The Impact of Ad Expenditure on Sales: A Linear Regression Analysis

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1. Introduction

This project was carried out to analyze the relationship between a company's advertising expenditure and its corresponding sales figures. Using the R programming language and the RStudio environment, a simple linear regression analysis was performed to determine if an increase in ad spending has a measurable impact on sales.

2. Methodology

A small, self-generated dataset was used for this analysis, consisting of 7 observations. The independent variable was `ad_expenditure` (in thousand dollars), and the dependent variable was `sales` (in thousand units).

The following steps were taken to complete the analysis:

- The data was first visualized with a scatter plot to observe any potential linear relationship.
- A linear regression model was then developed to quantify this relationship mathematically.
- Finally, the model's summary was examined to interpret the statistical findings and draw conclusions.

3. Key Findings

The analysis revealed a strong and positive relationship between advertising expenditure and sales.

Visual Analysis

As shown in the scatter plot below, the data points clearly indicate a strong upward trend. This visual evidence suggests that an increase in advertising budget is directly associated with an increase in sales.

Regression Model Results

The statistical summary of the linear regression model provided valuable insights into the nature of the relationship. The full console output is as follows:

```
Call:
lm(formula = sales ~ ad_expenditure, data = data_frame)

Residuals:
     1      2      3      4      5      6      7
-1.607  3.214 -1.964  2.857 -2.321 -2.500  2.321

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)     31.2500     2.9483   10.60 0.000129 ***
ad_expenditure   2.0357     0.1095   18.59 8.29e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.897 on 5 degrees of freedom
Multiple R-squared:  0.9857,   Adjusted R-squared:  0.9829
F-statistic: 345.6 on 1 and 5 DF,  p-value: 8.287e-06
```

The key interpretations are:

- **Ad Expenditure Coefficient (**beta_1**):** The coefficient for `ad_expenditure` is **2.0357**. This is a crucial finding, indicating that for every **$1,000 increase** in advertising expenditure, sales are expected to increase by an average of **2.036 units** (2,036 units).
- **Adjusted R-squared:** The `Adjusted R-squared` value is **0.9829** (98.29%). This remarkably high value signifies that the model explains almost all of the variability in sales using advertising expenditure alone.
- **Statistical Significance:** The p-value for the `ad_expenditure` coefficient is `8.29e-06`, which is much less than 0.05. This confirms that the relationship is **statistically significant** and highly unlikely to be a result of random chance.

4. Conclusion

In conclusion, the analysis provides strong evidence that there is a powerful and statistically significant positive relationship between a company's advertising expenditure and its sales performance. The constructed linear regression model is a reliable tool for forecasting, and its results can be directly applied to business decisions. These findings suggest that the company can confidently increase its advertising budget with a predictable positive return on sales.