2. Spreadsheets and decision support

1. Using spreadsheet formulas
2. Cell referencing
3. Presentation of data
4. Named functions

Inquiry

• Have you used a spreadsheet?
• Why are spreadsheet skills required for many majors?
• What is decision support?
• What will you need to know about spreadsheets in your personal and work life?
2. Spreadsheets

**Topic objective**

Explain and apply principles of spreadsheet use

**Essential and priority objectives**

2.0a Recall basic spreadsheet concepts*  
2.1a Explain why spreadsheet formulas are used**  
2.1b Use spreadsheet formulas**  
2.2a Explain or use relative and absolute referencing*  
2.3a Explain spreadsheet formatting features*  
2.3c Create a spreadsheet from a description of its contents*†
1. Using spreadsheet formulas

- What is spreadsheet software for?
- What is the key feature of a spreadsheet?
- What does algebra have to do with business?

Subtopic objectives

2.1a Explain why spreadsheet formulas are used**
2.1b Use spreadsheet formulas**
Spreadsheet software

- Data, numeric and text, is arranged as a grid
- Some numbers are computed from others
- Summary and projection info are needed for business purposes for decision support
- Formulas are mathematical expressions to compute values from other values

Examples:
- Sums of columns of numbers
- Statistics about sets of numbers

How businesses use spreadsheets

- Record keeping (journals, financial summaries)
- Analysis of trends and relationships of data for decision support
- Planning for profit by projecting current patterns into the future
- Analysis of data by breaking down quantities into their components
- Of special interest: to understand and show dependency relationships in the data
- Formulas can express these dependencies
Where spreadsheets started

- Businesses used yellow or green paper sheets with vertical and horizontal lines
- Business figures were recorded by item, time, and category
- To calculate totals, heavy mechanical adding machines were used
- In 1970s electronic hand calculators helped
- Electronic versions of spreadsheets did calculations automatically

Cell contents

- Three most common kinds:
  - Label (non-numeric)
  - Numeric literal (2, 3.52)
  - Formula, normally referring to contents of other numeric cells
- Columns are denoted by letters
- Rows are numbered
- Formulas begin “=“, e.g.:
  \[=A1 + A2\]
  \[=\text{sum}(A1, A2)\]
A principle of information integrity

Use formulas to calculate any values that depend on other cell values

Why?
- To apply consequences of changes in data values automatically, reliably
- To avoid errors when data changes

Formulas use algebra
- A spreadsheet formula is an algebraic expression with an equal sign to its left
- Elements:
  - constants (2, 3.5)
  - variables (cell references, e.g., C2)
  - operators (+, −, /, *)
  - named functions (see Sec. 2.4)
- Operators are applied using order of operations (add/sub before mult-divide)
Example: batting averages

<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>AB</th>
<th>R</th>
<th>H</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mauer, Min</td>
<td>457</td>
<td>73</td>
<td>159</td>
<td>=D2/B2</td>
</tr>
<tr>
<td>3</td>
<td>Jeter, NY</td>
<td>546</td>
<td>97</td>
<td>188</td>
<td>=D3/B3</td>
</tr>
<tr>
<td>4</td>
<td>Tejada, Bal</td>
<td>564</td>
<td>91</td>
<td>187</td>
<td>=D4/B4</td>
</tr>
<tr>
<td>5</td>
<td>Guerrero, La</td>
<td>546</td>
<td>82</td>
<td>180</td>
<td>=D5/B5</td>
</tr>
<tr>
<td>6</td>
<td>Ramirez, Bos</td>
<td>446</td>
<td>78</td>
<td>142</td>
<td>=D6/B6</td>
</tr>
<tr>
<td>7</td>
<td>Johnson, Tor</td>
<td>410</td>
<td>78</td>
<td>130</td>
<td>=D7/B7</td>
</tr>
<tr>
<td>8</td>
<td>DeRosa, Tex</td>
<td>453</td>
<td>71</td>
<td>143</td>
<td>=D8/B8</td>
</tr>
<tr>
<td>9</td>
<td>Suzuki, Sea</td>
<td>604</td>
<td>88</td>
<td>190</td>
<td>=D9/B9</td>
</tr>
</tbody>
</table>

- Note formula in “Avg” column (Formulas/Show)
- When formula is copied down, row number adjusts automatically

Ledger for a profit plan

<table>
<thead>
<tr>
<th></th>
<th>Option A</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit price</strong></td>
<td>$10.00</td>
<td>$15.00</td>
</tr>
<tr>
<td><strong>Projected sales qty</strong></td>
<td>5000</td>
<td>2500</td>
</tr>
<tr>
<td><strong>Gross sales income</strong></td>
<td>$50,000</td>
<td>$37,500</td>
</tr>
</tbody>
</table>

**Expenses**

<table>
<thead>
<tr>
<th></th>
<th>Option A</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>setup production</td>
<td>$2,000</td>
<td>$2,000</td>
</tr>
<tr>
<td>prod cost per unit</td>
<td>$3.00</td>
<td>$3.00</td>
</tr>
<tr>
<td>Production</td>
<td>$17,000</td>
<td>$9,500</td>
</tr>
<tr>
<td>Distribution</td>
<td>$6,250</td>
<td>$3,125</td>
</tr>
<tr>
<td>Marketing</td>
<td>$16,000</td>
<td>$16,000</td>
</tr>
<tr>
<td>Overhead</td>
<td>$4,000</td>
<td>$4,000</td>
</tr>
<tr>
<td><strong>Total expenses</strong></td>
<td>$43,250</td>
<td>$32,625</td>
</tr>
<tr>
<td><strong>Net profit</strong></td>
<td>$6,750</td>
<td>$4,875</td>
</tr>
</tbody>
</table>

This ledger helps determine unit price that would generate greatest profit, $10 or $15. Gross sales is computed as product of unit price and projected sales qty.

**Features:**
- Named cells
- Formulas with +, −, *
- What-if scenarios
- Currency formatting
Excel array formulas

- Place an entire column or row under the control of a single editable formula

- **Steps:**
  1. Select destination cells
  2. Type formula
  3. Press `ctrl-shift-enter`

Screen operations (Excel)

- **Edit cell:** [F2] or right-click
- **Freeze panes:** To keep headings on screen when scrolling
- **Copy** a cell or range by dragging small square at lower-right corner of cell
- **Insert** row or column: `Alt-I, R` or `Alt-I, C`
- **Delete** row or column: Select column or row in margin; `Alt-E, D`
- **Widen column** or **deepen row:** Select solid bar between rows or columns at edge of worksheet
2. Spreadsheets

Paging, scrolling and zooming

• To change worksheet, press Control-PgDn or click tab
• Paging (PgUp, PgDn) moves through a worksheet a page or screen at a time
• Home and End keys move to start or end of row
• Ctrl-Home, Ctrl-End to top or bottom of sheet
• Scrolling (up, down, scroll bars) changes what part of a sheet is displayed
• Zooming changes size of the sheet’s image; is specified in %; may be set for fit-in-window

Group exercise

1. Download the file sales-exercise.txt
2. Paste into a spreadsheet
3. Write formulas to calculate totals for each quarter and for each division

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>21</td>
<td>42</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>West</td>
<td>25</td>
<td>106</td>
<td>74</td>
<td>81</td>
</tr>
<tr>
<td>North</td>
<td>33</td>
<td>40</td>
<td>27</td>
<td>127</td>
</tr>
<tr>
<td>South</td>
<td>105</td>
<td>82</td>
<td>102</td>
<td>93</td>
</tr>
</tbody>
</table>
2. Spreadsheets

2. Cell referencing

• What happens when we *copy* a formula from one cell to another?
• *Example*: a column consisting of sums of rows in the batting-average sheet

Subtopic objectives

2.2 Explain or use relative and absolute referencing*
Referencing cells

- **Principle:** write formulas that are convenient to copy
- Relative references adjust column or row when copied
- Absolute references do not adjust
- Multiple worksheets in the same file may reference each other’s cells
- **Circular references** (error!) refer directly or indirectly to a cell that refers back

Relative and absolute references

- A2 is an example of a *relative reference*, because when it is used in A1, for example, A2 means “the cell just to the right”
- When copied down, A2 becomes A3
- When copied to the right, A2 becomes B2
- To prevent adjustment of row or column in a reference, make it an *absolute (fixed) reference* by using “$”:
  - A$2 means the 2 (for row) is fixed
  - $A2 means the A (for column) is fixed
Absolute-referencing example

- This grade-keeping worksheet illustrates relative and absolute referencing. Weights for problems 1, 2, and 3 are 40%, 50%, and 10%.
- Percentage weights for quiz questions are absolute references

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weight</td>
<td>40</td>
<td>50</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Problem #</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Total</td>
</tr>
<tr>
<td>3</td>
<td>Smith</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>60*</td>
</tr>
<tr>
<td>4</td>
<td>Jones</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
<td>85*</td>
</tr>
</tbody>
</table>

* = B$1*B3 + C$1*C3 + D$1*D3

Using multiple worksheets

- A spreadsheet file may contain multiple worksheets; e.g., in Excel
- Each worksheet may be named; names are on tabs at lower-left corner of Excel screen
- The default names are “Sheet1,” “Sheet2,” etc. right-click to rename a worksheet
- Reference a cell in a different worksheet by using worksheet name followed by exclamation point, e.g., “=february!F4”
2. Spreadsheets

Named cells

• A cell may be referenced by name if a name is defined for it

  Example: =C5 + bonus adds the contents of cell D1 to C5’s contents if D1 is named “bonus”

• Names of cells are absolute references

• Excel: right-click on a cell or range, give a name to it

Copy/paste options

• May copy selectively:
  – Values only
  – Formulas only
  – Formats only

• May transpose cells in pasting, so that a horizontal series of cells is copied vertically or vice versa

  Copy horizontal range to stack vertically: Select; Copy; Edit/Paste Special/Transpose

• Use Paste Special to access these options
Applying relative and absolute references

Problems:
1. What is “A4” copied two cells down?
2. “$D2” copied one cell to the right?
3. “$D2” copied one cell down?

Solutions:
1. A6, because row is relative
2. $D2, because column D is absolute
3. $D4, because row is relative

3. Presentation of data

- How do you format a table?
- How are business transaction records recorded and presented?
- What’s a budget?
Subtopic objectives

2.3a Explain spreadsheet formatting features*
2.3b Explain ways to present data in spreadsheets
2.3c Create a spreadsheet from a description of its contents*†

Formatting cells

- **Alignment:** Left, right, centered; top, bottom, vertically centered
- **Word wrap:** Enables multiple lines of text in one cell
- **Border rules:** outside, inside, horizontal only, vertical only; weight, color, style
- Precision of numeric display may be set
- Currency, percentage formats are available
- **Merging cells:** e.g., to center one heading over two or more columns
2. Spreadsheets

Named styles in Excel

- Cell formats may be defined as are named styles in MS Word
- In Excel, choose *Home / Styles / Cell Styles*
- Any cell attributes may be set in a named style; e.g., font, border, background, alignment, numeric precision

Journals and budgets

- A *journal* lists transactions in chronological order
- A transaction has a *date*, a *description*, an *amount* (or sub-amounts), and *budget categories* for the sub-amounts
- A *budget* summarizes information in a journal according to budget category and projects future planning for those categories
Journal example

<table>
<thead>
<tr>
<th>Date</th>
<th>Chk Description</th>
<th>Amt.</th>
<th>Balance</th>
<th>Income</th>
<th>Expenses</th>
<th>Food</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>FSC</td>
<td>200</td>
<td>1200</td>
<td>550</td>
<td>0</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>FSC rent</td>
<td>-400</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Nat. gas</td>
<td>-25</td>
<td>1150</td>
<td></td>
<td>350</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1125</td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

- Each budget category has a column; use categories for a business or organization (not for a student)
- For each transaction (check or deposit) enter *date* and *description*
- Enter sub-transaction amounts under columns
- Compute balance after transaction
- Compute transaction amount as sum of income sub-amounts minus expense sub-amounts

Budget example

Show *actual* and *projected* amounts by budget category

*Actual* amounts should reference cells in journal worksheet

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Budget</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Category</strong></td>
<td>Actual</td>
<td>Projected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Job</td>
<td>550</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Family</td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Expenses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rent</td>
<td>600</td>
<td>600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Food</td>
<td>200</td>
<td>220</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Transport</td>
<td>50</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Misc.</td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Surplus/deficit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>=SUM(B8:B11)</td>
<td>=SUM(E8:E11)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>=C6-C12</td>
<td>=F6-F12</td>
</tr>
</tbody>
</table>
Formulas used in journal, budget

Journal:
- Monthly total by budget category
- Transaction amount (total of sub-transactions)
- Balance after transaction

Budget:
- Actual amount by category (referencing category total in journal)
- Sums for income, expenses
- Surplus/deficit

Some generic formulas for journals

- To sum a column of numbers, the formula should be something like \( =\text{sum(d4:d12)} \)
- To find the amount of a transaction whose income sub-transactions are \( d4 \) to \( f4 \), with income \( g4 \) to \( k4 \), use \( =\text{sum(d4:f4)} - \text{sum(g4:k4)} \)
- To find the balance after a sub-transaction, add the current transaction amount to the balance after the previous transaction
2. Spreadsheets

Charts

- For time-series data, use bar or line graphs
- For non-time-based data, use pie chart

To make a pie chart of data (below-left) in Excel 2007:
1. Select from “Work” down to “12” below
2. Choose Insert / Charts / Pie, choose sample format
3. Labels may be changed by use of Design tab

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>40</td>
</tr>
<tr>
<td>Commute</td>
<td>10</td>
</tr>
<tr>
<td>Study</td>
<td>12</td>
</tr>
</tbody>
</table>

3D charts

A table of figures can be represented item by item in three dimensions

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>490.00</td>
<td>450.00</td>
<td>490.00</td>
</tr>
<tr>
<td>Food</td>
<td>189.00</td>
<td>175.00</td>
<td>150.00</td>
</tr>
<tr>
<td>Transport</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Entertainment</td>
<td>50.00</td>
<td>40.00</td>
<td>30.00</td>
</tr>
</tbody>
</table>
Linking and embedding spreadsheets in documents

• A spreadsheet may be copy-pasted (embedded) into documents such as Word, PowerPoint

• Alternative: linking (references; like Windows shortcuts, hyperlinks)
  – Double-clicking on a linked spreadsheet object runs the spreadsheet application to enable editing
  – Edits are saved to the linked file

Importing and embedding

• Example: using an Excel spreadsheet in a .PPT slide

• Importing: table becomes a .ppt table

• Embedding (with Paste): double-clicking table within .ppt file opens it in Excel for editing; original Excel file is not affected
2. Spreadsheets

Linking

Linking (with Paste / Special):

• Editing table in .ppt file, using Excel, does affect original Excel file
• Editing original Excel file affects table’s content in .ppt
• Linking is a case of the use of references; the .ppt file contains the location of the Excel file material, but does not contain the text

4. Named functions

• Are there alternatives to algebraic formulas?
• Can a formula perform a looping computation?
• How can letter grades be obtained from numeric quiz and project scores?
Subtopic objective

2.4 Describe some named spreadsheet functions

Features of named functions

- A function is a mapping from a set of parameter values to a set of return values.
- Parameters (arguments) are the data operated on.
- The return value is the result.
- A function such as SUM has parameters (in parentheses) and a return value (the value shown in the cell): 
  
  \[ =\text{SUM}(A2, A4, B5) \]
Cell ranges

- Some functions take two or more parameters
- The *SUM* function may take a *range* as a parameter:  \( =SUM(A2:B5) \)
- A range denotes the set of cells in the rectangle defined by the two cells referenced in the range formula
- A *cell* may contain a *numeric* value, but not a range

Some named functions on ranges

- *MAX* returns largest, *MIN* returns smallest
- *AVERAGE* returns arithmetic mean (sum divided by number of cells)
- *MEDIAN* returns middle value in range
- *MODE* returns most common value
- *STDDEV*: Standard deviation, a measure of variance from the mean
Functions that return counts

- \textit{COUNT}, \textit{COUNTA}, and \textit{COUNTIF} return the number of cells in a range that contain data or data with certain features
- \textit{COUNT} returns \# of nonempty numeric cells
- \textit{COUNTA} counts label cells
- \textit{COUNTIF}(\textit{range, expr}) returns the number of cells in a \textit{range} that satisfy the predicate \textit{expr}; example \texttt{COUNTIF(A2:C5, \textasciitilde\textgreater\textasciitilde\textasciitilde\textasciitilde\textasciitilde\textasciitilde1000)} returns the number of cells in range A2:C5 that contain values over 1000

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Loan amortization} & & \\
\hline
- Starting with interest rate, number of payments, and amount borrowed, function \texttt{PMT} returns the amount needed to pay off loan in \textit{x} years in monthly payments & & \\
\hline
\textbf{Loan amount} & & \\
\hline
\textbf{Monthly payment} & & \\
\hline
\textbf{Interest} & \textbf{30 yrs} & \textbf{15 yrs} & \\
\hline
4.00\% & \$1,909.66 & \$2,958.75 & \texttt{=PMT(A5/12, 15*12, -$C$3)} \\
5.00\% & \$2,147.29 & \$3,163.17 & \\
6.00\% & \$2,398.20 & \$3,375.43 & \\
7.00\% & \$2,661.21 & \$3,595.31 & \\
8.00\% & \$2,935.06 & \$3,822.61 & \\
9.00\% & \$3,218.49 & \$4,057.07 & \\
10.00\% & \$3,510.29 & \$4,298.42 & \\
\hline
\end{tabular}
\end{table}
Table lookup

- For a spreadsheet with a two-column table of reusable data, e.g., letter grades for certain ranges of numeric scores,
- To use values in col. 1 to look up values in col. 2:
  \[ =VLOOKUP(B2, E2:F6, 2) \]

<table>
<thead>
<tr>
<th>Student</th>
<th>Numeric score</th>
<th>Letter grade</th>
<th>Grading criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>74</td>
<td>C</td>
<td>0 F</td>
</tr>
<tr>
<td>Bell</td>
<td>57</td>
<td>F</td>
<td>60 D</td>
</tr>
<tr>
<td>Crane</td>
<td>95</td>
<td>A</td>
<td>70 C 80 B 90 A</td>
</tr>
</tbody>
</table>

Goal seeking

- Example: What price can we afford for a machine if we have $5000/yr. to budget, given interest on five-year financing of 8%?
- Solution: Given the values of interest rate, term, and Yearly payment, use Data / Whatif analysis / Goal seek to set the price of machine

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of machine</td>
<td>$19,963.55</td>
</tr>
<tr>
<td>Interest rate</td>
<td>8%</td>
</tr>
<tr>
<td>Term in years</td>
<td>5</td>
</tr>
<tr>
<td>Yearly payment</td>
<td>$5,000.00</td>
</tr>
</tbody>
</table>
Users co-create their computing environments

- *Formulas* are small, reusable programs
- Formulas may be copied
- Spreadsheets are larger reusable computing environments

Metadata in this topic

- Formulas
- Cell references
- Table headings
- Function names
References

