

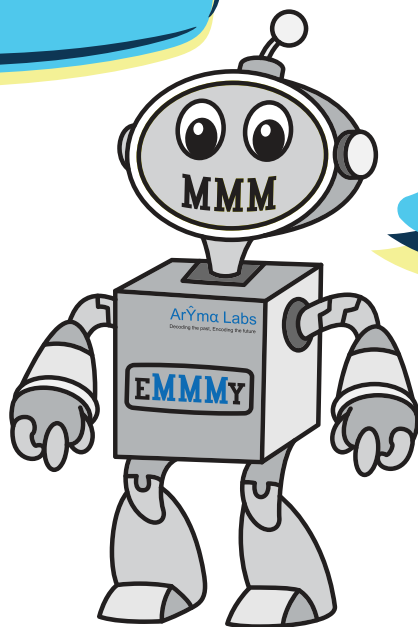
# Marketing Mix Modeling

with

**EMMMY**

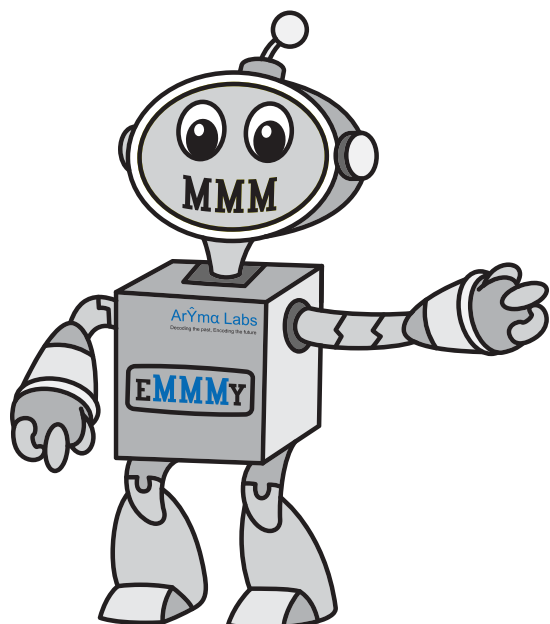
## Interaction Effects Explained

What is an Interaction Effect in Regression ?



An interaction effect is the simultaneous effect of two or more independent variables on at least one dependent variable in which their joint effect is significantly greater (or significantly less) than the sum of the parts. It helps in understanding how two or more independent variables work in tandem to impact the dependent variable.

It is important to understand two components first-Main Effects and interaction effects.



**Main Effects:**

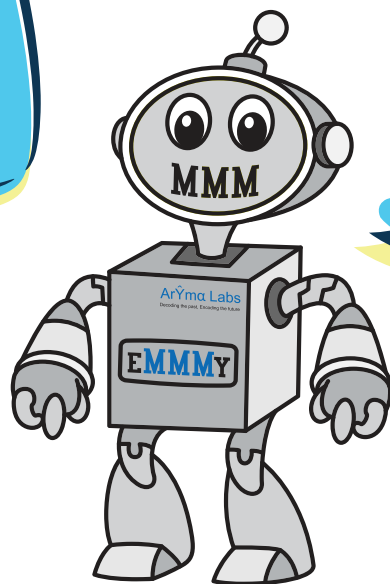
Main Effects is the effect of single independent variable on dependent variable - ignoring the effect of all other independent variables.

**Interaction Effects:**

Interaction Effects is the simultaneous effect of two or more independent variables on at least one dependent variable in which their joint effect is significantly greater (or significantly less) than the sum of the parts.

# Types of Interaction Effects

What are the different types of Interaction Effects ?



For explanation purpose, Let us consider interactions between 2 variables.

Interaction Effects hence can be between two

- 1) Categorical variables
- 2) Continuous variables
- 3) One categorical and one continuous variable

## Interaction Effects between Two Categorical Variables:

Imagine someone is trying to lose weight. Weight Loss could be a result of exercising or following a diet plan or due to both working in tandem.

### Case 1:

		Exercising	
		Yes	No
Diet Plan	Yes	3	2
	No	5	0

### Case 2:

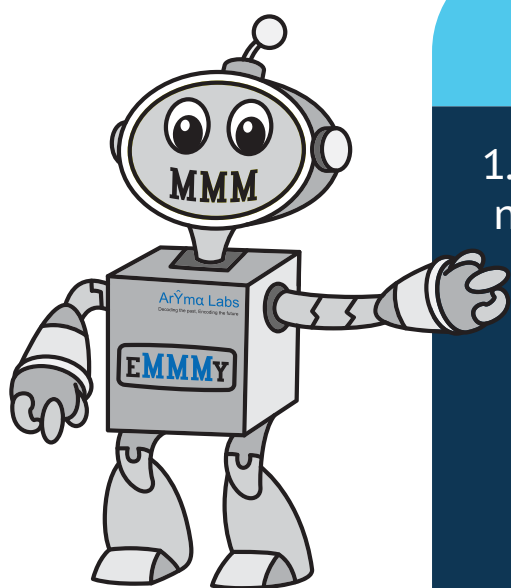
		Exercising	
		Yes	No
Diet Plan	Yes	5	2
	No	3	0

What does the above result indicate?

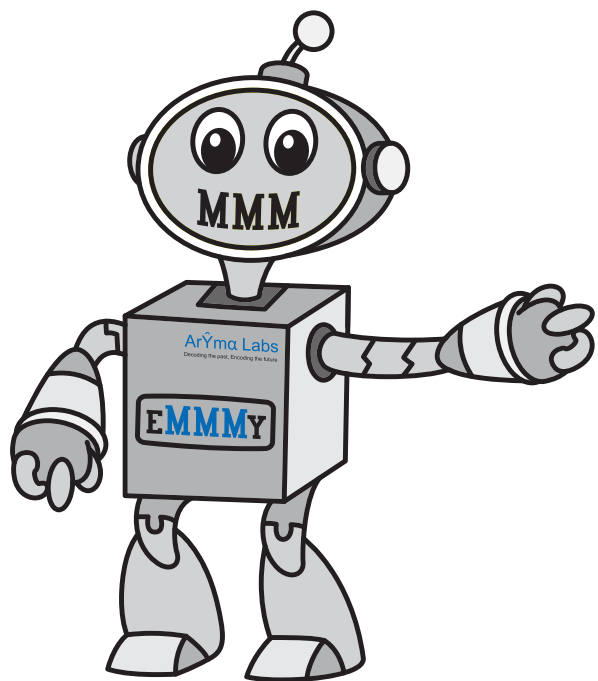
1. It shows that exercising alone is more effective than diet plan and results in 5 kg weight loss
2. Only exercising causes more weight loss as compared to a scenario when both exercising and diet plan are followed together (Your diet plan is not working :))

What does the above result indicate?

It shows that the weight loss is higher when exercising and diet plan are implemented together. So, we can say that there is an interaction effect between exercising and diet plan.



# Types of Interaction Effects



## Interaction Effects between Two Continuous Variables:

Let us view a Regression equation showing both main effect and interaction effect components.

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_1 X_2$$

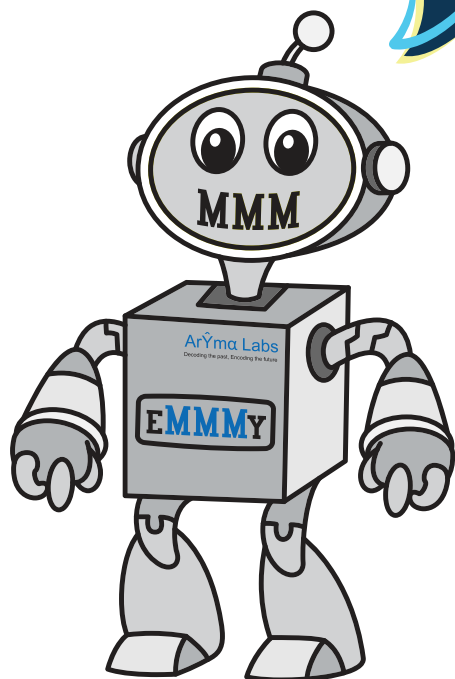
The above equation is interpreted as follows:

$\beta_1$  is the effect of  $X_1$  on  $Y$  when  $X_2$  equal to 0 i.e. one unit increase in  $X_1$  causes  $\beta_1$  unit increase in  $Y$ , when  $X_2$  equals 0.

Similarly,  $\beta_2$  is the effect of  $X_2$  on  $Y$  when  $X_1$  equal to 0 i.e. one unit increase in  $X_2$  causes  $\beta_2$  unit increase in  $Y$ , when  $X_1$  equals 0.

In case, neither  $X_1$  nor  $X_2$  is zero, the effect of  $X_1$  on  $Y$  depends on  $X_2$  and the effect of  $X_2$  on  $Y$  depends on  $X_1$ .

Let's expand a bit more on the above



Let us rewrite the above equation in another format.

$$Y = \beta_0 + (\beta_1 + \beta_3 * X_2) X_1 + \beta_2 * X_2$$

$$Y = \beta_0 + \beta_1 * X_1 + (\beta_2 + \beta_3 * X_1) X_2$$

$(\beta_1 + \beta_3 * X_2)$  is the effect of  $X_1$  on  $Y$  and it depends on the value of  $X_2$

$(\beta_2 + \beta_3 * X_1)$  is the effect of  $X_2$  on  $Y$  and it depends on the value of  $X_1$

# Types of Interaction Effects

## One continuous variable and one categorical variable:

The interaction between one categorical variable and one continuous variable is similar to two continuous variables.

Let's go back to our regression equation:

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_1 X_2$$

Where  $X_1$  is categorical variable, say (Female = 1, Male = 0) and  $X_2$  = Continuous variable

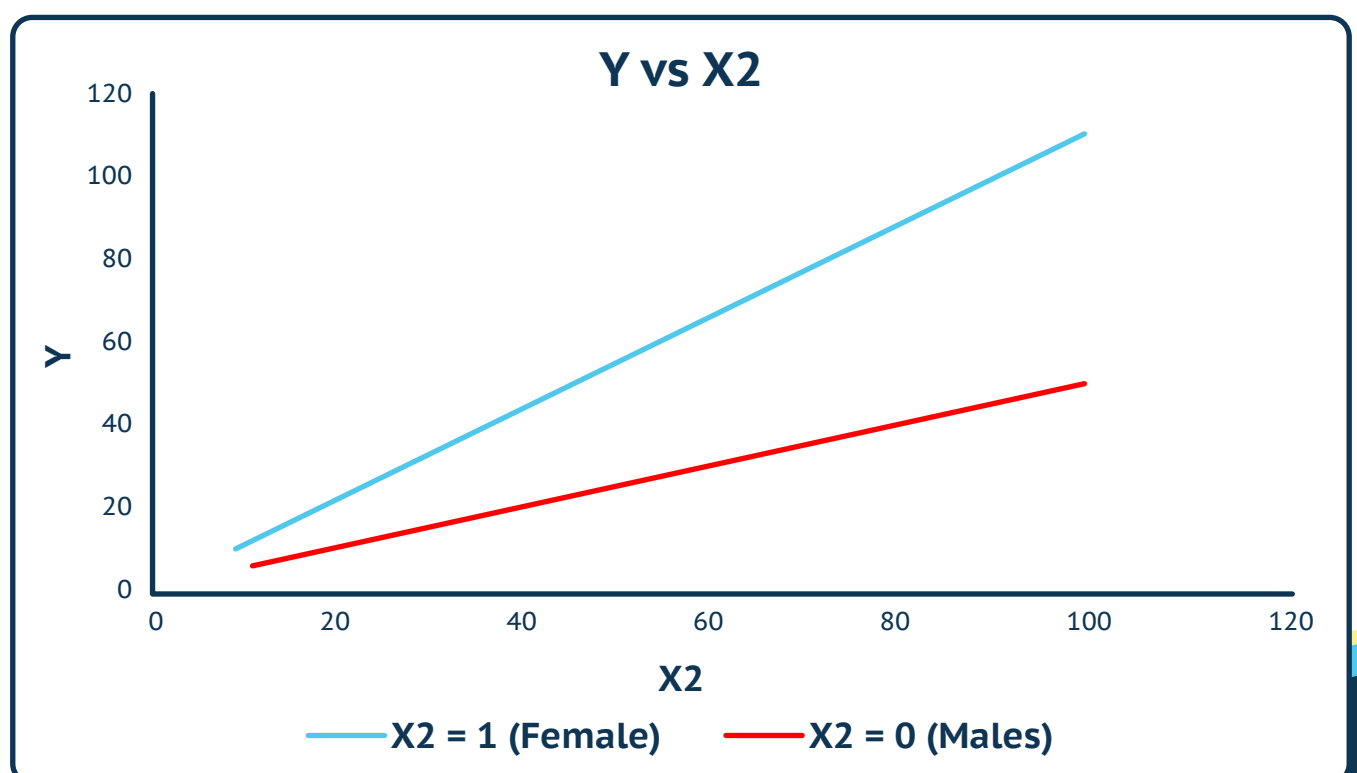
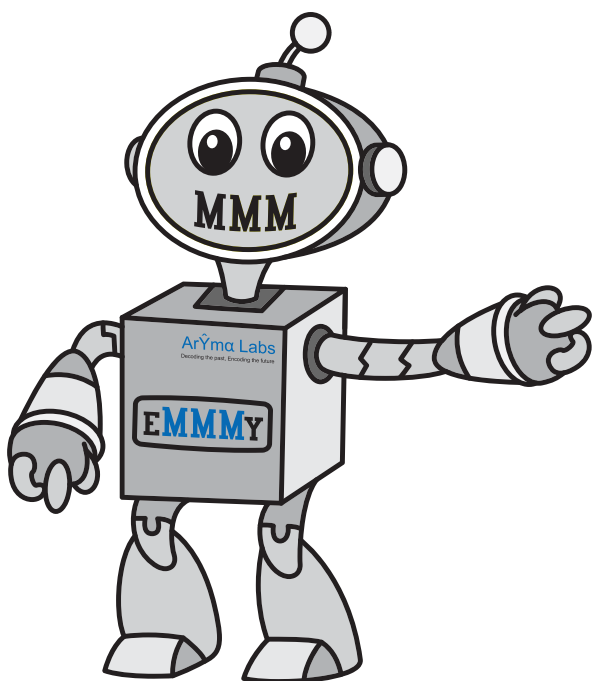
When  $X_1 = 0$ ,  $Y = \beta_0 + \beta_2 * X_2$

One unit increase in  $X_2$  will cause  $\beta_2$  units increase in  $Y$  for males

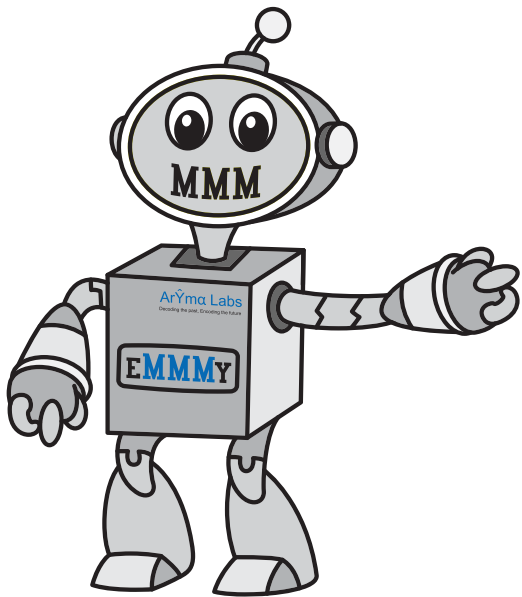
When  $X_1 = 1$ ,  $Y = \beta_0 + \beta_1 + (\beta_2 + \beta_3) * X_2$

One unit increase in  $X_2$  will cause  $\beta_2 + \beta_3$  units increase in  $Y$  for females

Effect of  $X_2$  on  $Y$  is higher for females than males (See figure below)



# Interpretation of Interactions in MMM



## 1. Both categorical variables:

Let's take two categorical variables - seasonality and some launch of product.

Assume that both seasonality and launch of product have a positive relationship with sales. Seasonality and product launch in their individual capacity will lead to sales. If there is an interaction effect between them, this might lead to incremental sales.

$$Y = \beta_0 + \beta_1 * \text{Seasonality} + \beta_2 * \text{Product launch} + \beta_3 * \text{Seasonality} * \text{Product Launch}$$

$$Y = \beta_0 + \beta_1 + \beta_2 + \beta_3$$

where *Seasonality and Product Launch = 1*

In case there is no interaction,  $Y = \beta_0 + \beta_1 + \beta_2$

## 2a. Both continuous variables (Positive Interaction):

Example of interaction between two continuous variable in a MMM could be - effect of TV advertisement and Digital ads together on sales.

So, when there is an interaction term, effect of TV ads on Sales depend on Digital ads and effect of Digital ads on Sales depends on TV ads.

$$Y = \beta_0 + \beta_1 * \text{TV Ad} + \beta_2 * \text{Digital Ad} + \beta_3 * \text{TV Ad} * \text{Digital Ad} \rightarrow \text{Positive interaction term}$$

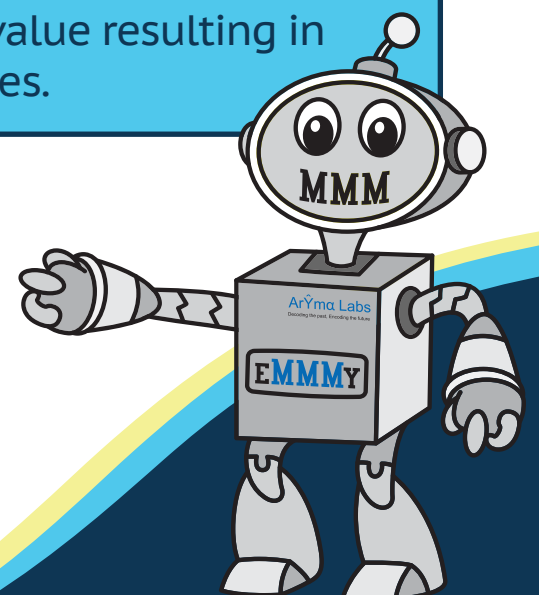
If the interaction term is positive, then the joint effect of these two variables is synergistic as it is leading to additional sales.

## 2b. Both continuous variables (Negative Interaction):

$$Y = \beta_0 + \beta_1 * \text{TV Ad} + \beta_2 * \text{Digital Ad} - \beta_3 * \text{TV Ad} * \text{Digital Ad} \rightarrow \text{Negative interaction term}$$

If the interaction term is negative, the interaction component takes away some part of Sales thus reducing the overall sales.

Note that the main effects of these two inputs is positive but the combined effect has a negative Beta value resulting in reduction in total sales.





# Interpretation of Interactions in MMM

## 3. One continuous variable and one categorical variable:

Where X1 is categorical variable, say Seasonality (1 if there is seasonality, 0 otherwise)

And X2 = Continuous variable: TV advertisement

Y = Sales

Sales are impacted by seasonality and TV advertisement individually and when they work together.

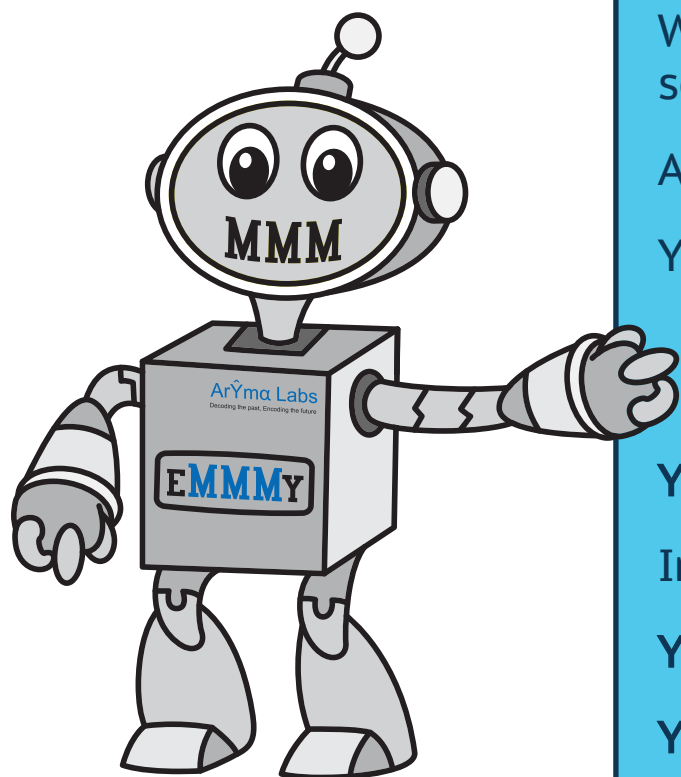
$$Y = \beta_0 + \beta_1 * \text{Seasonality} + \beta_2 * \text{TV ad} + \beta_3 * \text{TV Ad} * \text{Seasonality}$$

In this scenario, when seasonality component is there, then:

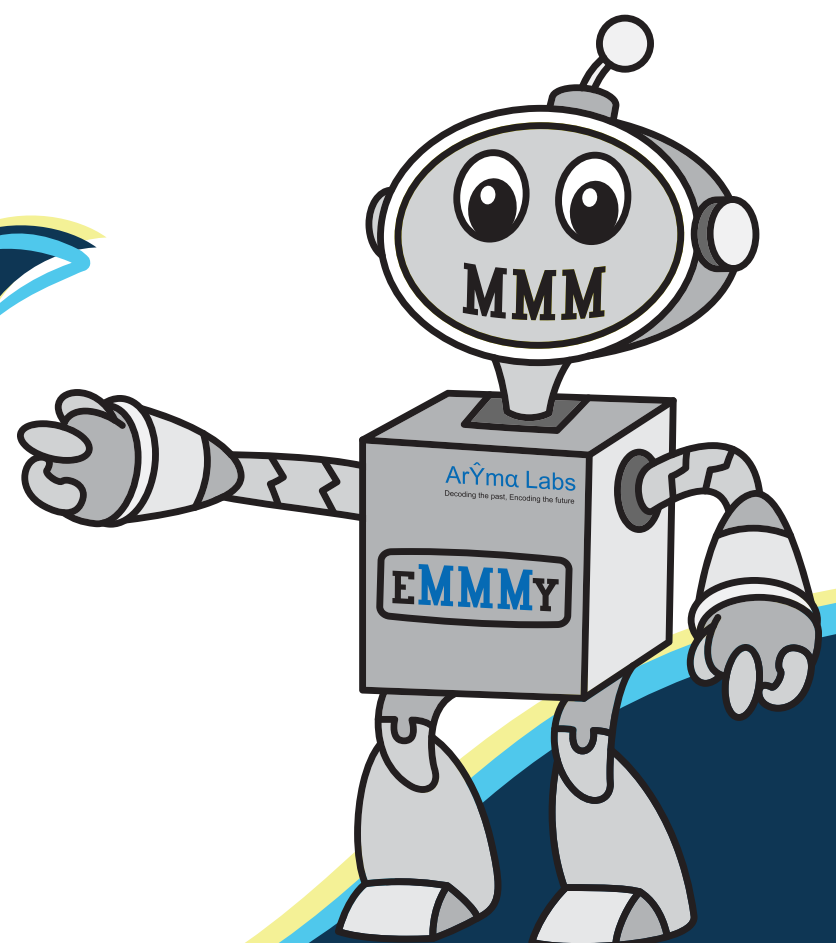
$$Y = \beta_0 + \beta_1 + \beta_2 * \text{TV ad} + \beta_3 * \text{TV Ad}$$

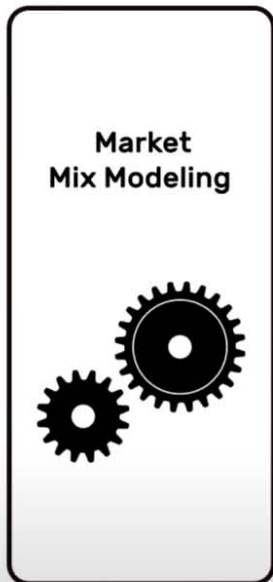
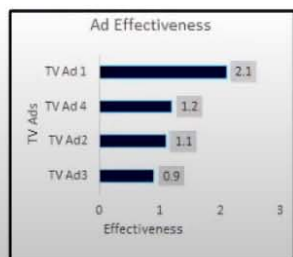
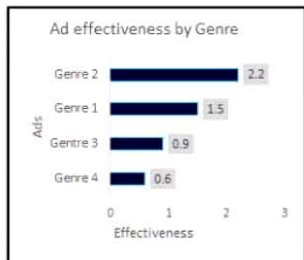
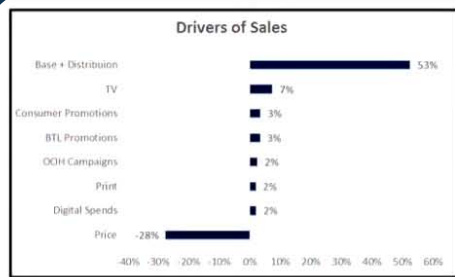
$$Y = \beta_0 + \beta_1 + (\beta_2 + \beta_3) * \text{TV Ad}$$

The interaction effect between TV and seasonality has led to additional sales.

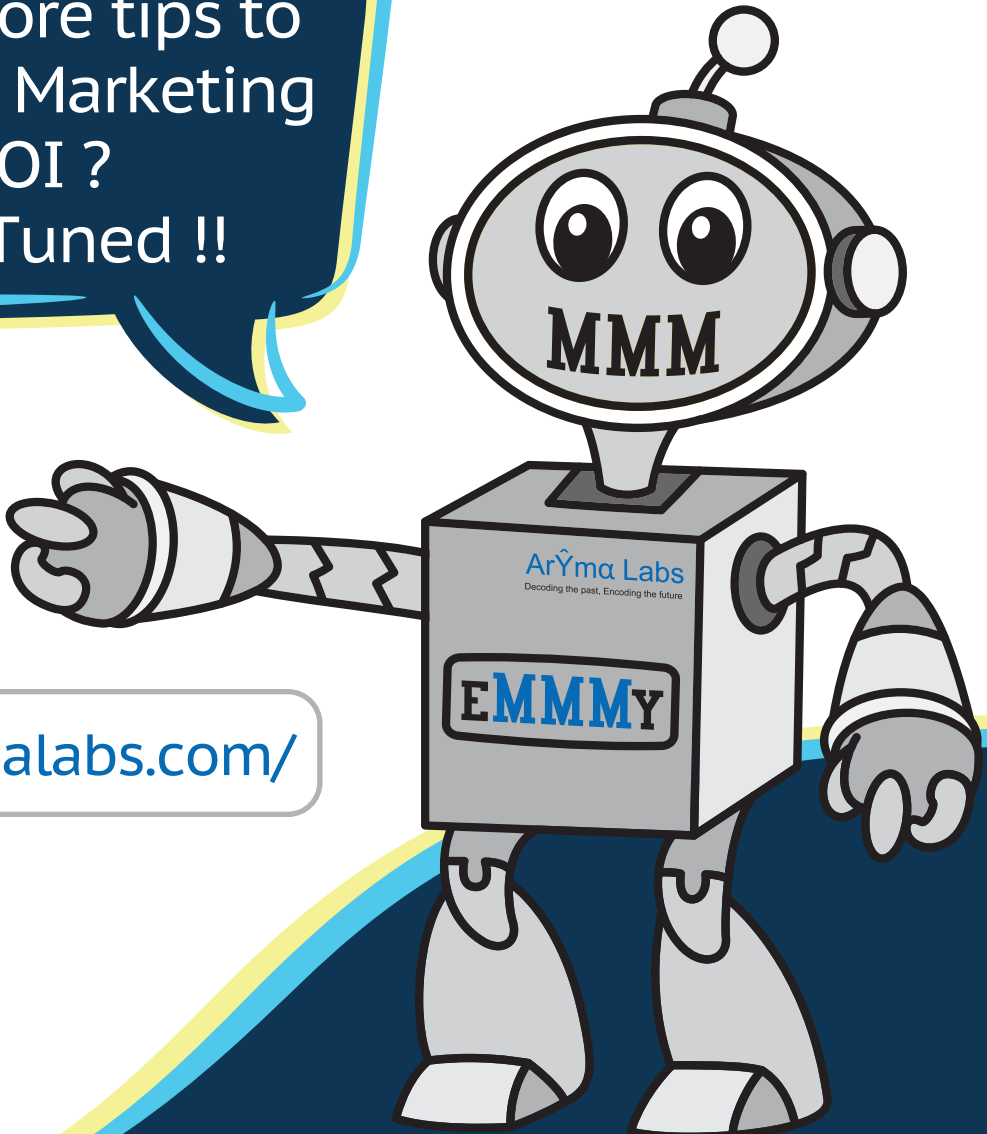


That wraps up explanations on Interaction effects. Hope you enjoyed it.





Want more tips to improve Marketing ROI?  
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