

Teaching Case

Using Product and Sales Data to Create an Inventory Purchase Plan that Maximizes Profits

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Abstract

Various data analytics techniques can be combined into an integrative project that illustrates a relevant business context and purpose. In this teaching case, a customer orders database (Northwind) provides a basis for category management teams to analyze product sales, pricing, and costs in order to create an optimized purchase plan to replenish inventory. Such a context can make use of a spectrum of analyses, from data retrieval to summarization to optimization. Widely available tools such as Microsoft Access and Excel provide ample (and powerful) functionality to conduct such analyses and to show how data-driven decisions can be made.

Keywords: Data analytics, Data Summarization, Excel Pivot tables, Excel Solver, Optimization.

1. PHASE 1: INTRODUCTION

Northwind Traders (aka "Northwind") is a fictional company used by Microsoft for demonstration purposes. Northwind imports specialty food items, maintains some level of inventory, and then sells the products to its customers (who are retailers and grocery stores). The sample Access database for Northwind (provided by Microsoft) contains customer order data, including current product inventory and prices, as well as line item (i.e., order detail) sales data that identifies the products that were sold (on customer orders) along with the number (i.e., quantity) of units sold and the price paid per unit. This case utilizes an older version of the Northwind database with a few revisions (such as adding average cost of a product).

Every product in Northwind's database belongs to one category, such as Beverages, Condiments, etc. Each group of students is assigned as the category managers for a specific category of products inventoried by Northwind. Each category management team will summarize and analyze the pricing and sales of their category's products,

including how prices are related to sales, and then determine an optimal purchase plan for ordering specific quantities of the products in the category. The goal of the purchase plan is to maximize potential profits within a constrained budget and inventory levels, the latter of which is driven in part by the perishability of food items.

Context

Consider the following scenario. In the past, and due to perishability of food items, Northwind's upper management allotted only enough funds to purchase a one-month supply of inventory for each product. Category managers would look at the previous year's sales (quantity sold) and use that as a basis for ordering for the current year. Purchase orders were placed each month, and the products were normally sold out by month end. The cycle repeated, and orders were continually placed for one month's inventory of each product to arrive by the start of the next month.

However, Northwind management has invested in new refrigeration and climate-controlled storage facilities, and they now can store any food product for at least three months. They realize

that past sales have been limited due to the practice of intentionally depleting inventory each month. Now, Northwind management has allotted a budget to cover the cost to buy a minimum of one month of inventory for all products and up to three months (i.e., one quarter) of inventory for select products.

It is unclear as to which products might naturally have greater demand and potentially greater sales because, in the past, Northwind salespeople have pushed and promoted the products that they knew were left in stock. So, for this first round of purchasing and until natural demand trends can be better ascertained, the category managers will focus on maximizing total potential profit by assuming that everything purchased for inventory can be sold before it expires. As such, product cost and profit margin will be driving factors in the purchase plan described here.

Process

Within this context, each category management team will identify the relevant information about the products in their category, summarize the past year's sales, and then create an optimal purchase plan that maximizes potential profit within a fixed budget. While the Northwind data are stored in an Access database, the data will be queried out (with two simple queries) and placed into two Excel sheets where the analysis will take place.

The Access queries could be constructed to filter for non-discontinued products in a specific category, as well as the sales of those products over a specific time period. However, the process here assumes that the data will be filtered in Excel. The analysis in Excel will primarily rely on Pivot tables (for summarizing product and sales data) and Solver (for creating an optimal purchase solution that maximizes profit).

2. PHASE 2: DATA RETRIEVAL

To retrieve the data needed for analysis in Excel, the team will create two simple Access queries that will effectively result in two flat files (i.e., tables) that can be exported or copied into separate Excel sheets.

Query 1 (Product List)

In order to identify product information (such as price, cost, margin, inventory, etc.) pertaining to a specific category's products, the team needs a table that lists each product only once. The main table for this "product list" query is the Products table. While the supplier name may be in the Products table, the category name is not.

Ultimately, if needed information is not already in the Product table, then the tables containing that information also should be included in the query. The following is an example of the tables and fields that are relevant to this query (take note that there is a field that specifies whether or not a product is discontinued).

- Product (ProductName, ListPrice, UnitCost, Discontinued, Supplier)
- Category (CategoryName)

Query 2 (Line Item Data)

In order to summarize past sales information (such as quantity, price, discount, etc.) pertaining to a specific category's products, the team needs a table of line item data that identifies the units, price, and discount every time a product appears on an order. The main table for the "line item" query will be Order Details. In addition, the query will need to include the Orders table to retrieve the order date, and the Products table to retrieve product name, cost, discontinued, category, etc. The following is an example of the tables and fields that are relevant to this query.

- Details (Price, Quantity, Discount)
- Order (OrderDate)
- Product (ProductName, UnitCost, Discontinued)
- Category (CategoryName)

3. PHASE 3: DATA SUMMARIZATION

After the data are queried and exported into Excel (as per Phase 2), the team will use Excel calculations and Pivot tables and charts to summarize product and sales data with respect to pricing. The goal here is to get a general understanding of how the category's products are priced and have sold. All tables and charts will be filtered on only non-discontinued products within the category assigned to the team. As the Pivot tables and charts are created, they will be copied into a PowerPoint document to be presented to Northwind management.

Product Summarization (Using Product List)

The team will identify and summarize information pertaining to the non-discontinued products carried by Northwind that fall within the category the team is managing. This would include a calculation (in the Excel sheet) of the profit margin of each product, defined as the current list "price" (that Northwind charges to sell the product to a customer) minus the current unit "cost" (that Northwind pays to buy the product from a supplier).

- Unit margin = price - cost.

Filtering on a specific category and on non-discontinued products, the team will produce the

following summarizations and will copy each table and chart into separate PowerPoint slides.

- A table of information that shows product name, supplier name, list price, unit cost, and unit margin.

- A Pivot chart showing the number (COUNT) of products per price groups (of 10's). This chart will show how many products (in the category) are priced at 0-9.99, at 10-19.99, etc., thus providing an overview for later framing and analyzing future purchases and sales.

Sales Summarization (Using Line Items)

The team will summarize the sales information, again pertaining to the non-discontinued products in their category. This would include calculations (in the Excel sheet) of the sales revenue and profit based on the following equations. Note that these equations use "price" from the Line Items sheet, which can be different from the current list price in the Product sheet if the product was sold at a different price in the past. Also note that "cost" is the current unit cost of a product, which also can differ from the past; but since the past cost is not stored in the database, the current cost is the best proxy available. Finally, note that "quantity" refers to the number of units sold.

- Revenue = price X quantity X (1 - discount)
- Profit = revenue - (cost * quantity)

By summing the revenue (or profit) figures based on which product was sold on a line item, the total revenue (or profit) can be shown per each product. The team will produce the following summarizations (filtering on a specific category and on non-discontinued products) and will copy each chart into separate PowerPoint slides. Again, note that "quantity" refers to the number of units sold.

- Pivot chart(s) showing the total (SUM) of the quantity, revenue, and profit per each product. If possible (if the data values are of a similar magnitude), these three measures might be shown on one chart such that the legend can differentiate between measures.

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4. PHASE 4: DATA PREPARATION

After summarizing product and sales information (as per Phase 3), the team must prepare the data to be used in Excel Solver to run a purchase plan optimization. As noted in the context of the case, product purchases will be constrained to a range of one to three months of inventory based on the

previous year's units sold. There are two methods for determining past sales: 1. Total units sold per product for the entire year, and then computed into an average monthly figure by simply dividing by 12; or 2. Total units sold for a specific month or quarter. Given the seasonality of product sales, the second method could provide for more relevant figures. However, for the sake of simplicity, the first method will be described here.

Compute Min and Max from Last Year's Sales

To determine the past year's sales for the non-discontinued products in their category, the team will create a Pivot table using the Line Item sheet. That table will:

- Filter on:
 - . a specific year
 - . a specific category
 - . non-discontinued products.
- Total (SUM) the quantity sold per each product. The total quantity sold per product can then be divided by 12 (and rounded to an integer). This identifies one month of sales, which will represent one month of product inventory, or the minimum to be purchased. The maximum to be purchased is three months (i.e., one quarter) of inventory and will be represented by simply multiplying the monthly figure by three.

Constructing a Table to be Used in Solver

The data preparation for Excel Solver primarily requires the expansion of the table previously created (at the start of Phase 3) that identifies each product and its unit cost and unit margin. To begin with, two new columns will be added to this table for the minimum and maximum units to purchase as described in the previous paragraph. In addition, new columns will be created to identify the actual number of "units to buy" (which is currently unknown) and the resulting cost to do so ("cost to buy"). Lastly, a column will be added to identify the "potential profit" that would be earned if all purchased products were sold before expiration. Summations will be calculated at the bottoms of the "cost to buy" and "potential profit" columns to identify the total cost and total profit.

In summary, the prepared table will contain eight columns, with all data filtered on a specific category's non-discontinued products:

- Product Name
- Unit Cost (from Phase 3)
- Unit Margin (from Phase 3)
- Min Purchase (last year's sales divided by 12)
- Max Purchase (Min Purchase times 3)
- Units to Buy (currently unknown and left blank)
- Cost to Buy (Units to Buy times Unit Cost)
- Potential Profit (Units to Buy times Unit Margin)

In addition, the table will contain two summation cells:

- Total Cost (Sum of the Cost to Buy column)
- Total Profit (Sum of the Potential Profit column)

5. PHASE 5: OPTIMIZATION

After the data are prepared in a table (as per Phase 4), the team will run Excel Solver to identify the number of units to buy of each product based on specified constraints and a goal to maximize potential profit. As such, Solver will be set up as follows:

- Set Target Cell [To]: the "Total Profit" cell
- [Set Objective] Equal To: Max
- By Changing Cells: the "Units to Buy" cell range
- Subject to the Constraints:
 - . "Total Cost" cell \leq specified budget amount
 - . "Units to Buy" cell range = Integer ("Int")
 - . "Units to Buy" \geq "Min Purchase" cell range
 - . "Units to Buy" \leq "Max Purchase" cell range

The above settings will enable Excel Solver to produce an optimal purchase plan that maximizes potential profit.

Upon running Solver, the team will include the results (appropriately summarized as a purchase plan) in the PowerPoint presentation. The team also should explain/justify the plan by considering and describing (in additional slides as needed) any connection between the purchase plan and the information identified in the earlier phases.

In explaining the plan, the team should consider the following questions as they reflect on the entirety of the project:

- Were there any trends in the past sales, especially with respect to the number of products that were sold per price group?
- Were there any trends in the purchase plan quantities, especially with respect to a product's margin?

6. PHASE 6: MANAGERIAL DISCUSSION

In addition to presenting the purchase plan, Northwind management wants the team to consider and discuss several factors that could

affect this or future purchase plans. These are not meant to be included in the presentation but rather are meant to be discussed with Northwind management.

Additional Context

Pivot analyses can easily identify the customers who spend the most with Northwind. How might this knowledge affect the purchase plan, and how would you incorporate it into the process? What other data might add relevant information to constructing a purchase plan?

Sales Summarization

Consider that past profits are calculated using the current cost of a product. How might you use price changes over time to better estimate past costs? Is the accuracy of calculating past profits even important – why or why not?

Inventory Estimates

With minimum and maximum inventory levels being based on past sales, how important is it to factor in seasonal sales fluctuations? Run another purchase plan using "same month sales" to compare it to first plan that used average monthly sales that was based on an entire year.

Fixed Budgets

Why is it possible that if the Total Cost is set to be less than or equal to the budget, the optimization can produce a different (possibly better) result than if it was set exactly equal to the budget? Run multiple models – including with expenditures that slightly exceed the budget – to see how much of a difference is at stake and whether or not a team could justify additional funds.

Future Purchase Plans

How would you go about getting a better idea of natural demand trends, especially given the fact that you may have been prematurely depleting inventory every month? For the next purchase plan, would you change the process in any way – why or why not?