Section 3 Project

Analysis & Recommendations for Northwind

// FLATIRON SCHOOL

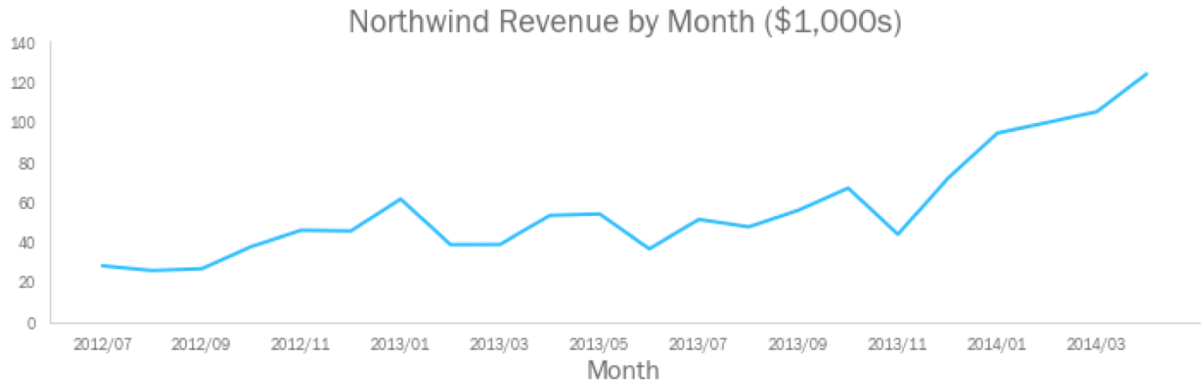
Executive summary

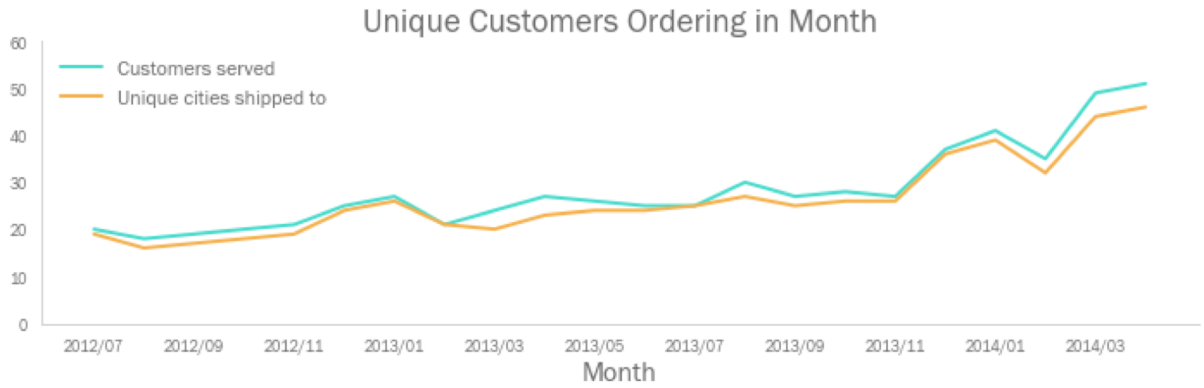
- The business case
- CB91's findings:
  - Customer quality by region
  - Effects of discounting
  - Increasing order frequency
  - Cost of shipping firms
- Possible next steps

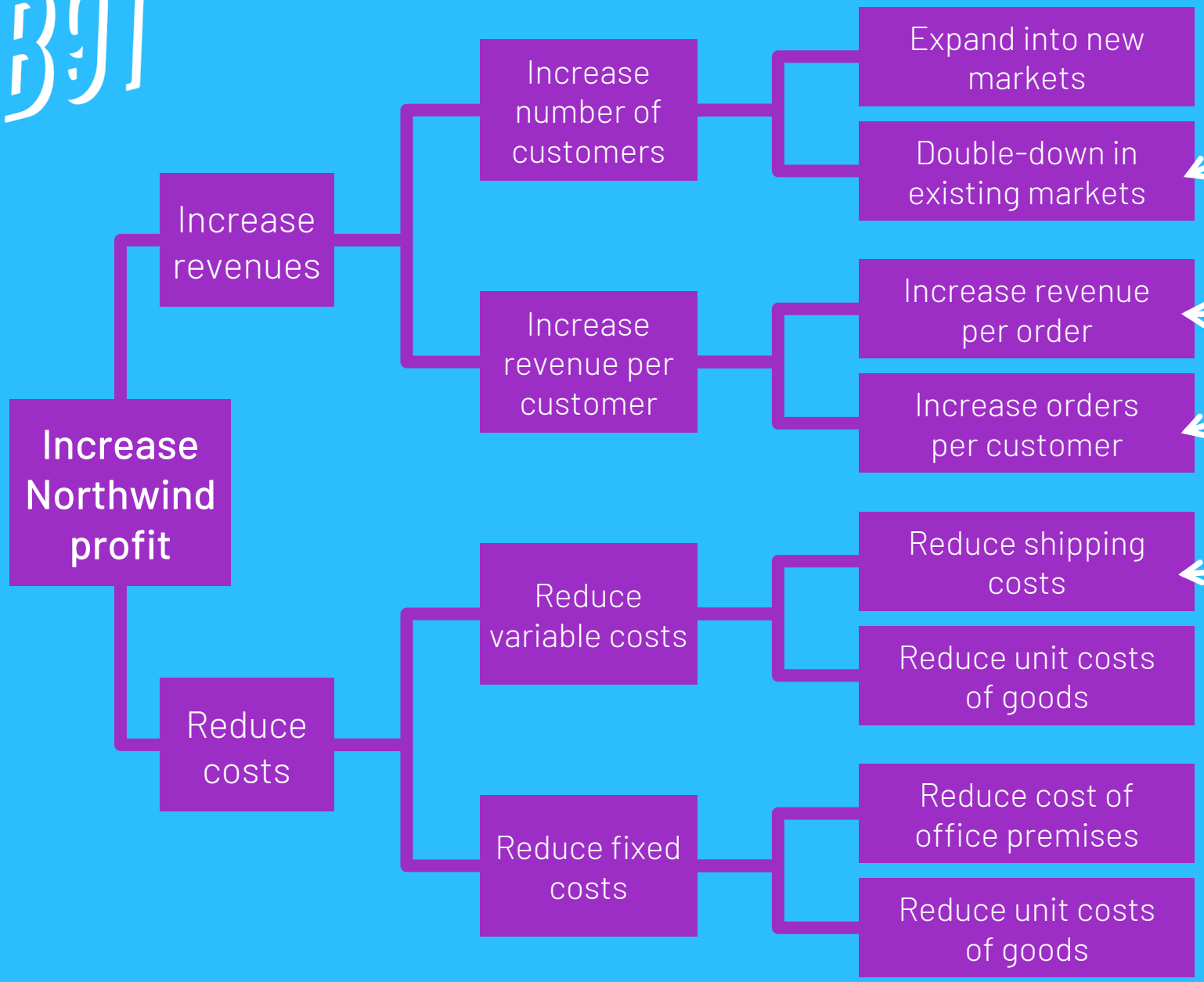
Appendix contains additional analysis

The business case

- Northwind's monthly revenues have grown quickly in the last 6 months
- This is due to an increase in the number of customers, and geographic expansion
- However, average revenue per customer is variable, and flat on average
- Northwind should explore all potential opportunities to improve profitability







1) Which existing markets should Northwind focus on?

2) Does offering discounts increase the volume of products ordered?

3) Do customers who order less frequently do so because they make bigger orders each time?

4) Which shipping companies are cheapest in each region?

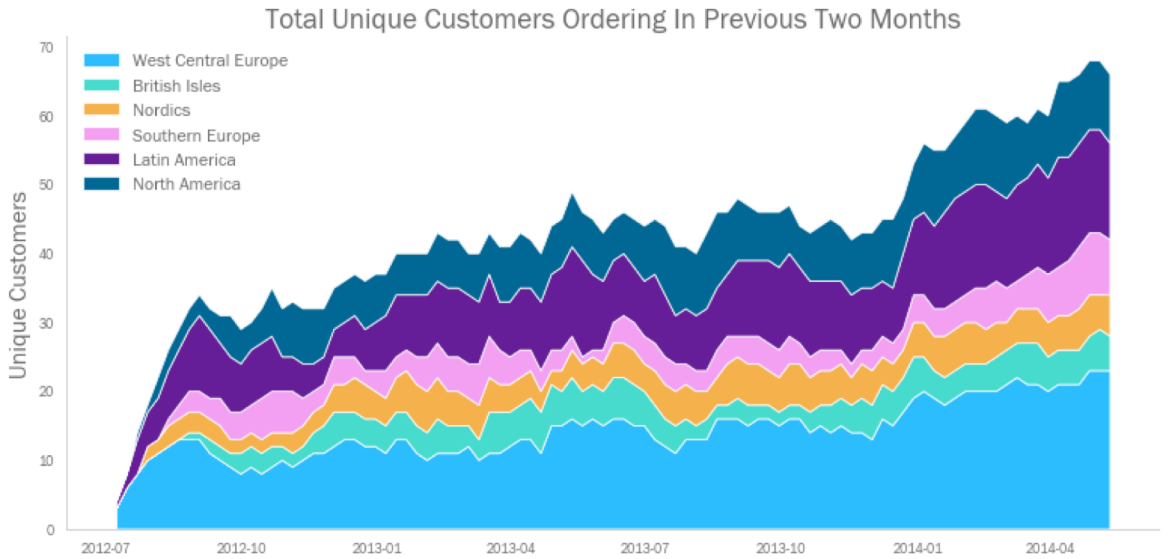
Customer quality by region

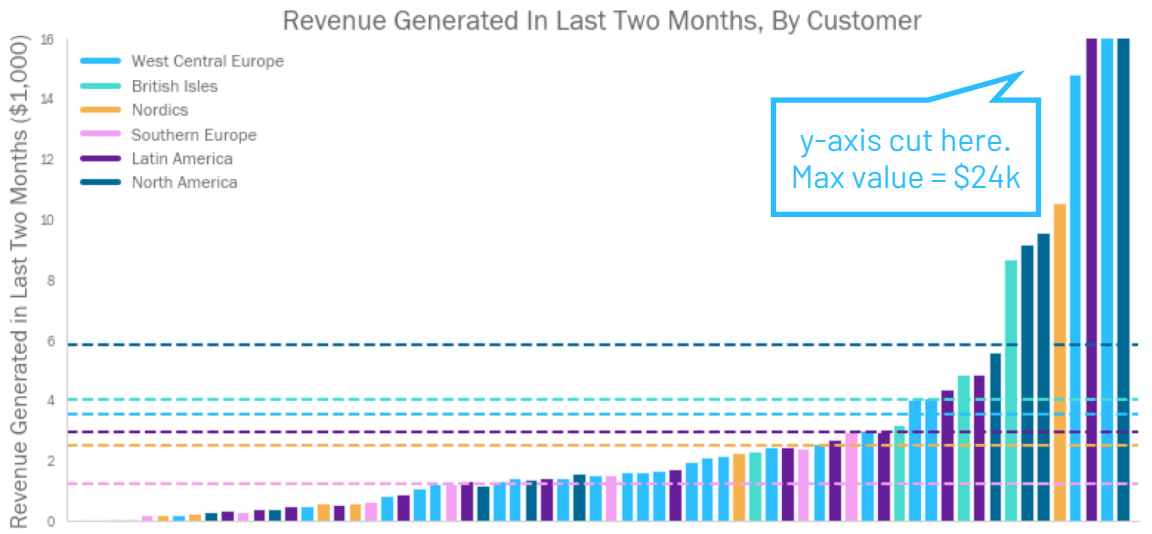
Customer expansion has been driven in Latin America, Southern Europe, and West/Central Europe.

There has been concern about the relative value of customers – particularly in Latin America and Southern Europe.

CB91 found that, though customers in these regions each generated less revenue on average, the differences were not statistically significant.

CB91 therefore recommends continued organic expansion across regions.



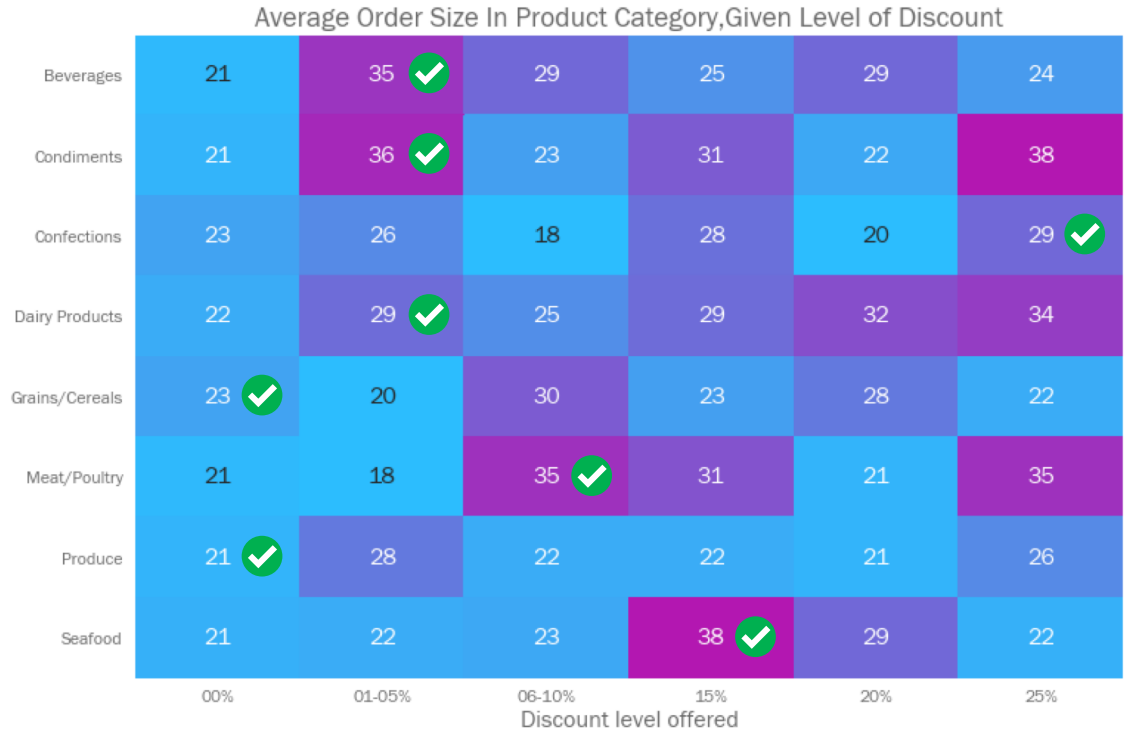


Monte Carlo simulations (n = 200,000, alpha = 0.05) used to determine statistical significance. Further details in this document's appendix.

The effect of discounting

Northwind could offer discounts more strategically. Some discount levels do not result in a significant uplift in sales. CB91 recommends discounting no more than the following in each given category:

Category	Acceptable Discount
Beverages	1-5%
Condiments	1-5%
Confections	25%
Dairy	1-5%
Meat / Poultry	6-10%
Seafood	15%



Monte Carlo simulations (n = 50,000, alpha = 0.05) used to determine statistical significance. Further details in this document's appendix.

Increasing customer order frequency

Could customers who make less frequent orders do so because they make bigger orders each time?

CB91 compared two customer cohorts – those that made at least one order every 2 months, and those that did not – and found that the opposite is true.

Customers making more than one order every 2 months, on average:

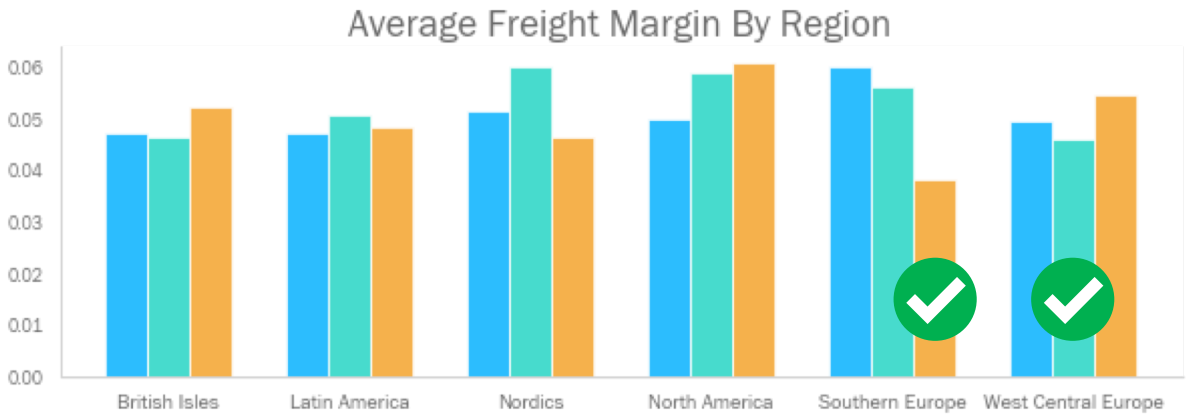
- *Make more valuable orders*
- *Purchase more units per order*
- *Include more unique types of product in each order*

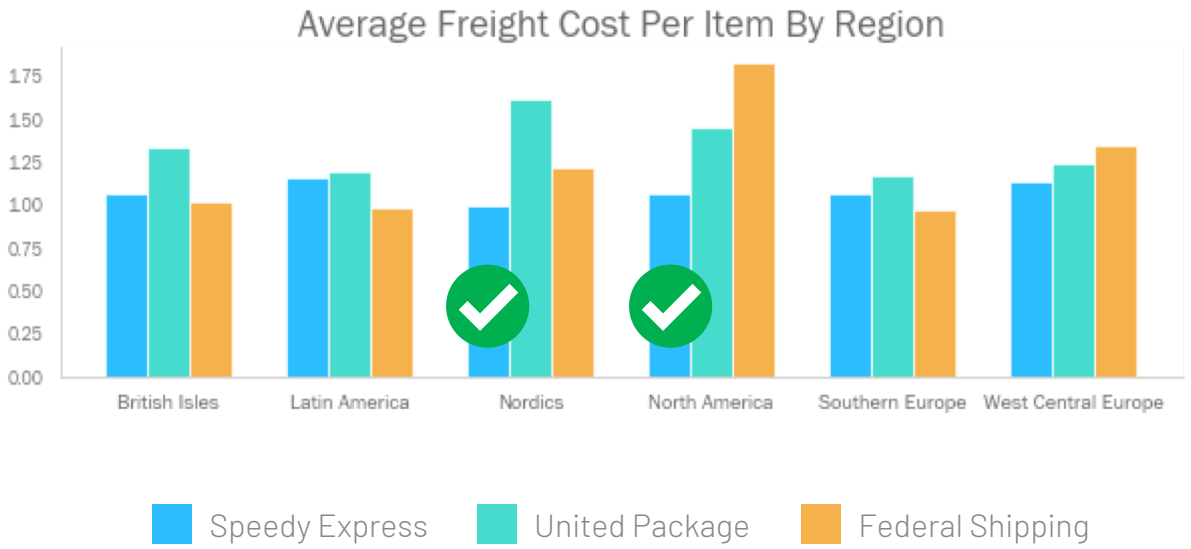
Monte Carlo simulations (n = 200,000, alpha = 0.05) used to determine statistical significance. Further details in this document's appendix.

The cost of shipping firms

Three shipping companies are used across regions. CB91 ran tests across two cost KPIs to determine if any one company is significantly cheaper in a given region.

Region	Company to Use
British Isles	*Any*
Latin America	*Any*
Nordics	*Speedy Express*
North America	*Speedy Express*
Southern Europe	*Federal Shipping*
West / Central Europe	*United Package*





Monte Carlo simulations (n = 50,000, alpha = 0.05) used to determine statistical significance. Further details in this document's appendix.

Possible next steps

There are further hypotheses we could test to drive revenue and reduce cost:

- A full investigation into the customer lifecycle – do orders increase as relationships mature?
- Relative unit cost of goods from suppliers
- Efficiency of Northwind's stock ordering and inventory holding strategy
- Employee salaries and the effect of sales incentives on performance

Thank you for your time

Further detail on the model, and additional analysis of the dataset is included in further pages

A note on Monte Carlo simulations (1/2)

Suppose we have two samples, of size 4 and 3 respectively. We can see that Sample A's mean is 1.67 bigger than Sample B's. Thus, we might want to conclude that Sample A is drawn from a different population than Sample B—one with a larger mean.

However, for the sake of argument, let's suppose that A and B are drawn from the same population (take this as a null hypothesis). Now, if we were to observe the same 7 datapoints, but in a different permutation (still drawing samples of sizes 4 and 3) how likely is it that we would observe a mean difference that is larger than 1.67?

If we find that drawing samples of these sizes often creates mean differences larger than 1.67, then this difference clearly wasn't very special in the first place—we can conclude that the two original samples are not significantly different.

Conversely, if we mostly see mean differences less than 1.67, then we can draw the opposite conclusion. Such a mean difference is unlikely, thus the two original samples are significantly different.

We therefore look at all the different ways that we could draw samples of size 4 and 3 from the 7 datapoints that we have.

We see that there are 3/35 instances (or 8.5%) where the mean difference is larger than 1.67. This percentage can be used in the same way as a p-value in a standard T-Test.

In other words, if we want to say with 95% certainty that the mean of Population A is greater than that of Population B (i.e, we want to use an alpha of 0.05), then we would need this value to be less than 5%.

Since 8.5% > 5%, we can not reject the null hypothesis that the two samples come from the same population. Sample A is not statistically different to Sample B, despite having a larger mean.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4-size sample: (2, 2, 3, 5), 3-size sample: (5, 6, 7), Mean-difference: -3.0
4-size sample: (2, 2, 3, 5), 3-size sample: (5, 6, 7), Mean-difference: -3.0
4-size sample: (2, 2, 3, 6), 3-size sample: (5, 5, 7), Mean-difference: -2.417
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4-size sample: (2, 2, 6, 7), 3-size sample: (3, 5, 5), Mean-difference: -0.083
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4-size sample: (5, 5, 6, 7), 3-size sample: (2, 2, 3), Mean-difference: 3.417
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A note on Monte Carlo simulations (2/2)

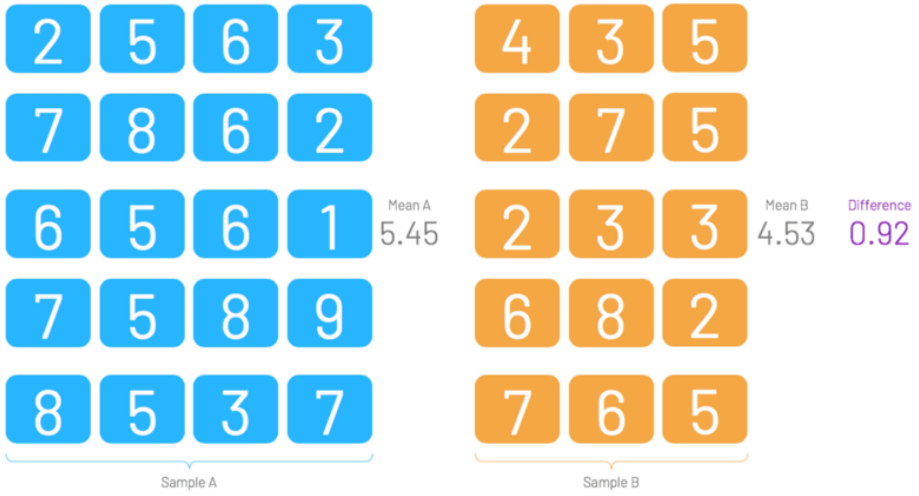
The previous example with 7 datapoints is fine for explaining the theory of permutation tests. However, the number of possible permutations of two combined samples explodes as we increase the sample sizes. If we have two samples of size 140, for example, then there are more possible permutations of these 280 datapoints than there are atoms in the known universe.

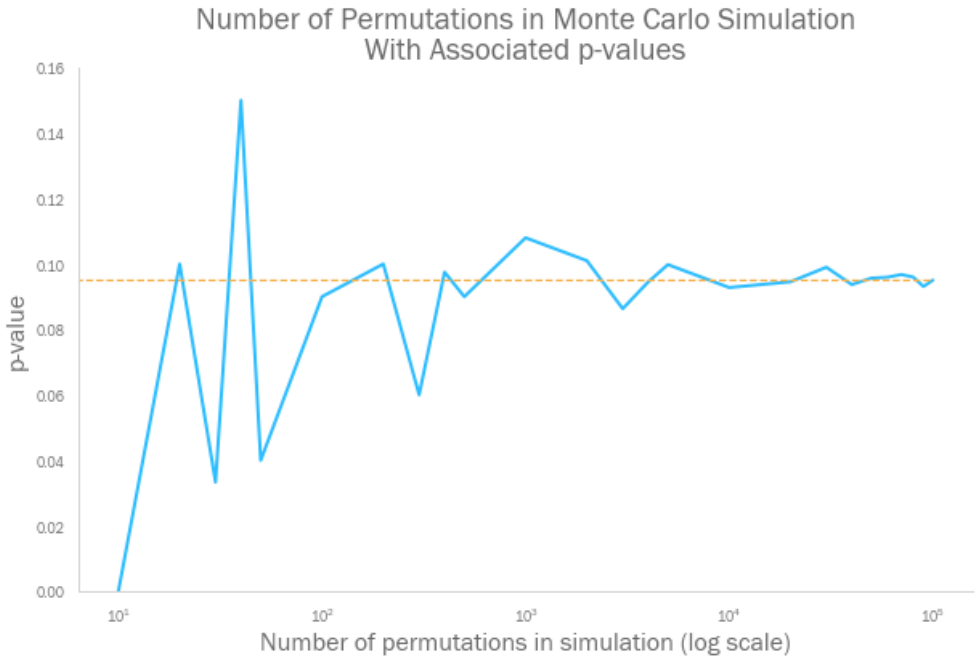
This is the problem that the Monte Carlo simulation method deals with. Rather than working out all possible permutations (which can number in the billions of billions of billions), a Monte Carlo simulation takes a random sample of the possible permutations, and calculates the mean difference of those instead.

Let's create a new example with larger samples, of sizes 20 and 15. Suppose we combine the two samples, and take a series of 20 and 15 sized samples (taking the difference of their means each time). There are 3,247,943,160 possible ways to do this, however we do not need to look at each of these. Remember - the Monte Carlo method will only take a sample of these permutations.

How many permutations do we need to take before we can be confident in our answer? As we can see, the share of mean differences below 0.92 (the mean difference of the original pair of samples) starts to stabilise once our simulation looks at more than 10,000 permutations. By the time we're doing Monte Carlo simulations that look at 100,000 permutations, we can be pretty certain that our p-value will be close enough to the real thing.

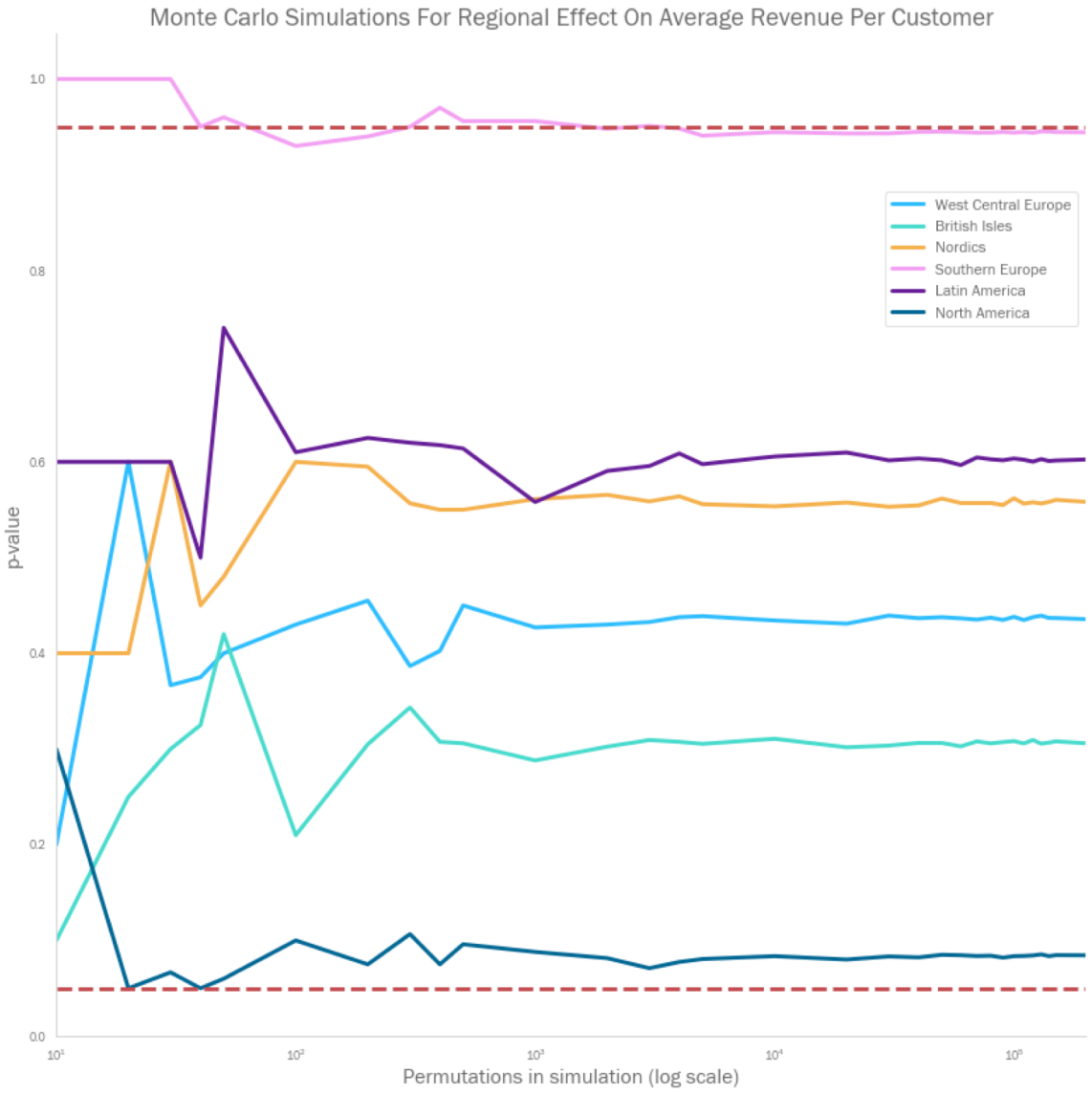
In this case, the p-value is stabilising at around 0.095. Again, this is larger than our standard alpha of 0.05, thus we can not reject the null hypothesis - Sample A and Sample B are not significantly different, despite the difference in their means.





Customer quality by region – in more detail

- CB91 ran Monte Carlo simulations across the revenue per customer across six regions
- It used increasing simulations of increasing sizes in each test to investigate how the p-value stabilises in each case (up to a maximum of 200,000 simulations).
- The hypotheses for each test took the following forms:
  - H_0: Revenue per customer in last two months in given region ≤ Revenue per customer in last two months in other regions
  - H_a: Revenue per customer in last two months in given region > Revenue per customer in last two months in other regions



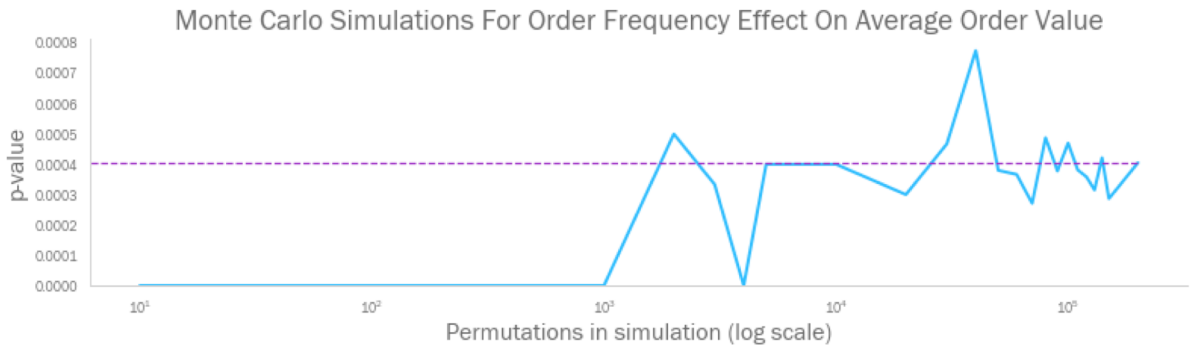
The effect of discounting – in more detail

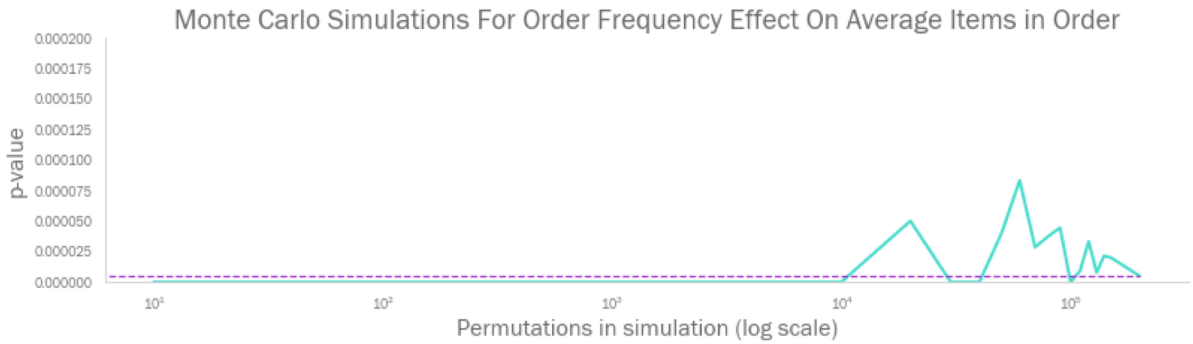
- CB91 ran Monte Carlo simulations across each discount level for each product category
- CB91 tested order sizes for a given discount level against all lower discount levels that did not result in statistically significant increases in order sizes
- Each test used 50,000 simulations, with an alpha of 0.05
- The hypotheses for each test were also automated, taking the following forms:
  - H_0: Order sizes of product category at discount level ≤ order sizes at lower discount levels
  - H_a: Order sizes of product category at discount level > order sizes at lower discount levels

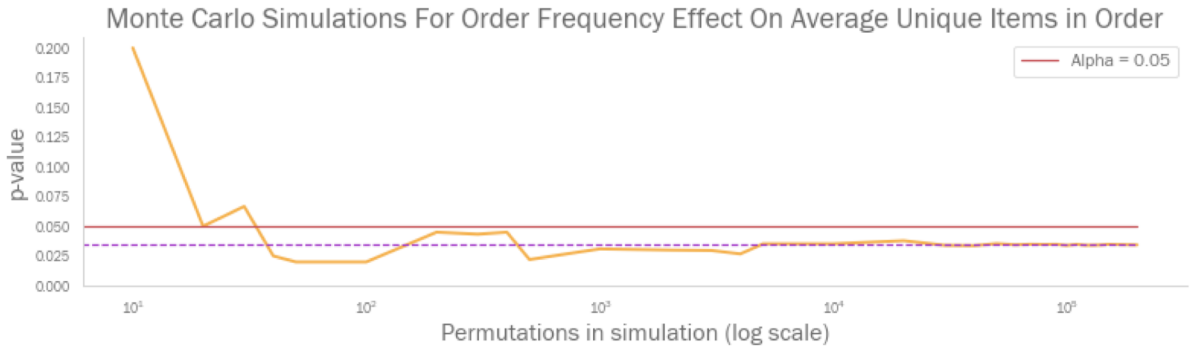
Product Category	Discount	Discount Levels Tested Against	P-Value	Reject
Dairy Products	**01-05%**	**['00%']**	**0.01778**	**Reject Null Hypothesis**
Dairy Products	06-10%	['01-05%']	0.78404	Do not reject Null Hypothesis
Dairy Products	15%	['01-05%', '06-10%']	0.37972	Do not reject Null Hypothesis
Dairy Products	20%	['01-05%', '06-10%', '15%']	0.18030	Do not reject Null Hypothesis
Dairy Products	25%	['01-05%', '06-10%', '15%', '20%']	0.14162	Do not reject Null Hypothesis
Grains/Cereals	01-05%	['00%']	0.67286	Do not reject Null Hypothesis
Grains/Cereals	06-10%	['00%', '01-05%']	0.09508	Do not reject Null Hypothesis
Grains/Cereals	15%	['00%', '01-05%', '06-10%']	0.44500	Do not reject Null Hypothesis
Grains/Cereals	20%	['00%', '01-05%', '06-10%', '15%']	0.17300	Do not reject Null Hypothesis
Grains/Cereals	25%	['00%', '01-05%', '06-10%', '15%', '20%']	0.56216	Do not reject Null Hypothesis
Produce	01-05%	['00%']	0.13576	Do not reject Null Hypothesis
Produce	06-10%	['00%', '01-05%']	0.42064	Do not reject Null Hypothesis
Produce	15%	['00%', '01-05%', '06-10%']	0.44978	Do not reject Null Hypothesis
Produce	20%	['00%', '01-05%', '06-10%', '15%']	0.46266	Do not reject Null Hypothesis
Produce	25%	['00%', '01-05%', '06-10%', '15%', '20%']	0.24806	Do not reject Null Hypothesis
Seafood	01-05%	['00%']	0.40030	Do not reject Null Hypothesis
Seafood	06-10%	['00%', '01-05%']	0.35570	Do not reject Null Hypothesis
Seafood	**15%**	**['00%', '01-05%', '06-10%']**	**0.00104**	**Reject Null Hypothesis**
Seafood	20%	['15%']	0.91012	Do not reject Null Hypothesis
Seafood	25%	['15%', '20%']	0.98480	Do not reject Null Hypothesis
Condiments	**01-05%**	**['00%']**	**0.00098**	**Reject Null Hypothesis**
Condiments	06-10%	['01-05%']	0.95932	Do not reject Null Hypothesis
Condiments	15%	['01-05%', '06-10%']	0.41854	Do not reject Null Hypothesis
Condiments	20%	['01-05%', '06-10%', '15%']	0.85078	Do not reject Null Hypothesis
Condiments	25%	['01-05%', '06-10%', '15%', '20%']	0.11268	Do not reject Null Hypothesis
Confections	01-05%	['00%']	0.21176	Do not reject Null Hypothesis
Confections	06-10%	['00%', '01-05%']	0.95098	Do not reject Null Hypothesis
Confections	15%	['00%', '01-05%', '06-10%']	0.06132	Do not reject Null Hypothesis
Confections	20%	['00%', '01-05%', '06-10%', '15%']	0.79054	Do not reject Null Hypothesis
Confections	**25%**	**['00%', '01-05%', '06-10%', '15%', '20%']**	**0.04660**	**Reject Null Hypothesis**
Beverages	**01-05%**	**['00%']**	**0.00078**	**Reject Null Hypothesis**
Beverages	06-10%	['01-05%']	0.75652	Do not reject Null Hypothesis
Beverages	15%	['01-05%', '06-10%']	0.91838	Do not reject Null Hypothesis
Beverages	20%	['01-05%', '06-10%', '15%']	0.45816	Do not reject Null Hypothesis
Beverages	25%	['01-05%', '06-10%', '15%', '20%']	0.87628	Do not reject Null Hypothesis
Meat/Poultry	01-05%	['00%']	0.68886	Do not reject Null Hypothesis
Meat/Poultry	**06-10%**	**['00%', '01-05%']**	**0.00722**	**Reject Null Hypothesis**
Meat/Poultry	15%	['06-10%']	0.59106	Do not reject Null Hypothesis
Meat/Poultry	20%	['06-10%', '15%']	0.90366	Do not reject Null Hypothesis
Meat/Poultry	25%	['06-10%', '15%', '20%']	0.25610	Do not reject Null Hypothesis

Customer order frequency – in more detail

- CB91 ran Monte Carlo simulations across three customer value KPIs
- It used increasing simulations of increasing sizes in each test to investigate how the p-value stabilises in each case (up to a maximum of 200,000 simulations).
- The hypotheses for each test took the following forms:
  - H_0: Given KPI for customers ordering less than once every two months ≤ Given KPI for customers ordering more than once every two months
  - H_a: Given KPI for customers ordering less than once every two months > Given KPI for customers ordering more than once every two months







The cost of shipping firms – in more detail

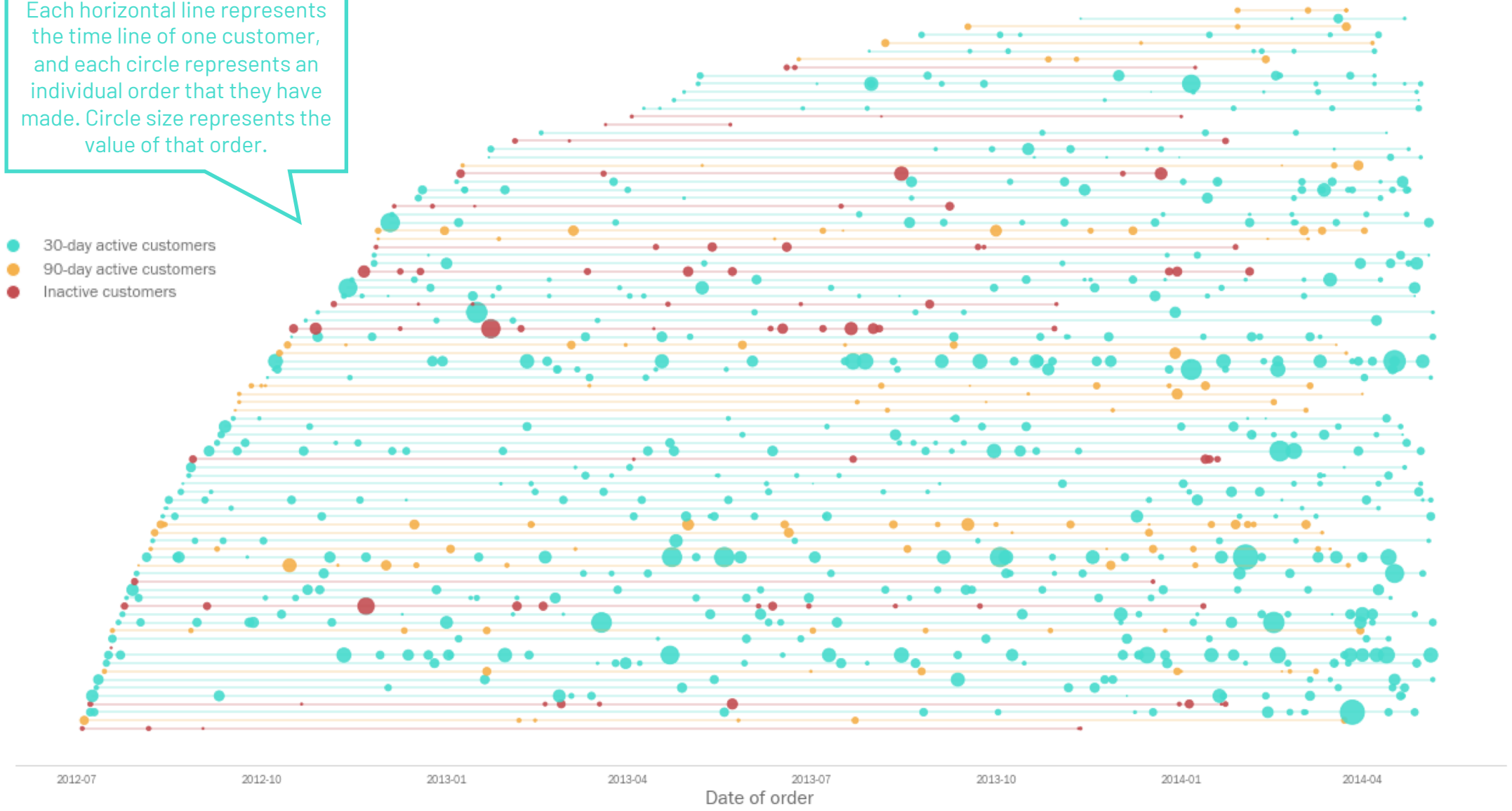
- CB91 ran a Monte Carlo simulation across all permutations of shipping company, region, and cost KPI
- Each test used 50,000 simulations, with an alpha of 0.05
- The hypotheses for each test were also automated, taking the following forms:
  - H_0: Company KPI in region = KPI in region of other two companies
  - H_a: Company KPI in region {<, >}* KPI in region of other two companies

** nature of inequality is automatically determined based on whether company's average cost in that KPI was above or below the market average*

Company	Region	KPI	Comparison to Others	P-Value	Reject
Speedy Express	West Central Europe	Freight Margin	Less	0.49296	Do not reject Null Hypothesis
Speedy Express	West Central Europe	Freight Cost Per Item	Less	0.17020	Do not reject Null Hypothesis
Speedy Express	Latin America	Freight Margin	Less	0.31006	Do not reject Null Hypothesis
Speedy Express	Latin America	Freight Cost Per Item	Greater	0.40138	Do not reject Null Hypothesis
Speedy Express	North America	Freight Margin	Less	0.30510	Do not reject Null Hypothesis
Speedy Express	**North America**	**Freight Cost Per Item**	**Less**	**0.04936**	**Reject Null Hypothesis**
Speedy Express	Nordics	Freight Margin	Less	0.37700	Do not reject Null Hypothesis
Speedy Express	**Nordics**	**Freight Cost Per Item**	**Less**	**0.04330**	**Reject Null Hypothesis**
Speedy Express	**Southern Europe**	**Freight Margin**	**Greater**	**0.04454**	**Reject Null Hypothesis**
Speedy Express	Southern Europe	Freight Cost Per Item	Less	0.49180	Do not reject Null Hypothesis
Speedy Express	British Isles	Freight Margin	Less	0.40284	Do not reject Null Hypothesis
Speedy Express	British Isles	Freight Cost Per Item	Less	0.37556	Do not reject Null Hypothesis
United Package	**West Central Europe**	**Freight Margin**	**Less**	**0.04186**	**Reject Null Hypothesis**
United Package	West Central Europe	Freight Cost Per Item	Less	0.49992	Do not reject Null Hypothesis
United Package	Latin America	Freight Margin	Greater	0.27982	Do not reject Null Hypothesis
United Package	Latin America	Freight Cost Per Item	Greater	0.30470	Do not reject Null Hypothesis
United Package	North America	Freight Margin	Greater	0.41868	Do not reject Null Hypothesis
United Package	North America	Freight Cost Per Item	Greater	0.59066	Do not reject Null Hypothesis
United Package	Nordics	Freight Margin	Greater	0.06632	Do not reject Null Hypothesis
United Package	**Nordics**	**Freight Cost Per Item**	**Greater**	**0.02202**	**Reject Null Hypothesis**
United Package	Southern Europe	Freight Margin	Greater	0.24076	Do not reject Null Hypothesis
United Package	Southern Europe	Freight Cost Per Item	Greater	0.24450	Do not reject Null Hypothesis
United Package	British Isles	Freight Margin	Less	0.27622	Do not reject Null Hypothesis
United Package	British Isles	Freight Cost Per Item	Greater	0.12556	Do not reject Null Hypothesis
Federal Shipping	**West Central Europe**	**Freight Margin**	**Greater**	**0.02996**	**Reject Null Hypothesis**
Federal Shipping	West Central Europe	Freight Cost Per Item	Greater	0.16532	Do not reject Null Hypothesis
Federal Shipping	Latin America	Freight Margin	Less	0.46678	Do not reject Null Hypothesis
Federal Shipping	Latin America	Freight Cost Per Item	Less	0.23416	Do not reject Null Hypothesis
Federal Shipping	North America	Freight Margin	Greater	0.35682	Do not reject Null Hypothesis
Federal Shipping	North America	Freight Cost Per Item	Greater	0.06570	Do not reject Null Hypothesis
Federal Shipping	Nordics	Freight Margin	Less	0.11028	Do not reject Null Hypothesis
Federal Shipping	Nordics	Freight Cost Per Item	Less	0.37198	Do not reject Null Hypothesis
Federal Shipping	**Southern Europe**	**Freight Margin**	**Less**	**0.00364**	**Reject Null Hypothesis**
Federal Shipping	Southern Europe	Freight Cost Per Item	Less	0.25942	Do not reject Null Hypothesis
Federal Shipping	British Isles	Freight Margin	Greater	0.20586	Do not reject Null Hypothesis
Federal Shipping	British Isles	Freight Cost Per Item	Less	0.20116	Do not reject Null Hypothesis

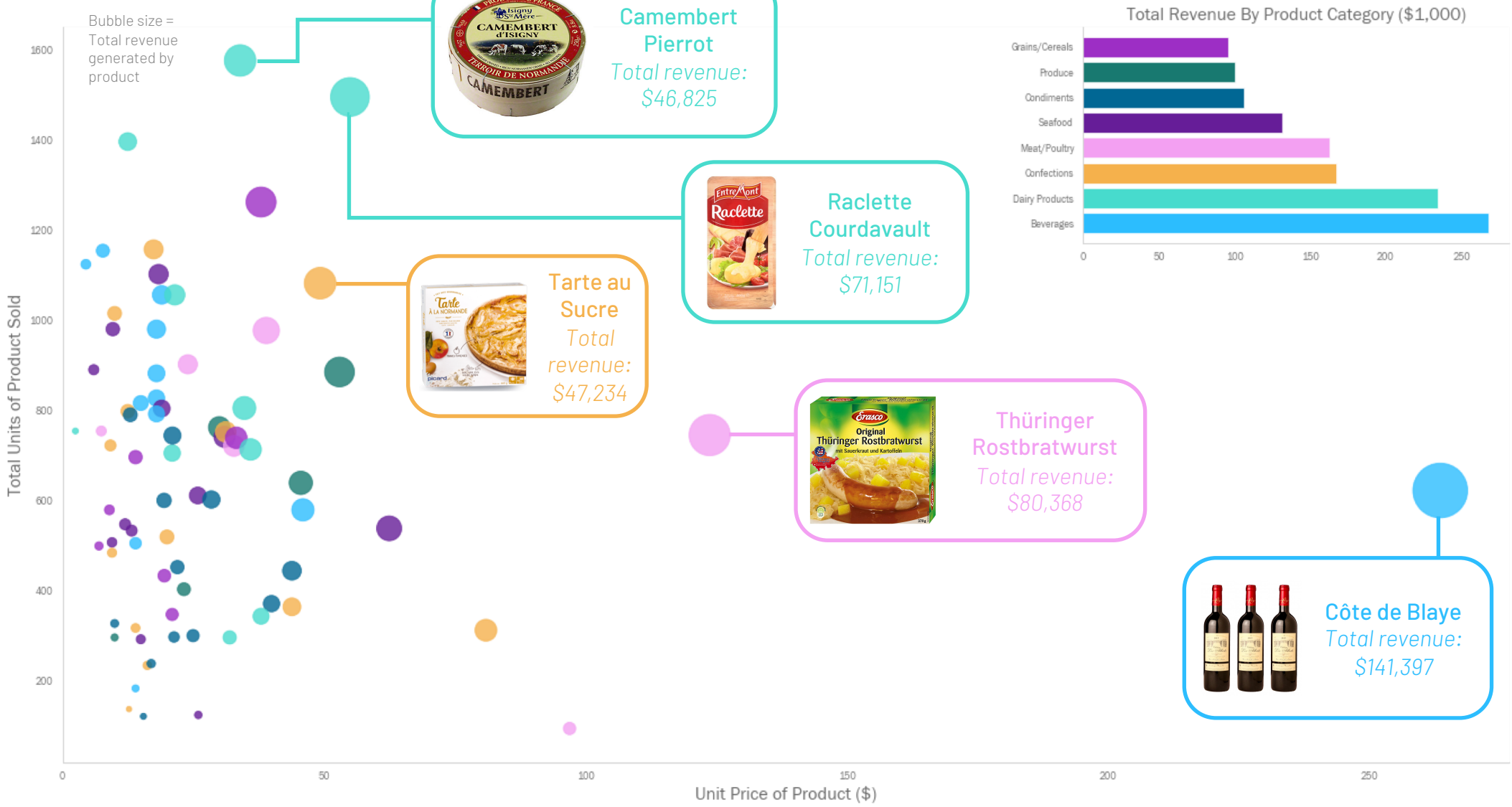
A lifetime view of Northwind's orders

Each horizontal line represents the time line of one customer, and each circle represents an individual order that they have made. Circle size represents the value of that order.



Northwind's product portfolio

Bubble size = Total revenue generated by product



Camembert Pierrot
Total revenue: $46,825

Raclette Courdavault
Total revenue: $71,151

Tarte au Sucre
Total revenue: $47,234

Thüringer Rostbratwurst
Total revenue: $80,368

Côte de Blaye
Total revenue: $141,397

Total Revenue By Product Category ($1,000)

Northwind customer engagement