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1 A New Method for Authoring Spreadsheet Models

ModelSheet is an authoring environment for spreadsheet models that differs from other spreadsheet authoring environments in several ways.

- ModelSheet raises the level of thinking and doing from cells to Analysis Variables, symbolic formulas, segmentation Dimensions, and Time Series.
- ModelSheet automates virtually all of the manual cell-level operations needed to build spreadsheets.
- ModelSheet specifies the quantitative model independently of sheet layouts, then specifies sheet layouts.
- ModelSheet delivers to report users Excel files that are indistinguishable from spreadsheets built by conventional methods.

These distinctive features enable ModelSheet to deliver four primary benefits.

- Reliability: Authors make fewer mistakes and auditors catch a higher percentage of mistakes.
- Productivity: With fewer formulas, fewer manual operations and more readable models, modelers get more done.
- Expressiveness: ModelSheet makes it easier to build more complex realistic models.
- Collaboration: Teams communicate at the level of Analysis Variables, Dimensions and Time Series, not cell addresses.

Here are some examples of operations that ModelSheet automates.

- Change time in a model.
  - Change start time, end time, and time grain (basic time unit) of a model.
  - Automatically convert quarterly growth rates to annual rates and vice-versa.
  - Intersperse quarterly totals in a table of monthly numbers, including inserting new columns and altering sheet layout.
- Change segmentation Dimensions.
  - Add a country or continental subtotals to a list of geographic locations used to segment revenue and other variables.
  - Roll up profit margin percent by country to get profit margin percent by country and globally.
- Change layout of a worksheet when tables change sizes.

ModelSheet represents relationships with symbolic formulas, without referring to layouts of cells and tables. For example, profit margin (gross margin, contribution margin, operating margin or after-tax profit) might be defined by the formula

\[
\text{profit} = \text{revenue} - \text{expense}
\]

which applies to all geographic locations and time periods.

A spreadsheet might represent this relationship in terms of cell addresses as

\[
C52 = D11 - D35
\]

or, for several geographic segments over time,

<table>
<thead>
<tr>
<th>Profit Margin</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americas</td>
<td>C52 = D11 – D35</td>
<td>D52 = E11 – F35</td>
<td>E52 = F11 – G35</td>
</tr>
<tr>
<td>EMEA</td>
<td>C53 = D12 – D36</td>
<td>C53 = E12 – F36</td>
<td>E53 = F12 – G36</td>
</tr>
<tr>
<td>Asia</td>
<td>C54 = D13 – D37</td>
<td>C54 = E13 – F37</td>
<td>R54 = F13 – G37</td>
</tr>
</tbody>
</table>

1.1 Building Blocks of a Model in ModelSheet

A ModelSheet model has four main types of objects.

- Analysis Variable (“Avar” for short) is a named variable that captures the key concepts in a model, such as Profit, Revenue and Expense. An Avar takes on different (usually numerical) values for different points in time (or intervals of time) and different items of segmentation Dimensions. Defining an Analysis Variable in ModelSheet requires specifying the following information.
  - If the Avar has time dependence, then specify a Time Series.
Introductory Tutorial for ModelSheet

If the Avar is segmented (e.g. divided up by countries or products in a product line, or by organizational department), then specify one or more segmentation Dimensions.

- Specify any numerical data or formulas that define the values of the Avar for different times and segments.

- **Dimension**: A list of similar items used to segment Analysis Variables. For example, a list of countries forms a geographic “Locations” Dimension that can segment revenues, headcount etc. A Dimension can be hierarchical; for example: world/hemisphere/continent/country/state.

- **Time Series**: Captures the starting time, ending time and time grain (such as month, quarter, year) for any Analysis Variable using that Time Series.

- **Workbooks**: ModelSheet displays results in web workbooks, from which it generates Excel workbooks.

If you use spreadsheets, you are already familiar with all of these concepts. The figure below shows a simple income statement in spreadsheet form. It has a time series along the top, analysis variables embedded in the left table header, a dimension embedded twice in the left table header, and worksheets.

**Figure 1-1: Building Blocks of a Spreadsheet Income Statement**

1.2 **Workflow Using ModelSheet**
The workflow using ModelSheet has four basic steps.

1. Prepare the information needed to build the Analysis Variables.
   - Define a Time Series (starting time, ending time, and time grain) for the whole model, or different Time Series for different Avars if needed.
   - Define segmentation Dimensions. Examples: geographic locations, products in a product line, departments in an organization, Job titles or pay levels, stages in a manufacturing or business process flow.

2. Define the Analysis Variables and the relationships between them that
   - Create an Analysis Variable for each key concept in the model (such as Profit, Revenue, Expense). If an Avar depends on time, assign it a Time Series. If an Avar is segmented, assign it segmentation Dimensions. Specify an Accounting Type for each Avar that tells ModelSheet how to automate roll-up of the Avar over time and Dimensions. (Examples: quarterly revenues rolled up to annual revenues by adding; quarterly growth rates roll up to annual growth rates by compounding.)
   - Specify numerical data. Specify formulas that define values in the cells of an Avar by defining relationships among Avars. (Example: define values of the Avar Profit by the formula Profit = Revenue – Expense.)

3. Lay out web workbooks to display the model.

   If report users edit numerical data in generated Excel workbooks, you can re-import the changes into ModelSheet.

1.3 About This Tutorial
This tutorial consists of an introduction (part 1), and tutorials on how to build three progressively more realistic versions of an income statement (parts 2, 3, and 4) that build on one another. The tutorial is designed so that you can build the “Teeny” income statement (part 2) and stop there; or build the Teeny and “Tiny” income statements (parts 2 and 3) and stop there; or do the Teeny, Tiny, and “Simple income statements (parts 2, 3, and 4).

1.4 Getting Help
ModelSheet has “context-sensitive help” that shows you how to perform many operations. The selection of tasks varies depending on where you are in ModelSheet; it depends on the context of what you are doing. To access context-sensitive help, click on a button “?” anywhere in ModelSheet.
2 Getting Started – A “Teeny” Model
Let’s start by building a teeny model that illustrates the elements of model-building. In the next section we will extend this tiny model to a simple income statement.

A model in ModelSheet is composed of four types of structures: Analysis Variables, segmentation Dimensions (for the Analysis Variables), Time Series, and Workbooks.

- This model has one Analysis Variable named Revenue. (ModelSheet is case insensitive; you can also enter revenue.)
- The Analysis Variable Revenue is segmented by product. So define a Dimension called “Products” that has two Items, Product A and Product B.
- The model has a Time Series that defines the start time, end time and time grain (basic time unit).
- This model has one workbook with one worksheet to display the Analysis Variable Revenue.

2.1 Prepare: Build Time Series and Dimensions
When building the model, we recommend defining the Time Series and Dimensions before the Analysis Variables, because the Time Series and Dimensions are used in the definitions of the Analysis Variables.

a) Log in and create a new model.
   - Log in to ModelSheet: Open ModelSheet in a browser; enter your User ID and Password; click on “Login”.
   - Click on Models at the upper left of the opening screen. In the left column, in the section User Models, click on New (“+”) in the box labeled “Name”, enter “Teeny”; click OK.
   - On tab Summary, click on button Edit Model. On the new page, the left-hand column has section headers for the main type of objects in the model: Workbooks, Analysis Variables, Dimensions, and Time Series.

Note: The button “Model Assistant” opens the Model Assistant whose primary purpose is to provide a simplified way to build a model from scratch.

Figure 1-3: ModelSheet login screen before logging in
Figure 1-4: ModelSheet screen after logging in and selecting model “Teeny”, before clicking “Edit Model”

b) Define the Time Series. (You can skip this step if you accept the pre-defined time series Model Time.)
   • In the left column in the section Time Series, click on Model Time; select tab Properties; select tab Time; click button Edit; set the Time Grain (year, quarter, month, week, or day), start date, and end date. Enter Time Grain Quarter, Start Date 1/1/2009, and end date 12/31/2010. Click “OK.” Click on Apply Edits in the upper right part of the window. (xxx 12/11/08: “Apply Edits” may be removed when ModelSheet gets an “Undo” function.)
   • Note that the Time Series editor display a list of Avars that use the Time Series that is open in the editor.
c) Define the Dimension Products.
   - In the column on the left, in section Dimensions, click button New (“+”) to open a dialog box to define a new Dimension.
   - In the box labeled Name, enter Products; click OK. A screen appears with a box containing the name Products.
   - Select Products; click on New. This opens a dialog box for entering a new Item in the Dimension. In the box labeled Name, type Product A; click on OK.
   - Repeat for Product B. Click button “Apply Edits”.

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Figure 1-5: Screen for defining Time Series “Model Time”
2.2 Build Analysis Variable “Revenue”

a) Create the Analysis Variable.
- In the column on the left in section Analysis Variables, click on New (“+”) This opens a dialog box for defining a new Analysis Variable.
- In the box labeled Display Name, enter Revenue.
- In the listbox Accounting Type, select Revenue. This selection tells ModelSheet to format values as currency, and to roll up values over segmentation Dimensions and Time Series by adding.
- In the listbox Time, select Model Time so that Avar Revenue uses the start and end time and time grain specified by the Time Series Model Time.
- In the listbox Dimensions, select Products to segment the revenue by products. (You can unselect any Dimension that is highlighted by control-clicking on it.)
- At the bottom of the dialog box, check the box marked “Variable holds input data” to indicate that this variable contains numerical values that are inputs to the model. (Alternative method: click tab Properties; click tab Categories; move the Category Input to the right using the button “>>”.)
- Click on OK.

b) Define the numerical values for Revenue for selected products and time periods.
- Click on tab Data/Formula Table. You will see a table with Dimension Products on the left and a Time Series across the top.
- Click on the cell in the first time period in the row marked Product A. Type in the number 1000; <enter>.
Repeat for Product B and enter 500.

Figure 1-7: Screen for creating Analysis Variable “Revenue”

- Define a formula that specifies values of Revenue at remaining times and products.
  - Click on the cell Total in the lower left of the table. Type the formula `prev()*1.05`. (This formula is short for `previous(Revenue)*1.05`, which makes the revenue in each cell 1.05 times as large as in the previous time period.
  - Click Apply Edits.

Notes:
- We could have typed the sequence of numbers 1000, 1050, 1105.50,... for Product A and a similar sequence for Product B. It is easier to enter the two numbers and one formula than typing in all these numbers.
- We could have pasted the numbers from the clipboard. Here’s how: build a series or rectangular range of numbers in Excel; copy it to the clipboard; select the upper left cell of the paste region in the Avar table; click Menu, then Paste Data to Cells. This paste operation puts data only into leaf cells (that is, not into roll-up cells).
- If we could not recall the name or syntax of the built-in function `prev`, we could use the “Function Assistant” to discover this information.
  - Place the cursor in the formula bar.
  - Click on the button “Fx” to the left of the formula bar (above the Avar table). This brings up the Function Assistant dialog box with all the built-in functions, information about the syntax of the function, and brief descriptions of each function and its arguments.
  - Choose the desired function and click the button Insert. This pastes the function and its argument prompts into the formula bar at the cursor position, and closes the Function Assistant dialog.
  - Edit or remove the argument prompts as needed to compose the function expression you want.
You should see a table of the Analysis Variable Revenue with these properties.

- The products are listed down the left side and time periods are listed along the top.
- Below the table is the formula that resides in the cells Total.
- The cells in the first time period of the rows for Product A, Product B are colored pink. The cells labeled Total and Products (both of which refer to the entire table) are colored pink (except a selected cell becomes yellow). The pink indicates that these cells contain independent numbers or formulas that define values in other cells of the table.

*Important tip:* To find out what defines the values in an Avar table, you need only check the contents of the pink cells. You can check the contents of the white cells, but they contain only the formulas in the pink cells specialized to each white cell. The white cells contain no independent information, and there is nothing in them to edit.

- Select any cell in the table, and it will turn yellow to indicate that it is selected.
  - Select the pink cell Product A in the first time period. Its value 1000 appears in the type-in box above the table.
  - Select the pink cell Total and the formula below the table turns orange to indicate that it is associated with the selected cell. The formula appears in the type-in box above the table for editing, just like in Excel.
  - If you select any white cell in the table, then any formula (in the list of formulas below the table) that determines the value in that cell will be colored orange; also a version of the formula that is specialized to that cell appears below the table.

### 2.3 Create a Web Workbook and Worksheet

We shall create a workbook to display the Analysis Variable Revenue. While we can view any Analysis Variable on its own web Variable Editor page, we can display multiple Analysis Variables on a worksheet.

- Create a workbook.
  In the left column in the section Workbooks, click on New (“+”); enter the name “Master” for the workbook; click “OK”.

- Create a worksheet.
  - On tab Overview, click on Menu; click button New Sheet; in the type-in box Worksheet Name, enter Sales; in the listbox Worksheet Type, select Variables/Categories; click OK.
  - Select tab Edit. This tab contains a schematic (a cartoon) of the worksheet layout.
– Click on the light blue box that indicates a table. Two boxes appear below the schematic. The box on the left contains names of Categories and Analysis Variables that are available to include in the table. The box on the right is empty.

– In the bottom left box, click on Analysis Variable Revenue. Use the button “>>” to move Revenue to the box on the right, thereby including it in the table.

**Figure 1-9: Screen for creating worksheet “Sales”**
Figure 1-10: Worksheet Editor window for inserting Avar “Revenue” on worksheet “Sales”

- View the worksheet.
  Click tab Preview. The worksheet has these properties.
  - The single Analysis Variable Revenue is displayed as a table.
  - The color scheme for worksheets differs from that in the Variable Editor. Headers are light blue; cells containing input data are dark blue; cells that contain copies of input data (that should not be edited in this cell) are light blue. Other cells are pink. This color scheme is also used in generated Excel workbooks.
  - If you hover the mouse cursor over any data cell, the number or formula for that cell appears in a pop-up box.
2.4 Assign Worksheet Styles

ModelSheet can make changes in the workbook display with a few clicks that would take a lot of work in Excel. For example, we can easily change the time grain to Quarters with Annual Sums.

- In Workbook Master, select tab Overview; click button Style. This opens a dialog box that contains a list of available worksheet display styles on the left side.
- Click on style Year Sums and move it to the right by clicking on the arrow button “>>”.
- Click tab Preview to see Revenue displayed in quarters with yearly sums interspersed between the quarters.
Figure 1-13: Worksheet “Sales” with Quarter time grain and display Style “Annual Sums”

Note: Each worksheet has a tab Overview that contains a button Styles that opens a dialog box for display styles. Styles that you apply in this dialog box affect only that worksheet. Also, you can apply display styles to an individual table on a worksheet: go to tab Edit; select the blue table; click on the button Edit Table Style which brings up a dialog box for display styles.

2.5 Generate an Excel Workbook

Go to workbook Master, select tab Overview; click Menu; click button Export Excel to get an Excel workbook file. In a few seconds, a dialog will pop up asking whether you want to open or save the Excel workbook.

The Excel workbook has all the worksheets that the web workbook has with the same layouts. It also has additional worksheets (with names that include the word Default) that display Analysis Variables not shown in the worksheets you defined, but that are needed to compute the Analysis Variables you placed on worksheets. These extra worksheets make the generated Excel workbook self-contained.

Figure 1-14: Auto-generated Excel Workbook with Worksheet “Sales”

Congratulations! You have completed, on a tiny scale, the three main steps in the modeling workflow.

1) Define a model (including Dimensions, Time Series, an Analysis Variable, data, formulas).
2) Lay out a web workbook with one or more worksheets.
3) Generate an Excel file.

3 A Tiny Statement of Operations

Let’s extend the teeny model above to create a tiny statement of operations (income statement).

3.1 The Elements of the Model

We retain the Dimension Products, the Time Series Model Time, the Analysis Variable Revenue, and the workbook Master defined in the model Teeny. We must create some new objects:

- New Analysis Variables “Operating Expense”, “Operating Margin,” and Operating Margin pct.”
• A new worksheet named “Income Stmt” in workbook Master.

3.2 Initiating the Model
Tell ModelSheet you want to define a new model based on the previous model.
• If you have logged out, login to ModelSheet; click on “Models”.
• In the left column under the title User Models click on Teeny, which is the model whose construction is described in a previous major section of this tutorial.
• In the top window bar, click File, Save As and save this model under the name “TinyStmt_Opers.” On the tab Summary for the model, click Edit Model.

3.3 Define New Analysis Variables
a) Build Analysis Variable Operating Expense.
• Create the Analysis Variable
  – In the left column in section Analysis Variables, click button New (“+”) This opens a dialog in which you start to set up the Analysis Variable.
  – In the box labeled Display Name, enter Operating Expense. (ModelSheet automatically creates a version of the name for use in formulas that replaces blank spaces and some other characters with underscore “_”.)
  – In the listbox labeled Accounting Type, click on Expense.
  – In the listbox labeled Time, select Model Time.
  – In the listbox marked Dimensions, make sure nothing is selected. (To unselect an entry, use Control+click.)
  – At the bottom of the dialog box, check the box marked “Variable holds input data”.
  – At the bottom of the dialog box, click OK to close the dialog and create the variable.

Figure 1-15: Screen for creating Avar “Operating Expense”
• Define the numerical values of *Operating Expense* for some time periods.
  – Click on tab *Data/Formula Table*. You should see a table with the Time Series across the top.
  – Click on the cell in the first time period. In the type-in bar above the table, enter the number 450; click **OK**.

• Define a formula that specifies values of *Operating Expense* for the remaining time periods.
  – Click the cell *Total* located in the lower left of the table. In the type-in box above the table, enter the formula `prev() * 1.03`; click **OK** to close the dialog box. The table for *Operating Expense* should be filled with numbers that grow by 3% per time period.
  – At the bottom of the dialog box, check the box marked “Variable holds input data”.
  – Click **OK**. Click button **Apply Edits** at the upper right of the window.

b) Define the Analysis Variable *Operating Margin*.

• Create the Analysis Variable.
  – In the left column in section *Analysis Variables*, click button *New (“+”)*.  
  – In the type-in box marked *Display Name*, enter “*Operating Margin*.”  
  – In listbox labeled *Accounting Type*, click “Margin (profit)”.  
  – In the listbox labeled *Time*, select *Model Time*.
  – In the listbox labeled *Dimensions*, make sure no Dimensions are highlighted. (To deselect a Dimension, use `Control+Click`). Click on **OK** to close this dialog.

• Define a formula to specify values of *Operating Margin* for all time periods.
  – Click on tab *Data/Formula Table*. You should see a table with the Time Series across the top.
  – Click the cell *Total* located in the lower left of the table. In the type-in box above the table.
  – Enter the formula “*Revenue – Operating Expense*” in the formula bar. Click on the button “Av” to the left of the formula type-in box to open the “Avar Assistant.” You can choose an Avar from the list of Avars, and select optional filters for an explicit time period or dimension item. Alternatively, you can type in the formula including the Avar names.
  – You should verify that the table for “*Operating Margin*” is filled with numbers.
  – Click on **OK** to close this dialog. Click on **Apply Edits**.

---

1 The Avar assistant eliminates errors in remembering Avar formula names, errors in typing, and errors in the syntax for specifying specific time periods or dimension items.
  – Place the cursor in the formula bar in the place where you want the Avar to appear.
  – Click the button “Av” to the left of the formula bar. This brings up the Avar Assistant dialog box.
  – Select an Avar from the list of Avars.
  – If the Avar has a Time Series and you want to specify a specific time period, then select the time period from the listbox for time periods.
  – If the Avar has a Dimension and you want to specify a specific Item for one or more Dimensions, then select the Item you want from the listbox for each Dimension.

2 Avar formula names differ from Avar display names in the workbook. For example, if you created an Avar by typing in the display name *Operating Expense*, ModelSheet automatically creates the formula name *Operating Expense* in which spaces and special characters (such as %) are replaced with underscores.
3.4 Add a Worksheet to the Workbook

We inherited from the previous model (Teeny) a workbook named Master containing a worksheet named Sales. We want to add an income statement to this workbook.

- At the top of the left column of the main window, in the section Workbooks, click on Master.
- On tab Overview, in the Menu, click New Sheet; in the type-in box for Name, enter IncomeStmt; in the listbox labeled Worksheet Type, select Categories/Variables; click OK.
- Display three Avars in this table on this Worksheet.
  - Select tab “Edit”.

---

c) Define the Analysis Variable Operating Margin pct.

  - Create the Analysis Variable.
    - In the left column in section Analysis Variables, click button New.
    - In the type-in box marked Display Name, enter “Operating Margin pct”.
    - In the listbox labeled Accounting Type, click on “Margin % (profit %)”. (This choice causes ModelSheet to roll up this Analysis Variable by a method different from summing that is appropriate for a margin percentages.)
    - In the listbox labeled Time, select Model Time.
    - In the listbox labeled Dimensions, make sure that no Dimensions are highlighted. (To deselect a Dimension, control-click on it.)
    - Click on OK to close this dialog.

  - Define a formula to specify values of Operating_Margin_pct for each time period.
    - Click on tab Data/Formula Table. (You should see a table with the Time Series across the top.)
    - Click the cell “Total” located in the lower left of the table. In the type-in box above the table, enter the formula “if(Revenue=0, 0, Operating_Margin/Revenue)”. (Recall that in formulas you must replace spaces in variable names with underscores.) The table for “Operating_Margin” should be filled with numbers.
    - Click OK to close the dialog box. Click Apply Edits.
Click on the light blue box that indicates a table. Two boxes appear below the layout schematic. The box on the left contains names of Categories and Analysis Variables that are available to include in the table. The box on the right is empty because we have not placed anything in the table yet.

In the bottom left box, click on Analysis Variable Revenue. Use the button “>>” to move Revenue to the box on the right, thereby including it in the table.

In the bottom left box, click on Analysis Variable Operating Expense. Use the button “>>” to move Operating Expense to the box on the right, thereby including it in the table.

In the bottom left box, click on Analysis Variable Operating Margin. Use the button “>>” to move Operating Margin to the box on the right, thereby including it in the table.

In the bottom left box, click on Analysis Variable Operating Margin pct. Use the button “>>” to move Operating Margin_pct to the box on the right, thereby including it in the table.

- Fine point: Click the button Edit Table Properties and set the spacing between variables to 1 blank row. Click OK.
- Click Apply Edits.
- To view the worksheet IncomeStmt, click the tab Preview.

![Figure 1-17: The web worksheet IncomeStmt in ModelSheet](image)

4 A Simple Statement of Operations
Let’s extend the tiny model above to a model of a larger statement of operations.

4.1 Expanding the Sales Sector of the Model
The model has ten Analysis Variables, listed here in the top-to-bottom order in which they appear in a typical statement of operations.

- Retain the Analysis Variables Revenue, Operating Expense, Operating Margin and Operating Margin pct from the previous model.
- Introduce new Analysis Variables Sales Units, Price, Cost of Goods, Cogs per Unit, Gross Margin, and Gross Margin pct (all segmented by product).

Retain the Dimension Products and the Time Series Model Time from the previous model.

4.2 Initiating the Model
First, tell ModelSheet you want to define a new model based on the previous model.

- On the webpage that lists the models, select and open the model TinyStmt_Ops that was constructed in the previous section.
- On the top bar of the window, click on File, Save As and save this model under a different name, such as “SimpleStmt_Opers”.

4.3 Improving the Revenue Model
Instead of specifying Revenue as input, we shall define Revenue = Price * Sales Units.
a) Define the Analysis Variable Price.
   • Create the Analysis Variable.
     – In the left column in section Analysis Variables, click New (“+”).
     – In the box labeled Display Name, enter “Price.”
     – In the listbox labeled Accounting Type, click on “Price.”
     – In the listbox labeled Time, select Model Time.
     – In the listbox labeled Dimensions, select Products. Click OK.
     – At the bottom of the dialog box, check the box marked “Variable holds input data”. Click OK.
   • Define the numerical values of Price for some products and time periods.
     – Click on tab Data/Formula Table. (After clicking, you should see a table with the Products Dimension on the left and a time series across the top.)
     – Click on the cell in the first time period in the row marked Product A. In the type-in box above the table, enter the number 10; click OK. (The Price for Product A in the first time period is set to 10.)
     – Click on the cell in the first time period in the row marked Product B. In the type-in box above the table, enter the number 5; click OK.
   • Define a formula that specifies the value of Price for the remaining cells.
     – Click on cell Total located in the lower left of the table. In the type-in box above the table, enter the formula prev(). The table for Price should be filled with prices for each product that are constant over time.

b) Define the Analysis Variable “Sales Units”.
   • Create the Analysis Variable.
     – In the left column in section Analysis Variables, click New.
     – In the type-in box Display Name, enter “Sales Units”.
     – In the listbox labeled Accounting Type, click on Period Units.
     – In the listbox labeled Time, select Model Time.
     – In the listbox labeled Dimensions select Products. Click OK.
     – At the bottom of the dialog box, check the box marked “Variable holds input data”. Click OK.
   • Define the numerical values of “Sales Units” for each product in each time period.
     – Click on tab Data/Formula Table. (You will see a table with the “Products” Dimension on the left and a time series across the top.)
     – Click on the cell in the first time period in the row marked Product A. In the type-in box above the table, enter the number 100; click OK.
     – Click on the cell in the first time period in the row marked Product B. In the type-in box above the table, enter the number 150; click OK.
     – Click the cell Total located in the lower left of the table. In the type-in box above the table, enter the formula “prev() * 1.05”; click OK. The table for Sales Units should be filled with numbers for each product that grow at 5% per time period.

b) Define the Analysis Variable “Revenue”.
   • In the left column in the section labeled Analysis Variables, click the Analysis Variable Revenue.
   • On tab Data/Formula Table, select the cell for the first time period in the row for Product A. Press the Delete key to remove the numerical value for initial revenue of the first product; click OK.
   • Do the same to remove the numerical input for the first time period of the second product.
   • Click the cell Total located in the lower left of the table. In the type-in box above the table, delete the existing formula and replace it with “Price * Sales_Units”. Click OK. The table for Revenue should be filled with numbers for each product and for the Total that grow by 5% per time period.
   • Remove the input property of the Analysis Variable Revenue. (It is no longer an input variable because its values are determined by the formula Price * Sales_Units.) This can be accomplished in either of two equivalent ways.
Click on tab Properties; click on tab Accounting Type; uncheck the box “Variable contains input data”.

Alternatively, click on tab Properties; click on tab Categories. Select the Category Input in the box on the right; use the button “<“ to move this Category to the left.

d) Fine Point: Make average prices roll up over the product line as a units-weighted average. (The default price displayed for the entire product line is the simple average of the prices for the two products.)

- Open the variable Price in the Avar Editor. Click on the cell “Total” in the lower left.
- Click on the button “RU” (for “Roll-up formula”). Enter the formula
  \[
  \text{if}(\text{Sales\_Units}=0, 0, \text{Revenue}/\text{Sales\_Units})
  \]
- Type Enter, then click Apply Edits.

The average price displayed for the product line should have changed from $7.50 (the simple average of $5 and $10) to $7 (the units-weighted average of $5 and $10).

e) Add Price and Sales Units to the worksheet Sales

- Go to workbook Master and the worksheet Sales; select tab Edit.
- Select the light blue table container that contains Revenue; its top margin turns yellow to indicate that it is selected. Go to the boxes below the table and move Sales\_Units and Price to the box on the right using the arrow key.
- Fine point: Click the button Edit Table Properties and set the spacing between variables to 1 blank row. Click OK.
- Select the tab Preview and you will see a worksheet that displays the sales-related variables.

4.4 Include Cost of Goods and Gross Margin

We must define four Analysis Variables to complete the model of revenue and gross margin: Cogs per Unit, Cost of Goods, Gross Margin, and Gross Margin pct.

a) Define the Analysis Variable Cogs per Unit.

- Create the Analysis Variable.
  - In the left column in the section called Analysis Variables, click New ("+").
  - In the type-in box marked Name, enter “Cogs per Unit”.
  - In the listbox labeled Accounting Type, click on “Cost per Unit.”
  - In the listbox labeled Time, select Model Time.
  - In the listbox labeled Dimensions select Products. Click “OK.”
  - At the bottom of the dialog box, check the box marked “Variable holds input data”. Click OK.

- Define the numerical values of Cogs per Unit for some products and time periods.
  - Click on the tab Data/Formula Table. (You should see a table with the Products Dimension on the left and the Time Series across the top.)
  - Click on the cell in the first time period in the row marked Product A. In the type-in box above the table, enter the number 5; click OK.
  - Click on the cell in the first time period in the row marked Product B. In the type-in box above the table, enter the number 3; click OK.

- Define a formulas that specifies values of Cogs per Unit for remaining cells.
  - Click on cell Total located in the lower left of the table. In the type-in box above the table, enter the formula prev(). The table for Cogs per Unit should be filled with numbers that do not change with time.

b) Define the Analysis Variable Cost\_of\_Goods.

- Create the Analysis Variable.
  - In the left column in the section called Analysis Variables, click New ("+").
  - In the type-in box marked Name, enter “Cost of Goods.”
  - In the listbox labeled Accounting Type, click on “Expense.”
  - In the listbox labeled Time, select Model Time.
In the listbox labeled Dimensions select Products. Click “OK.”

- Define the numerical values of “Cost of Goods” by the formula “Sales_Units * Cogs_per_Unit”.

c) Define the Analysis Variable “Gross Margin”.

- Create the Analysis Variable with Accounting Type Margin.
- Define numerical values of Gross Margin by the formula “Revenue – Cost_of_Goods”.

d) Define the Analysis Variable Gross_Margin_pct.

- Create the Analysis Variable with Accounting Type Margin pct.
- Define numerical values of Gross Margin pct by the formula “if(Revenue=0, 0, Gross_Margin / Revenue)”.

a) Include new Analysis Variables on the Worksheet Income Stmt.

- Select worksheet Income Stmt; select tab Edit; select the blue table.
- In the boxes below the layout schematic, move the Analysis Variables Cost_of_Goods, Gross_Margin, and Gross_Margin_pct to the box on the right to include them in the worksheet.
- Use buttons ↑ and ↓ to put the Analysis Variables in the proper order for an Income statement: Revenue, Cost_of_Goods, Gross_Margin, Gross_Margin_pct, Operating_Expense, Operating_Margin, and Operating_Margin_pct.

b) Include new Analysis Variables on the worksheet Sales.

- Select worksheet Sales; select tab Edit; select the blue table. In the boxes below the layout schematic, move the Analysis Variables Price, Sales_Units, Cost_of_Goods, Cogs_per_Unit to the box on the right to include them in the worksheet.
- Select worksheet Income_Stmt; select tab Edit; select the blue table. In the boxes below the layout schematic, move the Analysis Variables Gross_Margin and Gross_Margin_pct to the box on the right to include them in the worksheet; and place them between Revenue and Operating Expense.

4.5 Exact Roll-up Formulas for Ratio Variables

Correctly computing some ratios across the entire product line presents a new problem. The global values of ratios should be computed as a weighted sum of the values for the products, not as the sum or average of the margin percents for the separate products. Analysis Variables that need this treatment should have a “Roll-up Formula” that tells how to roll up values over a Dimension. Examples:

a) Analysis Variable Gross_Margin_pct in the first time period is reported as 45%, which is an average of the values for the two products. This is only an approximate value. To get the correct value,

- Select tab Data/Formula Table for Gross_Margin_pct; click on cell Total. In the formula bar, select and copy the formula.
- Click the button “Ru” (which stands for “Roll-up”); paste in the formula; press the Enter key.
- Below the table, delete the “data formula” (not the Roll-up formula) by clicking on button X.

Analysis Variable Gross_Margin_pct for the first time period now displays the correct value, 45.7%.

b) Analysis Variable Cost_per_Unit in the first time period is reported as $4.00, which is an average of the values for the two products. This is only an approximate value. To get the correct value,

- Select tab Data/Formula Table for Cost_per_Unit; click on cell Total. In the formula bar, select and copy the formula.
- Click the button “Ru” (which stands for “Roll-up”); enter the formula if(Sales_Units=0, 0, Cost_of_Goods/Sales_Units); press the Enter key.

Analysis Variable Cost_per_Unit for the first time period now displays the correct weighted average value, $3.80.

Note that Analysis Variable Operating_Margin_pct does not have this problem rolling up to the total because its numerator, Operating_Margin, does not have a Dimension that needs to be rolled up.

4.6 View Web Workbook

You can now view two web worksheets:
- Worksheet Sales provides detail on revenue, sales units and prices, and cost of goods.
- Worksheet Income Stmt provides an overview of the model.

The dark blue cells are input data that can be edited in Excel and whose values can be re-imported to ModelSheet.
4.7 Generate an Excel Workbook
On the page for Workbook Master, select tab Overview; on the Menu click Export to Excel to get an Excel workbook file.

After a few seconds, a dialog will pop up asking whether you want to open or save the Excel workbook.

5 Three Ways to View a Model
As you may have noticed, ModelSheet provides three ways to view a model.

1. View Analysis Variables in the Variable Editor.
   • View the table layout and computed values of the variable. You can also view (and edit) the input data and formulas that determine the computed values.
   • View (and edit) properties of each Analysis Variable, such as its Dimensions, Time Series, Accounting Types, formats.

2. View the workbooks and worksheets of a model.
   • View (and edit) web workbooks and worksheets while creating the model.
   • View exported Excel workbook and worksheets.

3. Examine the “Formula View” of a model.
   • List the “Avar Formula View” for each Analysis Variable, by clicking on the tab “Formulas” in the Variable Editor.
   • Examine the “Global Formula View” for the entire model, by clicking on the button “F” at the top of the main window.
   • Examine the global Formula View in exported Excel workbooks (This introductory tutorial does not show you how to include the global Formula View in an exported Excel workbook. See the reference manual chapter on Workbooks for instructions.)
This is an incomplete display of the global Formula View
6 Conclusion
This tutorial has guided you through the issues encountered while authoring a model that combines ten Analysis Variables, three Worksheets, one Dimension and one Time Series. This model provides a simple income statement with backup detail about revenue and cost of goods. This example covers many of the issues you will encounter in authoring larger models.