



Milestone #4:

Moving to Experiment Data

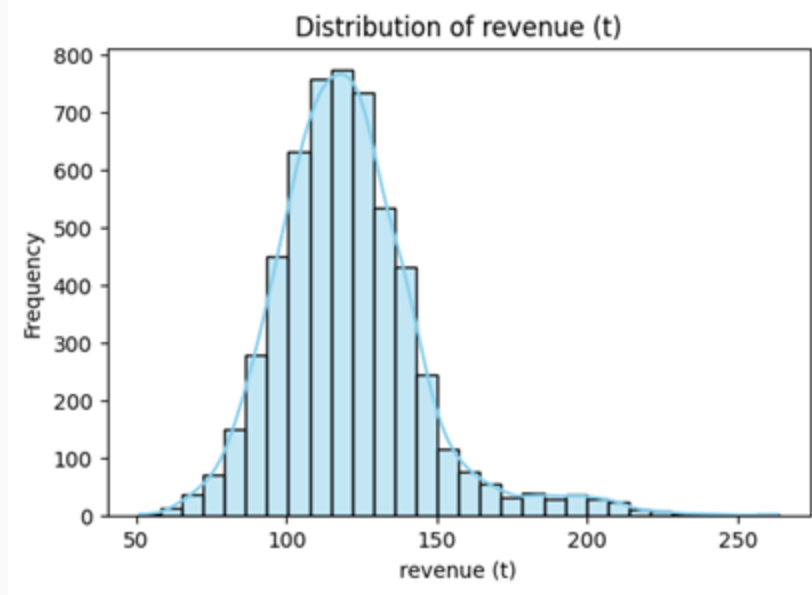
Estee Lauder 1B



01 ✨ Univariate Exploration ✨

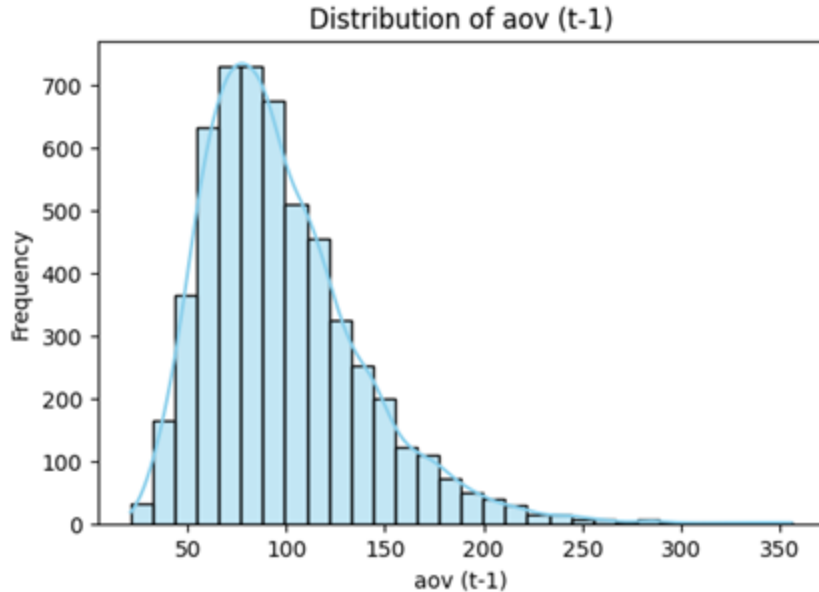
(Distribution of each variable)

Histogram - revenue (t)



This histogram of distribution of revenue appears to be normally distributed with a slight right skew. This shows that most customers contribute a similar level of revenue while, a few outliers show that a few customers spend more than average.

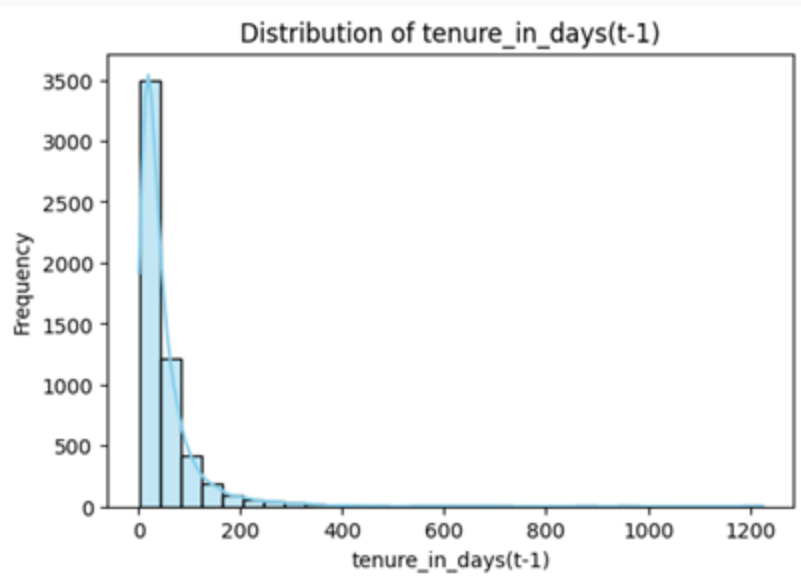
Histogram - aov(t-1)



This histogram of distribution of average order value is right-skewed. This means that the majority of costumes spend similar, moderate amounts per order, while a few customers spend a higher number extending the right of the histogram.

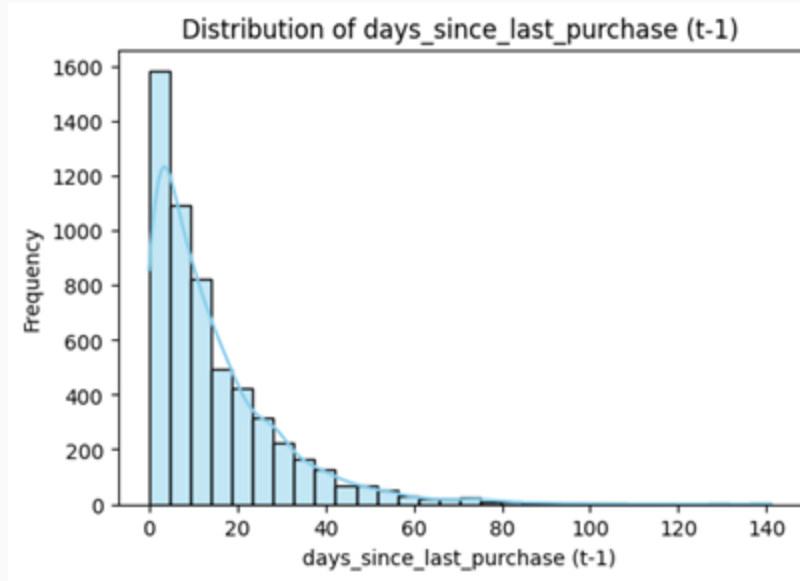


Histogram - tenure in days(t-1)



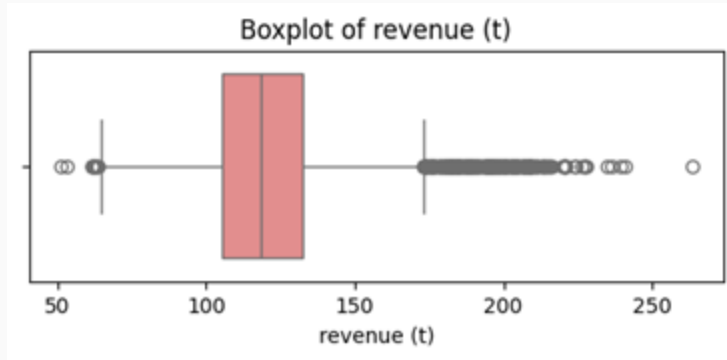
This histogram of distribution of tenure in days shows a strong right skew showing customers have short tenures so they are new, (less than 100 days), while a few have a longer period (been with the company longer).

Histogram - days since last purchase (t-1)



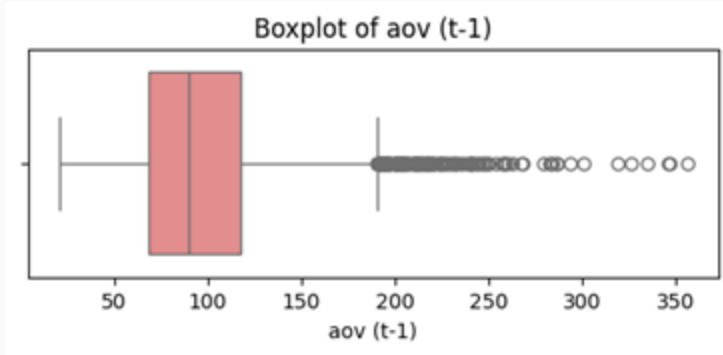
This histogram of distribution of days since last purchase is right-skewed, the data points are to the left side of the graph with a tail extended to the right. The graph is showing a large group of active customers who made recent purchases and a few customers who haven't made purchases in a long time on the tail.

Boxplot - revenue (t)



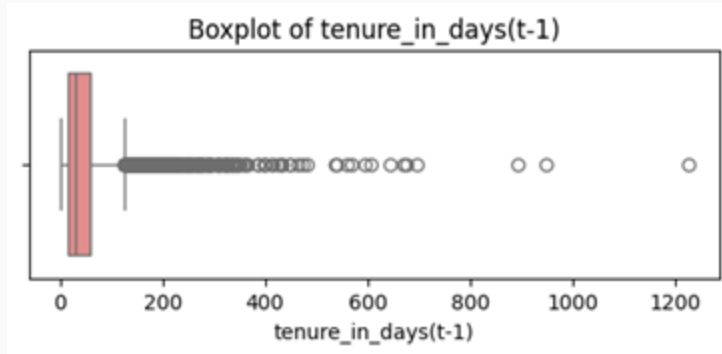
This distribution of revenue box plot shows the data is right-skewed with a median around 120. The IQR suggests that most revenue values fall between 100 to 135. The outliers are on the low end (\$50-60), and large amount of outliers on the high end 200+. This shows customers behaviors, the regular everyday purchases, and the less frequent but large sales.

Boxplot - aov (t-1)



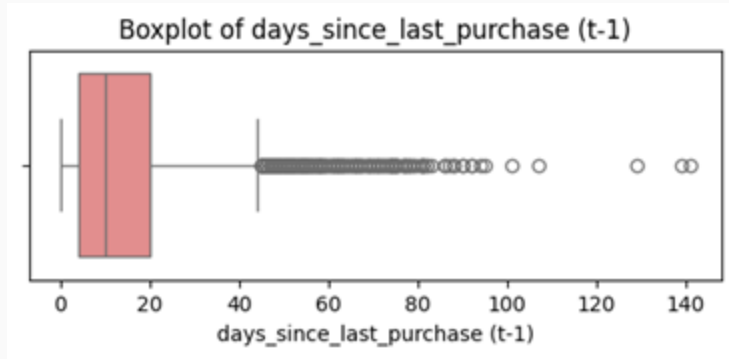
This plot shows the data is right skewed, The median is about \$95, the IQR falls between 75-110, meaning 50% of aov falls between that range. There are many outliers on the right \$200+, which represent transaction of aov being higher than the norm. Overall this graph shows an average range of \$75-110, and transactions with a higher average value are transactions of more expensive products.

Boxplot - tenure in days (t-1)



This boxplot shows the data is right skewed and the median is low, so 50% of the tenures are shorter than around 50 days while 50% are longer. The IQR shows that 50% of the tenures fall between roughly 25-100 days. There appears to be some outliers going beyond 600 days. Overall this plot shows customers have a short tenure but a small number have long tenure.

Boxplot - days since last purchase (t-1)



This boxplot shows days since last purchase. The data is right skewed showing that customers made a recent purchase while others haven't purchased in a while. The median is around 15 days so half the customers made their last purchase within the past 15 days. The IQR spans from 3 to about 35 days so 50% of customers made their purchase around that time. There are many outliers beyond 45 days some beyond 100, which represent customers who haven't purchased in a while.

02 ✨ comparisons ✨

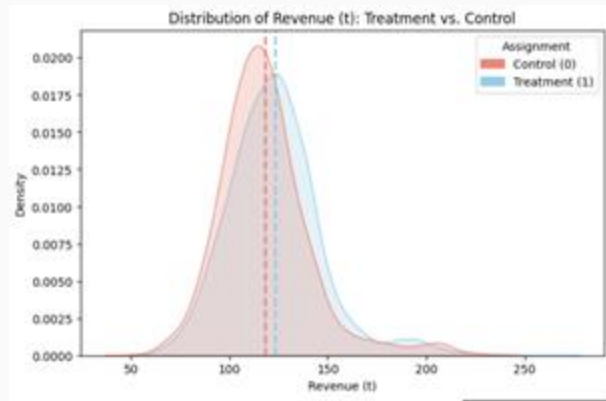
Control vs. Treatment

Compare distributions of revenue (t) between groups

	Covariate	Mean_Treatment	Mean_Control	SMD	p-value
0	aov (t-1)	97.09	97.86	-0.019	0.4747
1	days_since_last_purchase (t-1)	14.34	14.75	-0.027	0.3145
2	tenure_in_days(t-1)	49.40	49.81	-0.006	0.8119
3	loyalty_membership	0.07	0.06	0.014	0.6060

- **Goal:** To confirm the experiment was fair by ensuring the treatment and control groups were statistically similar *beforehand*.
- **Evidence 1: Standardized Mean Difference (SMD)**
 - All SMD values are near zero (well below the 0.1 industry standard), indicating excellent balance.
- **Evidence 2: p-values**
 - All p-values are high, confirming there were no significant pre-existing differences between the groups.
- **Conclusion: The randomization was successful.** We have a reliable foundation to trust that our results are due to the gift strategy itself.

Revenue Distributions (Control vs. Treatment)



Primary Observation: A qualitative comparison of the revenue distributions reveals a separation between the treatment and control groups, although there is considerable overlap.

Evidence from Density Plot:

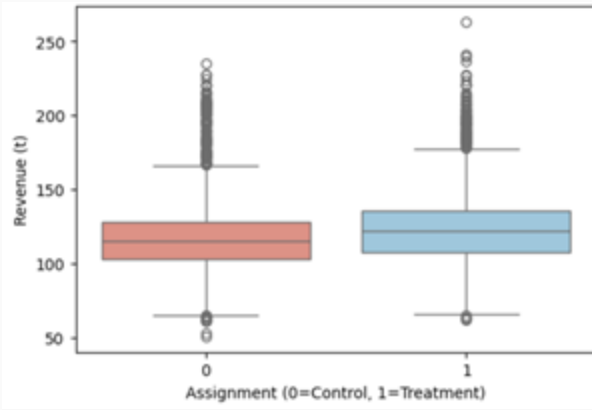
- The density plot for the treatment group (sky blue) exhibits a slight but observable rightward shift relative to the control group (salmon). **The average revenue for the treatment group is higher than the control group.**

Evidence from Box Plot:

- This directional difference is quantified in the box plot, which indicates an elevated median revenue for the treatment group.

Preliminary Conclusion:

- The exploratory evidence is **inconsistent with a null hypothesis of no effect**. Formal statistical testing is required to determine the significance of this observed difference.





Revenue (t) Summary by Group:				
	mean	median	std	count
assignment				
Control	117.952016	115.5700	23.870081	2773
Treatment	123.053486	121.8105	24.174141	2783

The group summary table shows:

- **Objective:** To quantitatively summarize the directional difference observed in the visual analysis of the revenue distributions.
- **Key Metrics:** The treatment group exhibits a higher mean revenue (+\$5.10) and a higher median revenue (+\$6.24) compared to the control.
- **Variance:** The standard deviations of the two groups are comparable, suggesting the intervention did not substantially increase revenue volatility.
- **Implication:** These descriptive statistics provide quantitative support for the visual evidence. The next step is to assess the statistical significance of this observed difference.

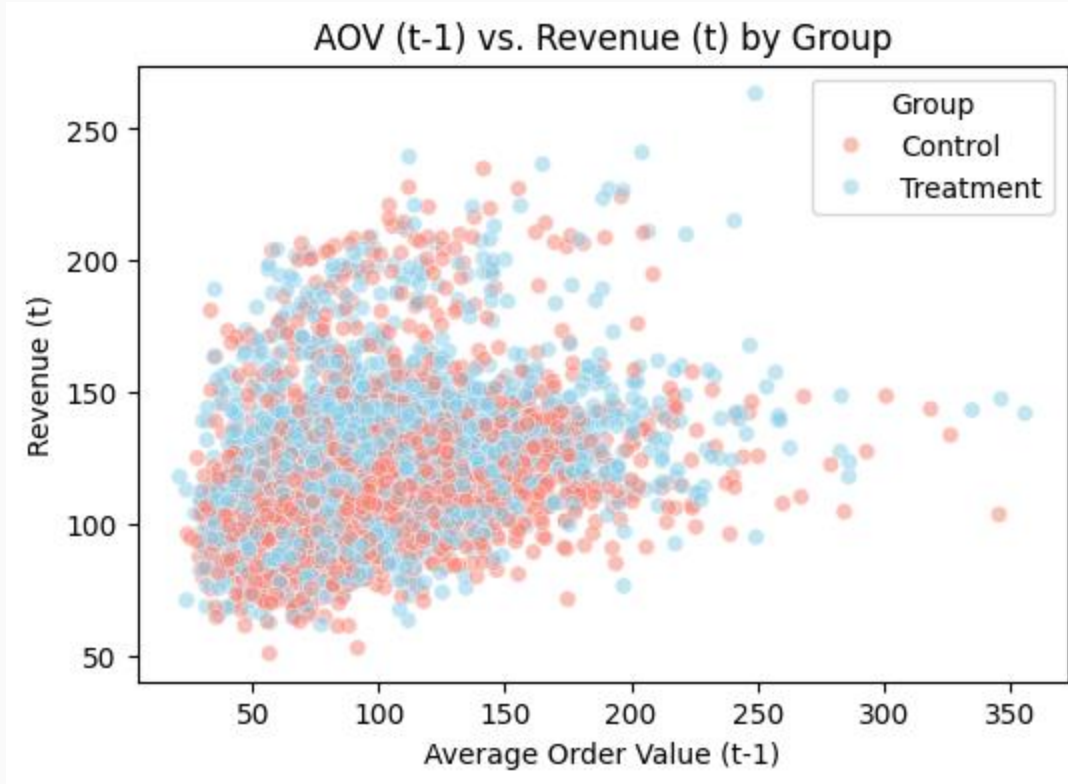


03

Explore relationships

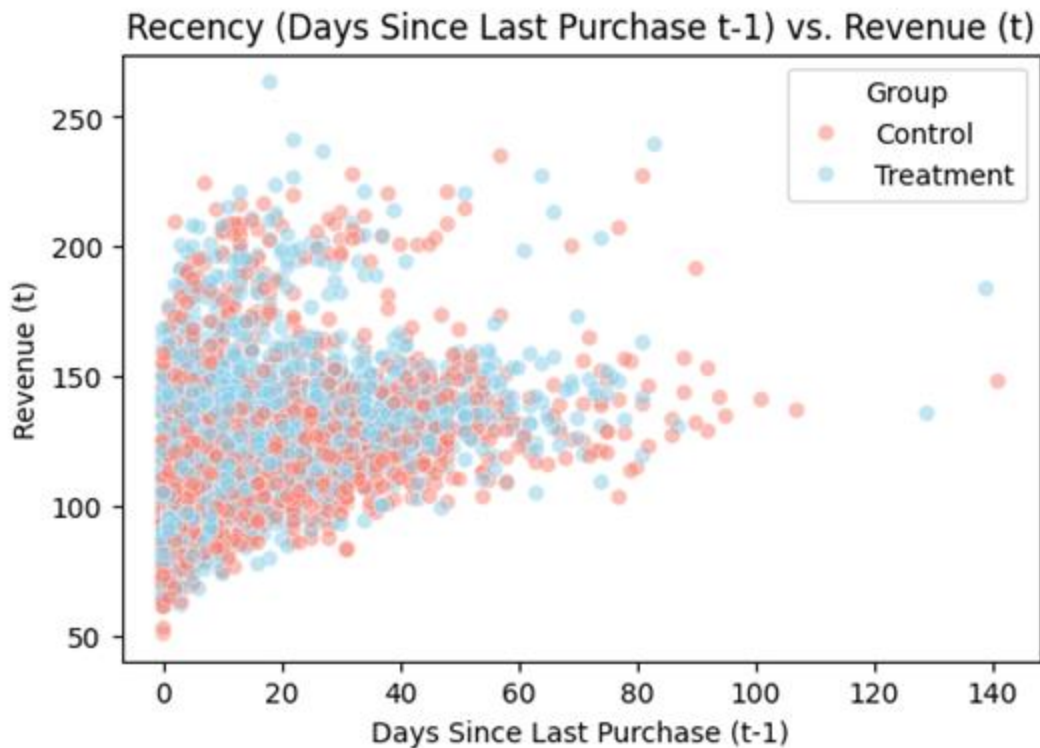
Goal: See correlations & treatment
heterogeneity patterns

Scatterplot – AOV (t-1) vs. Revenue (t) by Assignment



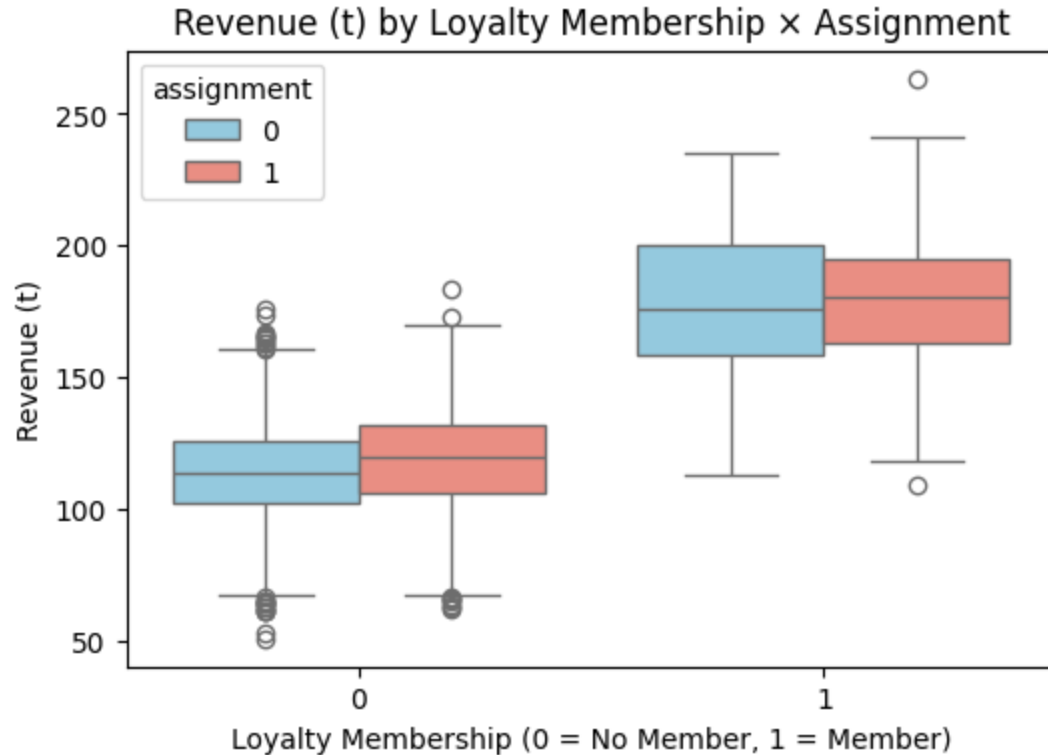
- **Question:** Did the treatment work better on customers who spend more per order?
- **Analysis:** We plotted each customer's pre-experiment Average Order Value (AOV) against their post-experiment revenue.
- **Finding:** The treatment group (blue) is consistently and slightly higher than the control group (salmon) across **all AOV levels**.
- **Conclusion:** The modest revenue lift was **broad-based** and not driven by a specific spending segment like high-value customers.

Scatterplot – Days Since Last Purchase (t-1) vs. Revenue (t)



- **Question:** Was the treatment more effective on our recent, most active customers?
- **Analysis:** We plotted the days since a customer's last purchase (Recency) against their post-experiment revenue.
- **Finding:** The treatment group again shows a consistent, modest lift over the control group, regardless of how recently a customer made a purchase.
- **Conclusion:** The treatment's small, positive effect is also **consistent across different levels of customer engagement**.

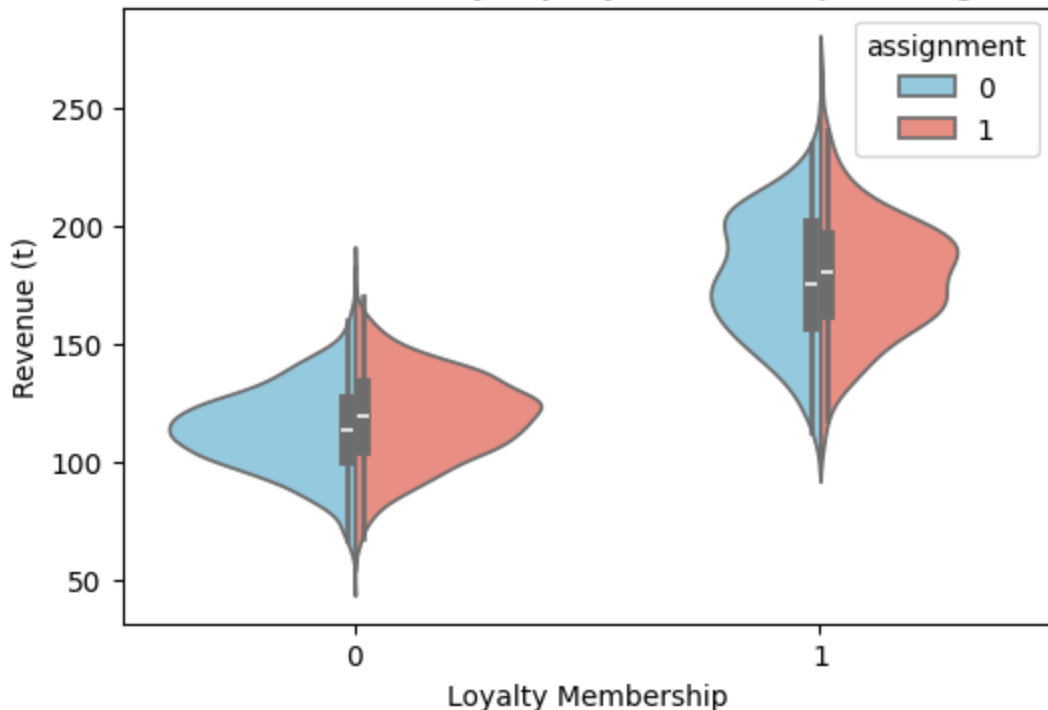
Boxplot – Revenue by Loyalty Membership



- Loyalty members (1) show much higher median revenue than non-members (0) across both groups.
- The treatment group's box is slightly higher within each loyalty category, especially for members, hinting at a modest uplift among loyal customers.
- **Interpretation summary:** Loyalty membership strongly predicts higher revenue overall. The treatment effect appears somewhat stronger among loyalty members, suggesting possible heterogeneous treatment impact.

Violin Plot – Revenue Distribution by


Revenue Distribution by Loyalty Membership × Assignment



- The wider, higher violins for loyalty = 1 confirm greater spending variation among members.
- The treatment violin (salmon) for members skews slightly upward relative to control (blue), reinforcing the idea of a small positive effect in that subgroup.
- Non-members show overlapping distributions, implying little or no effect there.
- **Interpretation summary:** Treatment shows a slightly higher and broader revenue distribution among loyalty members but minimal change among non-members — indicating treatment heterogeneity by loyalty status.



Overall Takeaway

- Across relationships, revenue aligns positively with prior AOV and negatively with recency. Treatment effects are subtle overall but may be somewhat stronger for loyal, high-spending customers.
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04 ★ Analyze & Understand Skews & Outliers



⇒ Skewness of numeric features:
aov (t-1): 1.26
days_since_last_purchase (t-1): 2.00
tenure_in_days(t-1): 5.06
revenue (t): 1.07

Outlier Summary (IQR method):

	Feature	Num Outliers	% Outliers	Lower Bound \
0	aov (t-1)	165	2.969762	-3.93625
1	days_since_last_purchase (t-1)	277	4.985601	-20.00000
2	tenure_in_days(t-1)	428	7.703384	-51.00000
3	revenue (t)	213	3.833693	64.53825

	Upper Bound
0	190.53375
1	44.00000
2	125.00000
3	172.89825

The distributions are not symmetric
and around 3 - 8% of rows per
feature have outliers



Interpretation Summary:

Feature	Skew	Num Outliers	% Outliers	Notes
aov (t-1)	1.26	165	3%	Moderately right-skewed; few high-spenders drive mean up
days_since_last_purchase	2.00	277	5%	Highly skewed; most customers purchased recently, some very inactive
tenure_in_days	5.06	428	7.7%	Extremely skewed; few long-term customers dominate upper range
revenue (t)	1.07	213	3.8%	Moderately skewed; high-revenue customers influence mean

- The numeric features in the experiment dataset show right-skewed distributions, indicating that most customers cluster at lower values while a few high-value customers form a long tail.
- Specifically, tenure_in_days is extremely skewed (5.06), reflecting a small number of very long-term customers, while days_since_last_purchase is highly skewed (2.00), showing that most customers purchased recently but some had long gaps. aov (t-1) (1.26) and revenue (t) (1.07) are moderately skewed, suggesting a few high spenders drive up average values.
- Outlier analysis using the IQR method shows that outliers are mostly on the high end, including customers with exceptionally high spending, long tenure, or infrequent purchases.
- These points represent real customer behavior and are important for modeling, though they should be monitored as they may influence variance and effect estimates.



Interpretation Notes:

- Right-skewed distributions are common in customer datasets. Outliers mostly reflect high-value or long-tenure customers, not data errors.
- These outliers should generally be kept for modeling but monitored for impact on variance or treatment effect estimates. Also based off the previous diagrams above.



Thank you!



[Notebook Link](#)