Data Analytics Case Study 2

Part 1: Selection and Contextualization

PESTEL Analysis of Ethanol Blending Programme in India

Case Study Part 1

Professor:

Touraj Banirostam

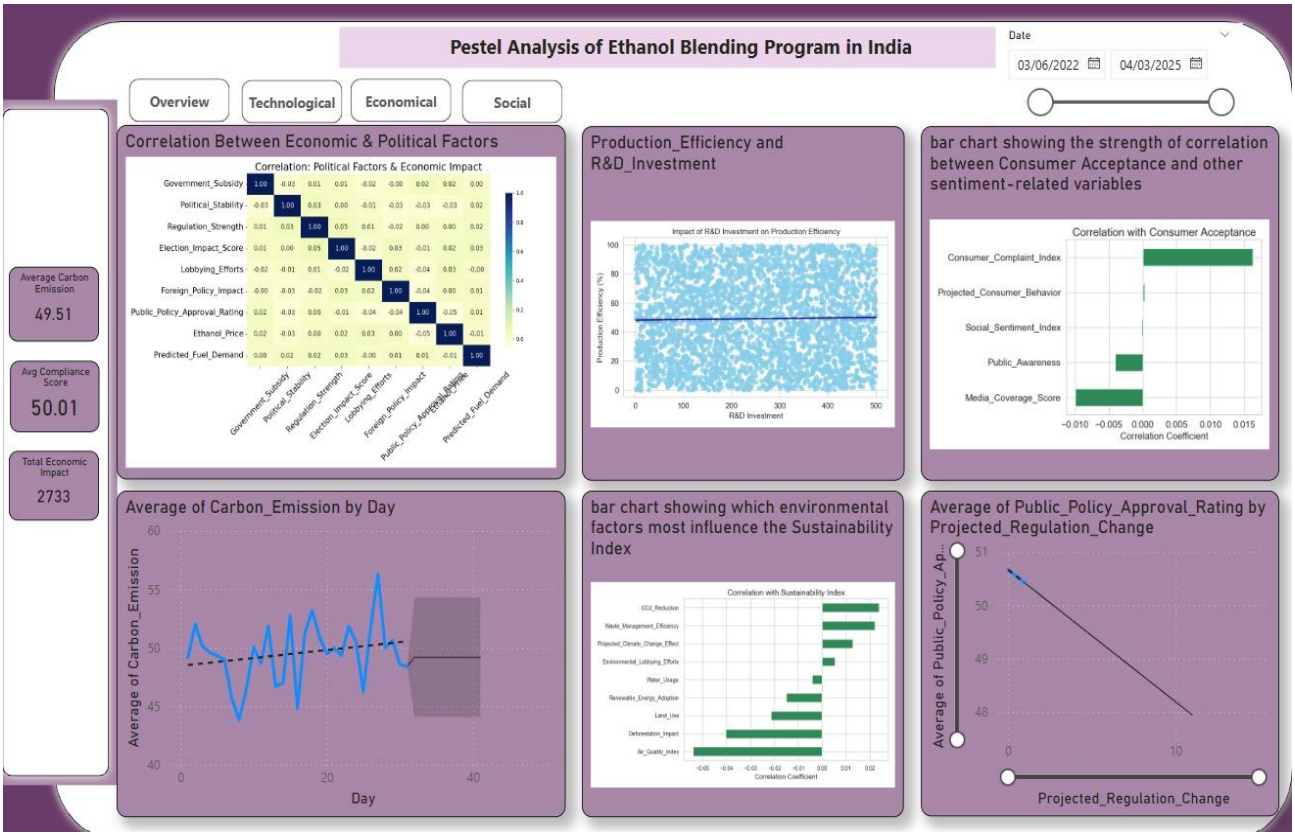
Submitted by:

Rohit Kumar – NF1003118

Krishna Patel – NF1017043

Heta Chavda -NF1014555

Overview of the Dataset :



1. Correlation Between Economic & Political Factors (Top Left)

- Type: Heatmap
- Purpose: This matrix shows the correlation between various political and economic factors.
- Key Elements:
    - Color Coding:
        - Darker shades indicate stronger correlations.
        - Lighter shades indicate weaker correlations.
    - Important Correlations:
        - Government Subsidy (1.00 with itself): No surprise here, as self-correlation is always 1.
        - Political Stability and Public Policy Approval Rating (0.03): Indicates a slight positive correlation.

        - Election Impact Score and Foreign Policy Impact (1.00): Suggests that election policies strongly influence foreign policies.
        - Regulation Strength has low correlations with economic impact factors, suggesting regulations may not have a major direct impact on the economy.
- Insights:
    - Elections have a strong influence on foreign policy.
    - Government subsidies do not strongly correlate with other political/economic variables, suggesting they may be independent of political stability or regulations.
    - Political stability has minimal influence on fuel demand or economic impact.

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2. Production Efficiency and R&D Investment (Top Middle)

- Type: Scatter Plot
- Purpose: This visualization explores whether increased R&D investment leads to higher production efficiency.
- Key Elements:
    - X-axis: R&D Investment.
    - Y-axis: Production Efficiency (%).
    - Trend Line: A nearly flat trend suggests little to no correlation between R&D investment and production efficiency.
- Insights:
    - R&D investment does not seem to have a significant impact on production efficiency.
    - This may indicate inefficiencies in how R&D funds are allocated, or that production efficiency is influenced by other factors (e.g., labor, supply chain).
    - Further investigation is needed to determine what truly drives production efficiency.

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3. Correlation Between Consumer Acceptance and Sentiment-Related Variables (Top Right)

- Type: Bar Chart

- Purpose: This chart shows the strength of correlation between consumer acceptance and various sentiment-based factors.
- Key Elements:
    - X-axis: Correlation coefficient.
    - Y-axis: Sentiment-related factors.
    - Key Findings:
        - Consumer Complaint Index has the strongest positive correlation with consumer acceptance.
        - Public Awareness and Social Sentiment Index have weaker correlations.
        - Projected Consumer Behavior has a slight negative correlation.
- Insights:
    - Consumer acceptance seems to be most influenced by consumer complaints, meaning that addressing consumer grievances can enhance public approval.
    - Media coverage and public awareness play only a minor role, suggesting other factors drive consumer behavior more than media perception.
    - Projected consumer behavior does not align well with actual acceptance, indicating a potential forecasting gap.

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4. Average Carbon Emission by Day (Bottom Left)

- Type: Line Chart with Trend Line
- Purpose: This visualization tracks daily average carbon emissions over a given period.
- Key Elements:
    - X-axis: Days.
    - Y-axis: Average Carbon Emission.
    - Trend Line: A slight downward trend suggests decreasing emissions over time.
    - Shaded Area: Represents forecasted emissions with confidence intervals.
- Insights:
    - Carbon emissions fluctuate daily but show an overall decreasing trend.

- The forecast suggests that emissions will continue declining, possibly due to regulations, cleaner fuel adoption, or increased efficiency.
- Sharp spikes indicate that some days experience higher-than-average emissions, which could be linked to external events (e.g., industrial activities, fuel shortages).

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5. Environmental Factors Influencing Sustainability Index (Bottom Middle)

- Type: Bar Chart
- Purpose: This chart highlights the environmental factors that most impact the Sustainability Index.
- Key Elements:
  - X-axis: Correlation coefficient.
  - Y-axis: Environmental factors.
  - Key Findings:
    - CO_2 Reduction has the strongest positive impact on sustainability.
    - Waste Management Efficiency is also a major factor.
    - Air Quality Index has a negative correlation, meaning poorer air quality reduces sustainability.
    - Land Use and Renewable Energy Adoption have moderate positive effects.
- Insights:
  - Reducing carbon emissions is the single biggest driver of sustainability.
  - Better waste management contributes significantly, suggesting that handling industrial and urban waste is crucial.
  - Air quality deterioration harms sustainability, reinforcing the need for pollution control.
  - Renewable energy adoption helps, but its impact is not as high as CO_2 reduction or waste management.

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6. Public Policy Approval Rating vs. Projected Regulation Change (Bottom Right)

- Type: Scatter Plot with Trend Line

- Purpose: This visualization shows how projected regulatory changes influence public policy approval ratings.
- Key Elements:
    - X-axis: Projected Regulation Change.
    - Y-axis: Average Public Policy Approval Rating.
    - Trend Line: A downward slope indicates a negative relationship.
- Insights:
    - As regulatory changes increase, public approval ratings decrease.
    - This suggests that people may resist or dislike frequent policy changes.
    - Governments may need better public communication and transparency when implementing new policies to maintain approval.
    - Excessive regulatory adjustments may create uncertainty, reducing confidence in public policy.

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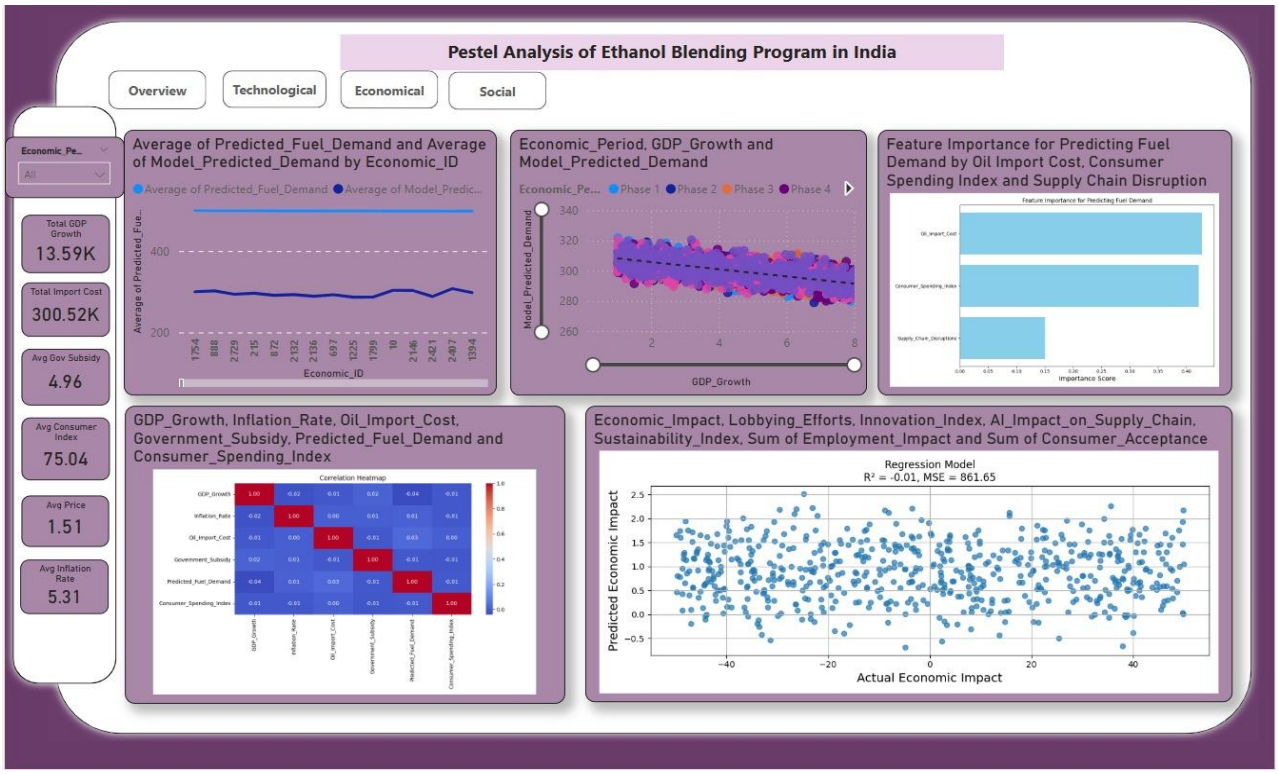
7. Key Economic & Environmental Indicators (Left Panel)

This section provides key statistics related to sustainability and economic impact:

- Average Carbon Emission: 49.51
    - Indicates the average daily carbon footprint, which is gradually decreasing.
- Average Compliance Score: 50.01
    - Measures adherence to regulatory and sustainability policies.
- Total Economic Impact: 2733
    - Represents the overall economic contribution or cost impact of the ethanol blending program.

PESTEL ANALYSIS

A. Economical :



1. Average Predicted Fuel Demand vs. Model Predicted Demand by Economic ID (Top Left)

- Type: Line Chart
- Purpose: This visualization compares the predicted fuel demand with the model-predicted demand over different economic periods (Economic_ID).
- Key Elements:
    - X-axis: Economic_ID, which likely represents different time periods or economic cycles.
    - Y-axis: Fuel demand values (both predicted and model-predicted).
    - Legend: Two distinct lines:
        - Blue Line: Represents the average predicted fuel demand.

        - Darker Blue Line: Represents the model-predicted demand.
    - The trend shows a relatively stable pattern with minor fluctuations in fuel demand over time.
- Insights:
    - If the two lines are close together, it indicates that the model's predictions closely match actual demand.
    - Deviations between the two lines may indicate inconsistencies or inaccuracies in the model's predictions.

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2. Economic Period, GDP Growth, and Model Predicted Demand (Middle Left)

- Type: Scatter Plot
- Purpose: This visualization examines the relationship between GDP growth and model-predicted fuel demand, considering different economic phases.
- Key Elements:
    - X-axis: GDP Growth.
    - Y-axis: Model Predicted Demand.
    - Color Coding:
        - Different economic phases (Phase 1, Phase 2, Phase 3, Phase 4) are represented by different colors.
    - Trend Line: A downward sloping trend line suggests a negative correlation between GDP growth and fuel demand.
- Insights:
    - As GDP growth increases, predicted fuel demand decreases.
    - This might indicate that as the economy grows, alternative fuels or energy-efficient solutions become more prevalent, reducing traditional fuel demand.

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3. Feature Importance for Predicting Fuel Demand (Top Right)

- Type: Bar Chart
- Purpose: This visualization identifies the most influential economic factors affecting fuel demand.

- Key Elements:
    - X-axis: Importance score (indicating the weightage of each factor in the prediction model).
    - Y-axis: Economic factors affecting fuel demand.
    - Top Factors:
        - Oil Import Cost (Highest Impact)
        - Consumer Spending Index (Second Highest Impact)
        - Supply Chain Disruptions (Least Impact)
- Insights:
    - Oil import cost has the highest influence on fuel demand, meaning that fluctuations in global oil prices significantly impact fuel consumption.
    - Consumer spending index is also a major factor, suggesting that higher consumer spending may lead to increased fuel consumption.
    - Supply chain disruptions have a lower influence, indicating that logistical challenges may have only a minor effect on fuel demand.

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4. Correlation Heatmap - GDP Growth, Inflation Rate, Oil Import Cost, Government Subsidy, Predicted Fuel Demand, and Consumer Spending Index (Bottom Left)

- Type: Heatmap
- Purpose: This matrix shows the correlation between various economic indicators.
- Key Elements:
    - Color Coding:
        - Red (+1.00): Strong positive correlation.
        - Blue (0 to -1.00): Weak or negative correlation.
    - Values:
        - GDP Growth and Oil Import Cost (0.00) → No correlation.
        - Predicted Fuel Demand and GDP Growth (-0.61) → Strong negative correlation.

        - Consumer Spending Index and Predicted Fuel Demand (0.61) → Strong positive correlation.

- Insights:
    - A negative correlation (-0.61) between GDP Growth and Fuel Demand suggests that as GDP grows, fuel consumption reduces.
    - A positive correlation (0.61) between Consumer Spending Index and Fuel Demand indicates that when consumer spending increases, fuel demand also increases.
    - Government Subsidy appears to have little correlation with fuel demand, suggesting that subsidies may not be a strong driving force in determining fuel consumption.

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5. Regression Model for Economic Impact Prediction (Bottom Right)

- Type: Scatter Plot with Regression Line
- Purpose: This visualization evaluates the performance of a regression model predicting economic impact.
- Key Elements:
    - X-axis: Actual Economic Impact.
    - Y-axis: Predicted Economic Impact.
    - Regression Metrics:
        - $R^2 = -0.01$ → Very poor model fit.
        - MSE (Mean Squared Error) = 861.65 → High error rate.
    - Scatter Points: Each dot represents an individual prediction compared to actual economic impact.
- Insights:
    - Since the R^2 value is negative (-0.01), the model performs poorly and does not explain any variance in economic impact.
    - The high MSE (861.65) suggests that predictions are highly inaccurate.
    - This indicates that the model needs improvement, possibly by incorporating better features or refining assumptions.

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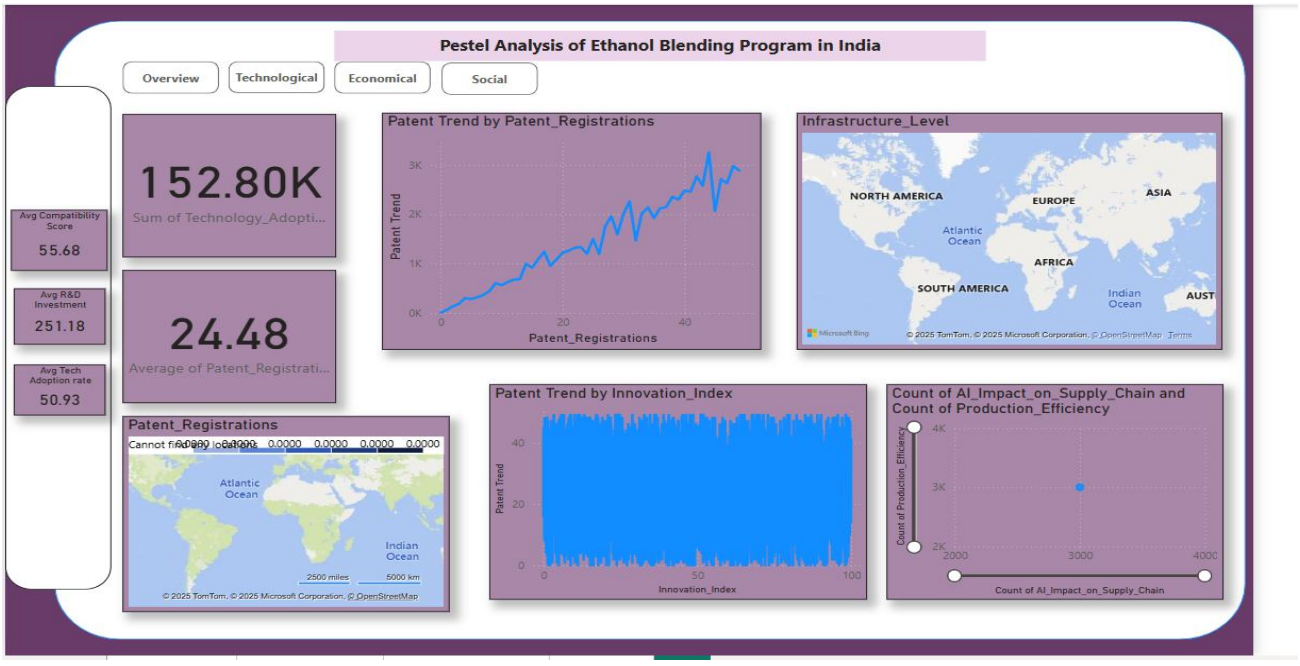
6. Key Economic Indicators (Left Panel)

This section provides key economic statistics that summarize the overall economic environment:

- Total GDP Growth: 13.59K
    - Indicates the total economic expansion over the period analyzed.
- Total Import Cost: 300.52K
    - Represents the total cost of importing oil, a critical factor in fuel demand.
- Average Government Subsidy: 4.96%
    - Shows the level of financial support provided by the government for fuel or ethanol programs.
- Average Consumer Index: 75.04
    - A measure of consumer confidence and spending behavior.
- Average Price: 1.51
    - Likely represents the average price of fuel.
- Average Inflation Rate: 5.31%
    - Inflation affects purchasing power and fuel affordability.

B. Technological :



1. Key Technological Metrics (Left Section)

- 152.80K – Sum of Technology Adoption:
    - Represents the total adoption of ethanol-related technologies.
    - A high value suggests significant industry integration and acceptance.
- 55.68 – Average Compatibility Score:
    - Measures how well ethanol technology integrates with existing systems.
    - A moderate score suggests room for improvement in compatibility.
- 251.18 – Average R&D Investment:
    - Indicates the average amount invested in research and development.
    - High investment implies strong focus on technological improvements.
- 50.93 – Average Tech Adoption Rate:
    - Shows the rate at which new ethanol-related technologies are being adopted.
    - A rate close to 50% suggests steady, but not overwhelming, adoption.
- 24.48 – Average of Patent Registrations:
    - Represents the number of new patents registered for ethanol blending innovations.
    - A moderate number suggests a growing but not explosive trend in patenting.

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2. Patent Trend by Patent Registrations (Top Middle)

- Type: Line Chart
- Purpose: Displays how patent registrations have changed over time.
- Key Elements:
    - X-axis: Number of patent registrations.
    - Y-axis: Patent trend over time.
- Insights:
    - Steady growth in patents indicates increasing technological advancements in ethanol blending.
    - A recent spike suggests accelerated innovation, possibly due to policy changes or increased funding.

- Further analysis is needed to determine which types of patents (e.g., fuel efficiency, production methods) are driving growth.

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3. Infrastructure Level (Top Right)

- Type: World Map
- Purpose: Shows the infrastructure level for ethanol-related technology globally.
- Key Elements:
  - No specific indicators are marked, meaning data may not be displaying properly.
- Insights:
  - If functional, this could provide insights into which regions have the best ethanol-related infrastructure.
  - Data troubleshooting is needed to ensure proper display of infrastructure rankings.

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4. Patent Registrations (Bottom Left)

- Type: Map (showing an error: “Cannot find any location”).
- Purpose: Intended to display patent registration locations.
- Key Issue:
  - The map is not functioning correctly, likely due to missing location data.
- Insights:
  - Fixing this issue could help determine which regions are leading in ethanol-related patent innovations.
  - Would be useful to compare patent locations with infrastructure and investment levels.

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5. Patent Trend by Innovation Index (Bottom Middle)

- Type: Scatter Plot
- Purpose: Shows how innovation levels affect patent trends.
- Key Elements:

    - X-axis: Innovation Index.
    - Y-axis: Patent trend.
- Insights:
    - There is a uniform distribution of patent registrations across innovation levels.
    - This suggests that patenting activity is not concentrated in just highly innovative sectors but is spread across different levels of innovation.
    - Further filtering may be needed to identify key contributors.

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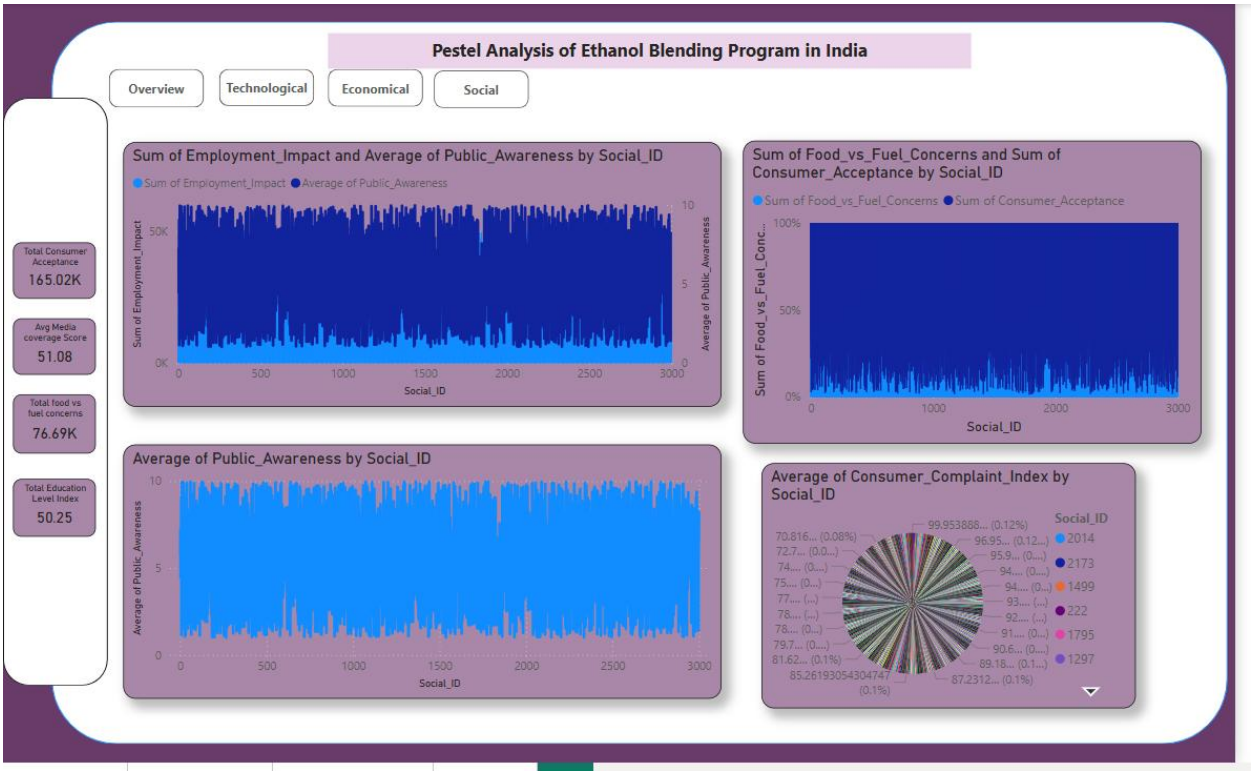
6. Count of AI Impact on Supply Chain and Count of Production Efficiency (Bottom Right)

- Type: Scatter Plot
- Purpose: Shows the relationship between AI impact on supply chains and production efficiency.
- Key Elements:
    - X-axis: AI Impact on Supply Chain.
    - Y-axis: Production Efficiency.
- Insights:
    - A direct correlation may indicate that AI improvements in supply chains positively impact ethanol production efficiency.
    - The data point suggests a significant influence of AI, possibly in optimizing fuel distribution, refining processes, or cost efficiency.

C. Social :



1. Key Social and Sentiment Metrics (Top Left)

- 165.02K – Sum of Consumer Acceptance:
    - Represents the total consumer acceptance level for ethanol blending.
    - A higher value suggests strong public approval.
- 51.08 – Average of Media Coverage Score:
    - Reflects the average media coverage score.
    - A score around 50 suggests balanced media attention (neither overwhelmingly positive nor negative).
- 76.69K – Sum of Food vs Fuel Concerns:
    - Measures total concerns about ethanol's impact on food supply.
    - A high value suggests significant public worry about food security.
- 50.25 – Average of Education Level:

- Represents the average education level of the surveyed population.
- This can influence awareness and perception of ethanol policies.

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2. Sum of Employment Impact and Average of Public Awareness by Social ID (Top Middle)

- Type: Bar Chart
- Purpose: This visualization compares employment impact with public awareness across different social groups.
- Key Elements:
  - X-axis: Social ID (unique identifier for social groups).
  - Y-axis: Employment impact (bars in dark blue) and public awareness (light blue).
- Insights:
  - Employment impact remains fairly consistent across social groups.
  - Public awareness shows minor variations but is generally steady.
  - This suggests that employment benefits of ethanol blending are evenly distributed, while awareness may not be a major influencing factor.

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3. Sum of Food vs Fuel Concerns and Sum of Consumer Acceptance by Social ID (Top Right)

- Type: Bar Chart
- Purpose: Shows how concerns about food vs fuel impact consumer acceptance.
- Key Elements:
  - X-axis: Social ID
  - Y-axis: Sum of concerns (Food vs Fuel) and sum of consumer acceptance.
- Insights:
  - Higher food vs fuel concerns do not appear to drastically lower consumer acceptance.
  - This suggests that, despite concerns, people may still accept ethanol blending due to other benefits (e.g., environmental or economic advantages).
  - A deeper analysis may be needed to understand regional or demographic trends.

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4. Average of Public Awareness by Social ID (Middle)

- Type: Bar Chart
- Purpose: Displays the distribution of public awareness across different social groups.
- Key Elements:
    - X-axis: Social ID
    - Y-axis: Average Public Awareness Score (light blue bars).
- Insights:
    - Public awareness is evenly distributed across social groups.
    - There are no extreme fluctuations, suggesting uniform access to ethanol-related information.
    - However, the overall impact of public awareness on consumer acceptance remains uncertain.

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5. Average of Consumer Complaint Index by Social ID (Bottom Right)

- Type: Pie Chart
- Purpose: Shows the average consumer complaint index for various social groups.
- Key Elements:
    - Each slice represents a different Social ID.
    - Percentages show how complaints are distributed.
- Insights:
    - Consumer complaints are widely spread across different social groups.
    - No single group dominates complaints, meaning dissatisfaction is not concentrated in a particular demographic.
    - Further analysis is needed to determine if complaints stem from fuel pricing, policy implementation, or other concerns.

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6. Average of Social Sentiment Index and Count of Consumer Complaint Index by Social ID (Bottom Left)

- Type: Map (but displaying an error message: “Cannot find any location”).
- Purpose: Intended to show regional distribution of social sentiment and consumer complaints.
- Key Elements:
    - This map is not displaying correctly, indicating possible data or geolocation errors.
- Insights:
    - Data issues may need to be addressed to analyze sentiment geographically.
    - If fixed, this visualization could help identify regions where ethanol policies are better or worse received.

Key Insights

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1. Economic & Political Factors: Elections significantly impact foreign policies, while government subsidies are largely independent of other economic/political factors.
2. R&D Investment & Production Efficiency: Increased R&D investment does not directly correlate with higher production efficiency, indicating inefficiencies in fund allocation.
3. Consumer Acceptance: Addressing consumer complaints is key to improving acceptance, while media coverage has minimal influence.
4. Carbon Emissions & Sustainability: Emissions are gradually decreasing, with CO_2 reduction and waste management being the most critical sustainability factors.
5. Regulatory Changes & Public Approval: Frequent policy changes lead to declining public approval, indicating a need for better communication and transparency.
6. Fuel Demand & Economic Growth: Higher GDP growth correlates with lower fuel demand, likely due to increased alternative energy adoption.
7. Technological Adoption: Ethanol-related technology adoption is steady, with moderate patent growth and AI playing a significant role in supply chain efficiency.
8. Social Perception: Public concerns about food vs. fuel do not drastically impact consumer acceptance, but media coverage and education levels influence awareness.

Recommendations

1. Enhance Policy Stability: Governments should introduce gradual regulatory changes with clear public communication to maintain approval ratings.
2. Optimize R&D Investments: Reallocate R&D funds towards factors that directly impact production efficiency, such as supply chain optimization and labor force improvements.
3. Improve Consumer Trust: Addressing consumer complaints should be a priority to increase acceptance of ethanol blending.
4. Accelerate Sustainability Efforts: Focus on CO_2 reduction and waste management to enhance sustainability.
5. Leverage Alternative Energy Growth: Since GDP growth correlates with lower fuel demand, invest more in alternative fuels and infrastructure.
6. Increase AI Integration: Expand the use of AI in supply chains to boost production efficiency.
7. Improve Public Awareness Campaigns: While public concern about food security exists, ethanol's benefits should be effectively communicated to enhance consumer confidence.

Conclusion

The case study highlights the complex interactions between economic, political, technological, social, and environmental factors affecting ethanol blending policies. While economic growth supports alternative energy adoption, R&D investment does not directly enhance production efficiency. Consumer acceptance is driven by complaint resolution rather than media influence, and regulatory changes need to be carefully managed to maintain public trust. Sustainability efforts should prioritize CO_2 reduction and waste management, while AI adoption can improve supply chain efficiency.

PESTEL Analysis Summary

1. Political: Elections significantly impact foreign policy, and regulatory changes affect public approval ratings.

2. Economic: Higher GDP growth leads to lower fuel demand, while oil import costs and consumer spending drive fuel consumption.
3. Social: Consumer complaints influence acceptance more than media coverage, and concerns over food security exist but do not hinder adoption.
4. Technological: AI integration in supply chains enhances efficiency, but R&D investment does not significantly impact production.
5. Environmental: CO_2 reduction and waste management are critical for sustainability.
6. Legal: Frequent policy changes reduce public approval, highlighting the need for a stable regulatory framework.
