# ISYE 6501 HW13

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**Question 19.1**
Describe analytics models and data that could be used to make good recommendations to the retailer. How much shelf space should the company have, to maximize their sales or their profit?

Of course, there are some restrictions – for each product type, the retailer imposed a minimum amount of shelf space required, and a maximum amount that can be devoted; and of course, the physical size of each store means there's a total amount of shelf space that has to be used. But the key is the division of that shelf space among the product types.

For the purposes of this case, I want you to ignore other factors – for example, don't worry about promotions for certain products, and don't consider the fact that some companies pay stores to get more shelf space. Just think about the basic question asked by the retailer, and how you could use analytics to address it.

As part of your answer, I'd like you to think about how to measure the effects. How will you estimate the extra sales the company might get with different amounts of shelf space – and, for that matter, how will you determine whether the effect really exists at all? Maybe the retailer's hypotheses are not all true – can you use analytics to check?

Think about the problem and your approach. Then talk about it with other learners, and share and combine your ideas. And then, put your approaches up on the discussion forum, and give feedback and suggestions to each other.

You can use the {given, use, to} format to guide the discussions: Given {data}, use {model} to {result}.

One of the key issues in this case will be data – in this case, thinking about the data might be harder than thinking about the models.

**Answer:**

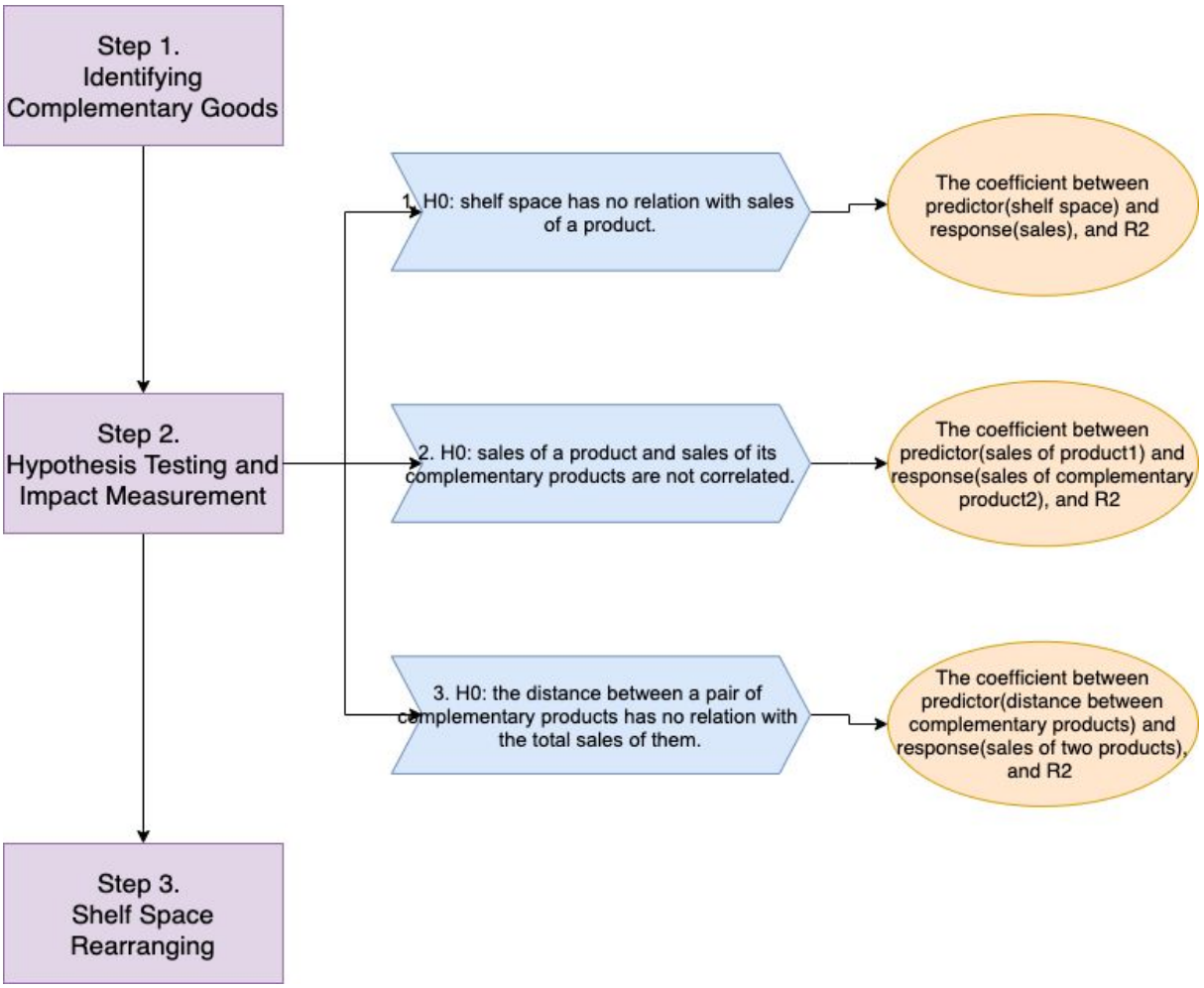


**Figure 1**

**1. Identify complementary products.**

| Data | | | Model | Result |
|---|---|---|---|---|
| **Data** | **Data Type** | **Data resource** | | |
| Point of sales data | numerical | grocery store history data | Louvain Algorithm/Clustering | All the products that are very likely to be purchased together |
| frequent-shopper card sales data | numerical | grocery store history data | | |

Given{point of sales data, frequent-shopper card sales data},
Use{Louvain algorithm, Clustering},
To{Identify complementary products}.

We use former POS data and frequent-shopper card sales data to see which products are more likely to be purchased together.

**2. Test hypothesis, and decide how to measure the impact.**

| Data | | | Model | Result |
|---|---|---|---|---|
| **Data** | **data type** | **Data resource** | | |
| POS data of last month | numerical | grocery store history data | A/B testing, Non-parametric test(Wilcoxon signed rank test), regression | Whether giving more shelf space creates more sales to a single product, as well as how strong such effects are. |
| shelf space devoted to several types of product last month | numerical | grocery store history data | | |
| POS data of this month | numerical | sales data | | |
| shelf space devoted to these products this month(after modification) | numerical | direct measurements | | |
| POS data of last month | numerical | grocery store history data | A/B testing, Non-parametric test(Wilcoxon signed rank test), regression | Whether more sales of a single type of product will increase sales of complementary product, and how strong these effects are. |
| POS data this month | numerical | sales data | | |
| POS data of last month | numerical | grocery store history data | A/B testing, Non-parametric test(Wilcoxon signed rank test), regression | Whether there's effects if store complementary products together and how strong such effects are. |
| distance between complementary products before we change the slotting policy | numerical | grocery store history data | | |
| new POS data after we store | numerical | sales data | | |

| | | | | |
|---|---|---|---|---|
| complementary products together | | | | |
| distance between complementary products after we change the slotting policy | numerical | direct measurements | | |

Given{point of sales data, the set of products that are more likely to be purchased together }
Use{ Design of Experiments, A/B testing, wilcoxon signed rank test}
To{Prove the former 3 assumptions, and how strong these effects are}.

We have 3 assumptions:more shelf space creates more sales for a single type of product, more sales of this product leads to more complementary product sales, and if complementary products are stored together, then the complementary effect is huge. We should prove if these assumptions are true, and how strong those effects are before we build the optimization model.

In order to prove the first assumption(more shelf space creates more sales for a single type of product), we increase the shelf space for several types (about 25, a representative subset of all products) of products, holding controlling factors fixed. We need to collect the following data for 1 month before and after the change take place: POS data, shelf space devoted to each products. And then we will implement wilcoxon signed-rank test to see whether the null hypothesis holds. If the null hypothesis is rejected(i.e. the assumption is true), we use regression model to see to what extent larger amount correlates with more sales. We should add several control variables.

In order to prove the second assumption(more sales of this product leads to more complementary product sales), we compare the sales data of several pairs of the complementary products this month and last month, to see if there's relationship between the sales of a product and its complementary product.

In order to prove the third assumption(if complementary products are stored together, then the complementary effect is huge), we store 25 pairs of complementary products together this month, and compare the sales data of the month before and after. We need to collect the sales data before and after the change, and the distances between these pairs of products before and after. In order to see how strong the effect is, we should build a regression model , add some control variables and evaluate the coefficients and R2 values.

**3. The optimization process:**

| Data | | | Model | Result |
|---|---|---|---|---|
| **Data** | **data type** | **Data resource** | | |
| history POS data | numerical | grocery store history data | Optimization, simulation | the slotting policy of the grocery store, where should we store each product and the amount of storage that helps the grocery store maximize profit. |
| profit of each product | numerical | grocery store history data | | |
| set of complementary products | catagorical | data collected from former step | | |
| how strong the complementary effects are | numerical | estimation from former step | | |
| min and max amount of products in stock | numerical | ask the manager of the grocery store | | |
| the size of each product | numerical | direct measurements | | |
| the size of the storage rack | numerical | direct measurements | | |
| total number of space | numerical | direct measurements | | |
| the layout of the rack | numerical | direct measurements | | |

Given{history POS data, the profit of each product, the set of complementary products, how strong the complementary effects are, min and max amount of products in stock, the size of each product, the size of the storage rack, total number of space, the layout of the rack}
Use{optimization, simulation}
To{maximize the total profit of the grocery store}

We divide the grocery store into different zones, and for each zone we build an optimization model to optimize the space devoted to each product, consider how to store the complementary products together.

We also use simulation model to evaluate walking distance & congestions, and generate constraints for the optimization model. We can repeat this process for several times to make a better design.

The objective function is to maximize the total profit.
The decision variables are where to store each products, how much space do we need to devote to each product, the amount of each product we need to store.
The constraints are the layout of the storage rack, the size of storage rack, the min & max size of the amount we should store, the total space in the grocery store, the complementary products which should be stored together, congestion.