EMS ANALYTICS

Consumer Insight Consultants

Correlation and Regression for Drivers

Topics for Correlation and Regression

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  - Decision Trees and Random Forest
  - Correlation Network
  - Partial correlations

For More Detail

https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/correlation-analysis/

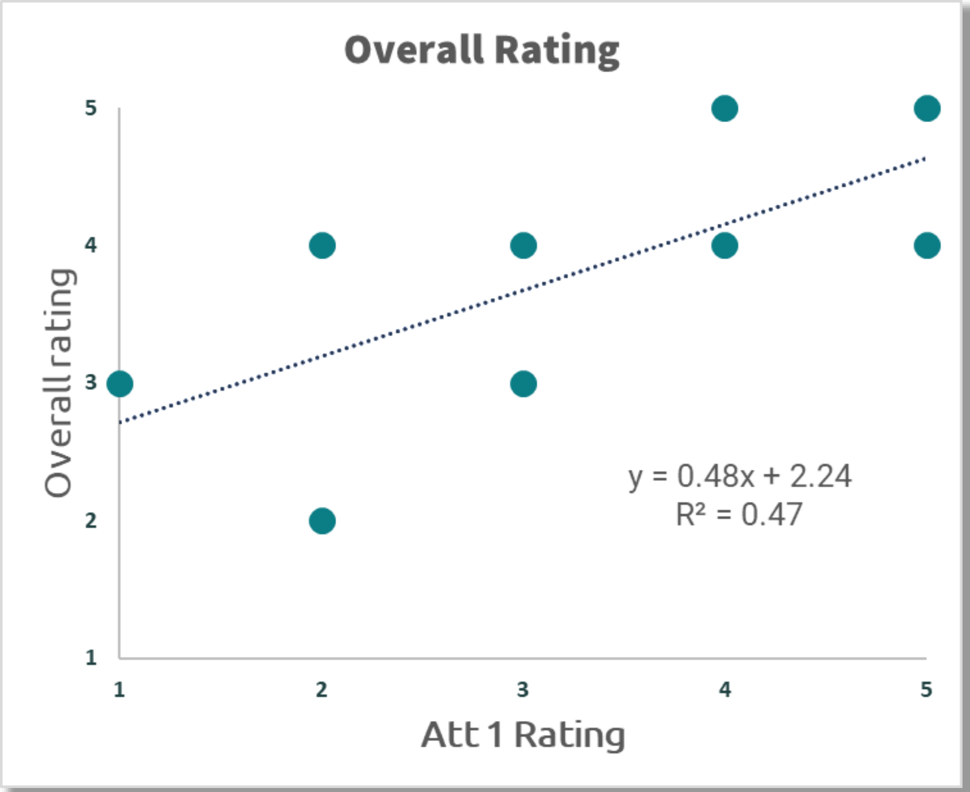
https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/regression-analysis/find-a-linear-regression-equation/

What’s an easy way to see how one item “drives” another?

A Simple Example (just 2 variables)

The Data

Resp	Att 1 Rating	Att 2 Rating	Att 3 Rating	Overall Rating
1001	3	4	2	4
1002	4	2	5	4
1003	1	5	4	3
1004	5	4	3	5
1005	4	4	2	5
1006	5	3	2	3
1007	2	5	4	2
1008	3	4	3	4
1009	5	4	5	5



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The Correlation

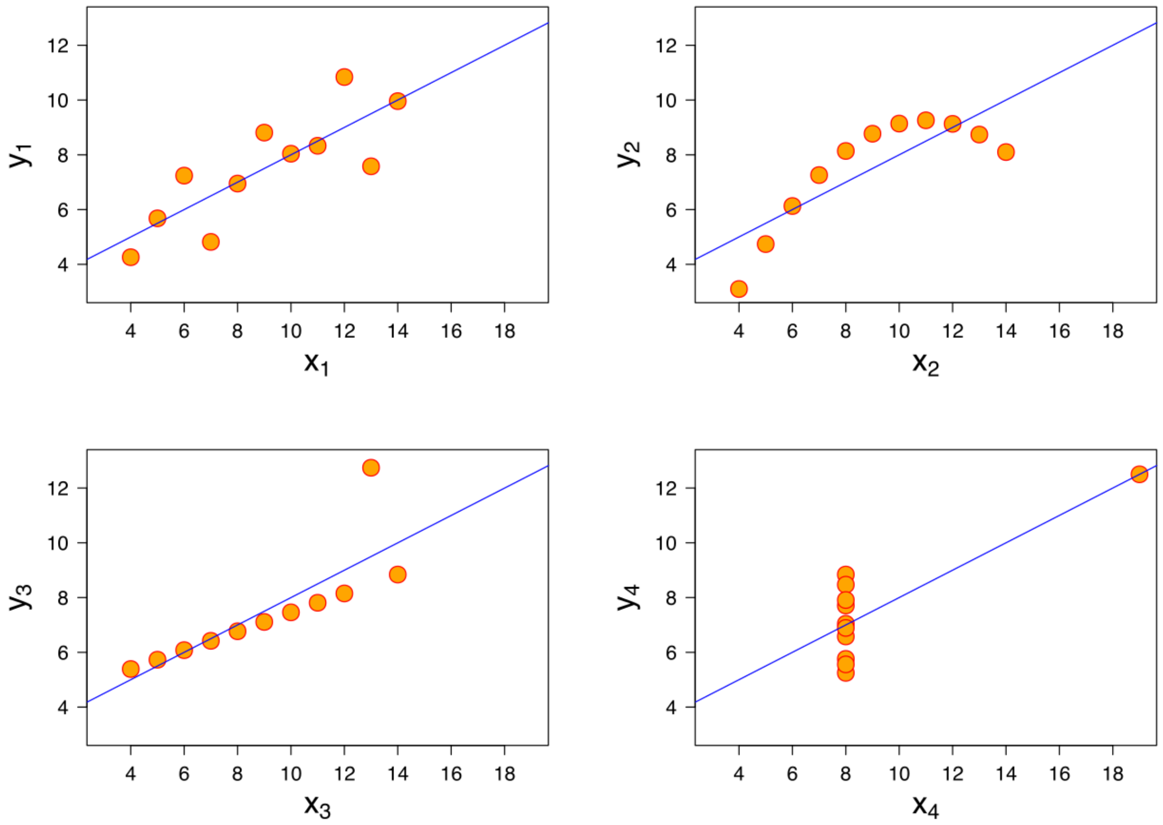
- A **correlation** is the strength of the linear relationship between two variables
  - +1.0 = perfect positive relationship
  - 0 = no relationship
  - -1.0 = perfect negative relationship
- For the previous data, the correlation (“r”) is about 0.69, which is usually considered moderately strong (depends on context)
- Correlations do not tell the whole story, but they are often used for driver analysis
- Beware spurious correlations and data that show “something else is going on” besides a linear effect

Correlations Often don't Tell the Whole Story

All four plots are for data with a 0.82 correlation.

Obviously (if it's plotted), there's something missing.

Moral: ALWAYS PLOT DATA before running correlations!



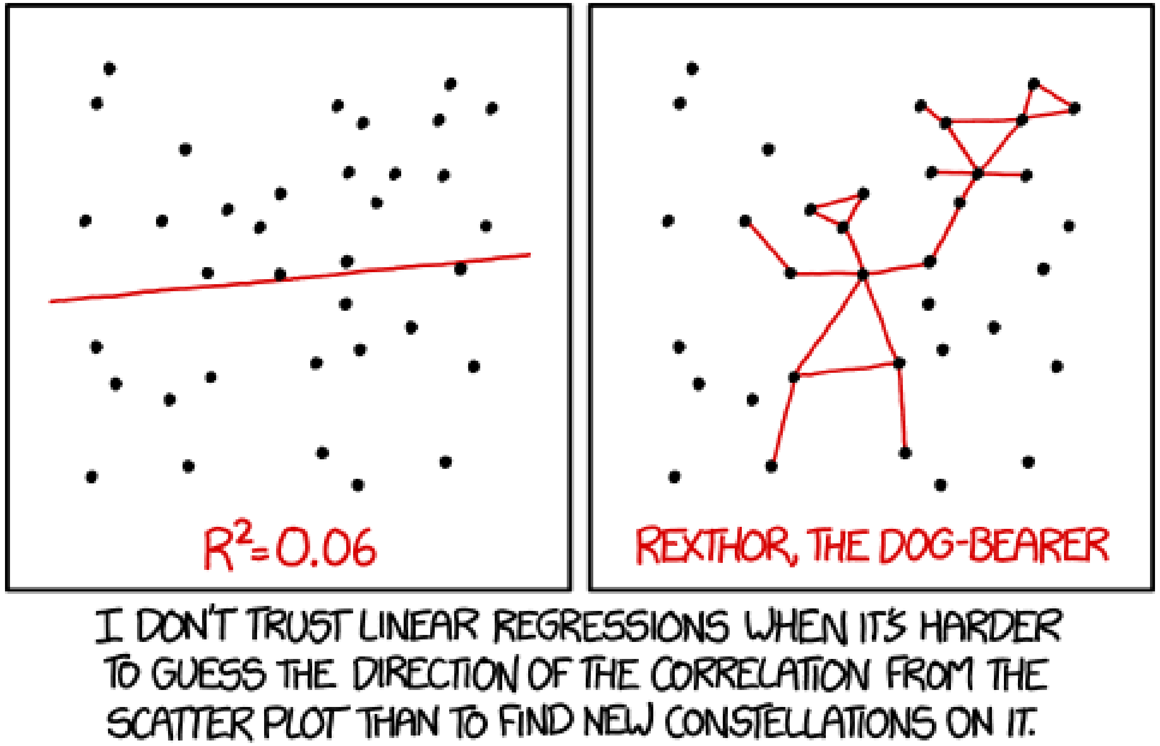
Final Notes on Correlations

- Actually, there are actually three “flavors” of correlation typically used:
  - Pearson – what we’ve been using so far and what’s used >95% of the time in MR
  - Spearman’s Rank – for rank data
  - Kendall’s Tau – also for rank data

The (Simple) Regression

- A (**simple**) **regression** is related in some ways to correlation, except it measures the magnitude of the linear relationship between two variables
  - Can be any value + or –
  - Goodness of fit is usually measured by the "r-squared", which is the percent variance of the target (dependent) variable explained by the other (independent) variable
  - standard error or the coefficient can also be used, but rarely is in MR
- For the previous data, the r-squared is about 0.47, which is usually considered moderately strong (depends on context)
- Like correlations, simple linear regressions do not tell the whole story, but they are often used for driver analysis

Regressions may not seem to (or actually) Tell the Whole Story



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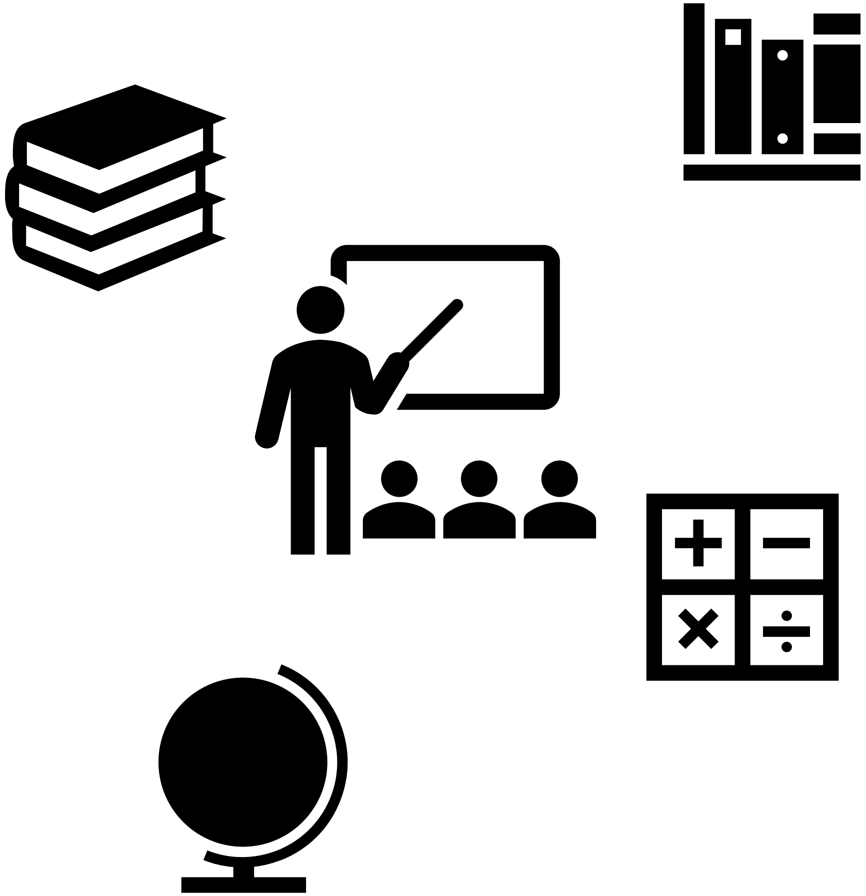
Final Notes on (simple) Regressions

- It's not a coincidence – r-squared from regression is the square of the correlation ("r")
- While so far we have been talking about Ordinary Least Squares (OLS) in the form of $y=mx+b$, you may find that other forms are more appropriate
- Both correlations and regressions assume both variables are normally distributed and they can be heavily influenced by outliers
  - It's often necessary to standardize or at least transform the data (i.e., using the logarithm) to make the results reliable



What if I need to use regression on multiple variables at once?

Multiple Regression Example

The Data (same as before)

Resp	Att 1 Rating	Att 2 Rating	Att 3 Rating	Overall Rating
1001	3	4	2	4
1002	4	2	5	4
1003	1	5	4	3
1004	5	4	3	5
1005	4	4	2	5
1006	5	3	2	3
1007	2	5	4	2
1008	3	4	3	4
1009	5	4	5	5

The Multiple Regression

- Multiple regression is perhaps the most widely-used predictive tool used
- For the previous data, the r-squared for a single independent variable is about 0.47. If all three independent variables are used in the regression, we would expect to do even better.
  - In fact, R^2 is better with two more explanatory variables: 0.65
  - However, the adjusted R^2, which penalizes the fit for “extra” variables, is only 0.07
- The coefficients generally don’t mean anything specific and can be outright misleading

Multiple Regression Output

To the left we see the Excel Data Analysis output for a multiple regression on the same data we have been using.

Not shown are the correlations between the attributes of:

Att 1 & Att 2 – -0.61

Att 1 & Att 3 – -0.12

Att 2 & Att 3 – -.07

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.646
R Square	0.418
Adjusted R Square	0.069
Standard Error	1.017
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	3.715	1.238	1.197	0.400
Residual	5	5.174	1.035		
Total	8	8.889			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.964	3.195	0.302	0.775	-7.250	9.178	-7.250	9.178
Att 1 Rating	0.555	0.326	1.704	0.149	-0.282	1.392	-0.282	1.392
Att 2 Rating	0.216	0.498	0.434	0.682	-1.063	1.495	-1.063	1.495
Att 3 Rating	0.034	0.301	0.111	0.916	-0.740	0.807	-0.740	0.807

Fit Measures
Notice drop from R square to Adjusted R square. Std. Error is of the predictions

Coefficients
The b's (usually called betas) of the model

Model Significance
Is model better than no model?

Coeff. P-values
Is coefficient different from zero?

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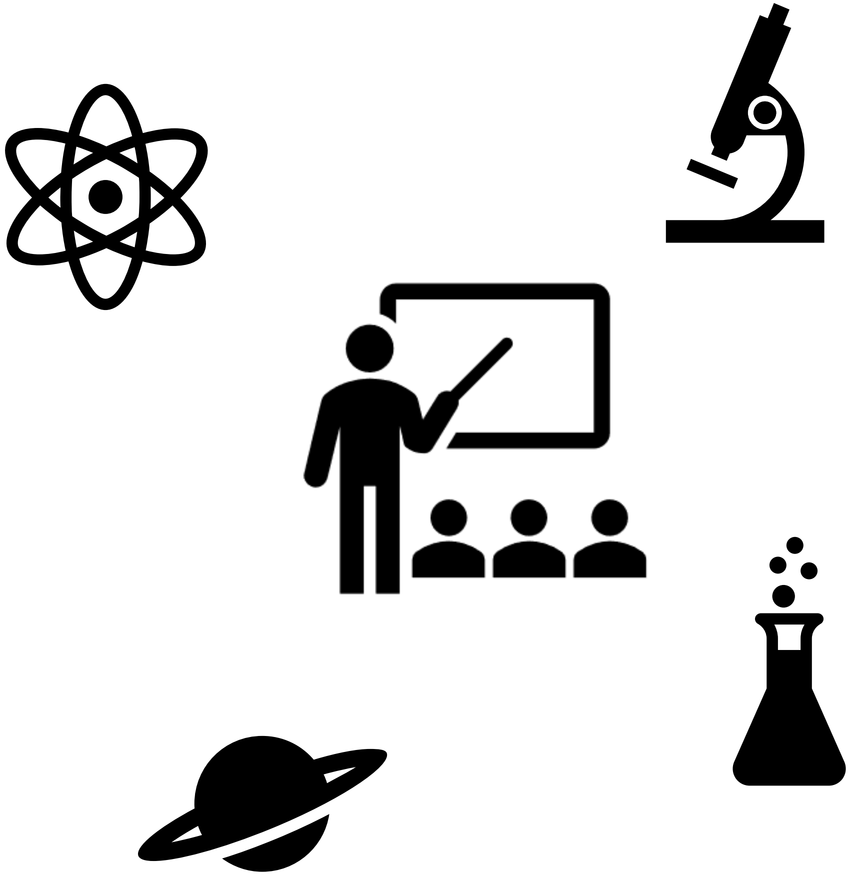
Final Notes on Regressions

- The regression coefficients generally don't mean anything specific for driver analysis, but be sure to have the input data on the same scale and transform to a normal distribution if needed
- Beware of multicollinearity (correlated ind. Variables)
- Outliers can have a big impact on results, so clean them before running a regression.
- For driver analysis, p-values of coefficients are much more important than adjusted R^2
- There are other, better, ways to do drivers (we'll get to those in a few slides).



Some More Advanced Stuff

Beware Multicollinearity

- When the independent variables are correlated, which in survey research is almost always the case, that's called multicollinearity.
  - This can result in a lot of uncertainty in driver results
- Our example had a potential, even probable, multicollinearity problem with Att 1 and Att 2.
  - Since Att 2 and Att 3 are not correlated, Att 1 should be dropped from model, <u>but this doesn't work for drivers</u>!!
- Multicollinearity doesn't affect predictions, but it does affect coefficients

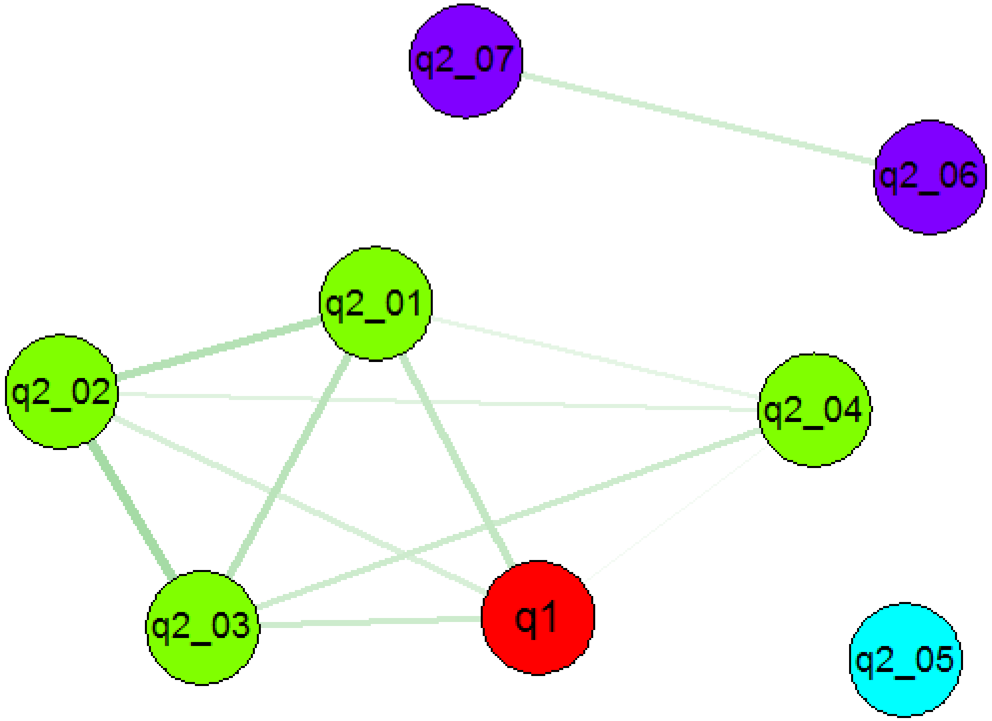
Shapley Regression

- One way to measure importance of attributes is to see which ones add the most to r^2 (explained variance) over all combinations of inputs.
- There are many names for this, but Shapley Regression is a common one.

Decision Trees and Random Forest

- Instead of OLS regression, decision trees (like CART) and their extension, random forest, can be used to estimate driver values.
- Like Shapley approach, these measure importance by an input's influence on model fit.
- Eliminates issues with the usual assumptions and doesn't have a problem with multicollinearity.
- Random forest is EMS's preferred method for drivers.

Correlation Network



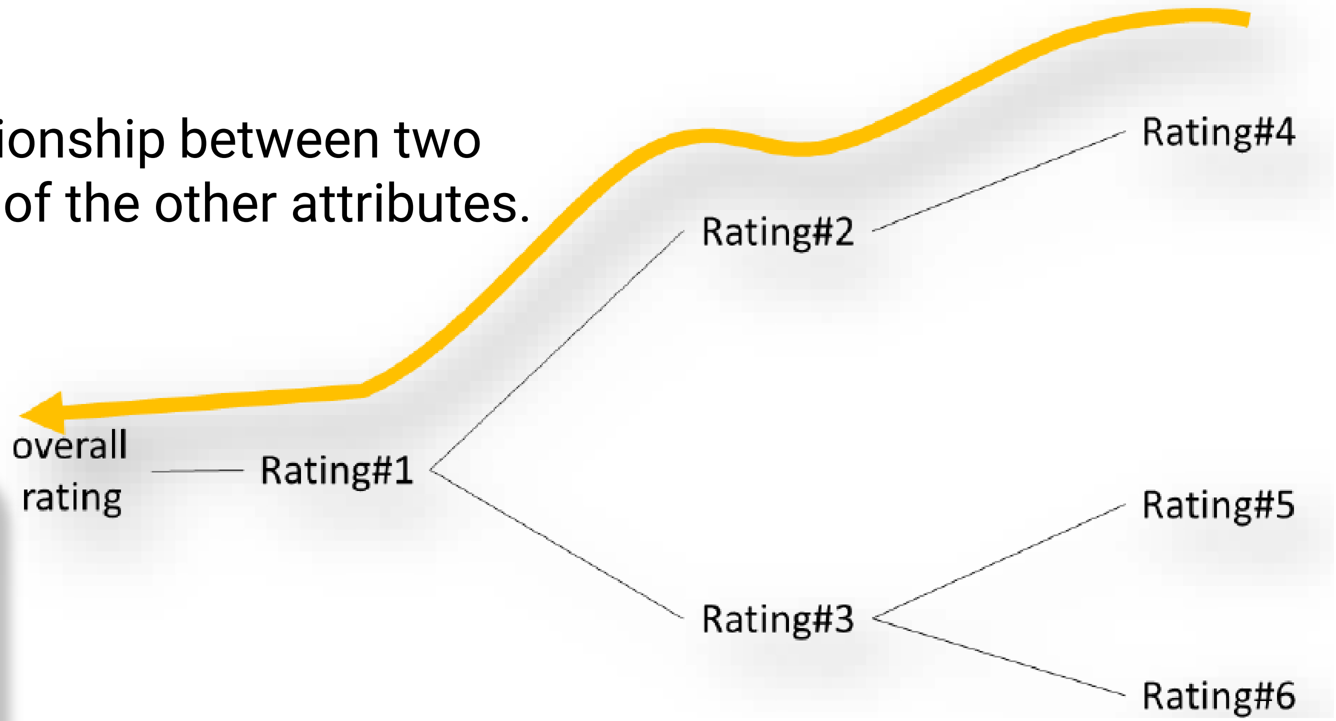
Design Thinking – Instead of listing values of drivers like they operate independently, use a correlation network to see how inputs interact.

In this example, q2_01 - 04 are all inter-related and 01 - 03 directly impact q1 (in this case, overall satisfaction). So, while q2_01 may be expensive to address, 02 and/or 03 may be better areas of focus.

Partial Correlation Network (Graphical Model)

Design Thinking – A great way to understand how to make improvements is with a partial correlation network.

Partial correlations are the relationship between two attributes, removing the effects of the other attributes.



Here, we see that ratings 4, 5, and 6 are good candidates for improving the overall rating. We would look to traditional drivers to help identify which ones are "best".

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Effective Solutions, Grounded Results