations:

- **Employee Awareness and Training:** Hold frequent training sessions to improve the workforce's skill set in the manufacturing chain. Keeping staff familiar with quality control procedures is a major factor in upholding constant standards for quality.
- **Experimentation and A/B Testing:** To determine which ad formats, content styles, or targeting methods work best across a range of platforms, run controlled experiments or A/B testing. The most effective advertising strategies for each platform are determined with the aid of this iterative process.
- **Targeted target Segmentation:** Create accurate target segmentation according to their characteristics, hobbies, and habits. Ad content and messaging should be specifically tailored to each category in order to increase the chance of engagement and conversions.
- **Call-to-Actions (CTAs) that are adaptive:** Creating strong, call-to-action CTAs for commercials may elicit quick reactions. CTAs that are obvious and compelling—like time-limited promotions or special offers—encourage people to interact and become customers.
- **Value-oriented material Creation:** Create interesting and worthwhile material that highlights the advantages of a product, solves problems faced by consumers, or offers solutions. Superior content creates trust and builds credibility, which subsequently leads to conversion.