MICROSOFT EXCEL:

INTRO TO **POWER QUERY**, **POWER PIVOT** & **DAX**

★★★★★ *With Best-Selling Excel instructor* ***Chris Dutton***

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GETTING STARTED

COURSE STRUCTURE

- **100+ Downloadable PDF Slides** to serve as helpful reference guides when you're offline or on the go (or just need a refresher!)
- **Interactive**, **hands-on demos** to keep you engaged, with **downloadable project files** that you can use to explore and learn at your own pace
- **Course Quizzes** and **Homework Exercises** to test and reinforce key concepts throughout the course

COURSE OUTLINE

1. **The "Power" Excel Landscape**
   - *Power Query/Power Pivot workflow and key benefits vs. "traditional" Excel*
2. **Power Query**
   - *Types of data connectors, query editing tools, loading options, etc.*
3. **Data Modeling 101**
   - *Excel Data Model interface, normalization, table relationships, hierarchies, etc.*
4. **Power Pivot & DAX**
   - *Power Pivots vs. "normal" pivots, calculated columns vs. measures, row & filter context, etc.*
5. **Common DAX Functions**
   - *Basic syntax, math & stats functions, filter functions, time intelligence tools, etc.*
6. **Final Project**
   - *VanArsdel sales data (2000-2010)*

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VERSIONS & COMPATIBILITY

IMPORTANT NOTE: Power Pivot is currently ***not available for Mac***, and is ***only available in certain versions of Excel for Windows/PC***

For a full, current list of compatible versions, visit **support.office.com** (or Google "*Where is Power Pivot?*"):

https://support.office.com/en-us/article/Where-is-Power-Pivot-aa64e217-4b6e-410b-8337-20b87e1c2a4b (or use: **bit.ly/2yd80rd**)

Other considerations:

- Power Pivot works best with **64-bit** Excel, which can access more processing power and memory (*not critical*)
  - ***Note:*** *make sure you're running a 64-bit operating system and that you've updated Office to the 64-bit version*
- Power Pivot menus, features and tools have evolved over time; **what you see on your screen may differ from what you see on mine, but the fundamental skills and concepts covered are universally applicable**
- Even if you have a compatible version of Excel, you may need to **enable the Power Pivot or Power Query plug-ins** to access the tools in this course (***File*** > ***Options*** > ***Add-Ins*** > ***Manage: COM Add-Ins***)

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GETTING TO KNOW THE FOODMART DATABASE

- Throughout the course, we'll be using sample data from a fictitious super market chain called "**FoodMart**"*
- In addition to daily transactional records from 1997-1998, our data set includes information about **products**, **customers**, **stores**, and **regions**
- All files are available for download in the **course resources** section of your course dashboard (***Course Dashboard*** > ***Course Content*** > ***All Resources***)

Transactions	**Returns**	**Customer Lookup**	**Calendar Lookup**	**Product Lookup**	**Store Lookup**	**Region Lookup**
-transaction_date	-return_date	customer_id	date	product_id	store_id	region_id
-stock_date	-product_id	customer_acct_num	month_num	product_brand	region_id	sales_district
-product_id	-store_id	first_name	quarter	product_name	store_type	sales_region
-customer_id	-**quantity**	last_name	year	product_sku	store_name	
-store_id		customer_address	weekday_num	product_retail_price	store_street_address	
-**quantity**		*etc..*	*etc…*	*etc…*	*etc…*	

*"**Data**" Tables*

*"**Lookup**" Tables*

**This data is provided by Microsoft for informational purposes only as an aid to illustrate a concept. These samples are provided "as is" without warranty of any kind. The example companies, organizations, products, domain names, e-mail addresses, people, places, and events depicted herein are fictitious, and no association with any real company, organization, product, domain name, e-mail address, person, place, or event is intended or should be inferred.*

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SETTING EXPECTATIONS

1. I'm using **Excel 2016 for PC (365 ProPlus, 64-bit)**
   - *Power Pivot is currently **not available for Mac***
   - *What you see on your screen **will not always match** what you see on mine (especially for Excel 2010 or 2013)*

2. This course is designed to get you **up & running** with Excel's BI tools
   - *The goal is to provide a solid **foundational understanding** of Power Query, Power Pivot and DAX; we may simplify some concepts to make them easier to grasp, and will not cover some of the more advanced tools*

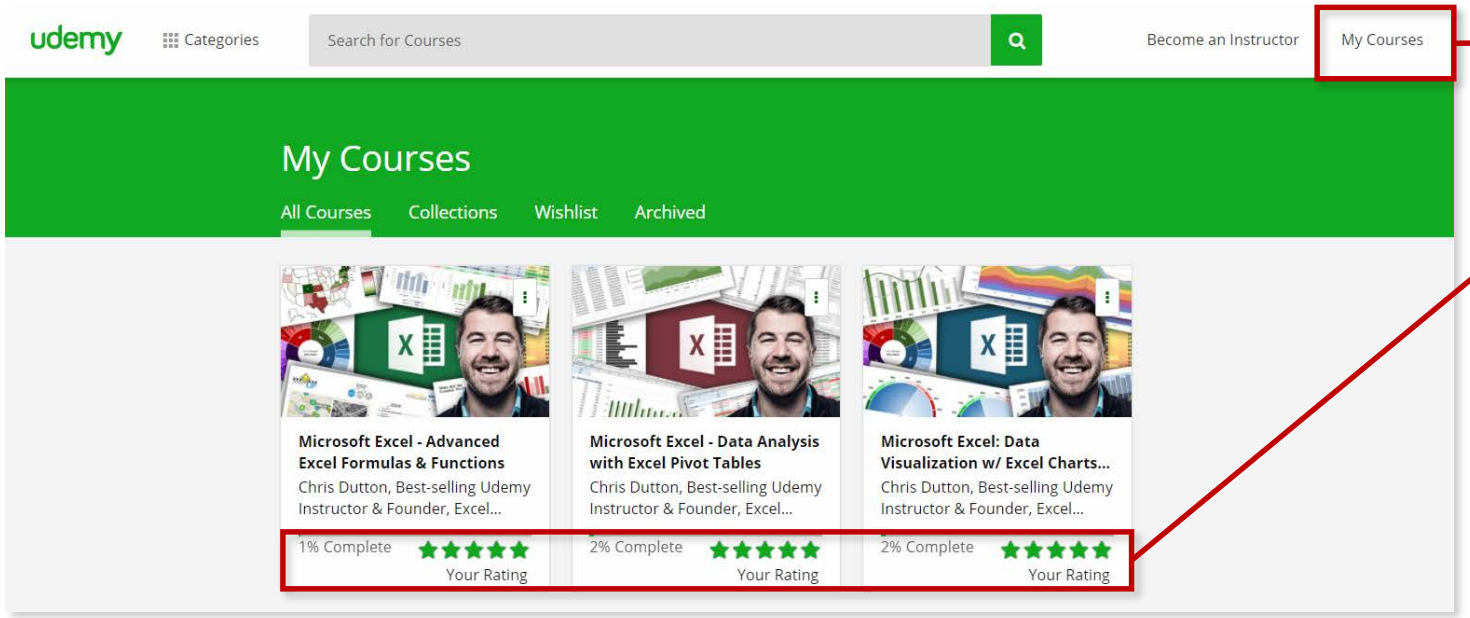
3. These tools are incredibly powerful, but still a little "**buggy**"
   - *Power Pivot uses a lot of processing power, so it helps to **close other workbooks and applications***
   - ***Save new versions** early and often; if you do crash, make sure you have a recent version to work from!*

4. When things get challenging, remember that **I'm here to help**
   - *If you feel stuck, remember that you can pause the videos and rewatch them as many times as you'd like!*
   - ***Still need support?** Post to the course Q&A section or message me directly and I'd be happy to lend a hand*

COURSE RATINGS & REVIEWS

Ratings and reviews help courses succeed, and provide valuable feedback that I can use to **make the course even better!**

- If you find yourself enjoying the course, or if you have feedback that might improve your experience, please take **15 seconds** to leave a rating or review *(when you're ready – no rush!)*



STEP 1: Click on "My Courses"

STEP 2: Click on the stars under the course thumbnail

STEP 3: Dance 

LET’S DO THIS.

INTRO TO “POWER EXCEL”

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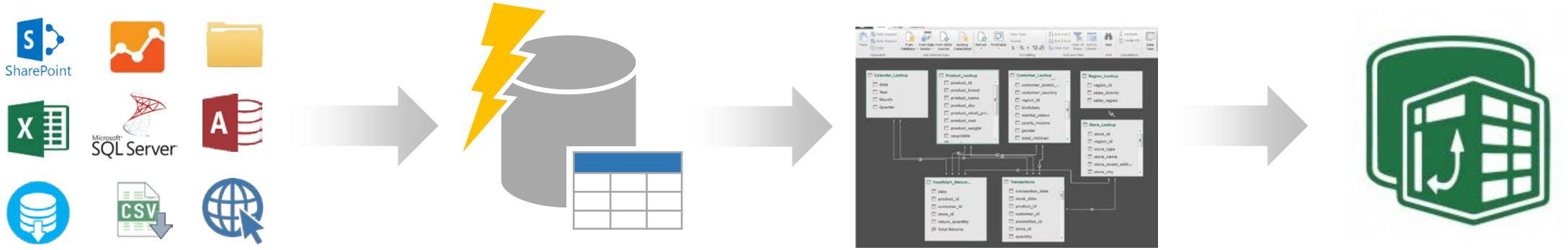
THE "POWER EXCEL" WORKFLOW

These are Excel's **Business Intelligence** tools, all of which are available directly in Excel (*provided you have a compatible version*); **no additional software is required!**



RAW DATA

Flat files (csv, txt), Excel tables, databases (SQL, Azure), folders, streaming sources, web data, etc.

POWER QUERY

*(aka "**Get & Transform**")*

Connect to sources, import data, and apply shaping and transformation tools (ETL)

DATA MODEL

Create table relationships, add calculated columns, define hierarchies and perspectives, etc.

POWER PIVOT & DAX

Explore and analyze the entire data model, and create powerful measures using Data Analysis Expressions (DAX)

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"THE BEST THING TO HAPPEN TO EXCEL IN 20 YEARS"

- **Import and analyze MILLIONS of rows of data in Excel**
  - *Access data from virtually anywhere (database tables, flat files, cloud services, folders, etc.)*
- **Quickly build models to blend and analyze data across sources**
  - *Instantly connect sources and analyze holistic performance across your entire data model*
- **Create fully automated data shaping and loading procedures**
  - *Connect to databases and watch data flow through your model with the click of a button*
- **Define calculated measures using Data Analysis Expressions (DAX)**
  - *No more redundant A1-style "grid" formulas; DAX expressions are flexible, powerful and portable*

**Quote by Bill Jelen (aka "Mr. Excel")*

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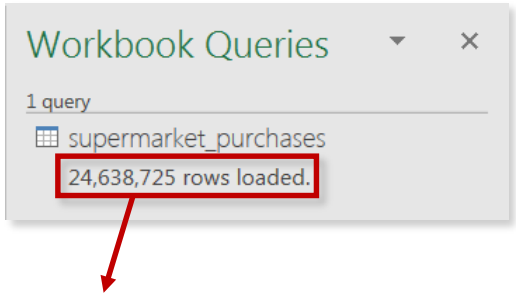
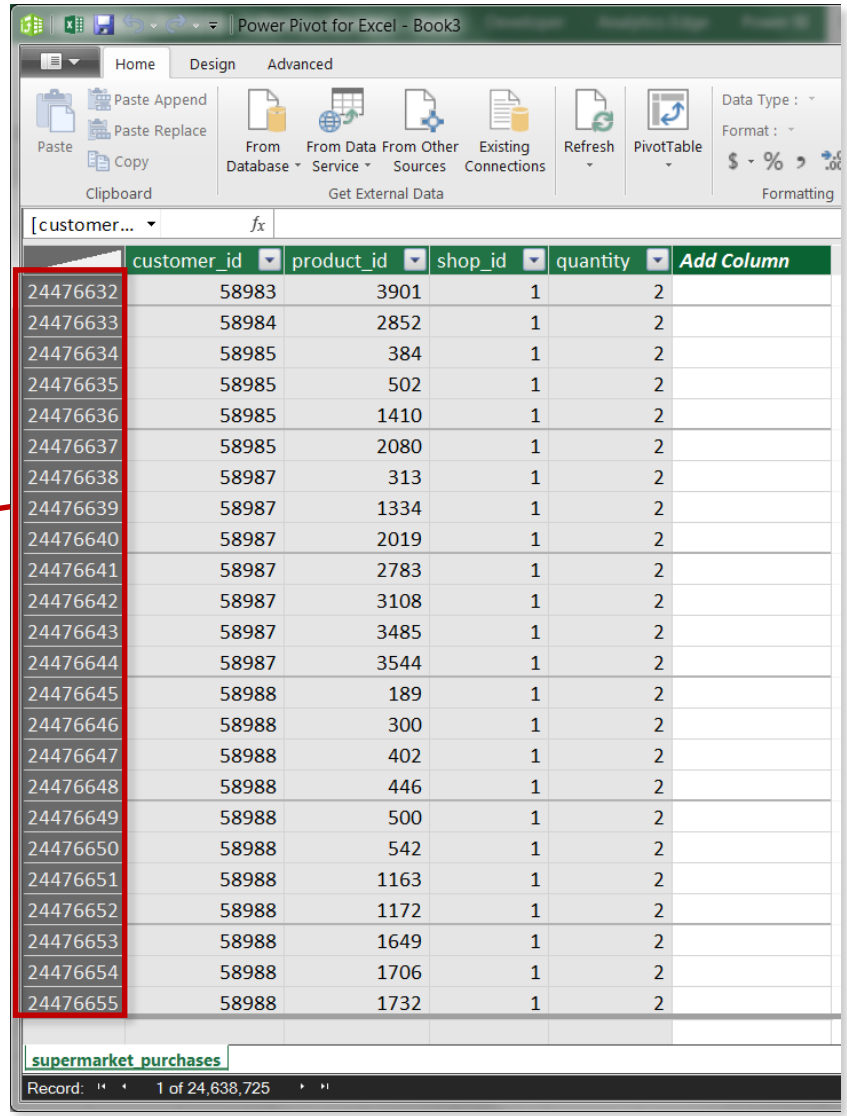
#1: IMPORT & ANALYZE MILLIONS OF ROWS



When was the last time you loaded **25,000,000** rows of data into Excel?

When you connect to data with **Power Query** and load it to Excel's **Data Model**, the data is compressed and stored in memory, NOT in worksheets (*no more 1,048,576 row limit!*)



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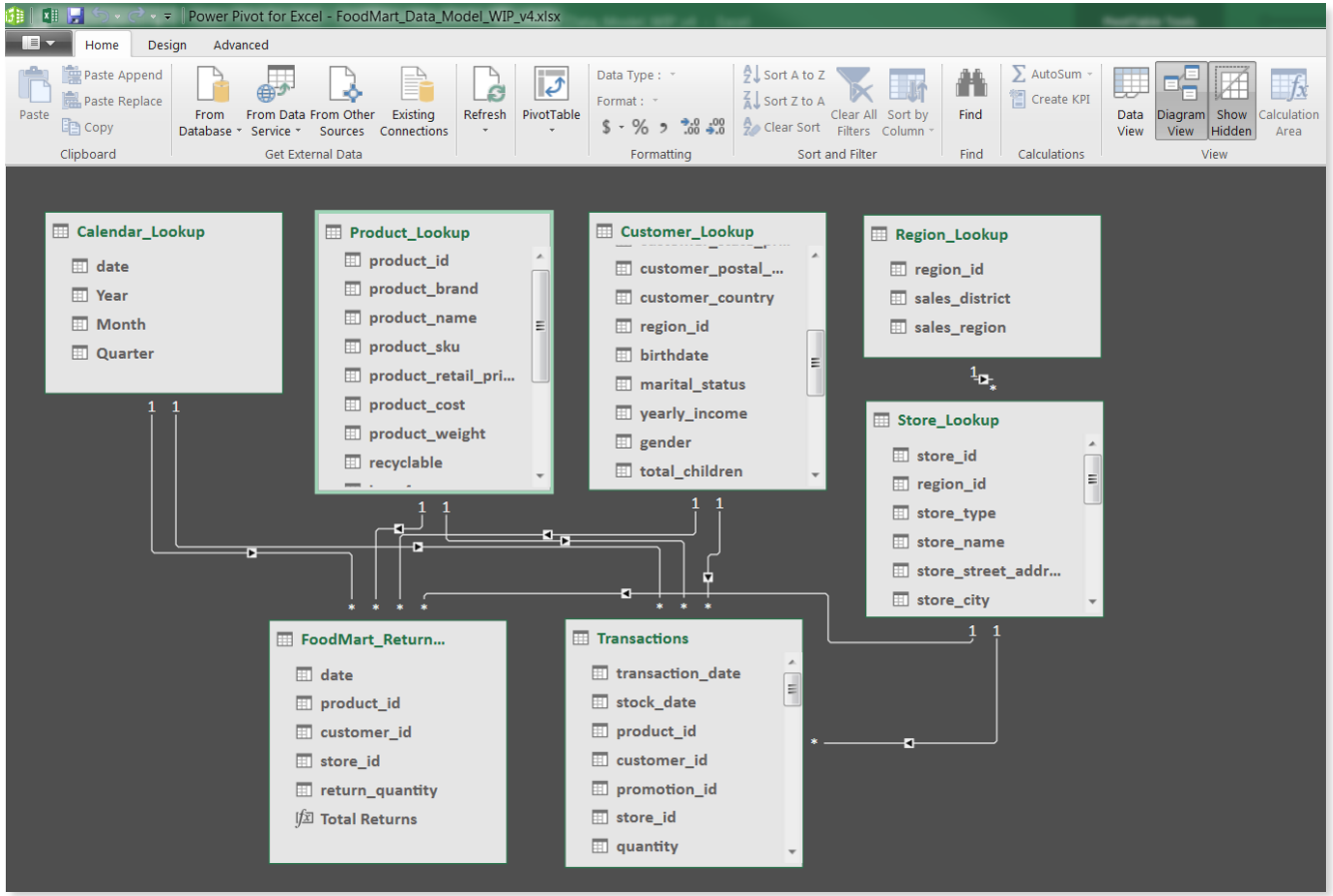
#2: BUILD DATA MODELS TO BLEND SOURCES



This is an example of a Data Model in "**Diagram View**", which allows you to create connections between tables

Instead of manually stitching tables together with cell formulas, you create ***relationships*** to blend data based on common fields

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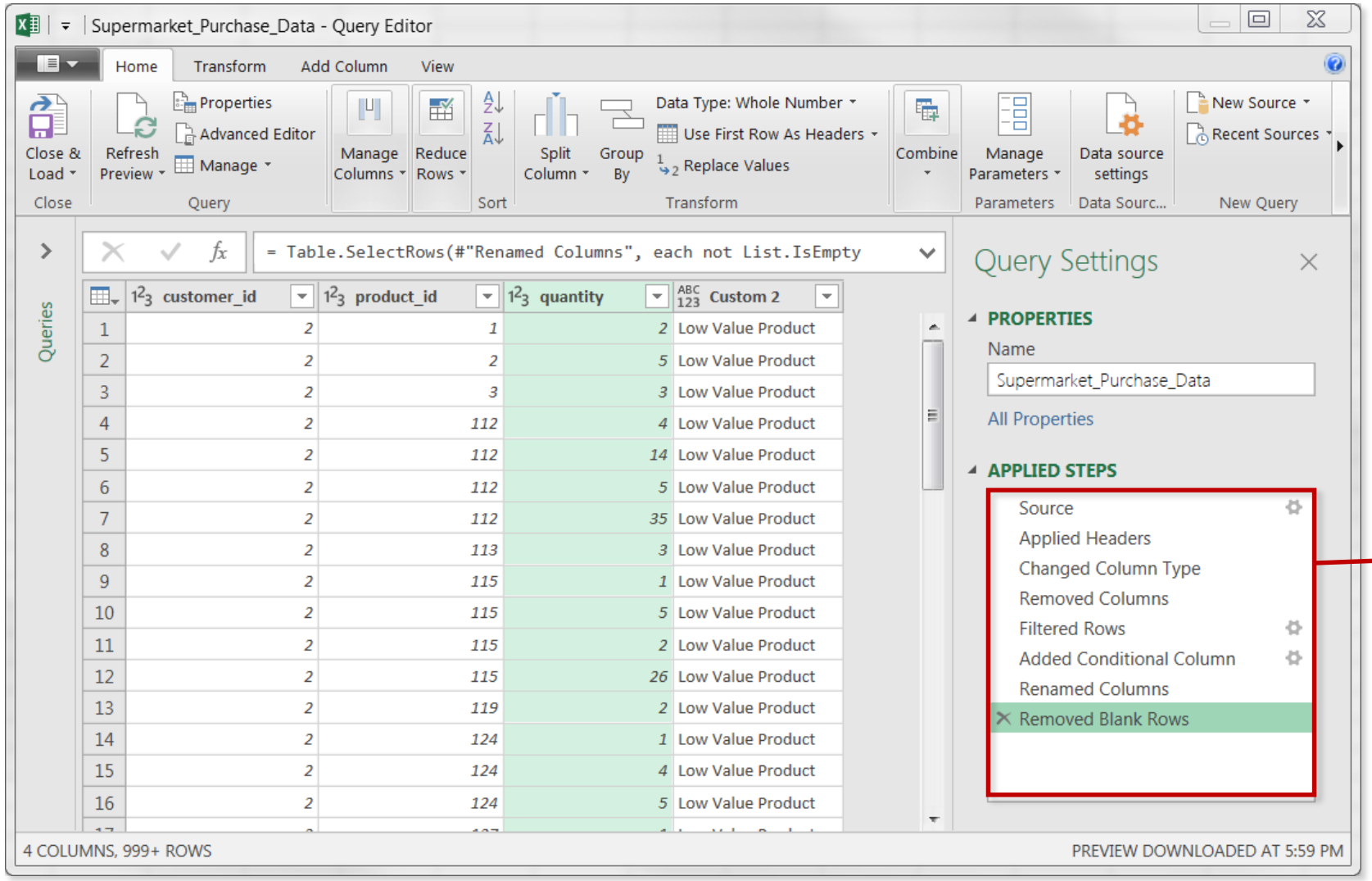
#3: AUTOMATE YOUR DATA PROCESSING



With Power Query, you can **filter**, **shape** and **transform** your raw data before loading it into the data model

Each step is **automatically recorded** and **saved with the query**, and applied whenever the source data is refreshed – like a macro!

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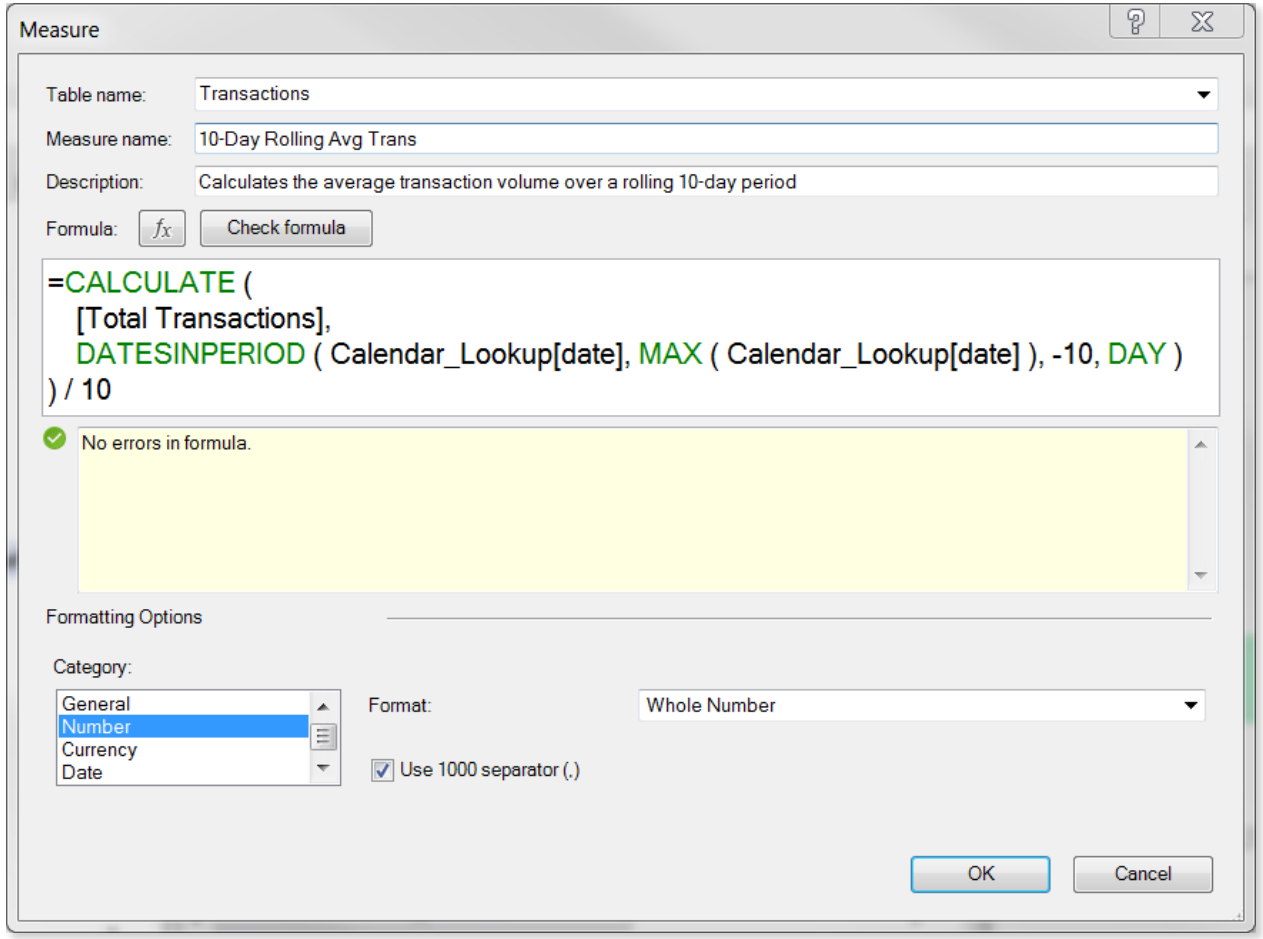
#4: CREATE POWERFUL MEASURES WITH DAX



Measures are flexible and powerful calculations defined using **Data Analysis Expressions (DAX)**

In this case we're using a DAX time intelligence formula to calculate a **10-day rolling average**

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WHEN TO USE POWER QUERY & POWER PIVOT

*Use **Power Query** and **Power Pivot** when you want to…*

- Analyze more data than can fit into a worksheet
- Create connections to databases or external sources
- Blend data across multiple large tables
- Automate the process of loading and shaping your data
- Unleash the **full business intelligence capabilities** of Excel

POWER QUERY

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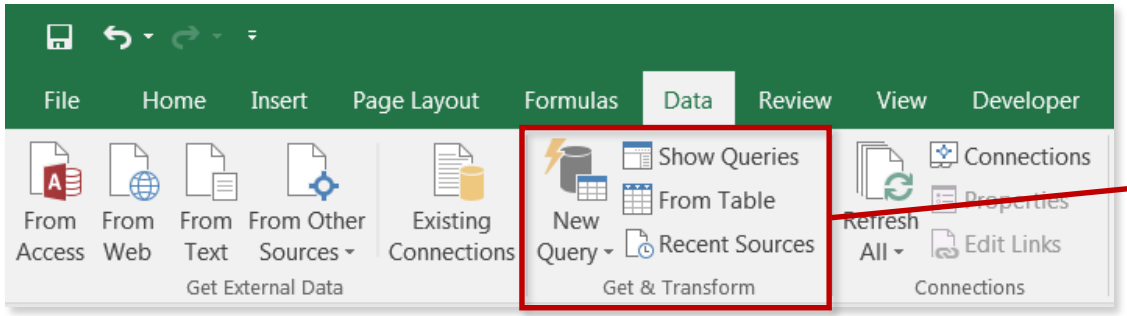
MEET POWER QUERY

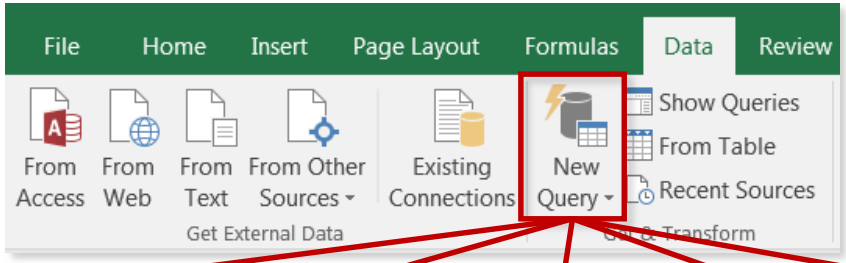
Power Query (aka "**Get & Transform**") allows you to:

- Connect to data across a wide range of sources
- Filter, shape, append and transform raw data for further analysis and modeling
- Create stored procedures to automate your data prep (*like a macro!)*



The Power Query tools live in the **Data** tab, under the "**Get & Transform**" section (Excel 2016)

TYPES OF DATA CONNECTIONS



From File

- From Workbook
- From CSV
- From XML
- From Text
- From JSON
- From Folder
- From SharePoint Folder

From Database

- From SQL Server Database
- From Microsoft Access Database
- From SQL Server Analysis Services Database
- From Oracle Database
- From IBM DB2 Database
- From MySQL Database
- From PostgreSQL Database
- From Sybase Database
- From Teradata Database
- From SAP HANA Database

FromAzure

- From Microsoft Azure SQL Database
- From Microsoft Azure SQL Data Warehouse
- From Microsoft Azure Marketplace
- From Microsoft Azure HDInsight
- From Microsoft Azure Blob Storage
- From Microsoft Azure Table Storage

From Online Services

- From SharePoint Online List
- From Microsoft Exchange Online
- From Dynamics CRM Online
- From Facebook
- From Salesforce Objects
- From Salesforce Reports

From Other Sources

- From Web
- From SharePoint List
- From OData Feed
- From Hadoop File (HDFS)
- From Active Directory
- From Microsoft Exchange
- From ODBC
- From OLEDB
- Blank Query

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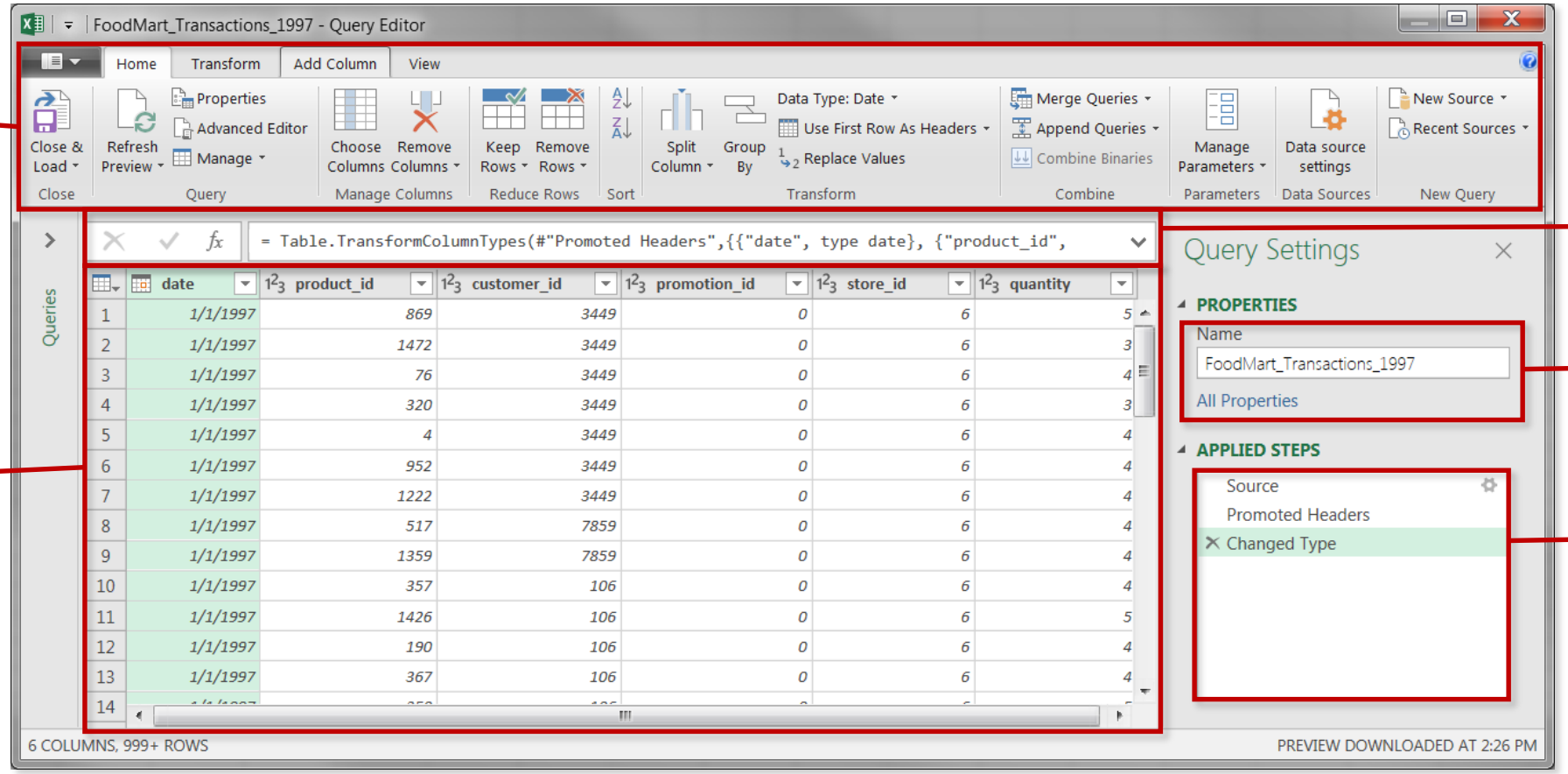
THE QUERY EDITOR



	date	product_id	customer_id	promotion_id	store_id	quantity
1	1/1/1997	869	3449	0	6	5
2	1/1/1997	1472	3449	0	6	3
3	1/1/1997	76	3449	0	6	4
4	1/1/1997	320	3449	0	6	3
5	1/1/1997	4	3449	0	6	4
6	1/1/1997	952	3449	0	6	4
7	1/1/1997	1222	3449	0	6	4
8	1/1/1997	517	7859	0	6	4
9	1/1/1997	1359	7859	0	6	4
10	1/1/1997	357	106	0	6	4
11	1/1/1997	1426	106	0	6	5
12	1/1/1997	190	106	0	6	4
13	1/1/1997	367	106	0	6	4
14						

Query Editing Tools

Data Preview

Formula Bar
(this is "M" code)

Name your table!

Applied Steps

Access the **Query Editor** by creating a new query and choosing the "*Edit*" option, or by launching the Workbook Queries pane (***Data*** > ***Show Queries***) and right-clicking an existing query to edit

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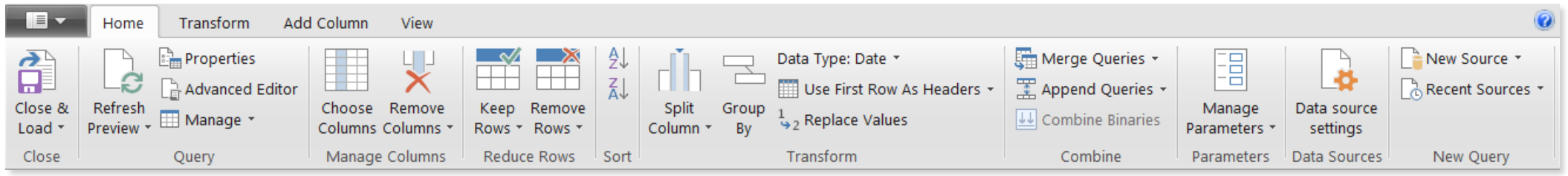
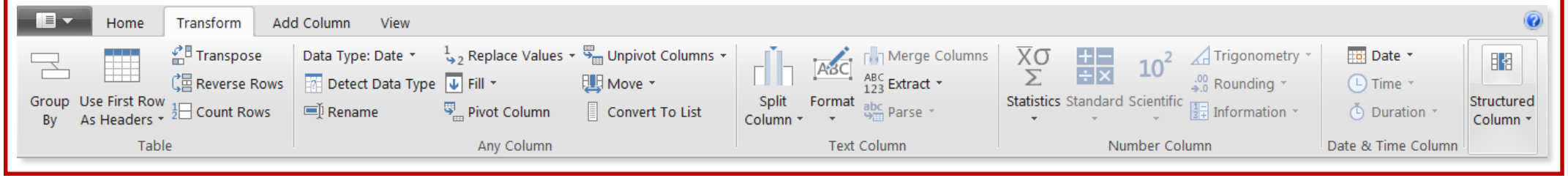
QUERY EDITOR TOOLS

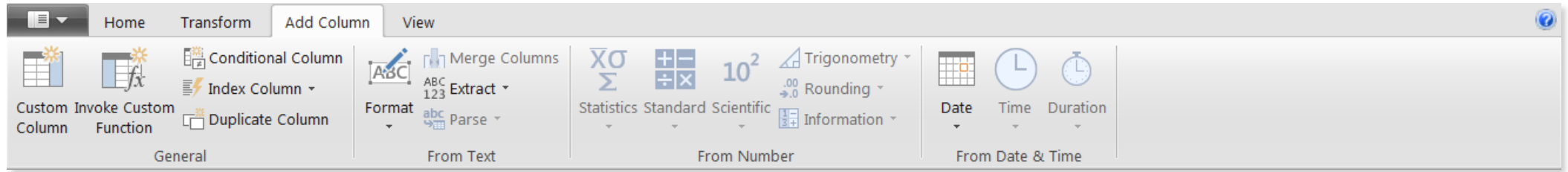
*The **HOME** tab includes **general settings** and **common table transformation tools***



*The **TRANSFORM** tab includes tools to **modify existing columns** (splitting/grouping, transposing, extracting text, etc.*



*The **ADD COLUMN** tools **create new columns** based on conditional rules, text operations, calculations, dates, etc.*



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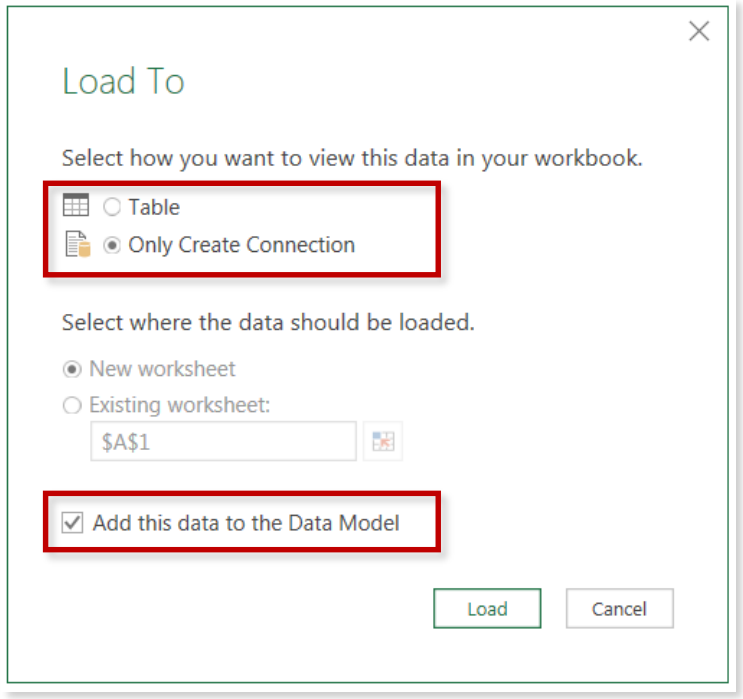
DATA LOADING OPTIONS



When you load data from Power Query, you have several options:

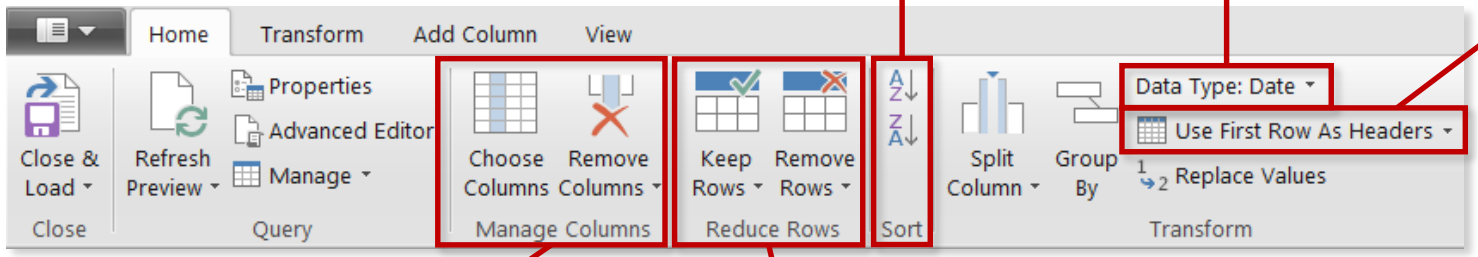
- **Table**
  - *Stores the data in a new or existing worksheet*
  - *Requires relatively small data sets (<1mm rows)*
- **Connection Only**
  - *Saves the data connection settings and applied steps*
  - *Data does not load to a worksheet*
- **Add to Data Model**
  - *Compresses and loads data to Excel's Data Model*
  - *Makes data accessible to Power Pivot for further analysis*

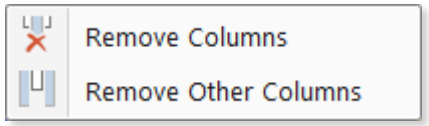
BASIC TABLE TRANSFORMATIONS

Sort values
(*A-Z, Low-High, etc.*)

Change data types
(*date, $, %, text, etc.*)

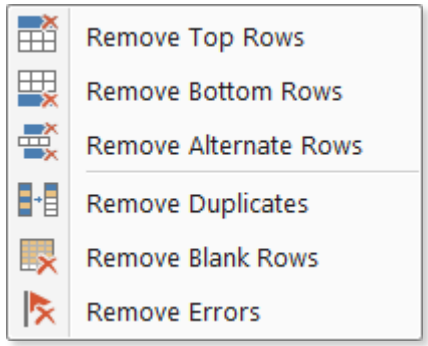
Promote header row





Keep or remove columns

Tip: *use the "Remove Other Columns" option if you always want a specific set*

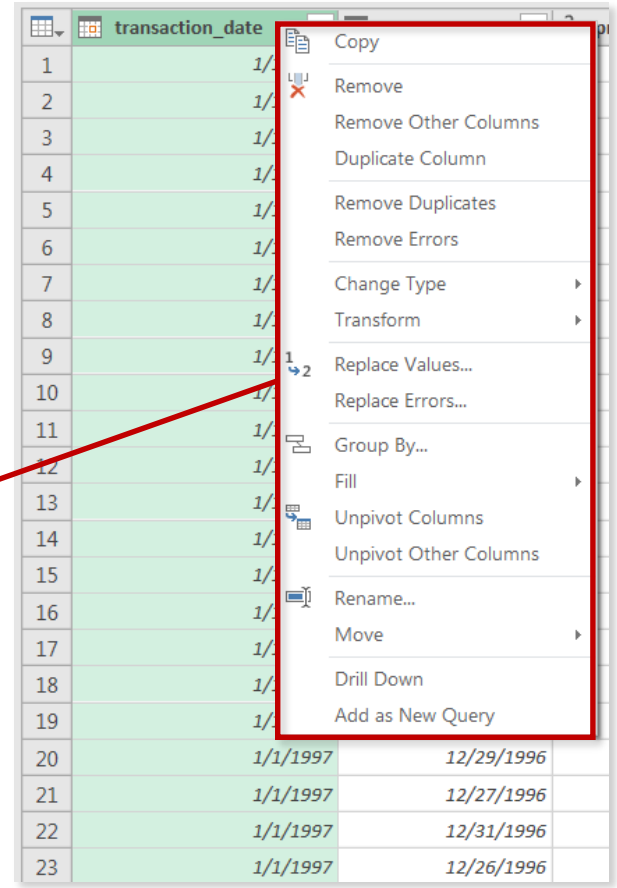


Keep or remove rows

Tip: *use the "Remove Duplicates" option to create a new lookup table from scratch*

Duplicate, move & **rename** columns

Tip: *Right-click the column header to access common tools*



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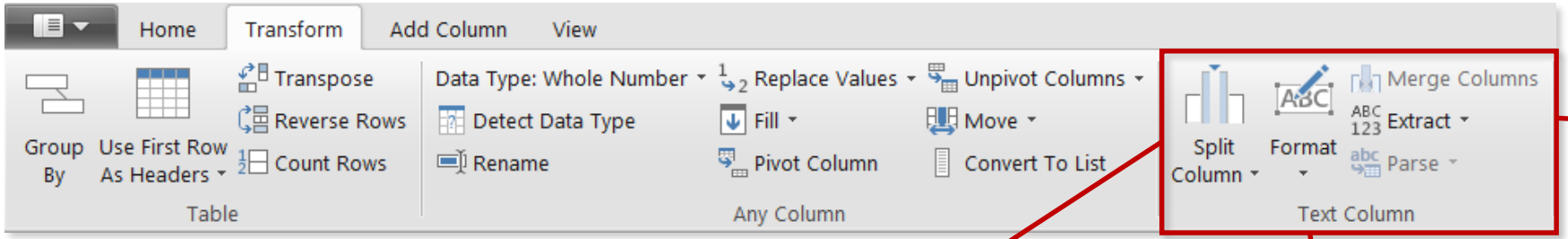
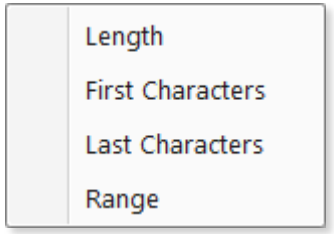
TEXT-SPECIFIC TOOLS

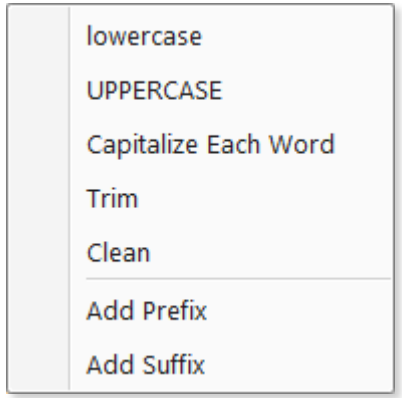


Split a text column based on either a specific delimiter or a number of characters



Extract characters from a text column using a fixed length, first or last, or a defined range

***Tip**: Select two or more columns to **merge** or **concatenate** fields*



Format a text column to upper, lower or proper case, or add a prefix or suffix

***Tip:** Use "Trim" to eliminate leading & trailing spaces, or "Clean" to remove non-printable characters*

HEY THIS IS IMPORTANT!

You can access many of these tools in both the "**Transform**" and "**Add Column**" menus -- the difference is whether you want to ***add a new column*** or ***modify an existing one***

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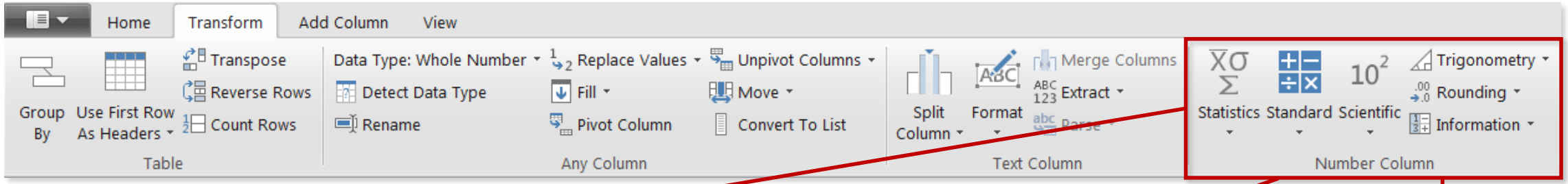
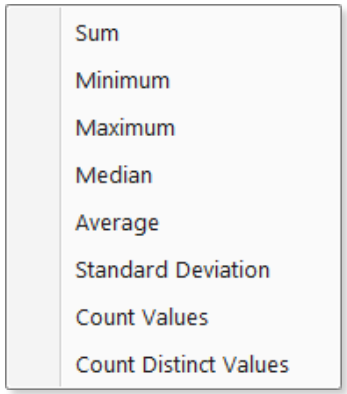
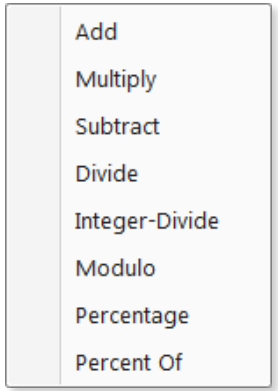
NUMBER-SPECIFIC TOOLS



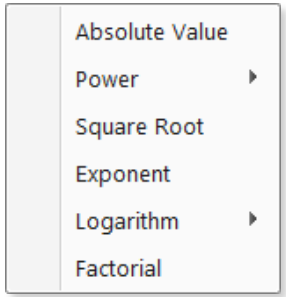


Statistics functions allow you to evaluate basic stats for the selected column (sum, min/max, average, count, countdistinct, etc)

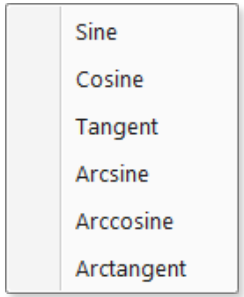
Note: *These tools return a SINGLE value, and are commonly used to explore a table rather than prepare it for loading*



Standard



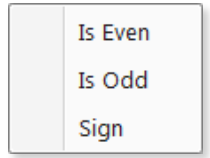
Scientific



Trigonometry

Standard, Scientific and **Trigonometry** tools allow you to apply standard operations (addition, multiplication, division, etc.) or more advanced calculations (power, logarithm, sine, tangent, etc) to each value in a column

Note: *Unlike the Statistics options, these tools are applied to each individual row in the table*



Information tools allow you to define binary flags (*TRUE/FALSE or 1/0*) to mark each row in a column as even, odd, positive or negative

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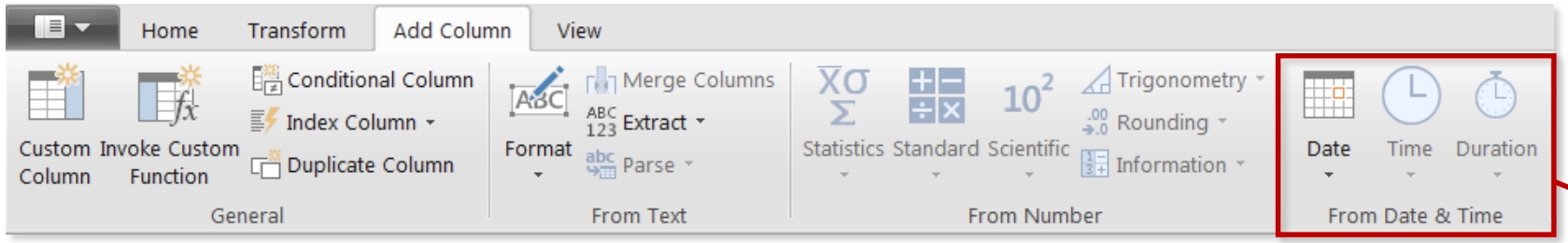
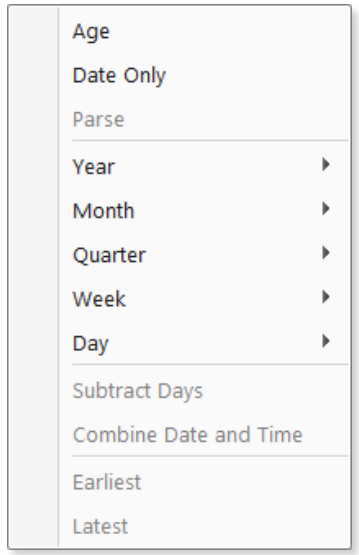
DATE-SPECIFIC TOOLS





Date & Time tools are relatively straight-forward, and include the following options:

- **Age**: Difference between the current time and the date in each row
- **Date Only:** Removes the time component of a date/time field
- **Year/Month/Quarter/Week/Day**: Extracts individual components from a date field (Time-specific options include Hour, Minute, Second, etc.)
- **Earliest/Latest:** Evaluates the earliest or latest date from a column as a single value (can only be accessed from the "Transform" menu)

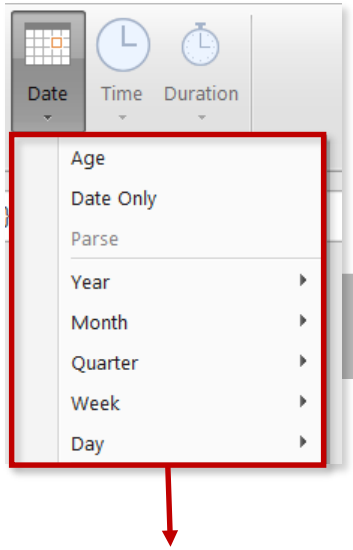
Note: *You will almost always want to perform these operations from the "Add Column" menu to build out new fields, rather than transforming an individual date/time column*

PRO TIP:

*Load up a table containing a **single date column** and use Date tools to build out an **entire calendar table***

CREATING A BASIC CALENDAR TABLE

	date
1	1/1/1997
2	1/2/1997
3	1/3/1997
4	1/4/1997
5	1/5/1997
6	1/6/1997
7	1/7/1997
8	1/8/1997
9	1/9/1997
10	1/10/1997
11	1/11/1997
12	1/12/1997
13	1/13/1997
14	1/14/1997
15	1/15/1997
16	1/16/1997
17	1/17/1997
18	1/18/1997
19	1/19/1997
20	1/20/1997
21	1/21/1997
22	1/22/1997
23	1/23/1997



Use pre-defined **Date** options in the "**Add Column**" menu to quickly build out a calendar table from a list of dates

	date	Year	Month	Quarter	WeekOfYear	Day Name
1	1/1/1997	1997	1	1	1	Wednesday
2	1/2/1997	1997	1	1	1	Thursday
3	1/3/1997	1997	1	1	1	Friday
4	1/4/1997	1997	1	1	1	Saturday
5	1/5/1997	1997	1	1	2	Sunday
6	1/6/1997	1997	1	1	2	Monday
7	1/7/1997	1997	1	1	2	Tuesday
8	1/8/1997	1997	1	1	2	Wednesday
9	1/9/1997	1997	1	1	2	Thursday
10	1/10/1997	1997	1	1	2	Friday
11	1/11/1997	1997	1	1	2	Saturday
12	1/12/1997	1997	1	1	3	Sunday
13	1/13/1997	1997	1	1	3	Monday
14	1/14/1997	1997	1	1	3	Tuesday
15	1/15/1997	1997	1	1	3	Wednesday
16	1/16/1997	1997	1	1	3	Thursday
17	1/17/1997	1997	1	1	3	Friday
18	1/18/1997	1997	1	1	3	Saturday
19	1/19/1997	1997	1	1	4	Sunday
20	1/20/1997	1997	1	1	4	Monday
21	1/21/1997	1997	1	1	4	Tuesday
22	1/22/1997	1997	1	1	4	Wednesday
23	1/23/1997	1997	1	1	4	Thursday

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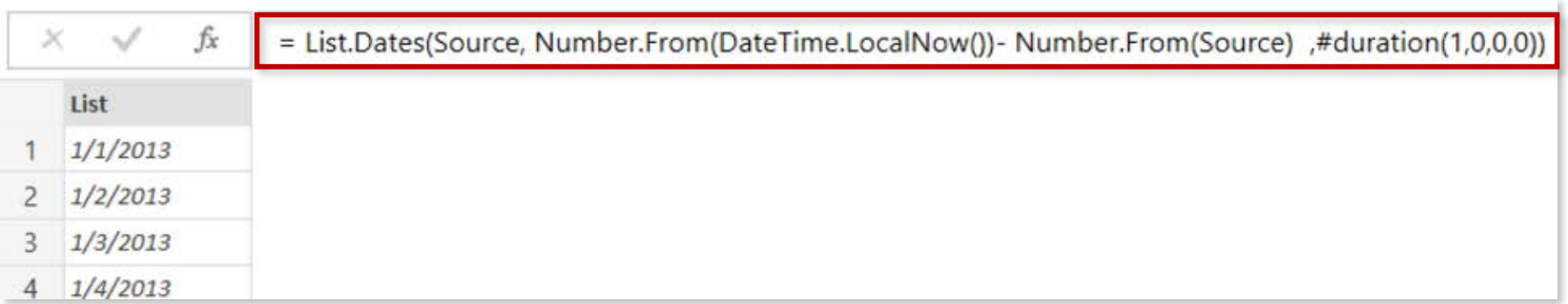
PRO TIP: CREATING A ROLLING CALENDAR

1) Create a new, blank query (***Data*** > ***New Query*** > ***From Other Sources*** > ***Blank Query***)

2) In the formula bar, generate a starting date by entering a "**literal**" (*1/1/2013 shown below*):

3) Click the **fX** icon to add a new custom step, and enter the following formula *exactly* as shown:

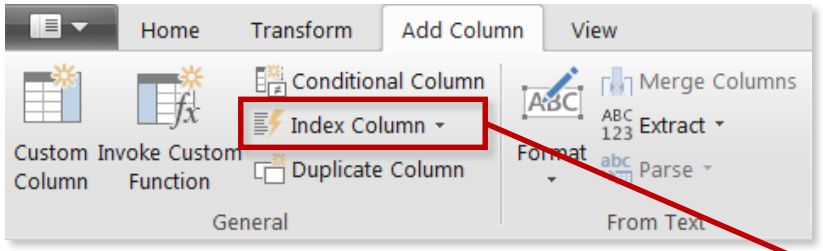


4) Convert the resulting list into a Table (***List Tools*** > ***To Table***) and format the column as a **Date**

5) Add calculated Date columns (*Year, Month, Week, etc.*) as necessary using the **Add Column** tools

EXCEL MAVEN

ADDING AN INDEX COLUMN



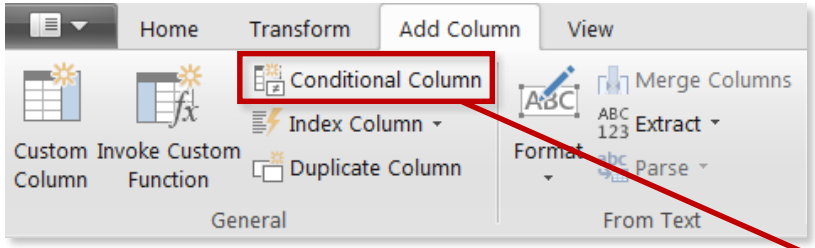
Index Columns contain a list of sequential values that can be used to identify each unique row in a table (*typically starting from 0 or 1*)

These columns are often used to create **unique IDs** that can be used to form relationships between tables (*more on that later!*)

	Index	transaction_date	stock_date	product_id	customer_id	promotion_id	st
1	0	1/1/1997	12/28/1996	761	6613	0	
2	1	1/1/1997	12/30/1996	1435	8830	0	
3	2	1/1/1997	12/29/1996	1175	8830	0	
4	3	1/1/1997	12/30/1996	1152	8830	0	
5	4	1/1/1997	12/31/1996	1245	5005	0	
6	5	1/1/1997	12/27/1996	209	5005	0	
7	6	1/1/1997	12/28/1996	1345	5005	0	
8	7	1/1/1997	12/28/1996	1468	5005	0	
9	8	1/1/1997	12/26/1996	84	7962	0	
10	9	1/1/1997	12/30/1996	966	7962	0	
11	10	1/1/1997	12/27/1996	1022	7962	0	
12	11	1/1/1997	12/29/1996	440	7962	0	
13	12	1/4/1997	12/28/1996	151	2274	1054	
14	13	1/4/1997	12/28/1996	1287	8648	1054	
15	14	1/4/1997	12/30/1996	1264	8648	1054	
16	15	1/4/1997	12/31/1996	188	8648	1054	
17	16	1/4/1997	1/1/1997	1526	8648	1054	
18	17	1/4/1997	12/29/1996	518	8762	1054	
19	18	1/5/1997	12/31/1996	963	4018	0	
20	19	1/5/1997	12/29/1996	154	1418	0	
21							

EXCEL MAVEN

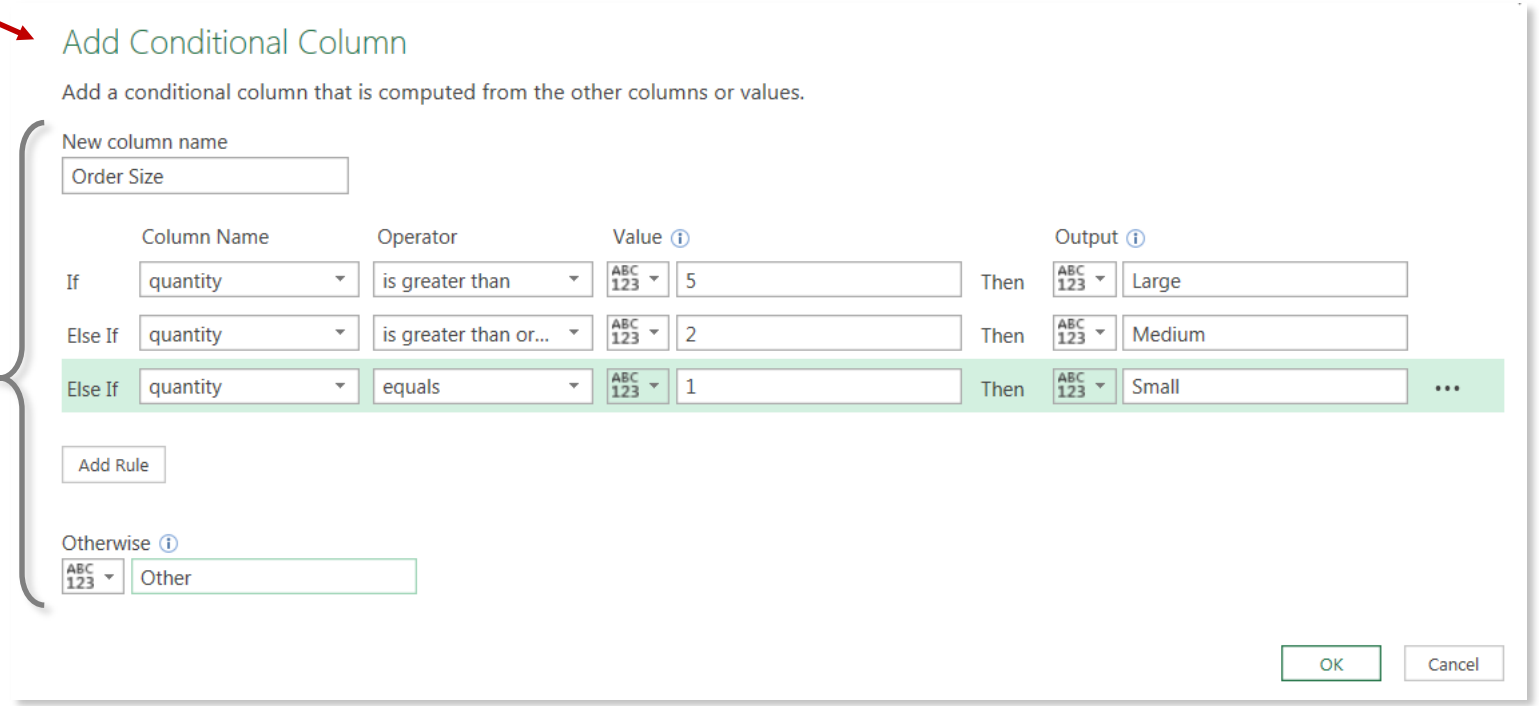
ADDING A CONDITIONAL COLUMN



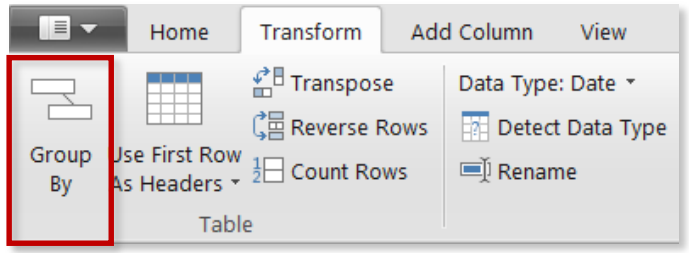
Conditional Columns allow you to define new fields based on logical rules and conditions (*IF/THEN statements*)

*In this case we're creating a new conditional column called "**Order Size**", which depends on the values in the "**quantity**" column, as follows:*

- *If quantity **>5**, Order Size = "**Large**"*
- *If quantity is **from 2-5**, Order Size = "**Medium**"*
- *If quantity **=1**, Order Size = "**Small**"*
- *Otherwise Order Size = "**Other**"*

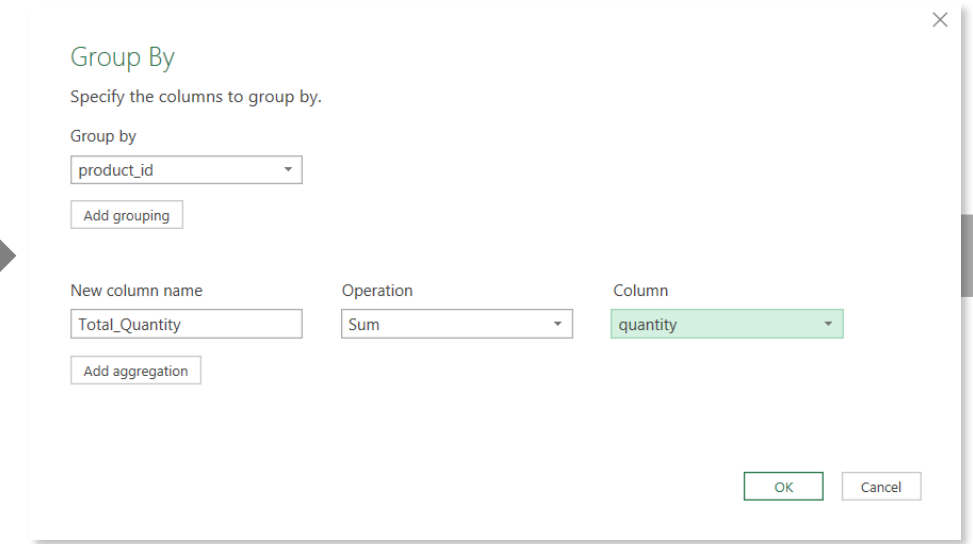


GROUPING & AGGREGATING DATA



Group By allows you to aggregate your data at a different level
(*i.e. transform daily data into monthly, roll up transaction-level data by store, etc.*)

	transaction_date	stock_date	product_id	customer_id	store_id	quantity
1	8/12/1997	8/7/1997	1	3441	3	3
2	6/17/1997	6/12/1997	1	456	15	4
3	9/20/1997	9/15/1997	1	10140	17	3
4	1/3/1997	12/29/1996	1	4728	7	4
5	7/29/1997	7/24/1997	1	7704	3	2
6	11/28/1997	11/23/1997	1	2270	11	3
7	5/3/1997	4/28/1997	1	1312	3	3
8	9/19/1997	9/14/1997	1	9652	14	2
9	2/17/1997	2/12/1997	1	6666	17	3
10	11/11/1997	11/6/1997	1	3065	3	2
11	12/22/1997	12/17/1997	1	4707	11	3
12	8/16/1997	8/11/1997	1	6248	24	4
13	9/7/1997	9/2/1997	1	1565	24	3
14	12/20/1997	12/15/1997	1	157	24	3
15	6/12/1997	6/7/1997	1	5607	6	4
16	4/7/1997	4/2/1997	1	916	7	4
17	1/11/1997	1/6/1997	1	9788	13	3
18	12/27/1997	12/22/1997	1	8202	3	3
19	7/23/1997	7/18/1997	1	923	15	3
20	5/14/1997	5/9/1997	1	9169	23	4
21	10/6/1997	10/1/1997	1	3528	17	3
22	8/18/1997	8/13/1997	1	5929	15	5
23	4/18/1997	4/13/1997	1	4461	11	3



	product_id	Total_Quantity
1	4	304
2	11	322
3	12	372
4	14	325
5	16	319
6	23	368
7	46	355
8	50	313
9	56	318
10	59	336
11	61	314
12	75	321
13	89	321
14	90	323
15	112	357
16	115	356
17	119	329
18	120	325
19	126	352
20	127	353
21	130	384
22	139	332
23	159	394

*In this case we're transforming a daily, transaction-level table into a summary of "**quantity**" by "**product_id**"*

Note that we lose any field not specified in the Group By settings

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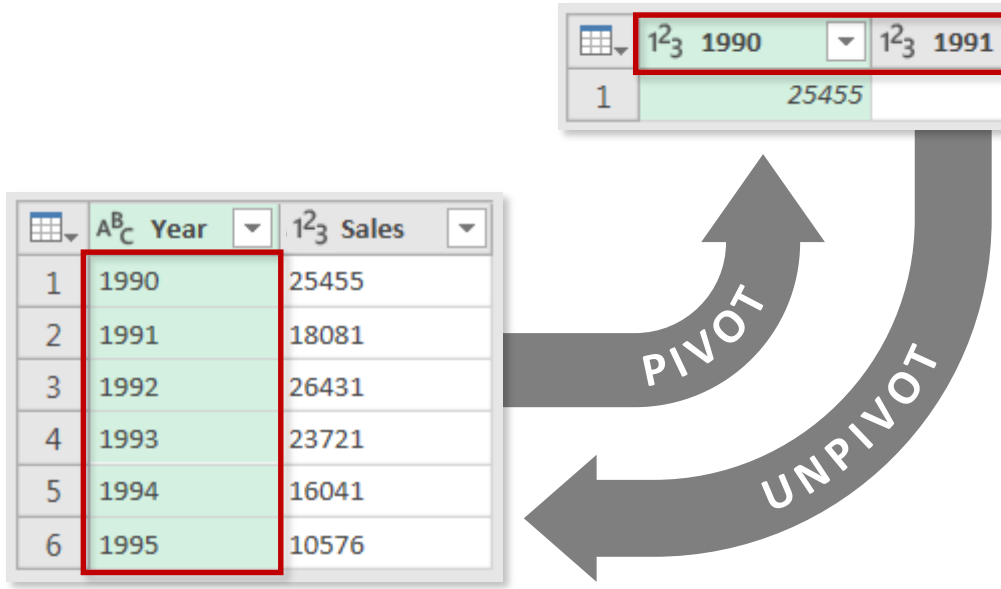
PIVOTING & UNPIVOTING

“Pivoting” is a fancy way to describe the process of turning **distinct row values** into **columns** (*“pivoting”*) or turning **columns** into **rows** (*“unpivoting”*)

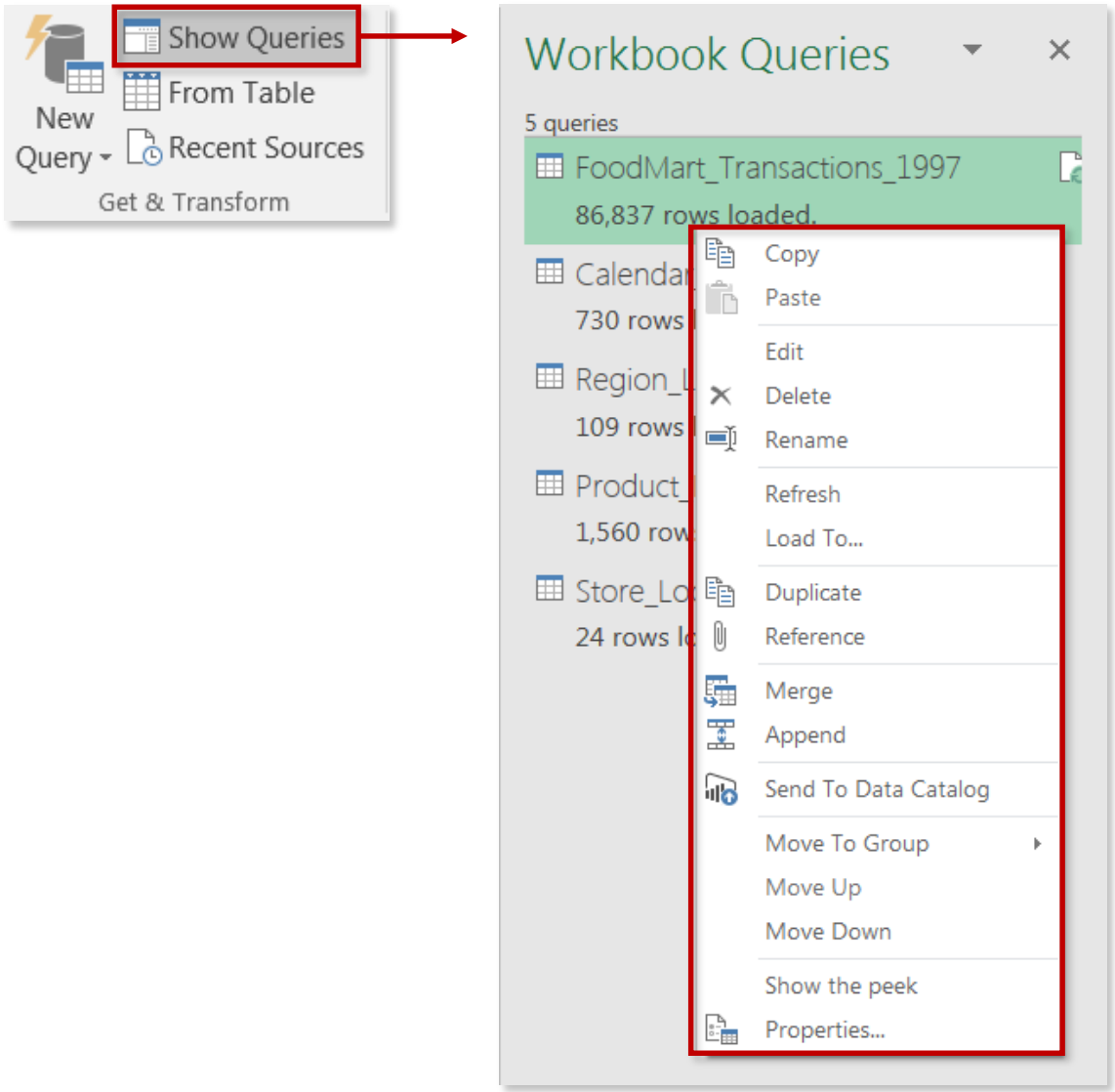


*Imagine that the table is on a hinge; pivoting is like rotating it from a **vertical** to a **horizontal** layout, and unpivoting is like rotating it from **horizontal** to **vertical***

***NOTE: Transpose** works very similarly, but doesn’t recognize unique values; instead, the entire table is transformed so that each row becomes a column and vice versa*

EXCEL MAVEN

MODIFYING WORKBOOK QUERIES

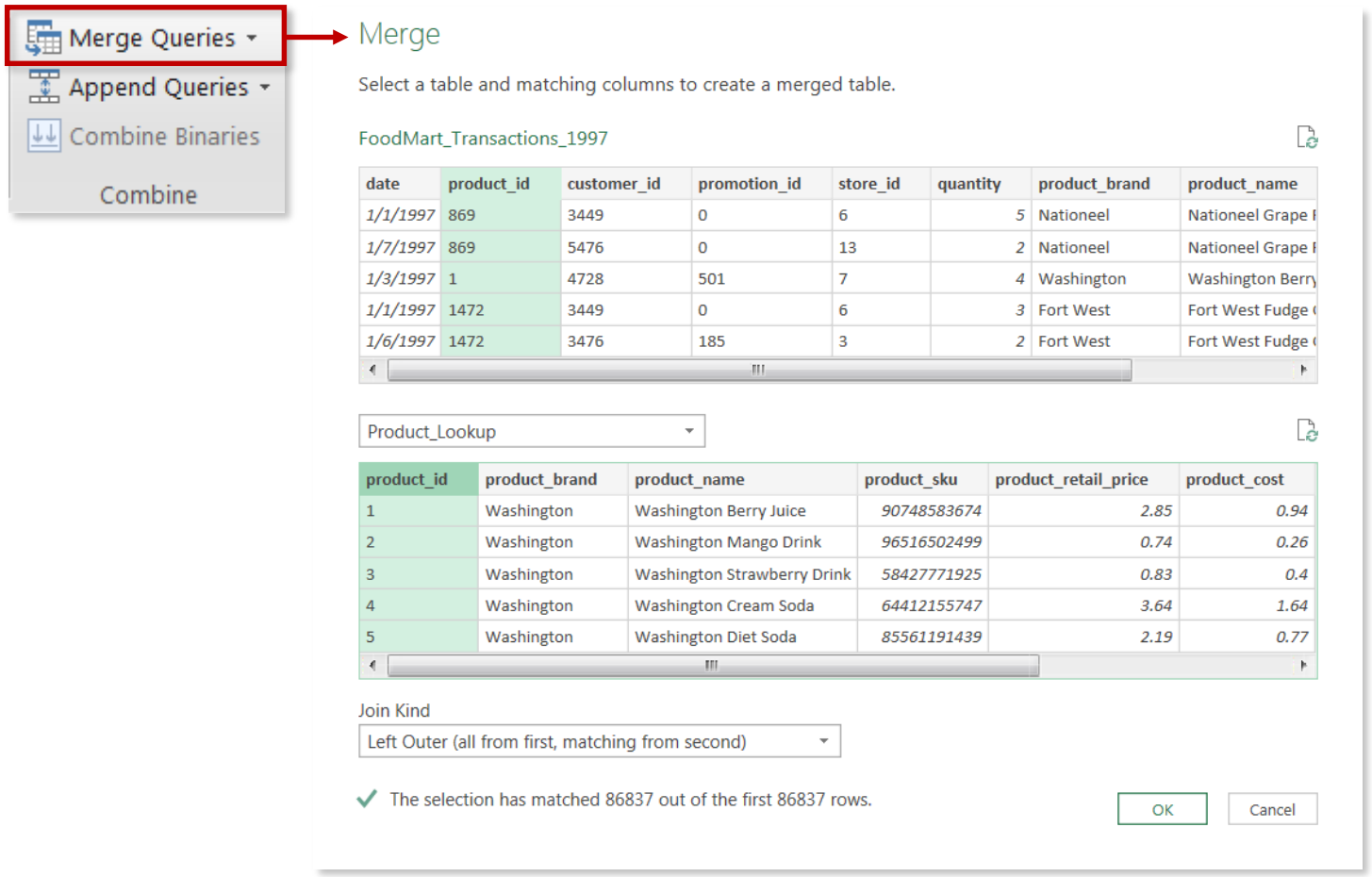


Click on **Show Queries** to launch the **Workbook Queries** pane

Right-click any individual query to access common options and tools:

- **Edit** (launches the Query Editor)
- **Delete**
- **Rename**
- **Refresh**
- **Duplicate**
- **Merge**
- **Append**

MERGING QUERIES



- Merging queries allows you to **join tables** based on a common column (like VLOOKUP)

- In this case we're merging the **FoodMart_Transactions_1997** table with the **Product_Lookup** table, which share a "*product_id*" column

TIP: Merging **adds columns** to an existing table

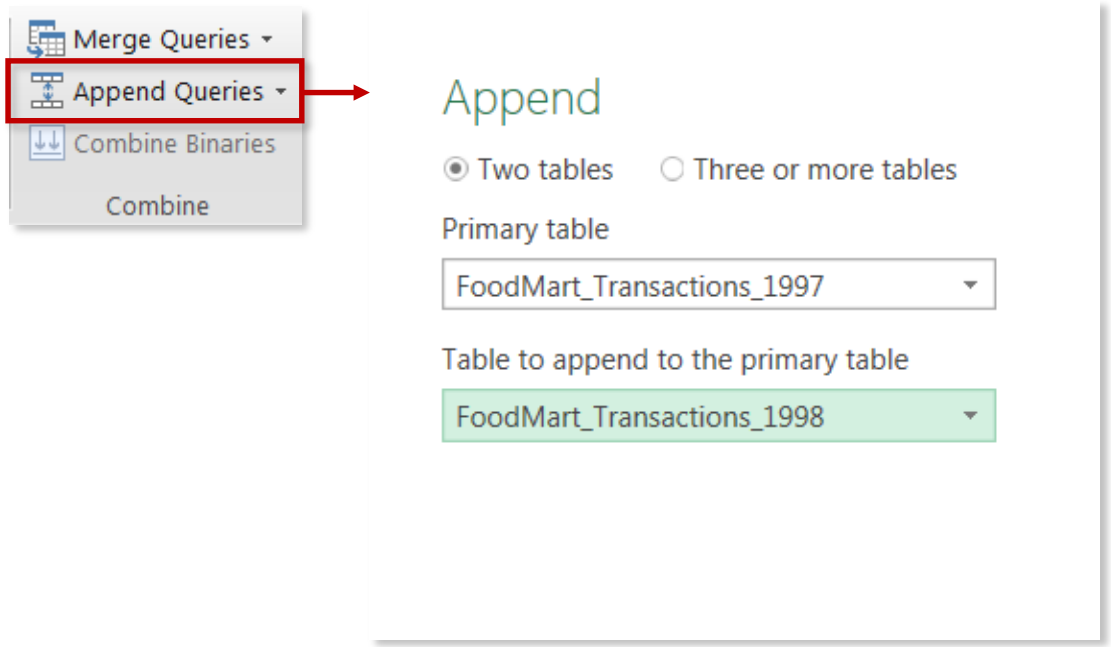
HEY THIS IS IMPORTANT!

Just because you ***can*** merge tables, doesn't mean you ***should***.

In general, it's better to keep tables separate and define **relationships** between them (*more on that later!*)

EXCEL MAVEN

APPENDING QUERIES



- Appending queries allows you to **combine** (or ***stack***) tables that share a common structure and set of columns

- In this case we're appending the **FoodMart_Transactions_1998** table to the **FoodMart_Transactions_1997** table, since they contain the same set of columns and data types

TIP: Appending **adds rows** to an existing table

PRO TIP:

*Use the "**From Folder**" query option to automatically append all files from within the same folder*

POWER QUERY BEST PRACTICES

Give your queries clear and intuitive names, *before* loading the data

- *Define names immediately; updating query & table names later can be a headache, especially if you've already referenced them in calculated measures*
- *Don't use spaces in table names (otherwise you have surround them with single quotes)*

Do as much shaping as possible at the source of the data

- *Shaping data at the source (i.e. SQL, Access) minimizes the need for complex procedures in Power Query, and allows you to create new models without replicating the same process*

When working with large tables, only load the data you need

- *Don't include hourly data when you only need daily, or product-level transactions when you only care about store-level performance; extra data will only slow you down*

EXCEL MAVEN

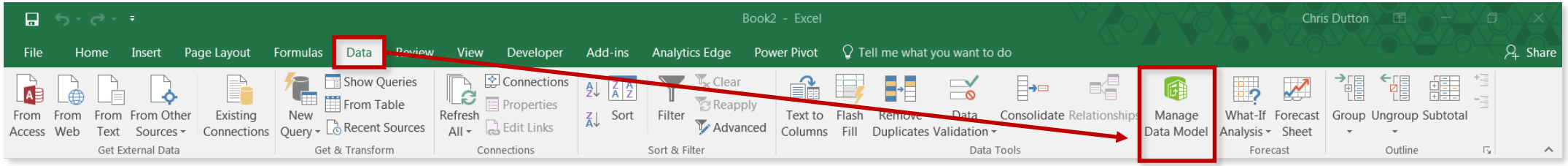
DATA MODELING 101

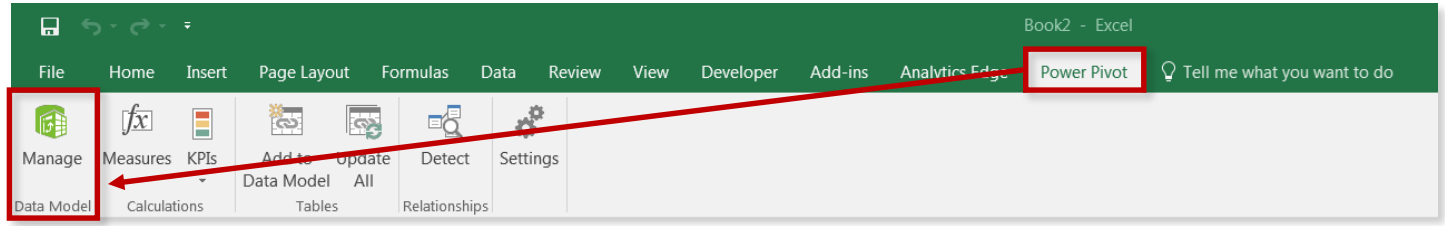
EXCEL MAVEN

MEET EXCEL'S DATA MODEL

The **Data Model** provides simple and intuitive tools for building relational databases directly in Excel. With the data model you can:

- Manage massive datasets that can't fit into worksheets
- Create table relationships to blend data across multiple sources
- Define custom hierarchies and perspectives



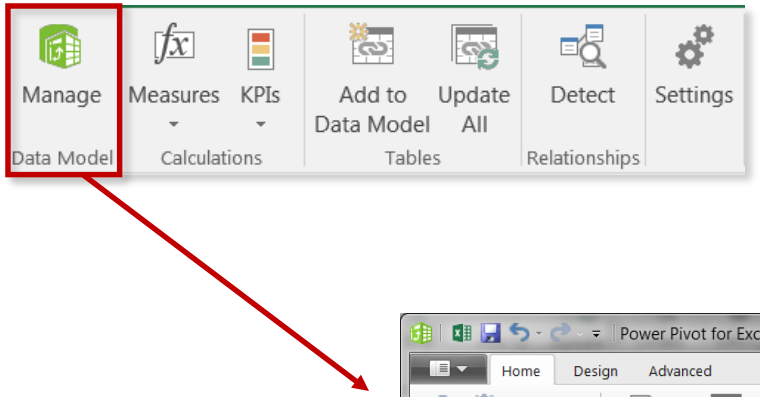


Access the **Data Model** through the **Power Pivot** tab or the **Data** tab

*(**Note:** you may need to enable the Power Pivot tab via **File > Options > Add-Ins > Manage COM Add-Ins**)*

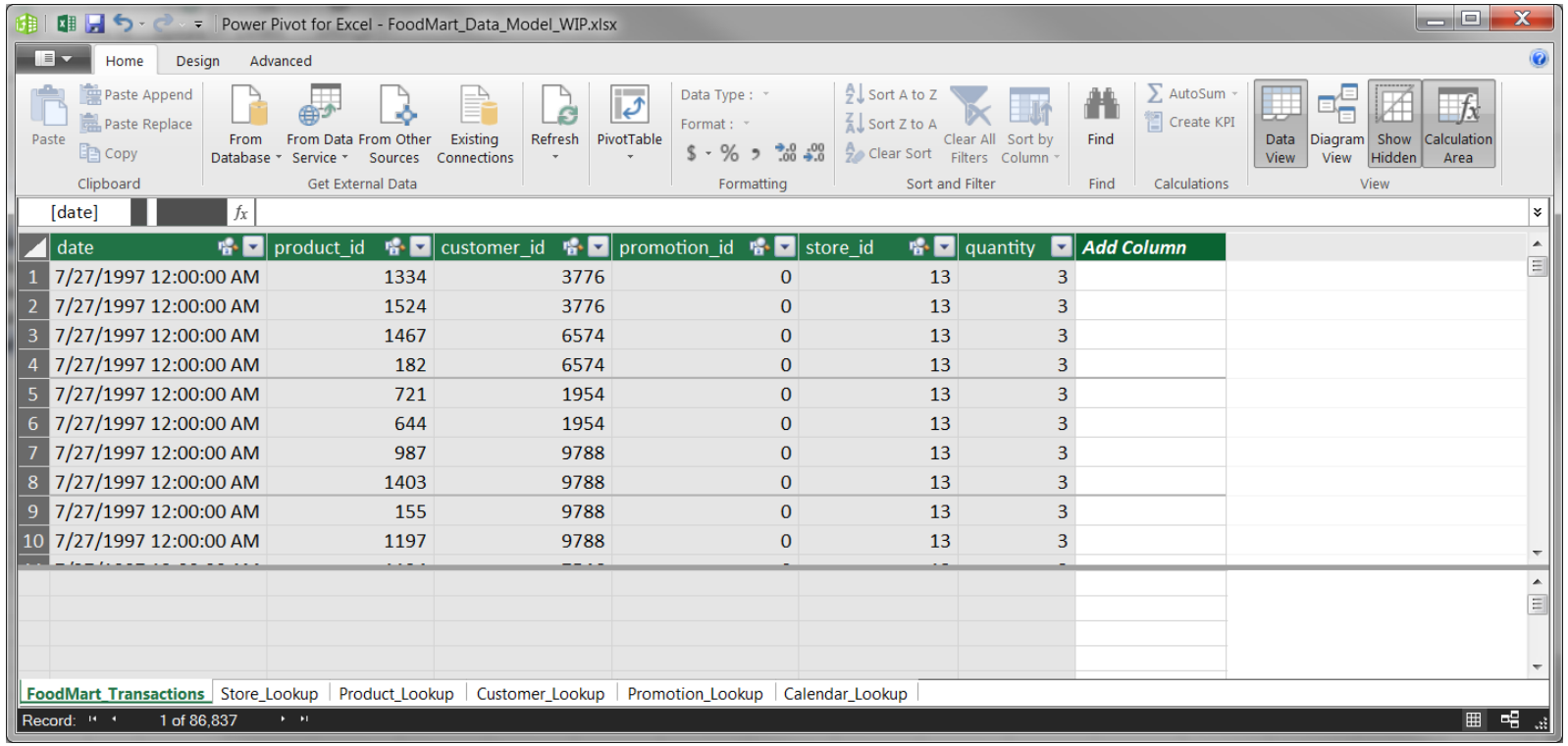
EXCEL MAVEN

THE DATA MODEL WINDOW



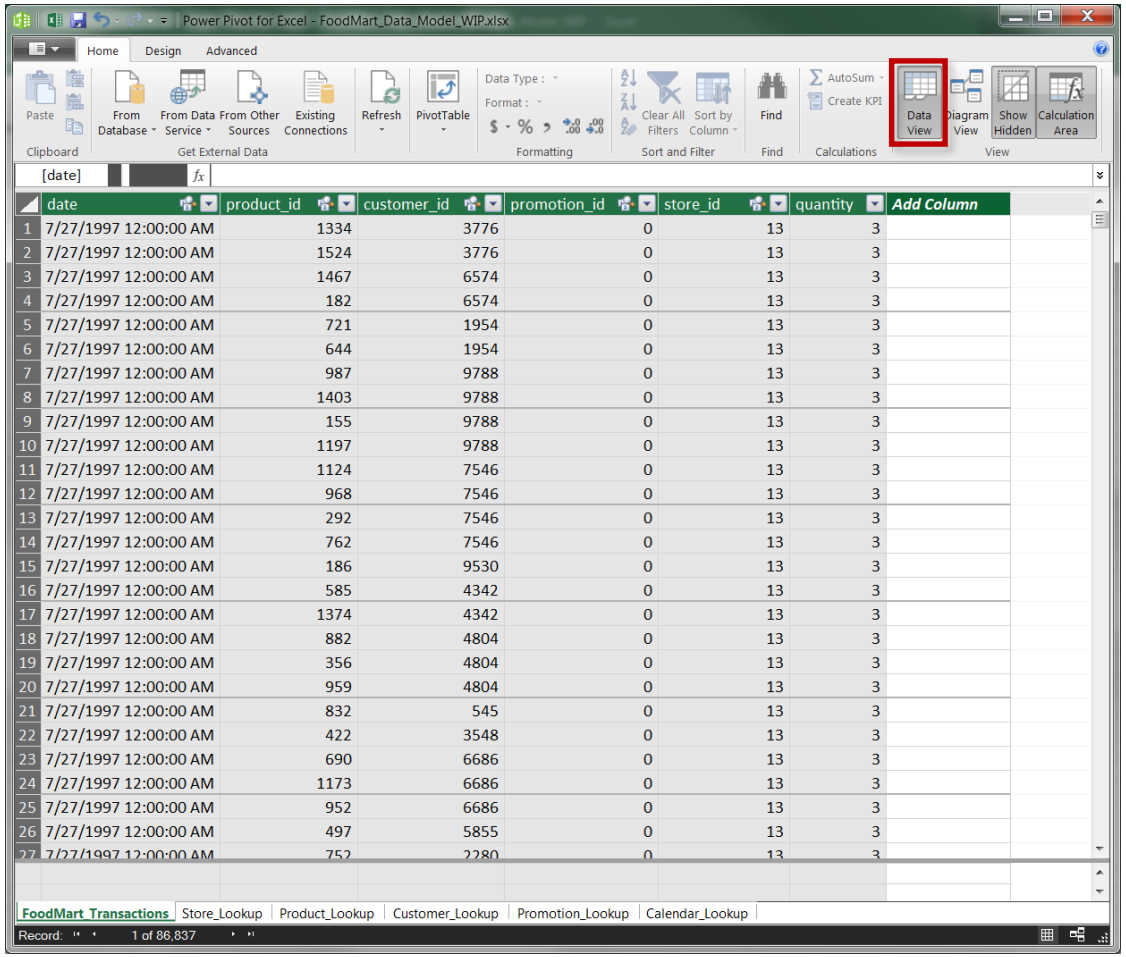
The **Data Model** opens in a separate Excel window, where you can view your data tables, calculate new measures, and define table relationships

Note: *Closing the Data Model window does NOT close your Excel workbook*



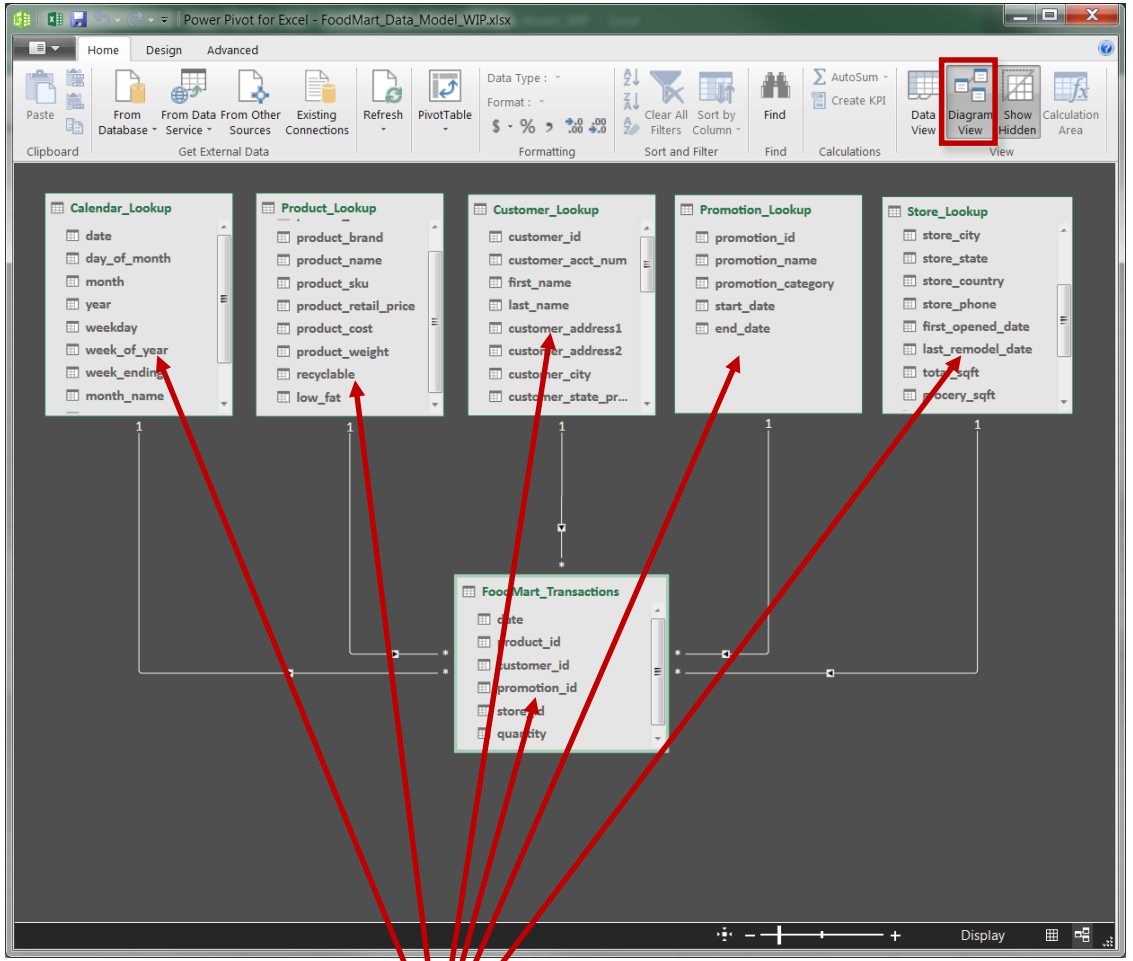
DATA VIEW VS. DIAGRAM VIEW

DATA VIEW



*Tables organized in **tabs***

DIAGRAM VIEW



*Tables organized as **objects***

EXCEL MAVEN

DATABASE NORMALIZATION

Normalization is the process of organizing the tables and columns in a relational database to reduce redundancy and preserve data integrity. It is commonly used to:

- **Eliminate redundant data** to decrease table sizes and improve processing speed & efficiency
- **Minimize errors and anomalies** from data modifications (inserting, updating or deleting records)
- **Simplify queries** and structure the database for meaningful analysis

In a normalized database, each table should serve a ***distinct*** and ***specific*** purpose (*i.e. product information, calendar fields, transaction records, customer attributes, etc.*)

date	product_id	quantity	product_brand	product_name	product_sku	product_weight
1/1/1997	869	5	Nationeel	Nationeel Grape Fruit Roll	52382137179	17
1/7/1997	869	2	Nationeel	Nationeel Grape Fruit Roll	52382137179	17
1/3/1997	1	4	Washington	Washington Berry Juice	90748583674	8.39
1/1/1997	1472	3	Fort West	Fort West Fudge Cookies	37276054024	8.28
1/6/1997	1472	2	Fort West	Fort West Fudge Cookies	37276054024	8.28
1/5/1997	2	4	Washington	Washington Mango Drink	96516502499	7.42
1/1/1997	76	4	Red Spade	Red Spade Sliced Chicken	62054644227	18.1
1/1/1997	76	2	Red Spade	Red Spade Sliced Chicken	62054644227	18.1
1/5/1997	3	2	Washington	Washington Strawberry Drink	58427771925	13.1
1/7/1997	3	2	Washington	Washington Strawberry Drink	58427771925	13.1
1/1/1997	320	3	Excellent	Excellent Cranberry Juice	36570182442	16.4

*When you **don't** normalize, you end up with tables like this; all of the duplicate product records could be eliminated with a lookup table based on **product_id***

This may not seem critical now, but minor inefficiencies can become major problems as databases scale in size

EXCEL MAVEN

DATA TABLES VS. LOOKUP TABLES

Models generally contain two types of tables: **data** (or "*fact*") tables, and **lookup** (or "*dimension*") tables

- **Data tables** contain numbers or values, typically at the most granular level possible, with ID or "*key*" columns that can be used to connect to each lookup table
- **Lookup tables** provide descriptive, often text-based attributes about each dimension in a table

date	product_id	quantity
1/1/1997	869	5
1/1/1997	1472	3
1/1/1997	76	4
1/1/1997	320	3
1/1/1997	4	4
1/1/1997	952	4
1/1/1997	1222	4
1/1/1997	517	4
1/1/1997	1359	4
1/1/1997	357	4
1/1/1997	1426	5
1/1/1997	190	4
1/1/1997	367	4
1/1/1997	250	5
1/1/1997	600	4
1/1/1997	702	5

*This **Data Table** contains "**quantity**" values, and connects to lookup tables via the "**date**" and "**product_id**" columns*

date	day_of_month	month	year	weekday	week_of_year	week_ending	month_name	quarter
1/1/1997	1	1	1997	Wednesday	1	1/5/1997	January	Q1
1/2/1997	2	1	1997	Thursday	1	1/5/1997	January	Q1
1/3/1997	3	1	1997	Friday	1	1/5/1997	January	Q1
1/4/1997	4	1	1997	Saturday	1	1/5/1997	January	Q1
1/5/1997	5	1	1997	Sunday	2	1/5/1997	January	Q1
1/6/1997	6	1	1997	Monday	2	1/12/1997	January	Q1

*This **Calendar Lookup** table provides additional attributes about each **date** (month, year, weekday, quarter, etc.)*

product_id	product_brand	product_name	product_sku	product_retail_price	product_cost	product_weigh
1	Washington	Washington Berry Juice	90748583674	2.85	0.94	8.39
2	Washington	Washington Mango Drink	96516502499	0.74	0.26	7.42
3	Washington	Washington Strawberry Drink	58427771925	0.83	0.4	13.1
4	Washington	Washington Cream Soda	64412155747	3.64	1.64	10.6
5	Washington	Washington Diet Soda	85561191439	2.19	0.77	6.66
6	Washington	Washington Cola	29804642796	1.15	0.37	15.8
7	Washington	Washington Diet Cola	20191444754	2.61	0.91	18
8	Washington	Washington Orange Juice	89770532250	2.59	0.8	8.97

*This **Product Lookup** table provides additional attributes about each **product** (brand, product name, sku, price, etc.)*

EXCEL MAVEN

PRIMARY & FOREIGN KEYS

date	product_id	quantity
1/1/1997	869	5
1/1/1997	1472	3
1/1/1997	76	4
1/1/1997	320	3
1/1/1997	4	4
1/1/1997	952	4
1/1/1997	1222	4
1/1/1997	517	4
1/1/1997	1359	4
1/1/1997	357	4
1/1/1997	1426	5
1/1/1997	190	4
1/1/1997	367	4
1/1/1997	250	5
1/1/1997	600	4
1/1/1997	702	5

These columns are **foreign keys**; they contain *multiple* instances of each value, and are used to match the **primary keys** in related lookup tables

date	day_of_month	month	year	weekday	week_of_year	week_ending	month_name	quarter
1/1/1997	1	1	1997	Wednesday	1	1/5/1997	January	Q1
1/2/1997	2	1	1997	Thursday	1	1/5/1997	January	Q1
1/3/1997	3	1	1997	Friday	1	1/5/1997	January	Q1
1/4/1997	4	1	1997	Saturday	1	1/5/1997	January	Q1
1/5/1997	5	1	1997	Sunday	2	1/5/1997	January	Q1
1/6/1997	6	1	1997	Monday	2	1/12/1997	January	Q1

product_id	product_brand	product_name	product_sku	product_retail_price	product_cost	product_weigh
1	Washington	Washington Berry Juice	90748583674	2.85	0.94	8.39
2	Washington	Washington Mango Drink	96516502499	0.74	0.26	7.42
3	Washington	Washington Strawberry Drink	58427771925	0.83	0.4	13.1
4	Washington	Washington Cream Soda	64412155747	3.64	1.64	10.6
5	Washington	Washington Diet Soda	85561191439	2.19	0.77	6.66
6	Washington	Washington Cola	29804642796	1.15	0.37	15.8
7	Washington	Washington Diet Cola	20191444754	2.61	0.91	18
8	Washington	Washington Orange Juice	89770532250	2.59	0.8	8.97

These columns are **primary keys**; they *uniquely* identify each row of a table, and match the **foreign keys** in related data tables

EXCEL MAVEN

RELATIONSHIPS VS. MERGED TABLES

*Can't I just **merge queries** or use **LOOKUP** or **RELATED** functions to pull those attributes into the fact table itself, so that I have everything in one place??*

-Anonymous confused man

*Original **Fact Table** fields* | *Attributes from **Calendar Lookup** table* | *Attributes from **Product Lookup** table*

date	product_id	quantity	day_of_month	month	year	weekday	month_name	quarter	product_brand	product_name	product_sku	product_weight
1/1/1997	869	5	1	1	1997	Wednesday	January	Q1	Nationeel	Nationeel Grape Fruit Roll	52382137179	17
1/7/1997	869	2	7	1	1997	Tuesday	January	Q1	Nationeel	Nationeel Grape Fruit Roll	52382137179	17
1/3/1997	1	4	3	1	1997	Friday	January	Q1	Washington	Washington Berry Juice	90748583674	8.39
1/1/1997	1472	3	1	1	1997	Wednesday	January	Q1	Fort West	Fort West Fudge Cookies	37276054024	8.28
1/6/1997	1472	2	6	1	1997	Monday	January	Q1	Fort West	Fort West Fudge Cookies	37276054024	8.28
1/5/1997	2	4	5	1	1997	Sunday	January	Q1	Washington	Washington Mango Drink	96516502499	7.42
1/1/1997	76	4	1	1	1997	Wednesday	January	Q1	Red Spade	Red Spade Sliced Chicken	62054644227	18.1
1/1/1997	76	2	1	1	1997	Wednesday	January	Q1	Red Spade	Red Spade Sliced Chicken	62054644227	18.1
1/5/1997	3	2	5	1	1997	Sunday	January	Q1	Washington	Washington Strawberry Drink	58427771925	13.1
1/7/1997	3	2	7	1	1997	Tuesday	January	Q1	Washington	Washington Strawberry Drink	58427771925	13.1
1/1/1997	320	3	1	1	1997	Wednesday	January	Q1	Excellent	Excellent Cranberry Juice	36570182442	16.4

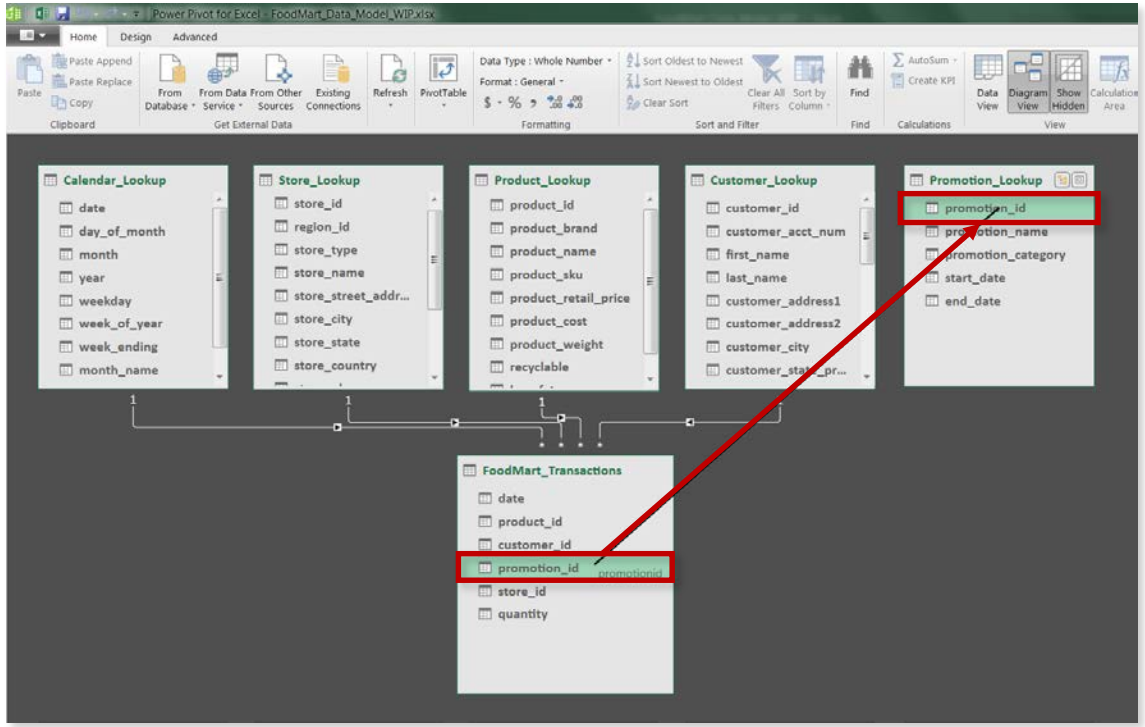
Sure, but **it's extremely inefficient.**

- Merging data in this way creates **redundant data** and utilizes **significantly more memory and processing power** than creating relationships between multiple small tables

EXCEL MAVEN

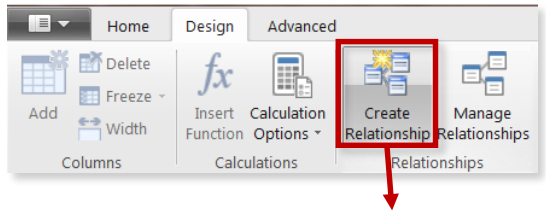
CREATING TABLE RELATIONSHIPS

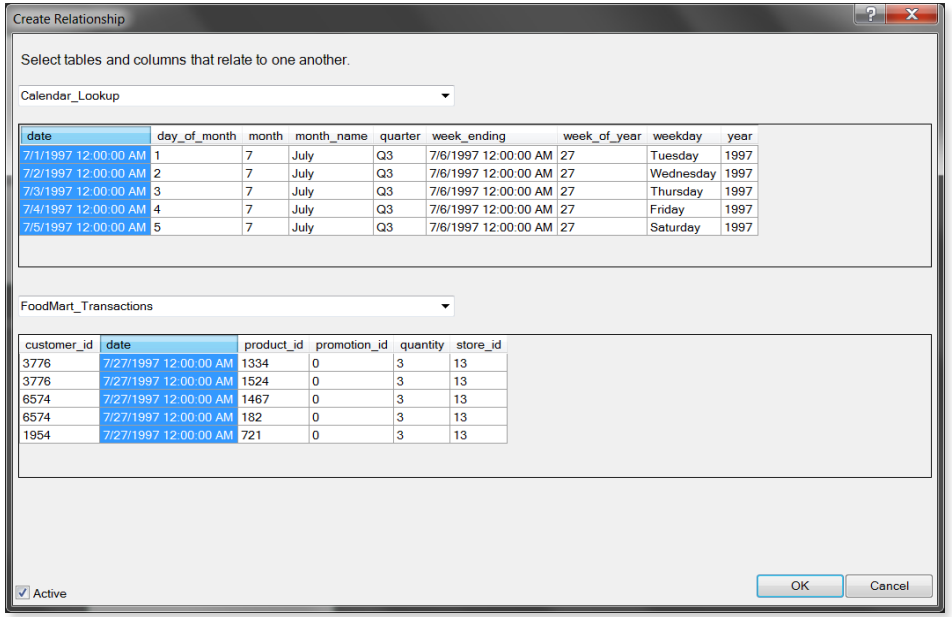
Option 1: Click and drag relationships in **Diagram View**



Tip: *Always drag relationships from the* ***Data*** *table to the* ***Lookup*** *tables*

Option 2: Use "**Create Relationship**" in the **Design** tab

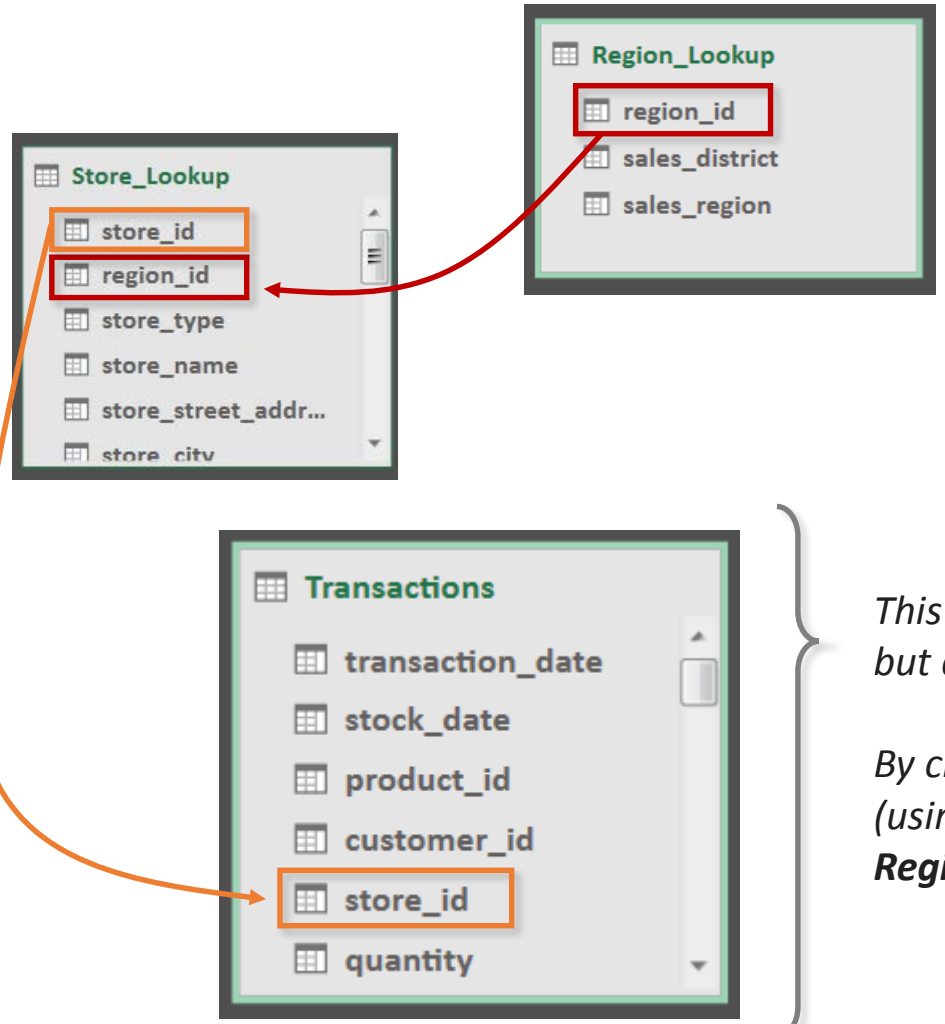




Note: *In Excel 2010/2013 the diagram view looks a bit different, and arrows point in the opposite direction by default*

EXCEL MAVEN

CONNECTING LOOKUPS TO LOOKUPS



PRO TIP:

*Models with multiple related lookup tables are called "**snowflake**" schemas*

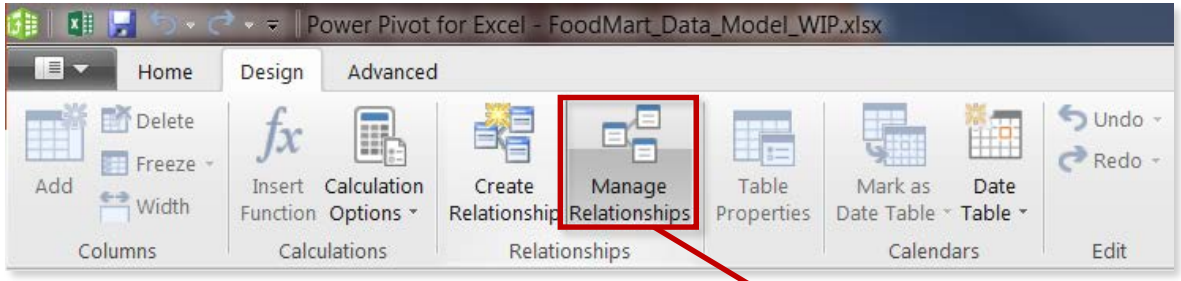
*Models with a single table for each lookup or dimension are called "**star**" schemas*

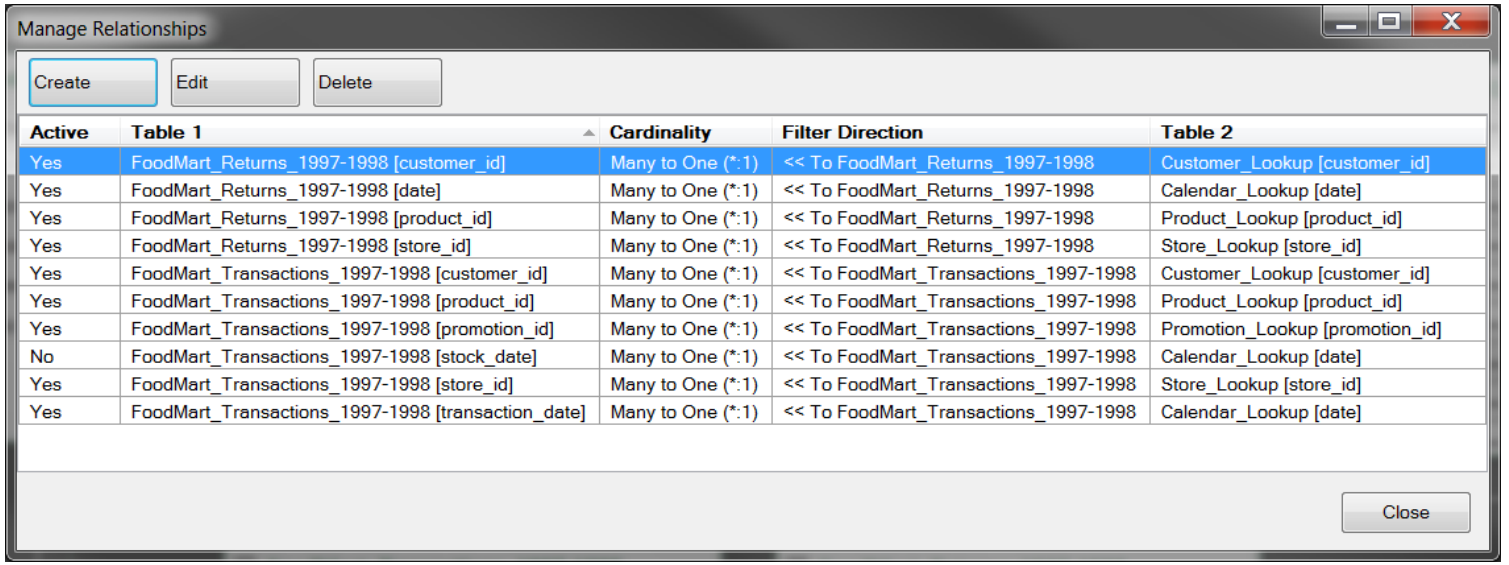
*This **Transactions** data table can connect to **Store_Lookup** using **store_id**, but does not contain a **region_id** to connect to the **Region_Lookup** table*

*By creating a relationship between **Store_Lookup** and **Region_Lookup** (using **region_id**), we have essentially connected **Transactions** with **Region_Lookup**; filter context will now flow all the way down the chain*

EXCEL MAVEN

MODIFYING TABLE RELATIONSHIPS



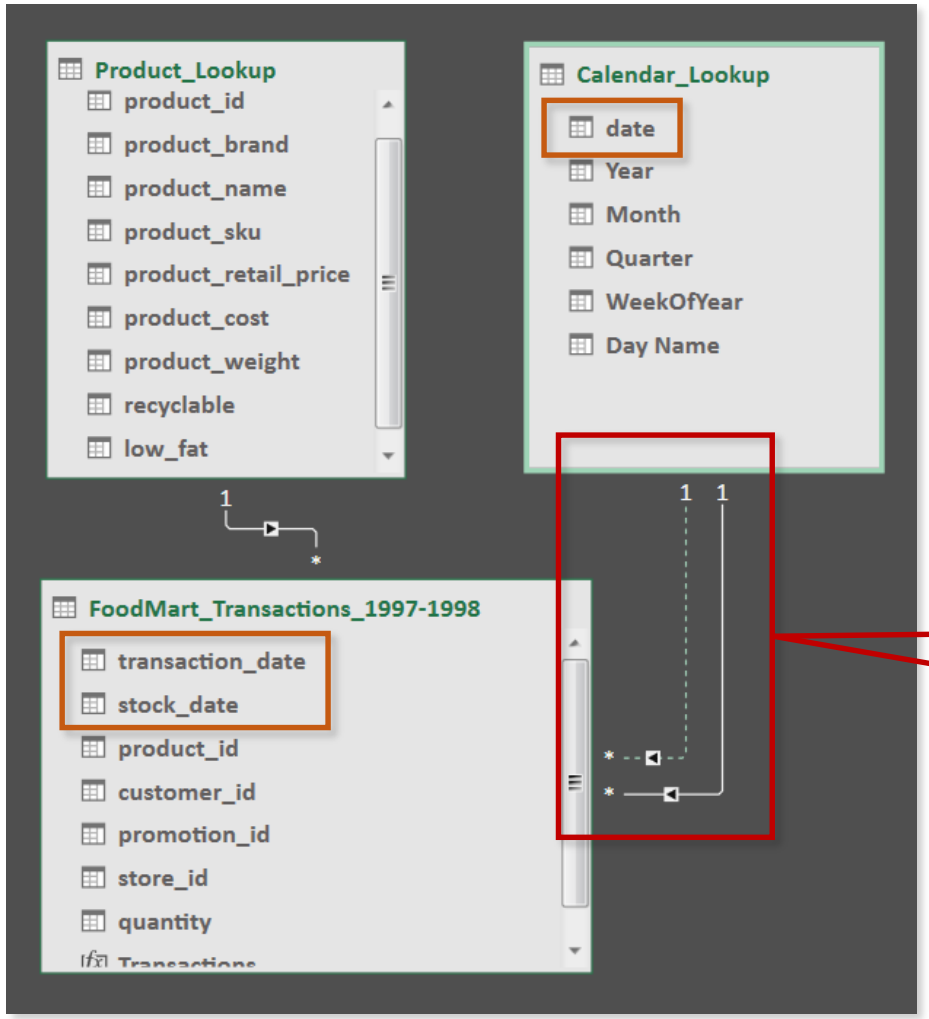


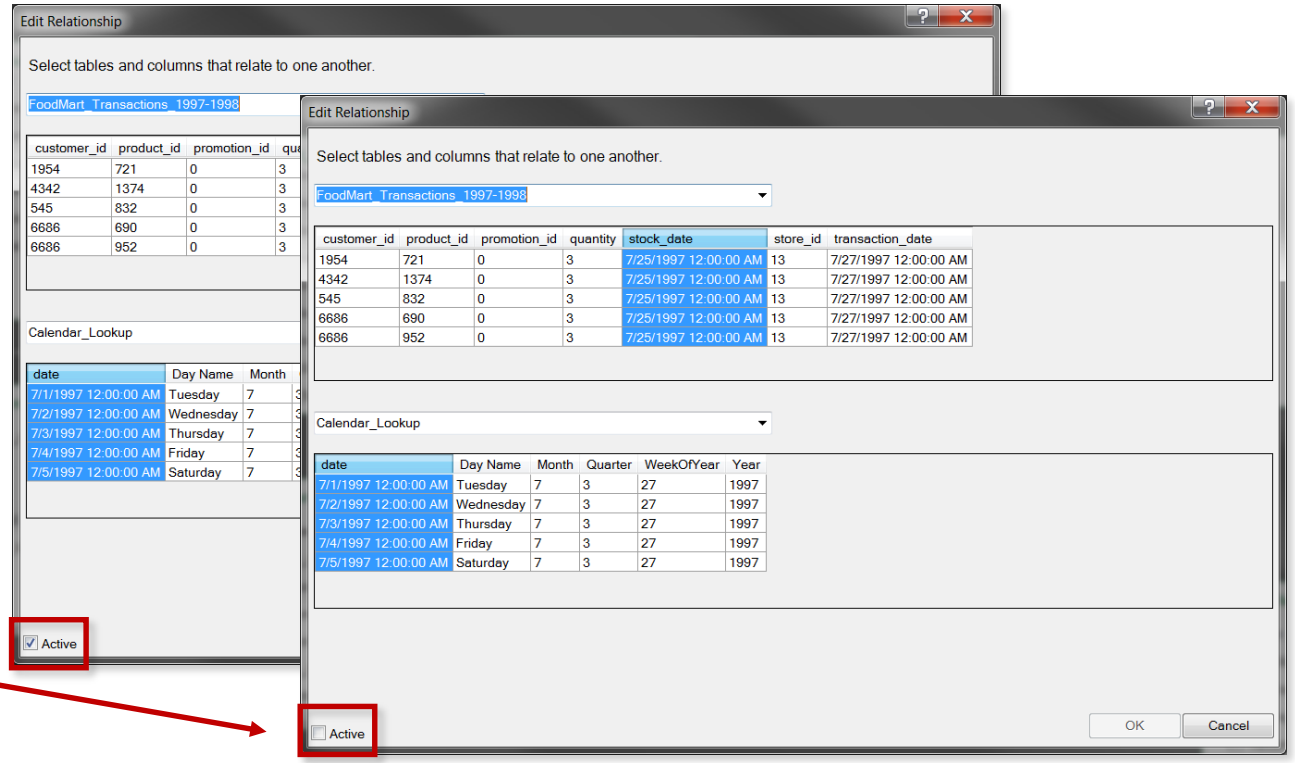
Active	Table 1	Cardinality	Filter Direction	Table 2
Yes	FoodMart_Returns_1997-1998 [customer_id]	Many to One (*:1)	<< To FoodMart_Returns_1997-1998	Customer_Lookup [customer_id]
Yes	FoodMart_Returns_1997-1998 [date]	Many to One (*:1)	<< To FoodMart_Returns_1997-1998	Calendar_Lookup [date]
Yes	FoodMart_Returns_1997-1998 [product_id]	Many to One (*:1)	<< To FoodMart_Returns_1997-1998	Product_Lookup [product_id]
Yes	FoodMart_Returns_1997-1998 [store_id]	Many to One (*:1)	<< To FoodMart_Returns_1997-1998	Store_Lookup [store_id]
Yes	FoodMart_Transactions_1997-1998 [customer_id]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Customer_Lookup [customer_id]
Yes	FoodMart_Transactions_1997-1998 [product_id]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Product_Lookup [product_id]
Yes	FoodMart_Transactions_1997-1998 [promotion_id]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Promotion_Lookup [promotion_id]
No	FoodMart_Transactions_1997-1998 [stock_date]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Calendar_Lookup [date]
Yes	FoodMart_Transactions_1997-1998 [store_id]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Store_Lookup [store_id]
Yes	FoodMart_Transactions_1997-1998 [transaction_date]	Many to One (*:1)	<< To FoodMart_Transactions_1997-1998	Calendar_Lookup [date]

The **Manage Relationships** window allows you to create, edit or delete any connection in the data model

- Use this to see all table relationships, as well as table names, cardinality and filter direction
- ***Note:*** *double-click a single connection in diagram view to edit an individual relationship*

ACTIVE VS. INACTIVE RELATIONSHIPS

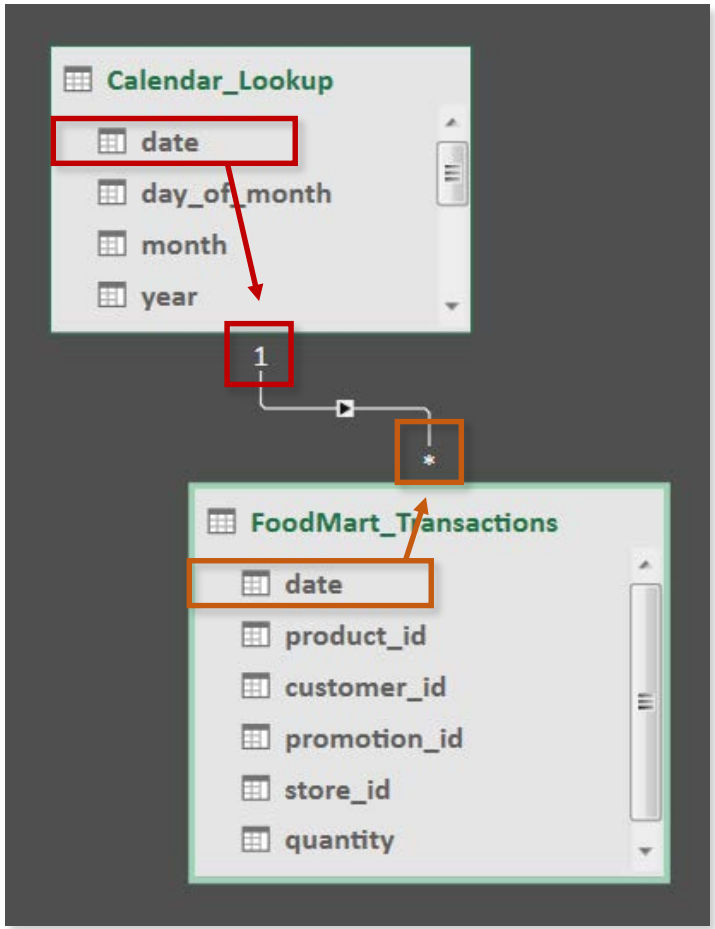




We can connect the **Calendar_Lookup** and **FoodMart_Transactions** tables on both **transaction_date** and **stock_date**; however, only one can be active at a time

To make a connection active or inactive, double-click the connection and check the box, or right-click the relationship line itself (**Note:** must deactivate one before activating another!)

RELATIONSHIP CARDINALITY



Cardinality refers to the uniqueness of values in a column

In Power Pivot, all relationships in a data model should follow a "**one-to-many**" cardinality

- Each column (or "key") used to join tables can only have **one instance** of each unique value in the lookup table (these are the *primary* keys), but may have **many instances** of each unique value in the data table (these are the *foreign* keys)

*In this case we're joining the **Calendar_Lookup** table to the **FoodMart_Transactions** data table using the **date** column as our key*

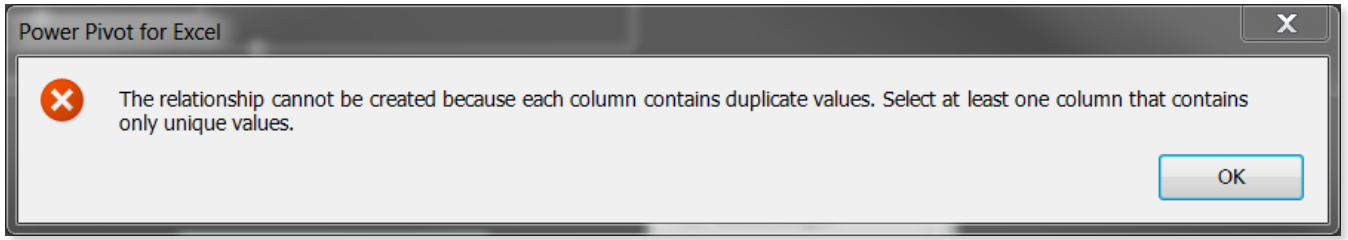
*There is only **one** instance of each date in the lookup table (noted by the "**1**"), but **many** instances of each date in the data table (noted by the asterisk "*****"), since multiple transactions occur each day*

***Note:** In Excel 2010/2013 the diagram view looks a bit different, and arrows point in the opposite direction by default*

BAD CARDINALITY: MANY-TO-MANY

product_id	product_name	product_sku
4	Washington Cream Soda	64412155747
4	Washington Diet Cream Soda	81727382373
5	Washington Diet Soda	85561191439
7	Washington Diet Cola	20191444754
8	Washington Orange Juice	89770532250

date	product_id	transactions
1/1/2017	4	12
1/2/2017	4	9
1/3/2017	4	11
1/1/2017	5	16
1/2/2017	5	19
1/1/2017	7	11



- If we try to connect these tables using the **product_id** field, we'll have a **many-to-many** relationship since there are multiple instances of each ID in both tables
- Even if we *could* create this relationship in Power Pivot, how would you know which product was actually sold on each date – ***Cream Soda*** or ***Diet Cream Soda***?

BAD CARDINALITY: ONE-TO-ONE

product_id	product_name	product_sku
4	Washington Cream Soda	64412155747
5	Washington Diet Soda	85561191439
7	Washington Diet Cola	20191444754
8	Washington Orange Juice	89770532250

product_id	product_price
4	$3.64
5	$2.19
7	$2.61
8	$2.59

- In this case, connecting the tables above using the **product_id** field creates a **one-to-one** relationship, since each ID only appears once in each table
- Unlike many-to-many, there is nothing *illegal* about this relationship; it's just **inefficient**

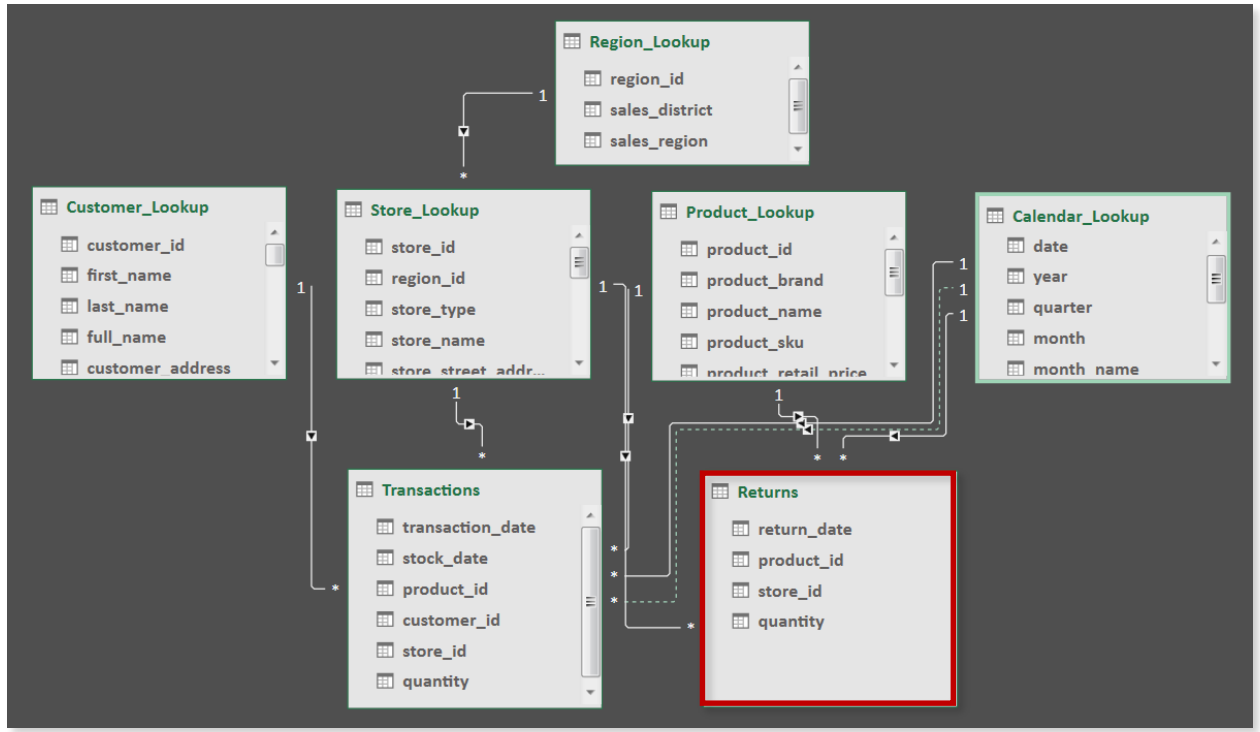
*To eliminate the inefficiency, you could simply **merge the two tables** into a single, valid lookup*

***Note:** this still respects the laws of normalization, since all rows are unique and directly related to the primary key*

product_id	product_name	product_sku	product_price
4	Washington Cream Soda	64412155747	$3.64
5	Washington Diet Soda	85561191439	$2.19
7	Washington Diet Cola	20191444754	$2.61
8	Washington Orange Juice	89770532250	$2.59

EXCEL MAVEN

CONNECTING MULTIPLE DATA TABLES



Here we've loaded a second data table named **Returns**, containing records of returns by date, product and store

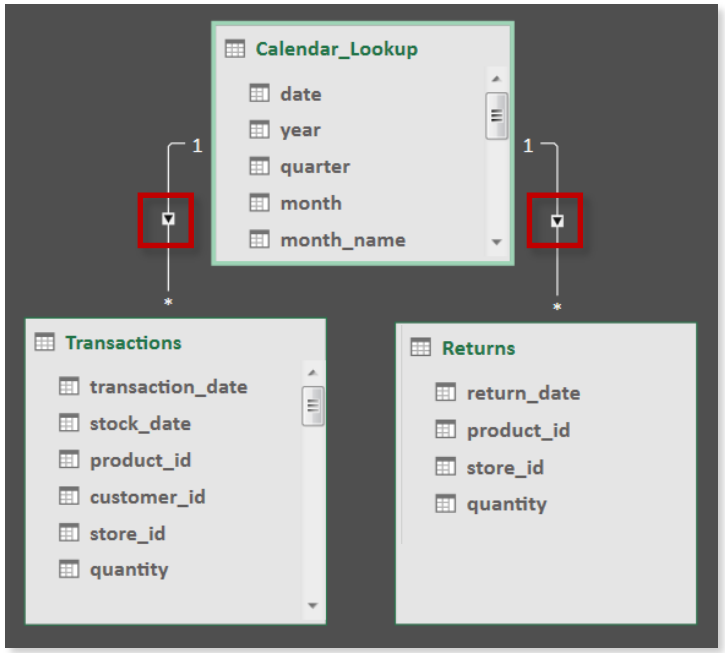
- This table connects to each lookup exactly like the **Transactions** table did, except that there is no way to connect the Returns table to Customer_Lookup
- This allows us to analyze data across both tables in the same pivot, **as long as we only filter or segment the data using lookups that are common to both**
  - In other words, we know which ***product*** was returned, which ***store*** it was returned to, and which ***date*** the return occurred, but NOT which ***customer*** was responsible

HEY THIS IS IMPORTANT!

NEVER try to connect data tables directly to each other; ***ALWAYS*** connect them indirectly via shared lookup tables!

EXCEL MAVEN

FILTER DIRECTION IS IMPORTANT



This model includes two data tables (**Transactions** and **Returns**), both connected to the **Calendar_Lookup**

Note the filter directions (shown as arrows) in each relationship; **in Power Pivot (2016) these will *always* point from the "one" side of the relationship (lookups) to the "many" side (data tables)***

- Filtering a table will impact any tables "downstream" of it, as defined by the filter relationship (i.e the direction of the arrow)
- Let's say we're analyzing both Transactions and Returns in the same PivotTable; filtering by the **Calendar_Lookup** date field will return correctly filtered data from both data tables, but filtering by the **Transactions** date field will yield *unfiltered* Returns values

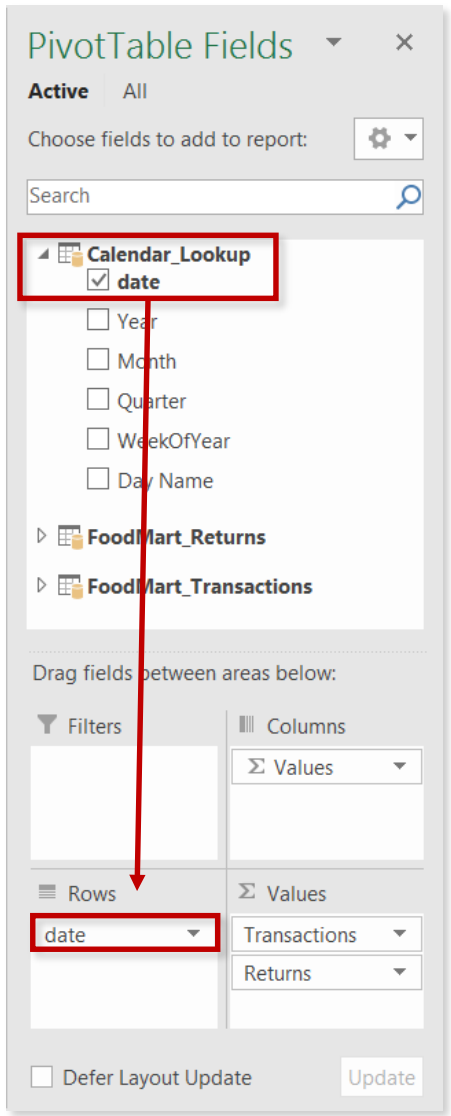
PRO TIP:

*Arrange your lookup tables **above** your data tables in diagram view to remind you that filters always flow "downstream"*

***Note:** In Excel 2010/2013 the diagram view looks a bit different, and arrows point in the opposite direction by default*

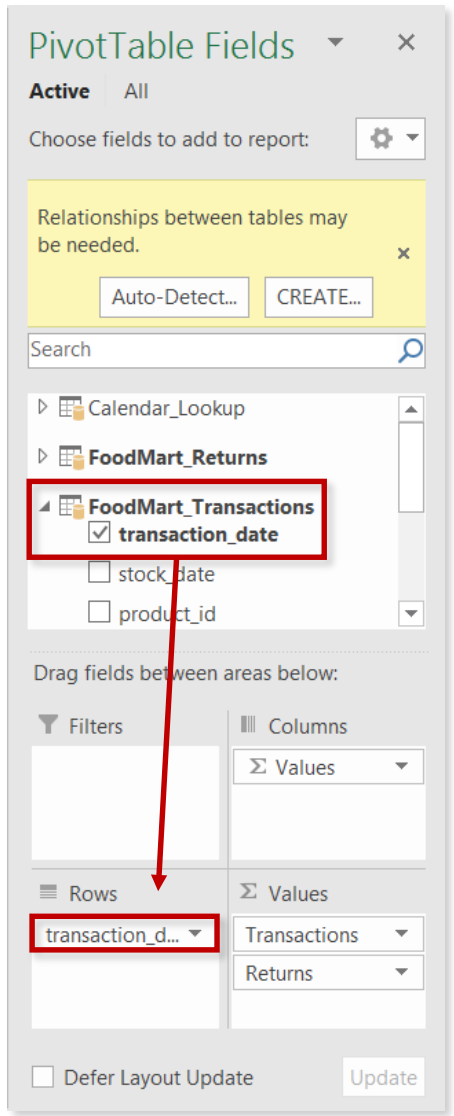
EXCEL MAVEN

FILTER DIRECTION IS IMPORTANT (CONT.)



	A	B	C
1	Row Labels	Transactions	Returns
2	1/1/1997	348	3
3	1/2/1997	635	6
4	1/3/1997	589	7
5	1/4/1997	20	
6	1/5/1997	966	10
7	1/6/1997	993	11
8	1/7/1997	1,265	8
9	1/8/1997	35	
10	1/9/1997	525	9
11	1/10/1997	460	5

***Calendar_Lookup** filters flow "down" to both the **Transactions** and **Returns** tables, so we can filter or segment those metrics using any field from the Calendar table*

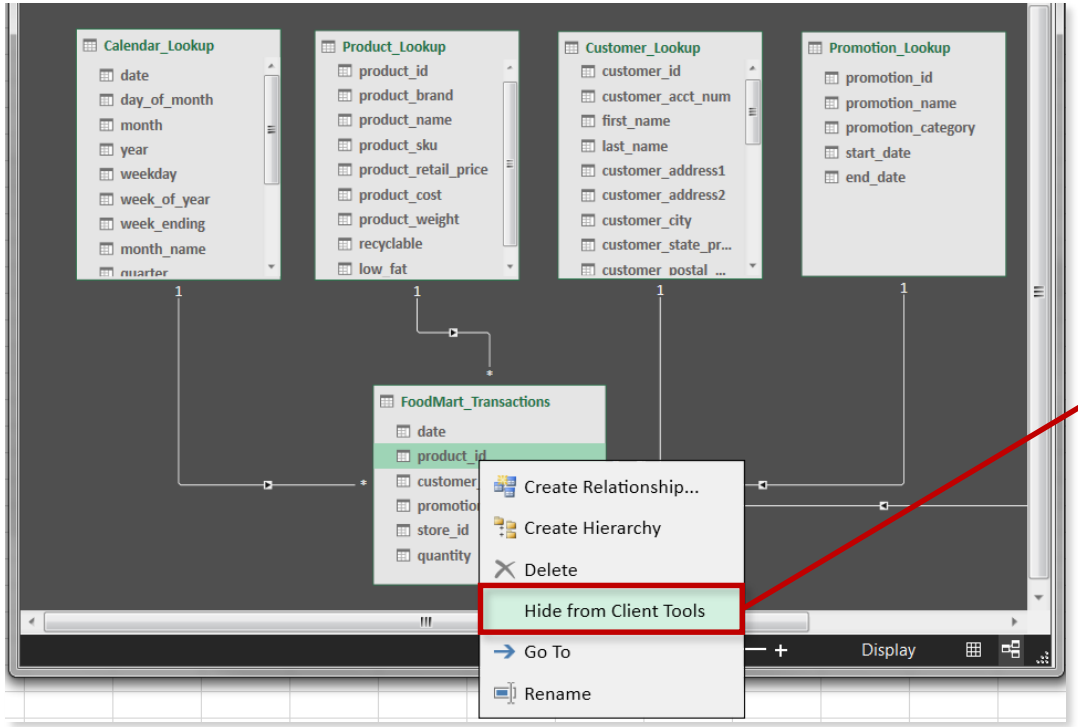


	A	B	C
1	Row Labels	Transactions	Returns
2	1/1/1997	348	8,289
3	1/2/1997	635	8,289
4	1/3/1997	589	8,289
5	1/4/1997	20	8,289
6	1/5/1997	966	8,289
7	1/6/1997	993	8,289
8	1/7/1997	1,265	8,289
9	1/8/1997	35	8,289
10	1/9/1997	525	8,289
11	1/10/1997	460	8,289

*Filtering by date in the **Transactions** table yields incorrect, unfiltered values from the **Returns** table, since filter context cannot flow "upstream" to the Calendar table*

EXCEL MAVEN

HIDING FIELDS FROM CLIENT TOOLS



When you **hide a field from Client Tools**, you make it invisible to tools outside of the data model (i.e. Power Pivot)

This can be used to prevent users from filtering or segmenting on invalid fields, or to hide irrelevant metrics from view

PRO TIP:

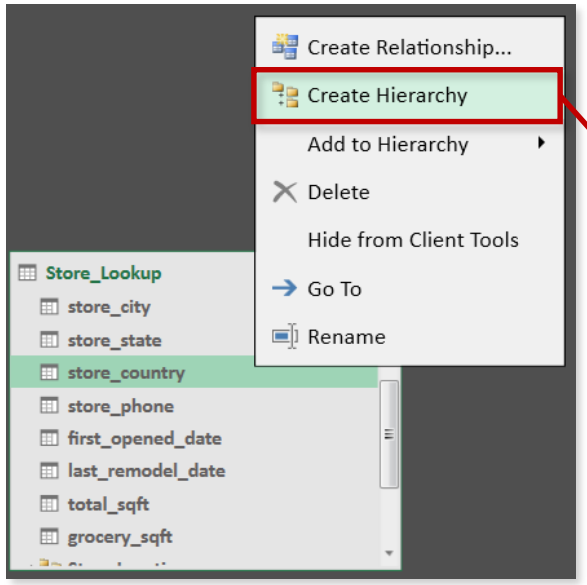
*Always hide the **foreign key columns** in your data tables to prevent users from accidentally filtering on them!*

EXCEL MAVEN

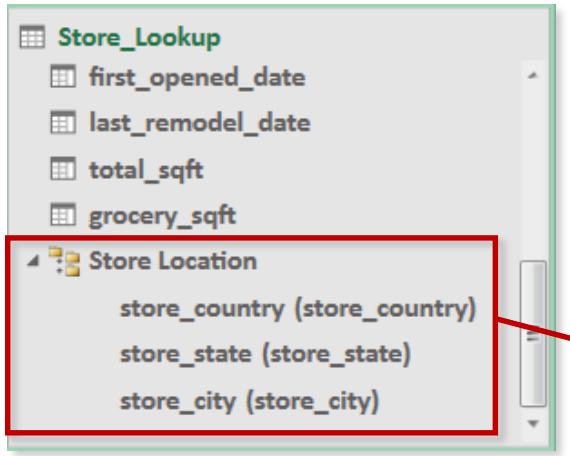
DEFINING HIERARCHIES

Hierarchies are groups of nested columns that reflect multiple levels of granularity

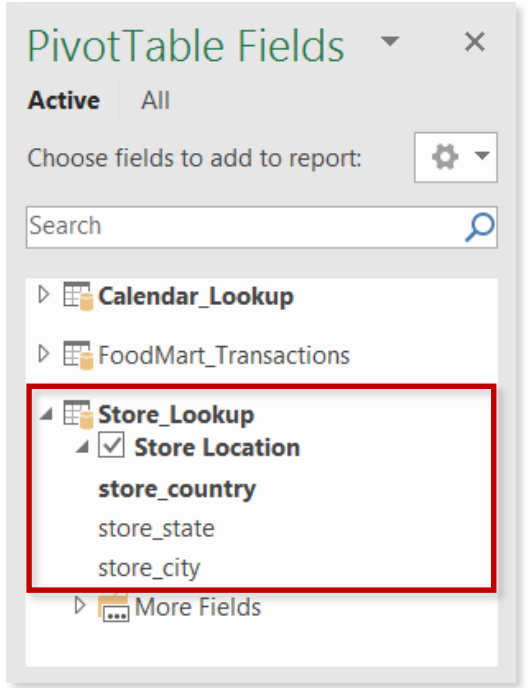
- For example, a "**Geography**" hierarchy might include **Country**, **State**, and **City** columns
- Each hierarchy is treated as a **single item** in PivotTables and PivotCharts, allowing users to "drill up" and "drill down" through different levels of the hierarchy in a meaningful way



***Right-click** a field to see the hierarchy options*



***Drag fields** to create a hierarchy*



*Hierarchies appear in **Power Pivot***

DATA MODEL BEST PRACTICES

Normalize your data model before you do anything else

- *Make sure that each table in your model serves a single, distinct purpose*
- *Use relationships vs. merged tables; long & narrow tables are better than short & wide*

Organize lookup tables *above* data tables in the diagram view

- *This serves as a visual reminder that filters always flow "**downstream**"*

Hide fields from client tools to prevent invalid filter context

- *All foreign key columns should be hidden from data tables, so that users are only able to use valid fields for filtering and segmentation*

POWER PIVOT & DAX 101

EXCEL MAVEN

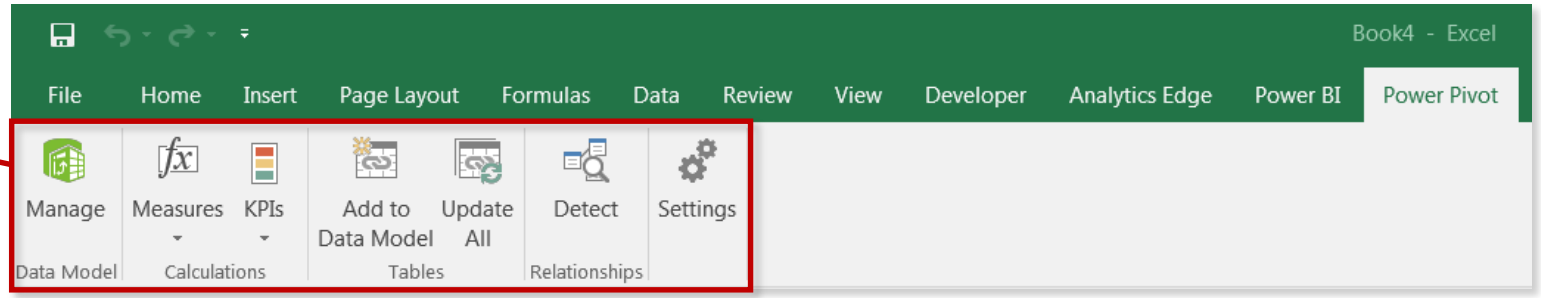
MEET POWER PIVOT

A **"Power" Pivot** is just like a normal PivotTable, except it sits on top of an *entire data model* rather than a single table or range. This allows you to:

- Explore massive datasets consisting of multiple sources and tables, using familiar, user-friendly PivotTable tools and options
- Create powerful and flexible calculations using Data Analysis Expressions (DAX)

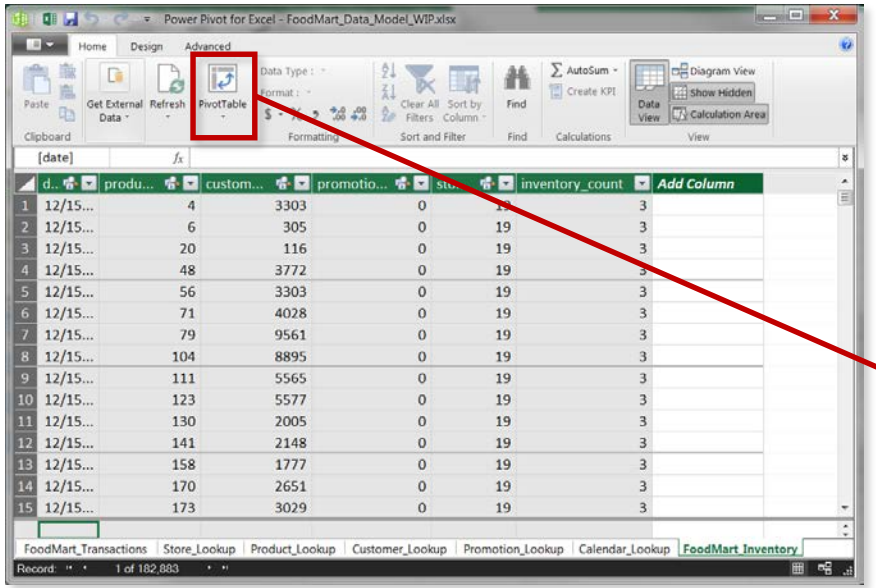
The **Power Pivot** tab includes tools to manage the data model and define new measures

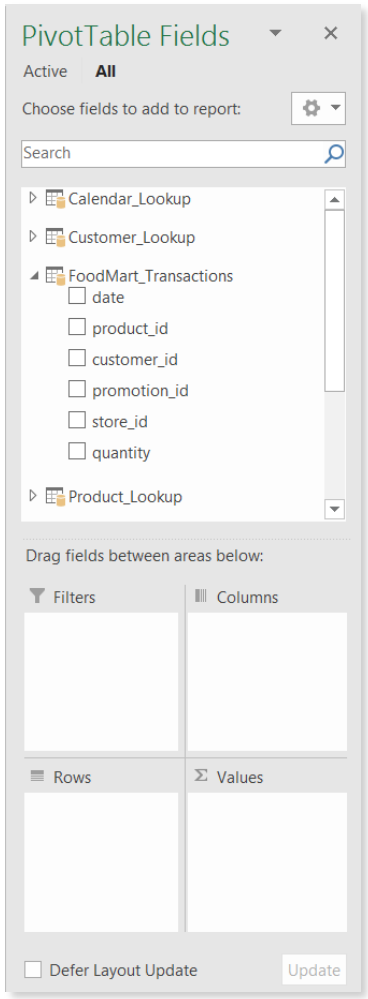
*(**Note:** you may need to enable this tab by selecting **File > Options > Add-Ins > Manage COM Add-Ins**)*



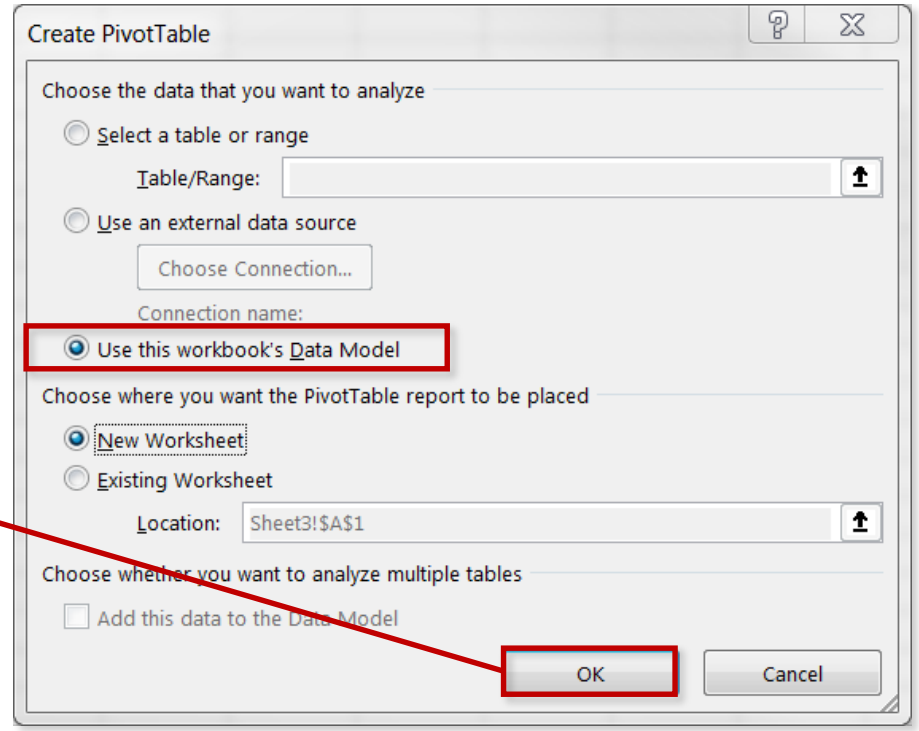
CREATING A “POWER” PIVOT TABLE

Option #1: From the Data Model

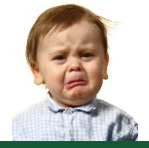




Option #2: From the *Insert* > *PivotTable* dialog box



“NORMAL” PIVOTS VS. “POWER” PIVOTS



NORMAL PIVOT

- Can analyze data from **one table at a time**; multiple tables must be flattened or “stitched” together with cell functions
- Restricted to the data capacity of a **single Excel worksheet** (1,048,576 rows)
- Limited to relatively **basic calculated fields**, using a sub-set of Excel functions

POWER PIVOT

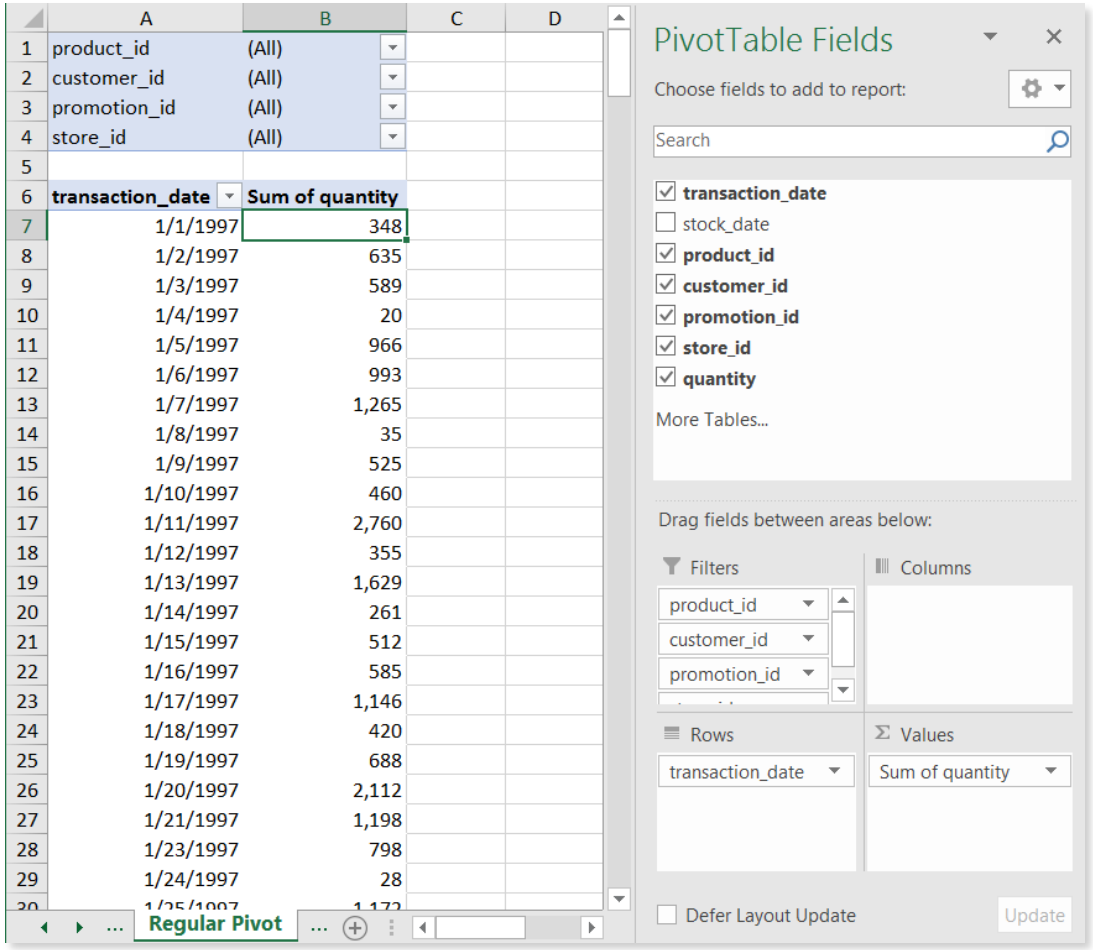
- Can analyze an **entire data model**, consisting of multiple tables connected via relationships rather than cell functions
- Virtually **unlimited data capacity** as tables are compressed outside of normal worksheets
- Performs **complex calculations** using Data Analysis Expressions (DAX)

NOTE: It’s not the ***PivotTable*** itself that’s different; it’s the ***data behind it***

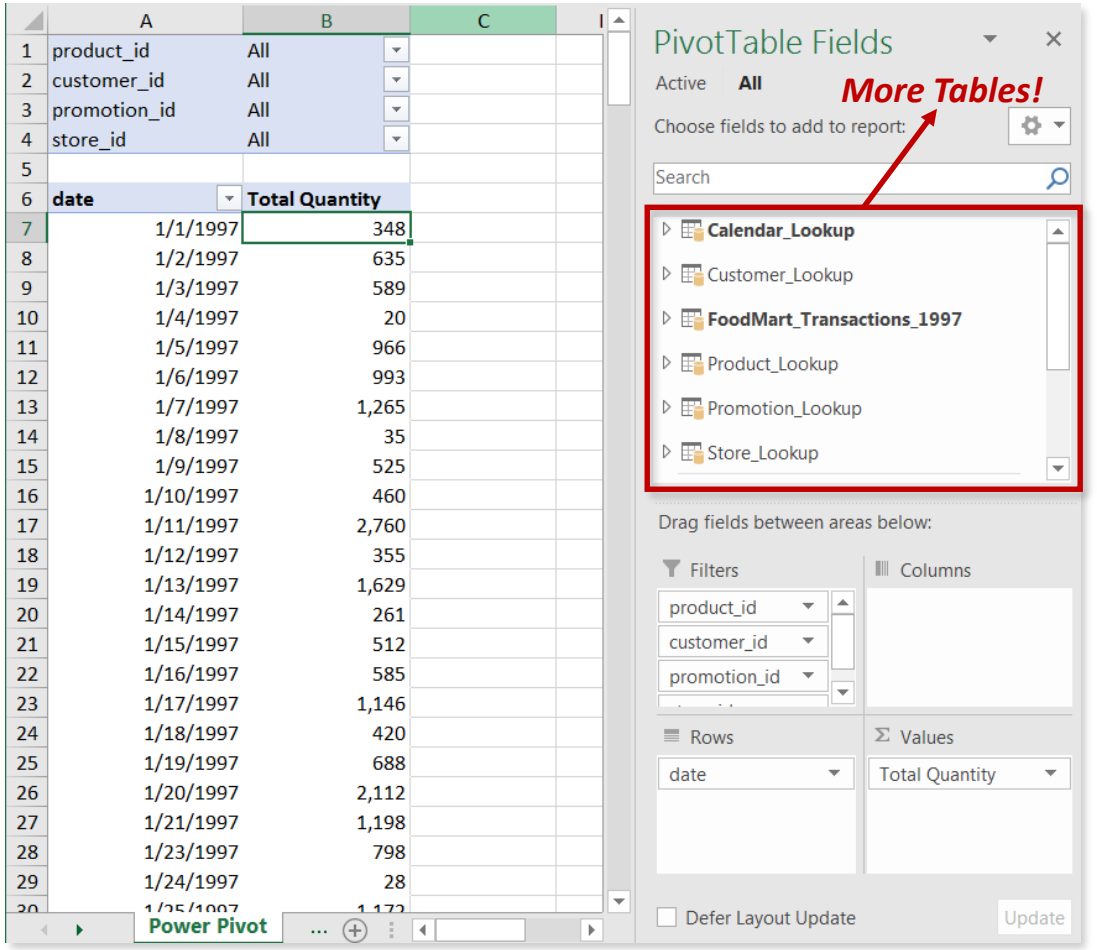
EXCEL MAVEN

“NORMAL” PIVOTS VS. “POWER” PIVOTS

Normal Pivot



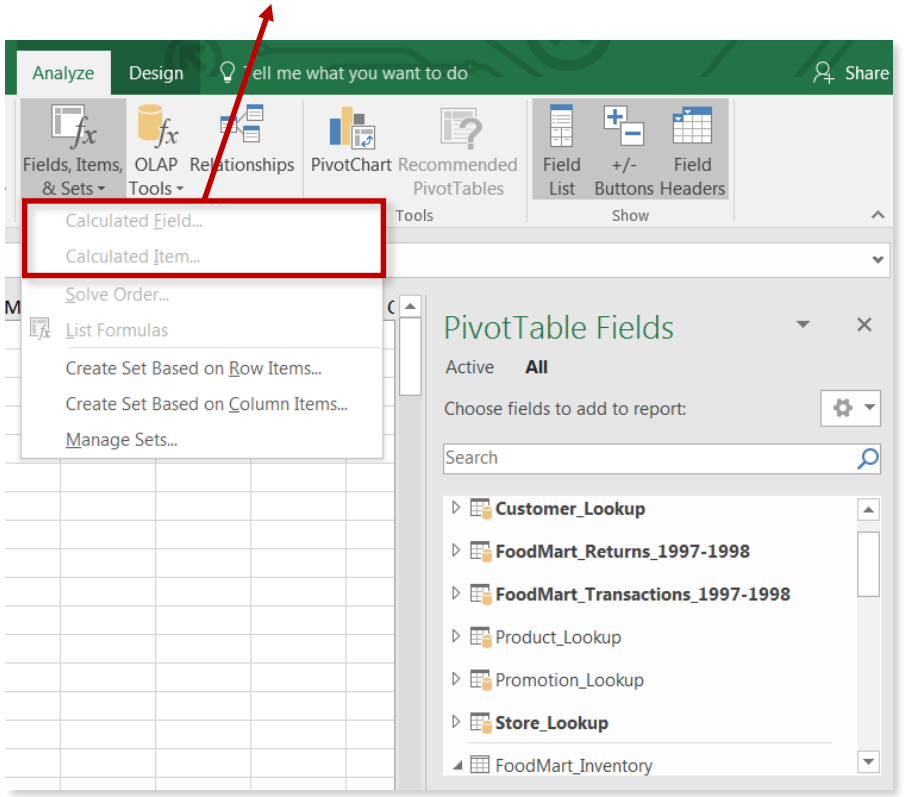
Power Pivot



EXCEL MAVEN

NO MORE "CALCULATED FIELDS"

*Oh rats, where are my **calculated fields**??*



One of the key Power Pivot features is the ability to create *much* more robust calculated fields, known as **measures***

Because these measures interact directly with the data model (including tables stored in memory), traditional cell formulas won't do the trick

- Instead, we'll use a new (but familiar) formula language called **Data Analysis Expressions** (DAX)

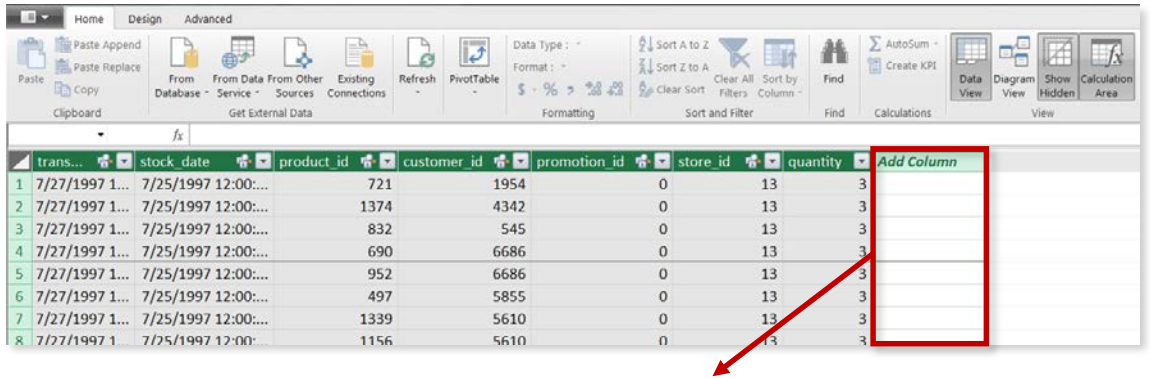
***Note:** Depending on the version of Excel you're using, you might see these referred to as either "**Measures**" (Excel 2010, 2016) or "**Calculated Fields**" (Excel 2013)*

DATA ANALYSIS EXPRESSIONS (DAX)

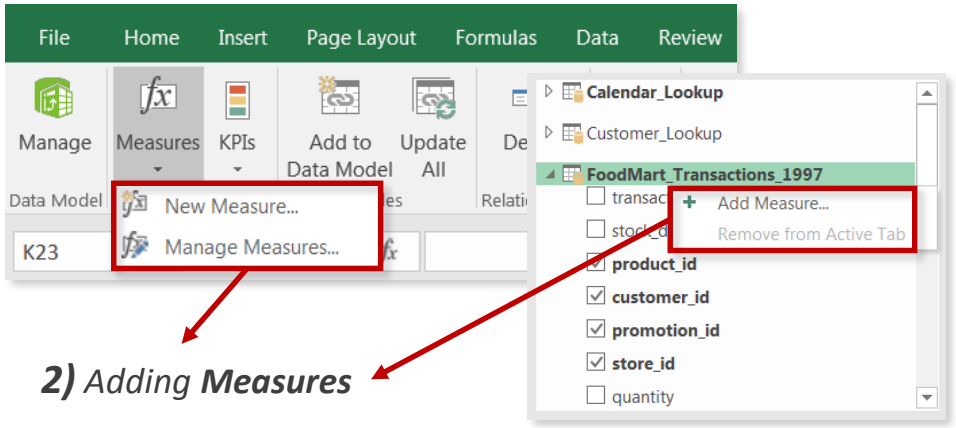
Data Analysis Expressions, commonly known as **DAX**, is the formula language that drives Power Pivot. With DAX, you can:

- Add **calculated columns** and **measures** to your model, using intuitive syntax
- Go beyond the capabilities of traditional "grid-style" formulas, with powerful functions built specifically to work with relational data

Two places to use DAX:



*1) Adding **Calculated Columns***



*2) Adding **Measures***

CALCULATED COLUMNS

Calculated columns allow you to add new, formula-based columns to tables

- No "A1-style" references; calculated columns refer to **entire tables** or **columns**
- Calculated columns are computed at the row-level, and **values are stored with the table** (*this eats up memory*)
- Calculated columns understand **row context**; they're great for defining new properties based on information in each row, but generally useless for aggregation (*SUM, AVERAGE, COUNT, etc.*)

HEY THIS IS IMPORTANT!

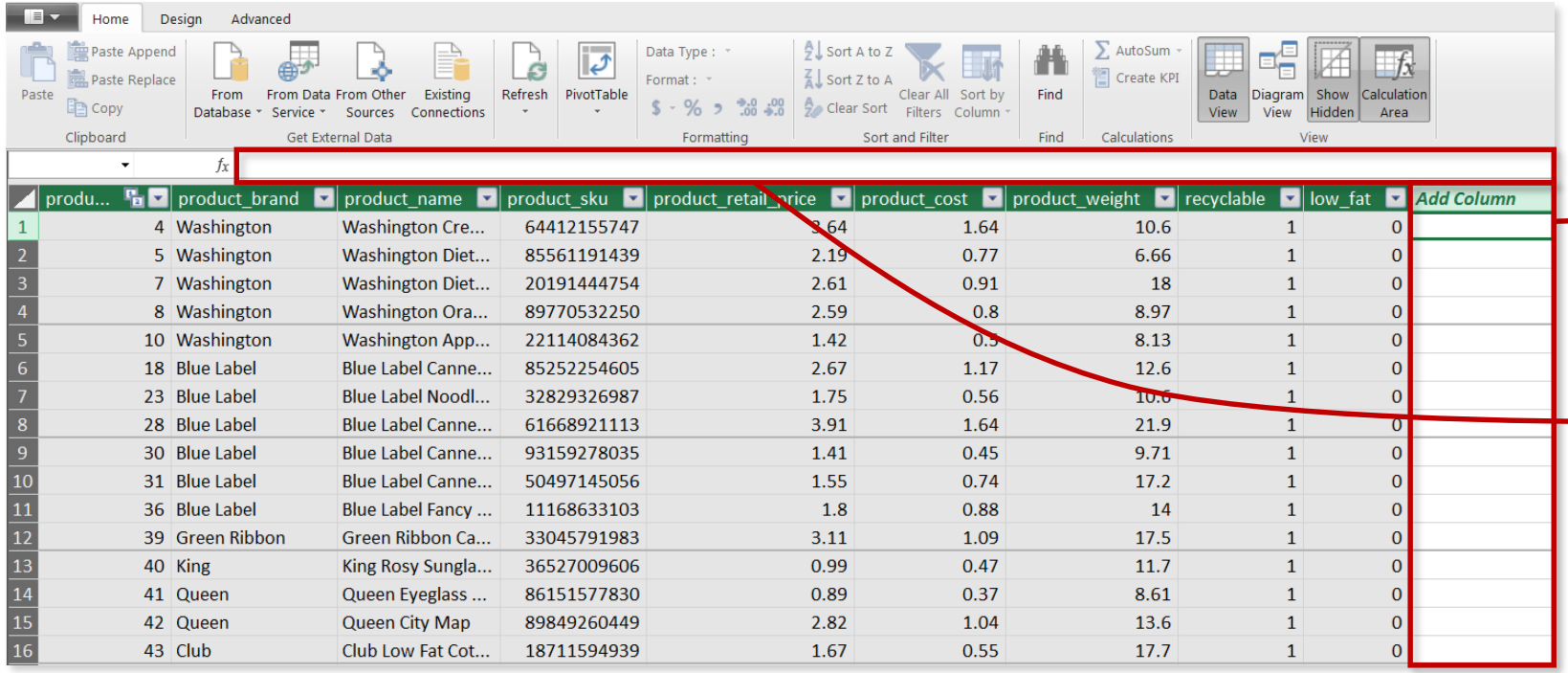
As a rule of thumb, **ONLY** use calculated columns if you want to "stamp" static, fixed values to each row in a table (*or use Power Query!*)

DO NOT use calculated columns for aggregation formulas, or to calculate fields for the "Values" area of a pivot (use **measures** instead)

PRO TIP:

*Calculated columns are typically placed in the **Filters, Slicers, Rows** or **Columns** areas of a pivot*

CREATING CALCULATED COLUMNS



	produ...	product_brand	product_name	product_sku	product_retail_price	product_cost	product_weight	recyclable	low_fat	Add Column
1	4	Washington	Washington Cre...	64412155747	3.64	1.64	10.6	1	0	
2	5	Washington	Washington Diet...	85561191439	2.19	0.77	6.66	1	0	
3	7	Washington	Washington Diet...	20191444754	2.61	0.91	18	1	0	
4	8	Washington	Washington Ora...	89770532250	2.59	0.8	8.97	1	0	
5	10	Washington	Washington App...	22114084362	1.42	0.5	8.13	1	0	
6	18	Blue Label	Blue Label Canne...	85252254605	2.67	1.17	12.6	1	0	
7	23	Blue Label	Blue Label Noodl...	32829326987	1.75	0.56	10.6	1	0	
8	28	Blue Label	Blue Label Canne...	61668921113	3.91	1.64	21.9	1	0	
9	30	Blue Label	Blue Label Canne...	93159278035	1.41	0.45	9.71	1	0	
10	31	Blue Label	Blue Label Canne...	50497145056	1.55	0.74	17.2	1	0	
11	36	Blue Label	Blue Label Fancy ...	11168633103	1.8	0.88	14	1	0	
12	39	Green Ribbon	Green Ribbon Ca...	33045791983	3.11	1.09	17.5	1	0	
13	40	King	King Rosy Sungla...	36527009606	0.99	0.47	11.7	1	0	
14	41	Queen	Queen Eyeglass ...	86151577830	0.89	0.37	8.61	1	0	
15	42	Queen	Queen City Map	89849260449	2.82	1.04	13.6	1	0	
16	43	Club	Club Low Fat Cot...	18711594939	1.67	0.55	17.7	1	0	

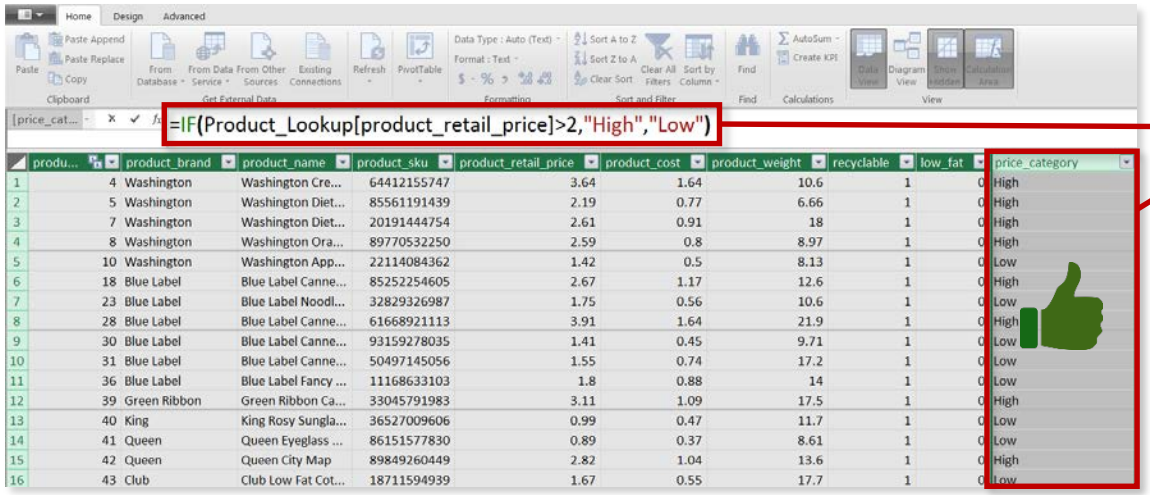
Step 1: In the data model "Data View", choose a table and then select any cell in the "**Add Column**" section

Step 2: Enter a DAX function in the formula bar (*we'll cover specific functions in the next section*)

Step 3: Press "Enter", and all cells in the column will update

EXCEL MAVEN

CALCULATED COLUMNS: GOOD & BAD



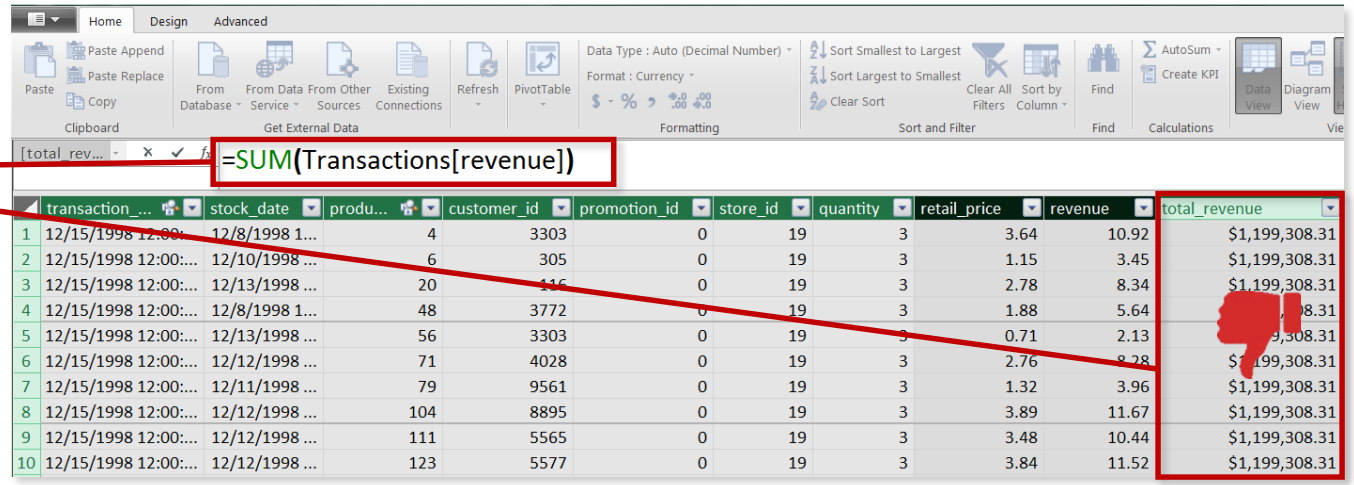
	produ...	product_brand	product_name	product_sku	product_retail_price	product_cost	product_weight	recyclable	low_fat	price_category
1	4	Washington	Washington Cre...	64412155747	3.64	1.64	10.6	1	0	High
2	5	Washington	Washington Diet...	85561191439	2.19	0.77	6.66	1	0	High
3	7	Washington	Washington Diet...	20191444754	2.61	0.91	18	1	0	High
4	8	Washington	Washington Ora...	89770532250	2.59	0.8	8.97	1	0	High
5	10	Washington	Washington App...	22114084362	1.42	0.5	8.13	1	0	Low
6	18	Blue Label	Blue Label Canne...	85252254605	2.67	1.17	12.6	1	0	High
7	23	Blue Label	Blue Label Noodl...	32829326987	1.75	0.56	10.6	1	0	Low
8	28	Blue Label	Blue Label Canne...	61668921113	3.91	1.64	21.9	1	0	High
9	30	Blue Label	Blue Label Canne...	93159278035	1.41	0.45	9.71	1	0	Low
10	31	Blue Label	Blue Label Canne...	50497145056	1.55	0.74	17.2	1	0	Low
11	36	Blue Label	Blue Label Fancy ...	11168633103	1.8	0.88	14	1	0	Low
12	39	Green Ribbon	Green Ribbon Ca...	33045791983	3.11	1.09	17.5	1	0	High
13	40	King	King Rosy Sungla...	36527009606	0.99	0.47	11.7	1	0	Low
14	41	Queen	Queen Eyeglass ...	86151577830	0.89	0.37	8.61	1	0	Low
15	42	Queen	Queen City Map	89849260449	2.82	1.04	13.6	1	0	High
16	43	Club	Club Low Fat Cot...	18711594939	1.67	0.55	17.7	1	0	Low

In this case we've added a **calculated column** called **price_category**, which equals "***High***" if the retail price is >$2, and "***Low***" otherwise (*just like you would write in Excel!*)

- Since calculated columns understand **row context**, a new value is calculated in each row based on that row's price
- This is a **valid use** of calculated columns; it creates a new row "property" that we can now use to filter or segment any related data within the model

Here we're using an aggregation function (SUM) to calculate a new column named **total_revenue**

- Since calculated columns do not understand **filter context**, the same grand total is returned in *every single row* of the table
- This is **not a valid use** of calculated columns; these values are statically "stamped" onto the table and can't be filtered, sliced, subdivided, etc.



	transaction_...	stock_date	produ...	customer_id	promotion_id	store_id	quantity	retail_price	revenue	total_revenue
1	12/15/1998 12:00:...	12/8/1998 1...	4	3303	0	19	3	3.64	10.92	$1,199,308.31
2	12/15/1998 12:00:...	12/10/1998 ...	6	305	0	19	3	1.15	3.45	$1,199,308.31
3	12/15/1998 12:00:...	12/13/1998 ...	20	116	0	19	3	2.78	8.34	$1,199,308.31
4	12/15/1998 12:00:...	12/8/1998 1...	48	3772	0	19	3	1.88	5.64	$1,199,308.31
5	12/15/1998 12:00:...	12/13/1998 ...	56	3303	0	19	3	0.71	2.13	$1,199,308.31
6	12/15/1998 12:00:...	12/12/1998 ...	71	4028	0	19	3	2.76	8.28	$1,199,308.31
7	12/15/1998 12:00:...	12/11/1998 ...	79	9561	0	19	3	1.32	3.96	$1,199,308.31
8	12/15/1998 12:00:...	12/12/1998 ...	104	8895	0	19	3	3.89	11.67	$1,199,308.31
9	12/15/1998 12:00:...	12/12/1998 ...	111	5565	0	19	3	3.48	10.44	$1,199,308.31
10	12/15/1998 12:00:...	12/12/1998 ...	123	5577	0	19	3	3.84	11.52	$1,199,308.31

DAX MEASURES

Measures are DAX formulas used to generate dynamic values within a PivotTable

- Like calculated columns, measures reference **entire tables** or **columns** (*no A1-style or "grid" references*)
- Unlike calculated columns, measures don't actually *live* in the table; they get placed in the **values** area of a PivotTable and dynamically calculated in each individual cell
- Measures are evaluated based on the **filter context** of each cell, which is determined by the PivotTable layout (filters, slicers, rows and columns)

HEY THIS IS IMPORTANT!

As a rule of thumb, use measures (*vs. calculated columns*) when a single row can't give you the answer (i.e. requires **aggregation**)

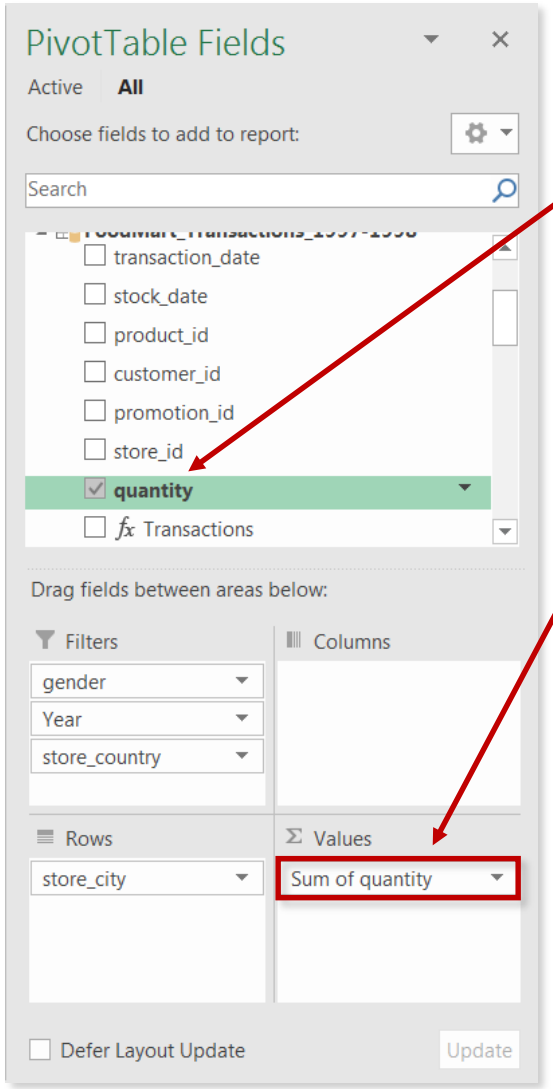
Measures can **ONLY** be placed in the values area of a PivotTable

PRO TIP:

*Use measures to create values **that users can explore with a pivot** (Power Pivot version of a "Calculated Field")*

EXCEL MAVEN

CREATING IMPLICIT MEASURES



STEP 1: Check the box next to a value field in a data table, or manually drag it into the "Values" box

STEP 2: Pat yourself on the back, you just created a measure!

HEY THIS IS IMPORTANT!

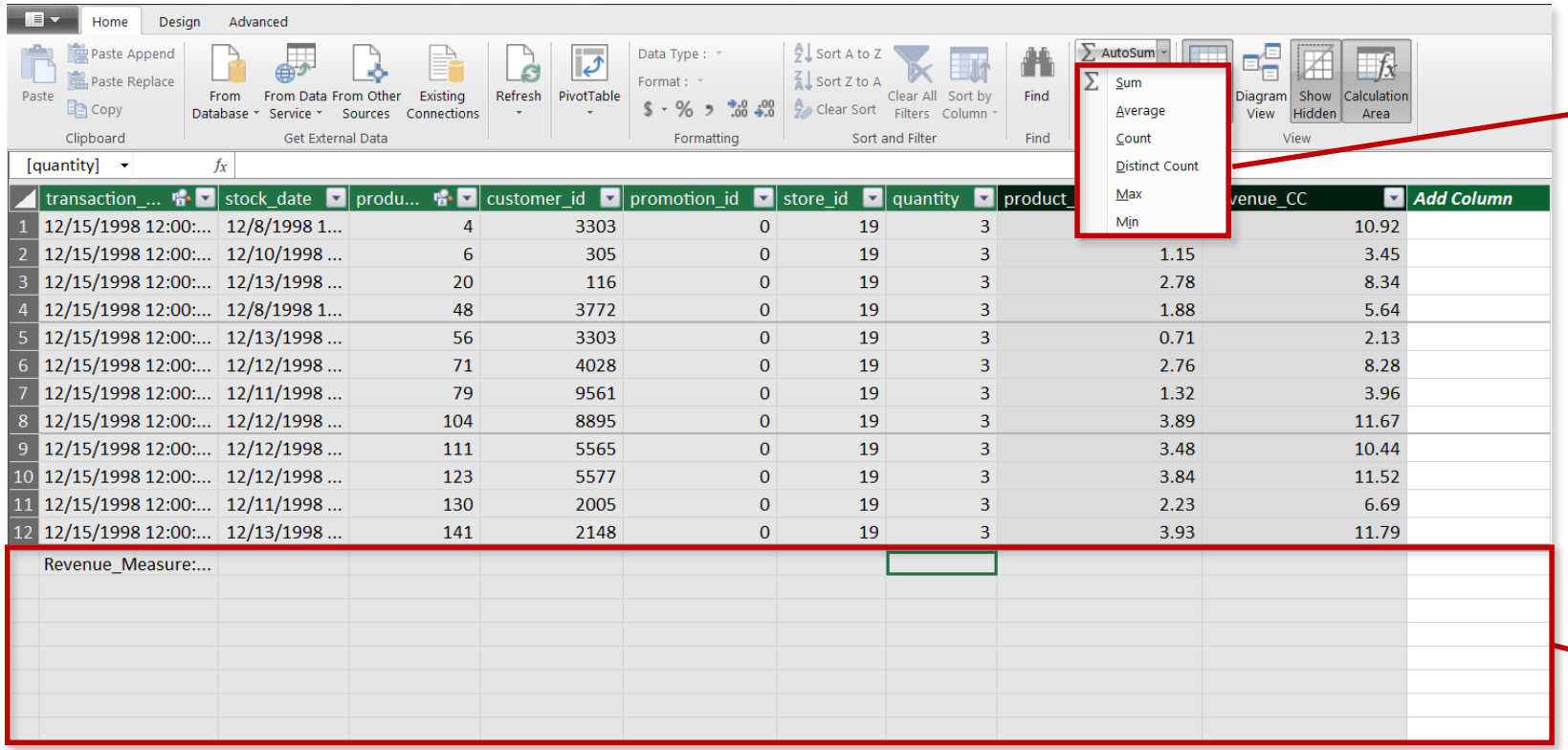
Before you pop the champagne, there's a catch. When you drag a raw data field into the values section of a pivot, you create what's called an **implicit measure**. While there's nothing *wrong* with implicit measures, they are extremely limited.

Explicit measures (defined using DAX) will give us *much* more flexibility, as well as the ability to reuse measures in multiple places (measure trees!)

FROM NOW ON, JUST SAY "NO" TO IMPLICIT MEASURES

EXCEL MAVEN

CREATING EXPLICIT MEASURES (AUTOSUM)



AutoSum is a shortcut for creating simple DAX formulas (*Sum, Average, Count, Distinct Count, Max and Min*)

To use AutoSum:

- Click on a cell in the Measures Pane (*see below*), within the column you want to evaluate
- Select the **AutoSum** menu and choose an option from the list

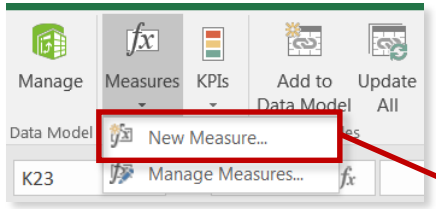
*The **Measures Pane** sits beneath the data in the "Data View" of the model*

PRO TIP:

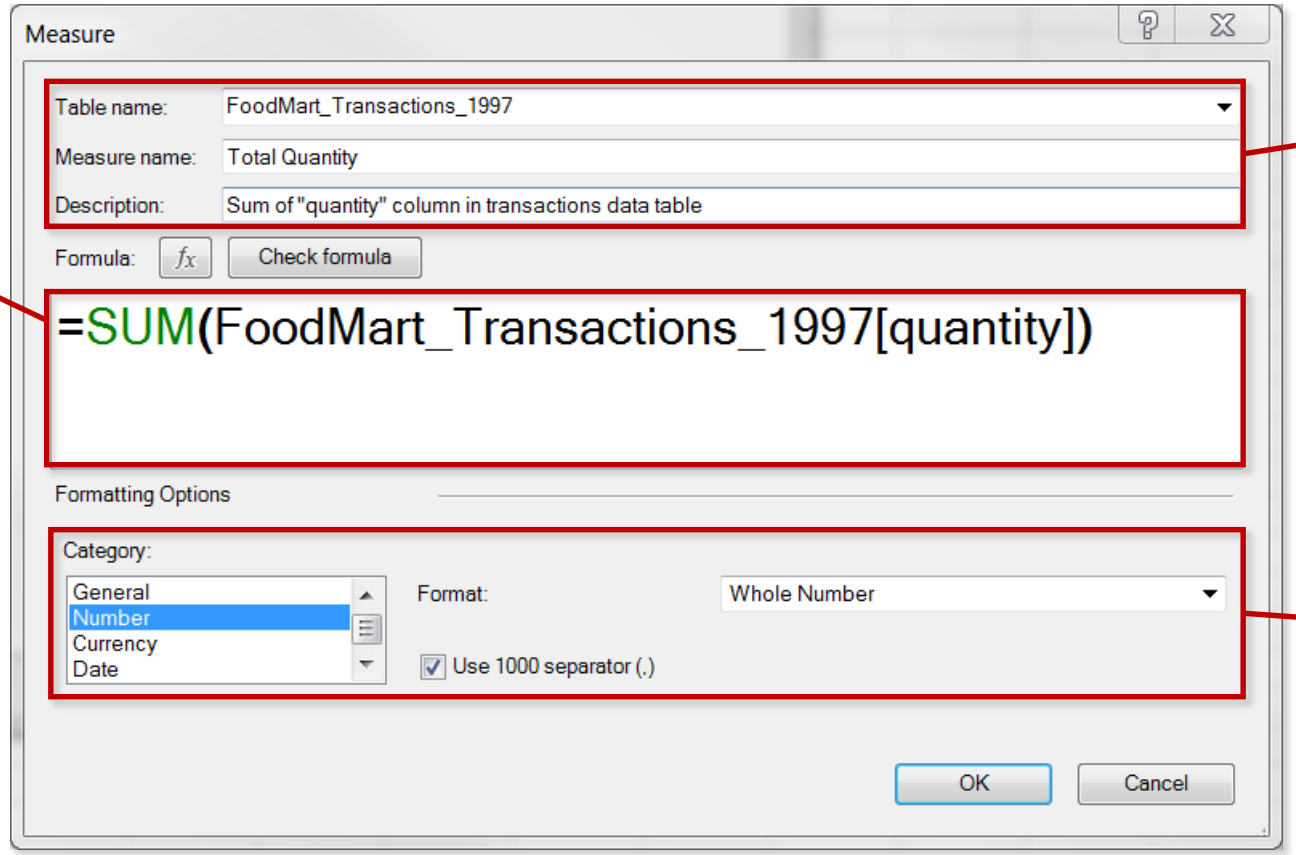
***AutoSum** is a nice way to get comfortable with basic DAX and quickly add measures; just don't rely on them when things start to get more complicated!*

EXCEL MAVEN

CREATING EXPLICIT MEASURES (POWER PIVOT)



The Measure Dialog Box



The **Formula** pane contains the actual DAX code, as well as options to browse the formula library or check syntax

Note: *just start typing, and "Intellisense" will kick in to help you auto-populate formula names and tables*

PRO TIP:

Ctrl+scroll *adjusts formula text size*

Each measure is **assigned to a table** and given a **measure name** (as well as an optional description)

Use the **Formatting Options** to specify a format for each measure

EXCEL MAVEN

UNDERSTANDING FILTER CONTEXT

Measures are calculated based on **filter context**, which is the set of filters (or "*coordinates*") determined by the PivotTable layout (filters, slicers, row labels and column labels)

HEY THIS IS IMPORTANT!

Each measure cell in the pivot **calculates independently**, based on its coordinates (*think of each cell as an island*)

When you change the pivot layout (by updating filters/slicers, row labels or column labels), each measure cell **detects its new coordinates** and then **recalculates its value**

customer_city	Total Quantity
Acapulco	16,428
Camacho	26,024
Hidalgo	52,888
La Cruz	10,251
Merida	40,994
Mexico City	10,666
Orizaba	27,334
San Andres	10,861
Santa Anita	11,834
Santa Fe	4,717
Tixapan	12,440
Guadalajara	2,401
Grand Total	**226,838**

The coordinate for this measure cell is **Customer_Lookup[customer_city] = "Hidalgo"**

- Given this coordinate, Excel filters down to the "Hidalgo" rows in the **Customer_Lookup** table, filters all *related* tables (based on the relationships in data model), then evaluates the arithmetic in the table defined by the measure (*in this case **Total Quantity** equals the **sum of quantity** from the transactions data table*)

This cell does NOT add up the values above it (*it's an island, remember?*)

- Total rows represent a **lack of filters**; since this cell does *not* have a customer_city coordinate, it evaluates the Total Quantity measure across the entire, unfiltered Customer_Lookup table

EXCEL MAVEN

FILTER CONTEXT EXAMPLES

customer_id	All
Year	1997
Month	All
customer_country	USA

customer_city	Total Quantity
Albany	6,806
Altadena	2,574
Anacortes	766

Cell coordinates:

- Calendar_Lookup[Year] = **1997**
- Customer_Lookup[customer_country] = **"USA"**
- Customer_Lookup[customer_city] = **"Altadena"**

customer_country

- Canada
- Mexico
- USA

Year	Quarter	Total Quantity
1997		266,773
	1	66,291
	2	62,610
	3	65,848
	4	72,024
1998		289,126
	1	69,785
	2	68,855
	3	68,574
	4	81,912
Grand Total		555,899

Cell coordinates:

- Calendar_Lookup[Year] = **1997**
- Customer_Lookup[customer_country] = **"USA"**

Cell coordinates:

- Calendar_Lookup[Year] = **1998**
- Calendar_Lookup[Quarter] = **1**
- Customer_Lookup[customer_country] = **"USA"**

Cell coordinates:

- Customer_Lookup[customer_country] = **"USA"**

store_country	Canada

Total Quantity	store_city		
product_brand	Vancouver	Victoria	Grand Total
ADJ	30	10	40
Akron	50	15	65
American	384	103	487
Amigo	50	31	81

Cell coordinates:

- Store_Lookup[store_country] = **"Canada"**
- Store_Lookup[store_city] = **"Vancouver"**
- Product_Lookup[product_brand] = **"Akron"**

Cell coordinates:

- Store_Lookup[store_country] = **"Canada"**
- Product_Lookup[product_brand] = **"Amigo"**

EXCEL MAVEN

STEP-BY-STEP MEASURE CALCULATION

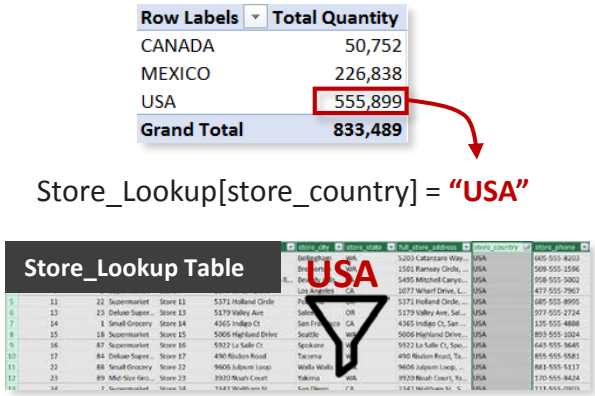
Row Labels	Total Quantity
CANADA	50,752
MEXICO	226,838
USA	555,899
Grand Total	**833,489**

How *exactly* is this measure calculated?

- **REMEMBER:** This all happens *instantly* behind the scenes, every time a measure cell calculates

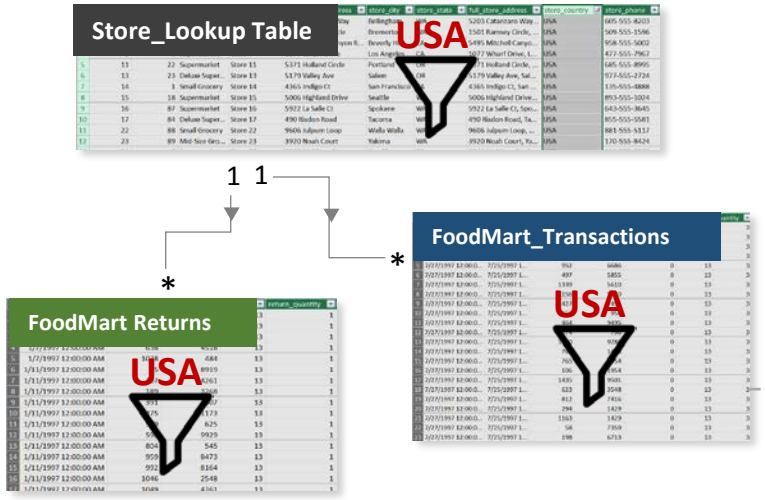
STEP 1

Detect pivot coordinates & apply filter context



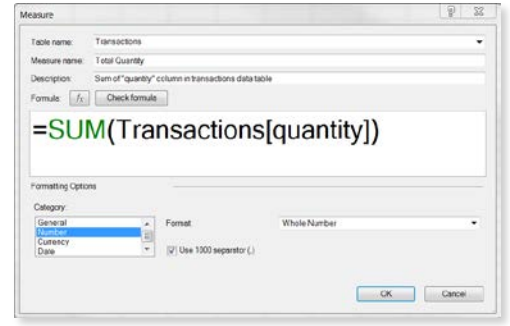
STEP 2

Carry filters "downstream" & apply to all related tables



STEP 3

Evaluate the measure formula against the filtered table

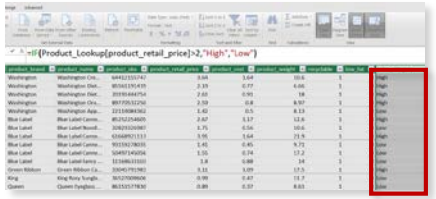


*Sum of Transactions[quantity] when store_country = "**USA**"* **= 555,899**

RECAP: CALCULATED COLUMNS VS. MEASURES

CALCULATED COLUMNS

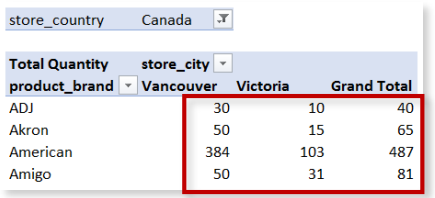
- Evaluated in the context of each row of the table to which it belongs (has **row context**)
- Appends static values to each row in a table and stores them in the model, increasing file size
- Only recalculated on data source refresh or changes to component columns
- Primarily used as **rows**, **columns**, **slicers** or **filters**



*Calculated columns "live" in **tables***

MEASURES

- Evaluated in the context of each cell of the PivotTable in which it is displayed (has **filter context**)
- Does not create new data in the tables themselves, and does not increase file size
- Recalculated in response to any change in the PivotTable view
- Can *only* be used as PivotTable **values**



store_country	Canada		
Total Quantity	store_city		
product_brand	Vancouver	Victoria	Grand Total
ADJ	30	10	40
Akron	50	15	65
American	384	103	487
Amigo	50	31	81

*Measures "live" in **PivotTables***

***Note:** Calculated columns CAN be placed in the values area of a pivot, but you can (and should) use a measure instead*

EXCEL MAVEN

POWER PIVOT BEST PRACTICES

Avoid using implicit measures whenever possible

- *Implicit measures are limited in functionality and restricted to the pivot in which they were created; explicit measures are more **portable** and **powerful***

Don't use a calculated column when a measure will do the trick

- *Only use calculated columns to "stamp" static, fixed values to each row in a table*
- *Use measures when aggregation is necessary, or to create dynamic values in a pivot*

Know your data model inside and out!

- *It's easy to produce incorrect results in Power Pivot if you don't respect the model's table relationships, and errors are often difficult to spot without a thorough QA*

COMMON DAX FUNCTIONS

DAX SYNTAX

MEASURE NAME

- ***Note:*** *Measures are always surrounded in brackets (i.e.* ***[Total Quantity]****) when referenced in formulas, so spaces are OK*

Referenced ***TABLE NAME***

Referenced ***COLUMN NAME***

Total Quantity: =SUM(Transactions[quantity])

FUNCTION NAME

- *Calculated columns don't always use functions, but measures do:*
  - *In a calculated column,* ***=Transactions[quantity]*** *returns the value from the quantity column in each row (since it evaluates for each row)*
  - *In a measure,* ***=Transactions[quantity]*** *will return an* ***error*** *since Excel doesn't know how to evaluate that as a single value in a pivot (you need some sort of aggregation)*

This is a ***"fully qualified"*** *column, since it's preceeded by the table name*

Note: *Table names with spaces must be surrounded by* ***single quotes****:*

- *Without a space:* ***Transactions****[quantity]*
- *With a space:* ***'Transactions Table'****[quantity]*

PRO TIP:

For ***column*** *references, use the fully qualified name (i.e.* ***Table[Column]****)*
For ***measure*** *references, just use the measure name (i.e.* ***[Measure]****)*

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DAX OPERATORS

Arithmetic Operator	Meaning	*Example*
+	Addition	*2 + 7*
-	Subtraction	*5 – 3*
*	Multiplication	*2 * 6*
/	Division	*4 / 2*
^	Exponent	*2 ^ 5*

Comparison Operator	Meaning	*Example*
=	Equal to	*[City]="Boston"*
>	Greater than	*[Quantity]>10*
<	Less than	*[Quantity]<10*
>=	Greater than or equal to	*[Unit_Price]>=2.5*
<=	Less than or equal to	*[Unit_Price]<=2.5*
<>	Not equal to	*[Country]<>"Mexico"*

Hey! Pay attention to these!

Text/Logical Operator	Meaning	*Example*
&	Concatenates two values to produce one text string	*[City]* **&** *" " &* *[State]*
&&	Create an **AND** condition between two logical expressions	*([State]="MA")* **&&** *([Quantity]>10)*
|| *(double pipe)*	Create an **OR** condition between two logical expressions	*([State]="MA")* **||** *([State]="CT")*
IN	Creates a logical **OR** condition based on a given list (using curly brackets)	*'Store Lookup'[State]* **IN** *{ "MA", "CT", "NY" }*

Head to **www.msdn.microsoft.com for more information about DAX syntax, operators, troubleshooting, etc.*

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COMMON FUNCTION CATEGORIES

MATH & STATS Functions

*Basic **aggregation** functions as well as "**iterators**" evaluated at the row-level*

Common Examples:

- SUM
- AVERAGE
- MAX/MIN
- DIVIDE
- COUNT/COUNTA
- COUNTROWS
- DISTINCTCOUNT

Iterator Functions:

- SUMX
- AVERAGEX
- MAXX/MINX
- RANKX
- COUNTX

LOGICAL Functions

*Functions for returning information about values in a given **conditional expression***

Common Examples:

- IF
- IFERROR
- AND
- OR
- NOT
- SWITCH
- TRUE
- FALSE

TEXT Functions

*Functions to manipulate **text strings** or **control formats** for dates, times or numbers*

Common Examples:

- CONCATENATE
- FORMAT
- LEFT/MID/RIGHT
- UPPER/LOWER
- PROPER
- LEN
- SEARCH/FIND
- REPLACE
- REPT
- SUBSTITUTE
- TRIM
- UNICHAR

FILTER Functions

***Lookup** functions based on related tables and **filtering** functions for dynamic calculations*

Common Examples:

- CALCULATE
- FILTER
- ALL
- ALLEXCEPT
- RELATED
- RELATEDTABLE
- DISTINCT
- VALUES
- EARLIER/EARLIEST
- HASONEVALUE
- HASONEFILTER
- ISFILTERED
- USERELATIONSHIP

DATE & TIME Functions

*Basic **date and time** functions as well as advanced **time intelligence** operations*

Common Examples:

- DATEDIFF
- YEARFRAC
- YEAR/MONTH/DAY
- HOUR/MINUTE/SECOND
- TODAY/NOW
- WEEKDAY/WEEKNUM

Time Intelligence Functions:

- DATESYTD
- DATESQTD
- DATESMTD
- DATEADD
- DATESINPERIOD

***Note:** This is NOT a comprehensive list (does not include trigonometry functions, parent/child functions, information functions, or other less common functions)*

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BASIC MATH & STATS FUNCTIONS

SUM()	*Evaluates the sum of a column*	=**SUM**(<column>)
AVERAGE()	*Returns the average (arithmetic mean) of all the numbers in a column*	=**AVERAGE**(<column>)
MAX()	*Returns the largest value in a column or between two scalar expressions*	=**MAX**(<column>) *or* =**MAX**(<exp1>, <exp2>)
MIN()	*Returns the smallest value in a column or between two scalar expressions*	=**MIN**(<column>) *or* =**MIN**(<exp1>, <exp2>)
DIVIDE()	*Performs division and returns the alternate result (or blank) if div/0*	=**DIVIDE**(<numerator>, <denominator>, <*other*>)

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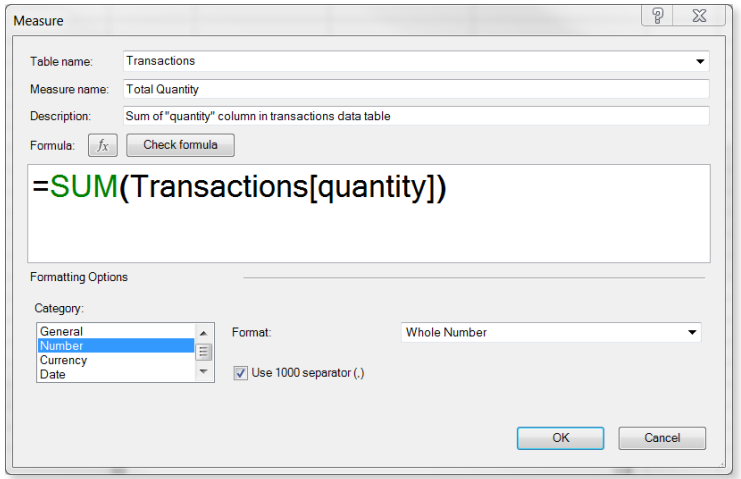
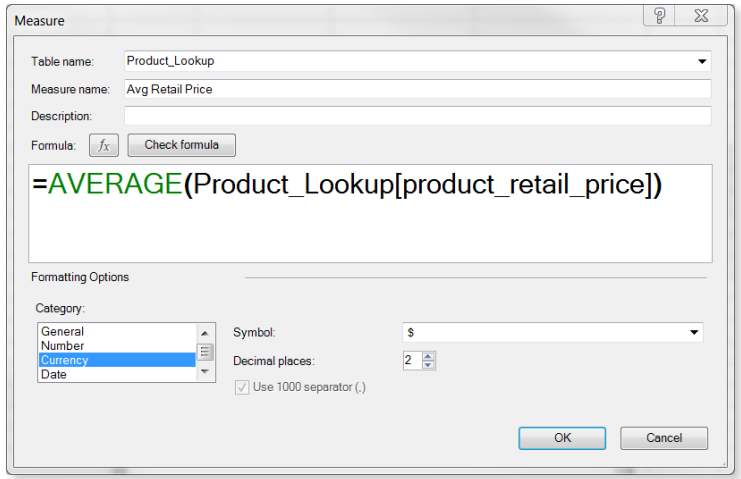
BASIC MATH & STATS FUNCTIONS (EXAMPLES)

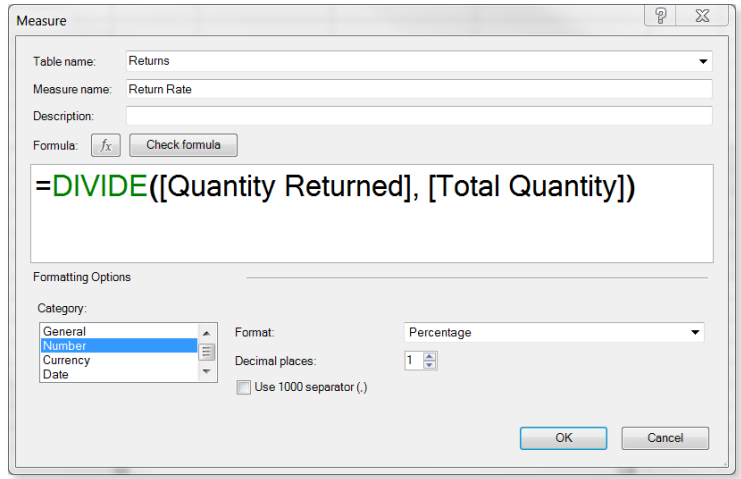
Sum of quantity from the Transactions table



Average of product_retail_price



Quantity Returned divided by Total Quantity



PRO TIP:

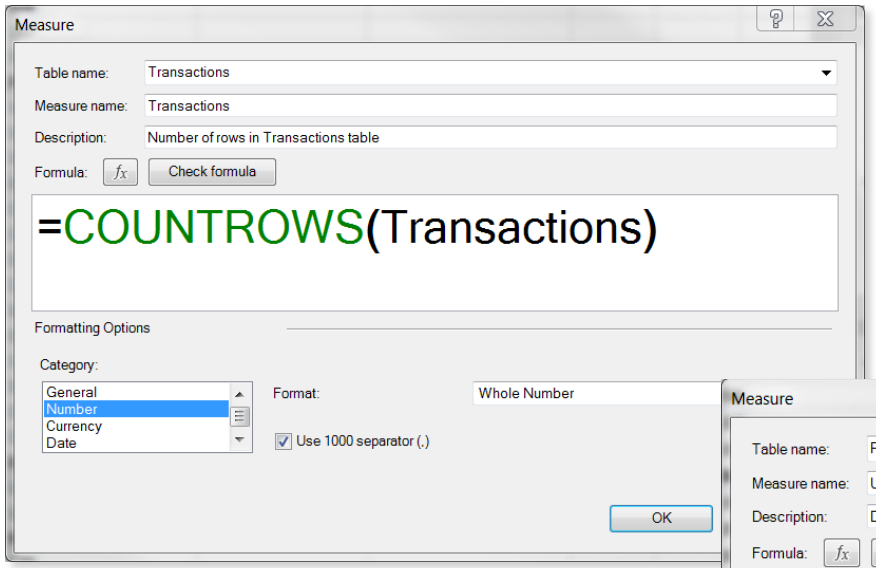
*Even though it might seem unnecessary, **creating measures for even simple calculations** (like the sum of a column) allows you to use those measures within other calculations, anywhere in the workbook*

COUNT, COUNTA, DISTINCTCOUNT & COUNTROWS

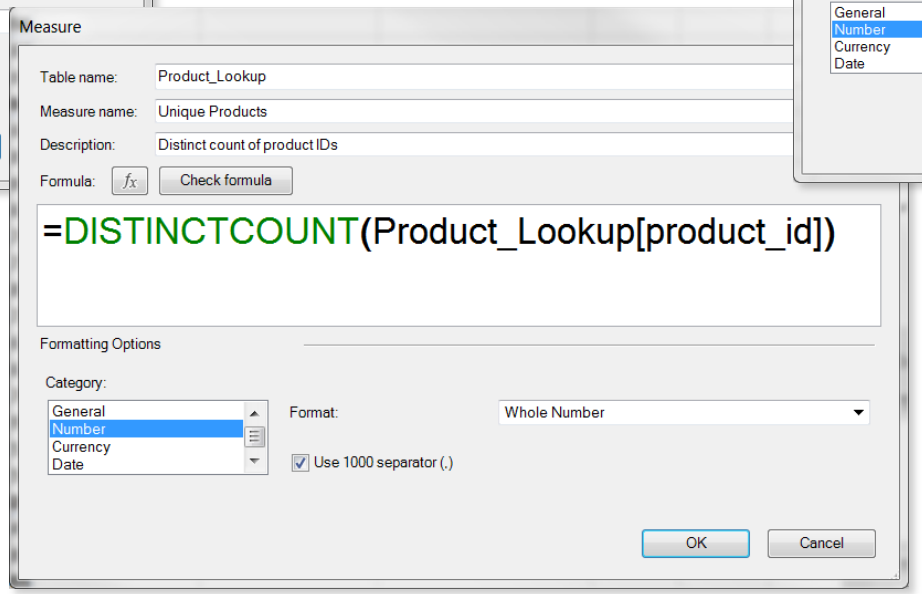
COUNTROWS()	*Counts the number of rows in the specified table, or a table defined by an expression*	**=COUNTROWS(**<table>**)**
COUNT()	*Counts the number of cells in a column that contain numbers*	**=COUNT(**<column>**)**
COUNTA()	*Counts the number of non-empty cells in a column (numerical and non-numerical)*	**=COUNTA(**<column>**)**
DISTINCTCOUNT()	*Counts the number of different cells in a column of numbers*	**=DISTINCTCOUNT(**<column>**)**

COUNT FUNCTIONS (EXAMPLES)

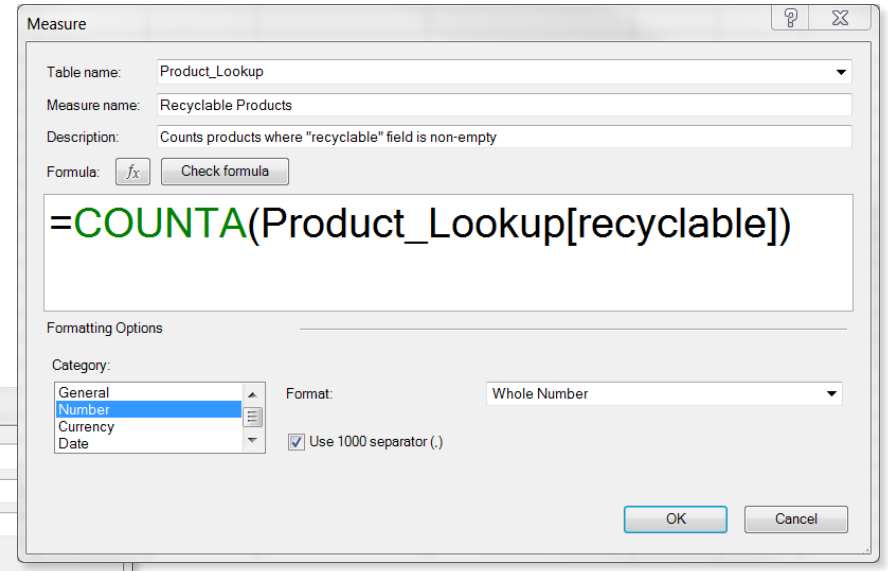
*Count of **all rows** in the Transactions table*



*Count of **unique values** in the product_id column*



*Count of **non-empty cells** in the recyclable column*



EXCEL MAVEN

BASIC LOGICAL FUNCTIONS (IF/AND/OR)

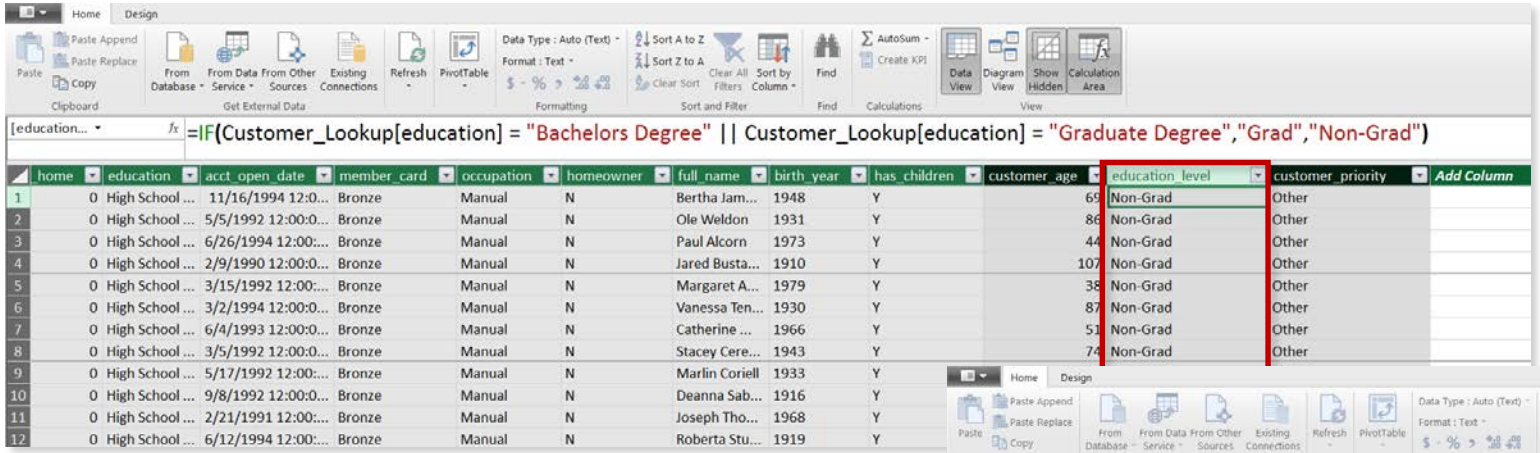
IF()	*Checks if a given condition is met, and returns one value if the condition is TRUE, and another if the condition is FALSE*	=**IF**(<logical test>, <value_if_true>, *<value_if_false>*)
IFERROR()	*Evaluates an expression and returns a specified value if the expression returns an error, otherwise returns the expression itself*	=**IFERROR**(value, value_if_error)
AND()	*Checks whether both arguments are TRUE, and returns TRUE if both arguments are TRUE, otherwise returns FALSE*	=**AND**(<logical1>, <logical2>)
OR()	*Checks whether one of the arguments is TRUE to return TRUE, and returns FALSE if both arguments are FALSE*	=**OR** (<logical1>, <logical2>)

Note: *Use the **&&** and **||** operators if you want to include more than two conditions!*

EXCEL MAVEN

BASIC LOGICAL FUNCTIONS (EXAMPLES)

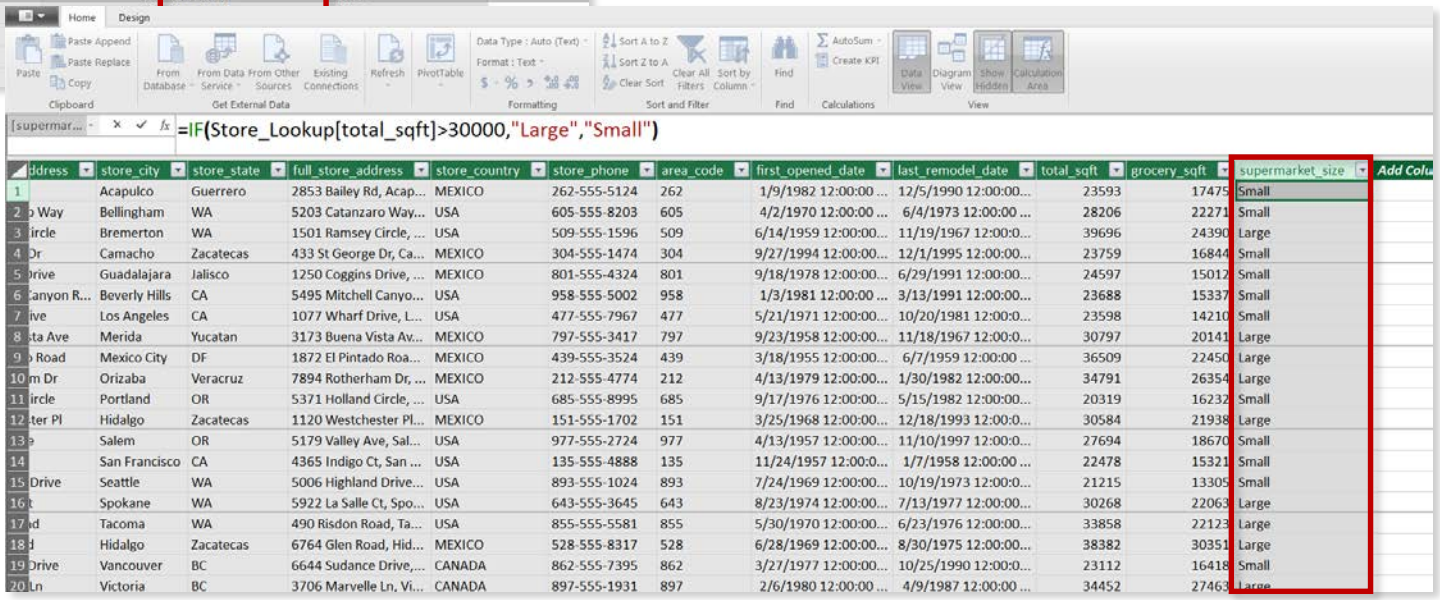
*Education level equals "**Grad**" if customer has a bachelors degree or a graduate degree, otherwise "**Non-Grad**"*



```
=IF(Customer_Lookup[education] = "Bachelors Degree" || Customer_Lookup[education] = "Graduate Degree","Grad","Non-Grad")
```

	home	education	acct_open_date	member_card	occupation	homeowner	full_name	birth_year	has_children	customer_age	education_level	customer_priority	Add Column
1	0	High School ...	11/16/1994 12:0...	Bronze	Manual	N	Bertha Jam...	1948	Y	69	Non-Grad	Other	
2	0	High School ...	5/5/1992 12:00:0...	Bronze	Manual	N	Ole Weldon	1931	Y	86	Non-Grad	Other	
3	0	High School ...	6/26/1994 12:00:...	Bronze	Manual	N	Paul Alcorn	1973	Y	44	Non-Grad	Other	
4	0	High School ...	2/9/1990 12:00:0...	Bronze	Manual	N	Jared Busta...	1910	Y	107	Non-Grad	Other	
5	0	High School ...	3/15/1992 12:00:...	Bronze	Manual	N	Margaret A...	1979	Y	38	Non-Grad	Other	
6	0	High School ...	3/2/1994 12:00:0...	Bronze	Manual	N	Vanessa Ten...	1930	Y	87	Non-Grad	Other	
7	0	High School ...	6/4/1993 12:00:0...	Bronze	Manual	N	Catherine ...	1966	Y	51	Non-Grad	Other	
8	0	High School ...	3/5/1992 12:00:0...	Bronze	Manual	N	Stacey Cere...	1943	Y	74	Non-Grad	Other	
9	0	High School ...	5/17/1992 12:00:...	Bronze	Manual	N	Marlin Coriell	1933	Y				
10	0	High School ...	9/8/1992 12:00:0...	Bronze	Manual	N	Deanna Sab...	1916	Y				
11	0	High School ...	2/21/1991 12:00:...	Bronze	Manual	N	Joseph Tho...	1968	Y				
12	0	High School ...	6/12/1994 12:00:...	Bronze	Manual	N	Roberta Stu...	1919	Y				

*Supermarket_size equals "**Large**" if sq ft >30,000, otherwise "**Small**"*



```
=IF(Store_Lookup[total_sqft]>30000,"Large","Small")
```

	ddress	store_city	store_state	full_store_address	store_country	store_phone	area_code	first_opened_date	last_remodel_date	total_sqft	grocery_sqft	supermarket_size	Add Colu
1		Acapulco	Guerrero	2853 Bailey Rd, Acap...	MEXICO	262-555-5124	262	1/9/1982 12:00:00 ...	12/5/1990 12:00:00...	23593	17475	Small	
2	Way	Bellingham	WA	5203 Catanzaro Way...	USA	605-555-8203	605	4/2/1970 12:00:00 ...	6/4/1973 12:00:00 ...	28206	22271	Small	
3	ircle	Bremerton	WA	1501 Ramsey Circle, ...	USA	509-555-1596	509	6/14/1959 12:00:00...	11/19/1967 12:00:0...	39696	24390	Large	
4	Dr	Camacho	Zacatecas	433 St George Dr, Ca...	MEXICO	304-555-1474	304	9/27/1994 12:00:00...	12/1/1995 12:00:00...	23759	16844	Small	
5	rive	Guadalajara	Jalisco	1250 Coggins Drive, ...	MEXICO	801-555-4324	801	9/18/1978 12:00:00...	6/29/1991 12:00:00...	24597	15012	Small	
6	anyon R...	Beverly Hills	CA	5495 Mitchell Canyo...	USA	958-555-5002	958	1/3/1981 12:00:00 ...	3/13/1991 12:00:00...	23688	15337	Small	
7	ive	Los Angeles	CA	1077 Wharf Drive, L...	USA	477-555-7967	477	5/21/1971 12:00:00...	10/20/1981 12:00:0...	23598	14210	Small	
8	sta Ave	Merida	Yucatan	3173 Buena Vista Av...	MEXICO	797-555-3417	797	9/23/1958 12:00:00...	11/18/1967 12:00:0...	30797	20141	Large	
9	Road	Mexico City	DF	1872 El Pintado Roa...	MEXICO	439-555-3524	439	3/18/1955 12:00:00...	6/7/1959 12:00:00 ...	36509	22450	Large	
10	m Dr	Orizaba	Veracruz	7894 Rotherham Dr, ...	MEXICO	212-555-4774	212	4/13/1979 12:00:00...	1/30/1982 12:00:00...	34791	26354	Large	
11	ircle	Portland	OR	5371 Holland Circle, ...	USA	685-555-8995	685	9/17/1976 12:00:00...	5/15/1982 12:00:00...	20319	16232	Small	
12	ter Pl	Hidalgo	Zacatecas	1120 Westchester Pl...	MEXICO	151-555-1702	151	3/25/1968 12:00:00...	12/18/1993 12:00:0...	30584	21938	Large	
13	e	Salem	OR	5179 Valley Ave, Sal...	USA	977-555-2724	977	4/13/1957 12:00:00...	11/10/1997 12:00:0...	27694	18670	Small	
14		San Francisco	CA	4365 Indigo Ct, San ...	USA	135-555-4888	135	11/24/1957 12:00:0...	1/7/1958 12:00:00 ...	22478	15321	Small	
15	Drive	Seattle	WA	5006 Highland Drive...	USA	893-555-1024	893	7/24/1969 12:00:00...	10/19/1973 12:00:0...	21215	13305	Small	
16	t	Spokane	WA	5922 La Salle Ct, Spo...	USA	643-555-3645	643	8/23/1974 12:00:00...	7/13/1977 12:00:00...	30268	22063	Large	
17	d	Tacoma	WA	490 Risdon Road, Ta...	USA	855-555-5581	855	5/30/1970 12:00:00...	6/23/1976 12:00:00...	33858	22123	Large	
18	d	Hidalgo	Zacatecas	6764 Glen Road, Hid...	MEXICO	528-555-8317	528	6/28/1969 12:00:00...	8/30/1975 12:00:00...	38382	30351	Large	
19	Drive	Vancouver	BC	6644 Sudance Drive,...	CANADA	862-555-7395	862	3/27/1977 12:00:00...	10/25/1990 12:00:0...	23112	16418	Small	
20	Ln	Victoria	BC	3706 Marvelle Ln, Vi...	CANADA	897-555-1931	897	2/6/1980 12:00:00 ...	4/9/1987 12:00:00 ...	34452	27463	Large	

SWITCH & SWITCH(TRUE)

SWITCH()

Evaluates an expression against a list of values and returns one of multiple possible result expressions

=**SWITCH**(<expression>, <value1>, <result1>, <value2>, <result2>, … <*else*>)

Any DAX expression that returns a single scalar value, evaluated multiple times (for each row/constant)

Examples:

- *Calendar_Lookup[month_num]*
- *Product_Lookup[product_brand]*

*List of **values** produced by the expression, each paired with a **result** to return for rows/cases that match*

Examples:

=SWITCH(Calendar_Lookup[month_num],
1, "**January**",
2, "**February**",
etc…

=SWITCH(TRUE(),
[retail_price]<5, "**Low Price**",
AND([retail_price>=5, [retail_price]<20), "**Med Price**",
AND([retail_price>=20, [retail_price]<50), "**High Price**"
"**Premium Price**")

Value returned if the expression doesn't match any value argument

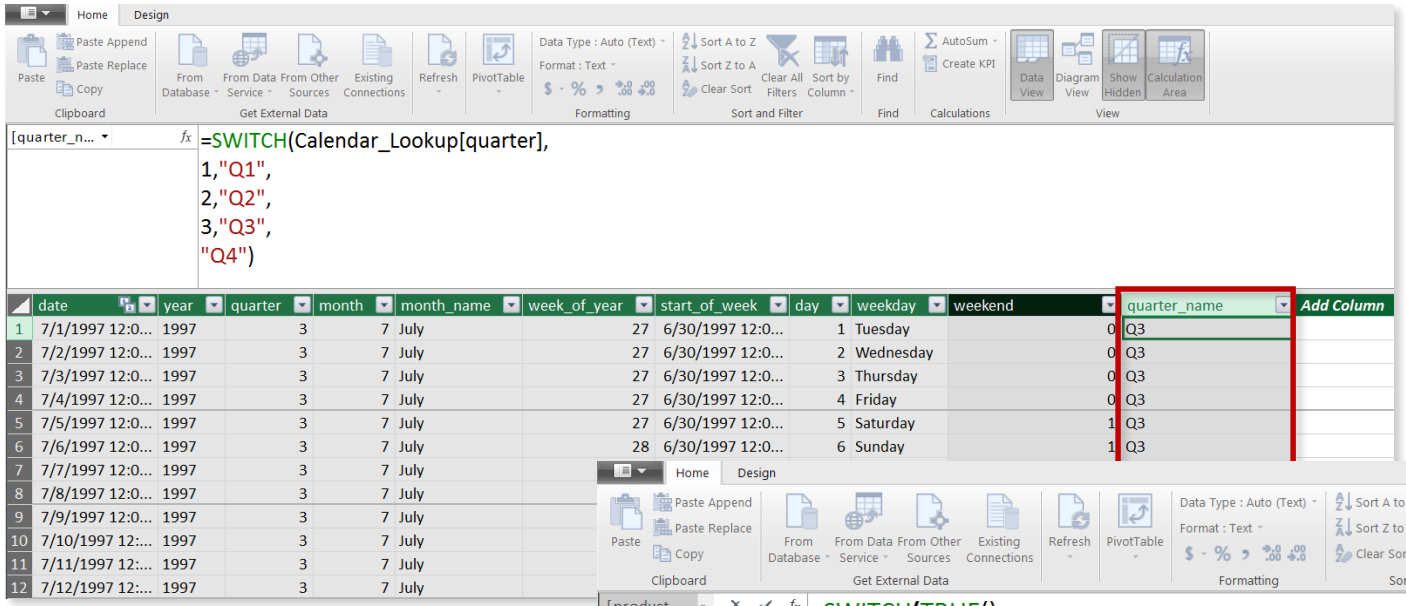
PRO TIP:

*Use the **SWITCH(TRUE()** combo to generate results based on Boolean (True/False) expressions (instead of those pesky nested IF statements!)*

EXCEL MAVEN

SWITCH & SWITCH(TRUE) (EXAMPLES)

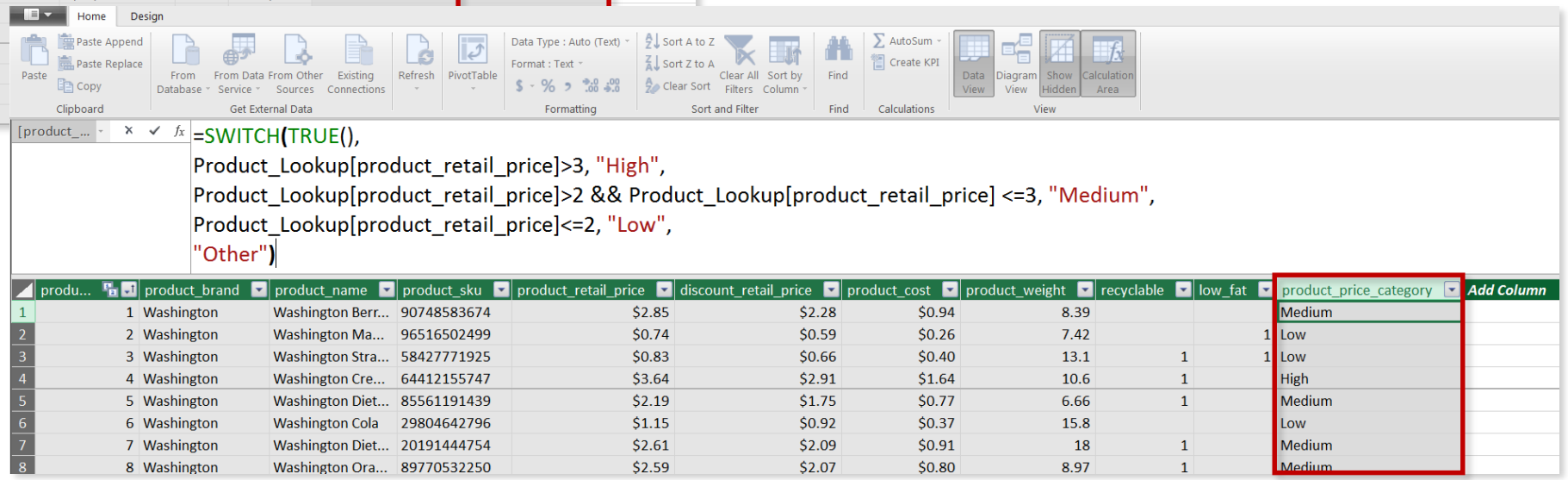
*Switch quarter 1 with "**Q1**", quarter 2 with "**Q2**", quarter 3 = "**Q3**", else "**Q4**"*



```
=SWITCH(Calendar_Lookup[quarter],
1,"Q1",
2,"Q2",
3,"Q3",
"Q4")
```

	date	year	quarter	month	month_name	week_of_year	start_of_week	day	weekday	weekend	quarter_name	Add Column
1	7/1/1997 12:0...	1997	3	7	July	27	6/30/1997 12:0...	1	Tuesday	0	Q3	
2	7/2/1997 12:0...	1997	3	7	July	27	6/30/1997 12:0...	2	Wednesday	0	Q3	
3	7/3/1997 12:0...	1997	3	7	July	27	6/30/1997 12:0...	3	Thursday	0	Q3	
4	7/4/1997 12:0...	1997	3	7	July	27	6/30/1997 12:0...	4	Friday	0	Q3	
5	7/5/1997 12:0...	1997	3	7	July	27	6/30/1997 12:0...	5	Saturday	1	Q3	
6	7/6/1997 12:0...	1997	3	7	July	28	6/30/1997 12:0...	6	Sunday	1	Q3	
7	7/7/1997 12:0...	1997	3	7	July							
8	7/8/1997 12:0...	1997	3	7	July							
9	7/9/1997 12:0...	1997	3	7	July							
10	7/10/1997 12:...	1997	3	7	July							
11	7/11/1997 12:...	1997	3	7	July							
12	7/12/1997 12:...	1997	3	7	July							

*Set product_price_category to "**High**" if retail price > $3, "**Medium**" if price is between $2 and $3, "**Low**" if price is <=$2, else "**Other**"*



```
=SWITCH(TRUE(),
Product_Lookup[product_retail_price]>3, "High",
Product_Lookup[product_retail_price]>2 && Product_Lookup[product_retail_price] <=3, "Medium",
Product_Lookup[product_retail_price]<=2, "Low",
"Other")
```

	produ...	product_brand	product_name	product_sku	product_retail_price	discount_retail_price	product_cost	product_weight	recyclable	low_fat	product_price_category	Add Column
1	1	Washington	Washington Berr...	90748583674	$2.85	$2.28	$0.94	8.39			Medium	
2	2	Washington	Washington Ma...	96516502499	$0.74	$0.59	$0.26	7.42		1	Low	
3	3	Washington	Washington Stra...	58427771925	$0.83	$0.66	$0.40	13.1	1	1	Low	
4	4	Washington	Washington Cre...	64412155747	$3.64	$2.91	$1.64	10.6	1		High	
5	5	Washington	Washington Diet...	85561191439	$2.19	$1.75	$0.77	6.66	1		Medium	
6	6	Washington	Washington Cola	29804642796	$1.15	$0.92	$0.37	15.8			Low	
7	7	Washington	Washington Diet...	20191444754	$2.61	$2.09	$0.91	18	1		Medium	
8	8	Washington	Washington Ora...	89770532250	$2.59	$2.07	$0.80	8.97	1		Medium	

EXCEL MAVEN

TEXT FUNCTIONS

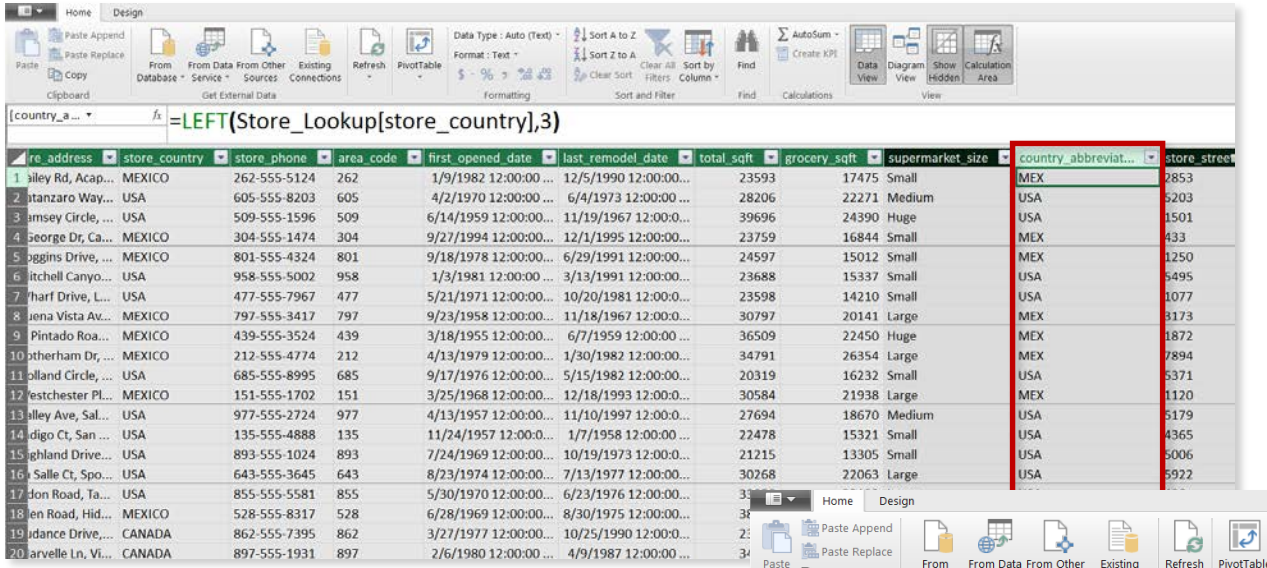
LEN()	*Returns the number of characters in a string*	=**LEN**(<text>)
CONCATENATE()	*Joins two text strings into one*	=**CONCATENATE**(<text1>, <text2>)
LEFT/MID/ RIGHT()	*Returns a number of characters from the start/middle/end of a text string*	=**LEFT/RIGHT**(<text>, <num_chars>) =**MID**(<text>, <start_num>, <num_chars>)
UPPER/LOWER/ PROPER()	*Converts letters in a string to upper/lower/proper case*	=**UPPER/LOWER/PROPER**(<text>)
SUBSTITUTE()	*Replaces an instance of existing text with new text in a string*	=**SUBSTITUTE**(<text>, <old_text>, <new_text>, *<instance>*)
SEARCH()	*Returns the position where a specified string or character is found, reading left to right*	=**SEARCH**(<find_text>, <within_text>, *<start_num>, <NotFoundValue>*)

***Note:** Use the **&** operator as a shortcut, or to combine more than two strings!*

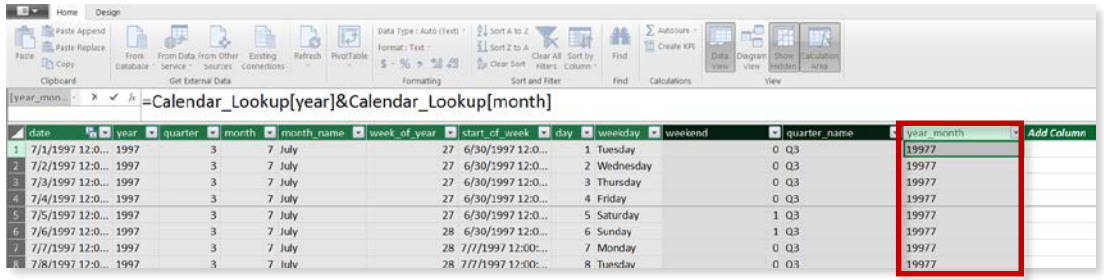
EXCEL MAVEN

TEXT FUNCTIONS (EXAMPLES)

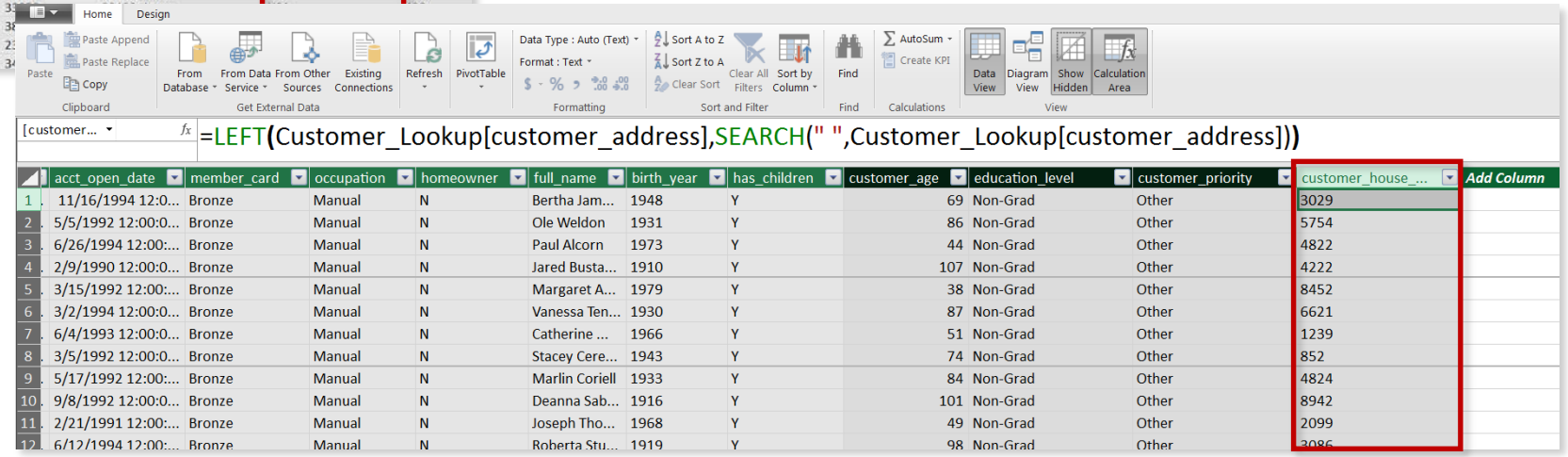
*Extract the **left 3 characters** from each value in the store_country column*



*Concatenate the values from the **year** and **month** columns*



*Extract characters from the left of the customer_address column, **up to the space***



CALCULATE

CALCULATE()

Evaluates a given expression or formula under a set of defined filters

=**CALCULATE**(<expression>, <filter1>, <filter2>,…)

Name of an existing measure or a formula for a valid measure

Examples:

- *[Total Transactions]*
- *SUM(Transactions[quantity])*

*List of simple Boolean (True/False) filter expressions (**note:** these require simple, fixed values; you cannot create filters based on measures)*

Examples:

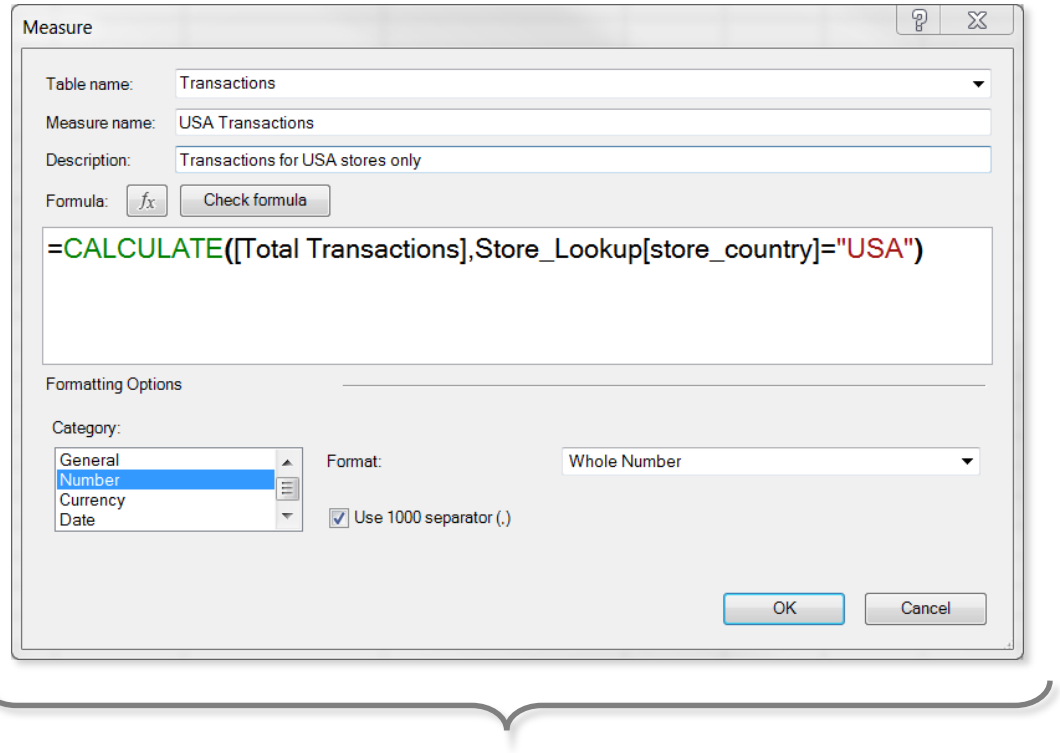
- *Store_Lookup[store_country]=**"USA"***
- *Calendar[Year]=**1998***
- *Transactions[quantity]>=**5***

PRO TIP:

*CALCULATE works just like **SUMIF** or **COUNTIF**, except it can evaluate measures based on ANY sort of calculation (not just a sum, count, etc); it may help to think of it like **"CALCULATEIF"***

EXCEL MAVEN

CALCULATE (EXAMPLE)



In this case we've defined a new measure named "**USA Transactions**", which evaluates the "**Total Transactions**" measure when the store country equals "**USA**"

store_country	Total Transactions	USA Transactions
CANADA	16,091	180,823
MEXICO	72,806	180,823
USA	180,823	180,823
Grand Total	**269,720**	**180,823**

*Why do we see the same repeating value when we add **store_country** to rows? Shouldn't these cells have filter contexts for Canada and Mexico?*

HEY THIS IS IMPORTANT!

The CALCULATE function **modifies filters** and **overrules** any competing ones defined by the PivotTable coordinates!

In this example, the MEXICO cell has a filter context of store_country= "**MEXICO**" (*defined by the row label*) AND story_country= "**USA**" (*defined by the CALCULATE function*)

Both cannot be true at the same time, so the MEXICO filter is overwritten and CALCULATE takes priority

EXCEL MAVEN

CALCULATE *CHANGES* THE FILTER CONTEXT

CALCULATE

Modify filters if measure contains CALCULATE

Store_Lookup[store_country] = **"USA"**

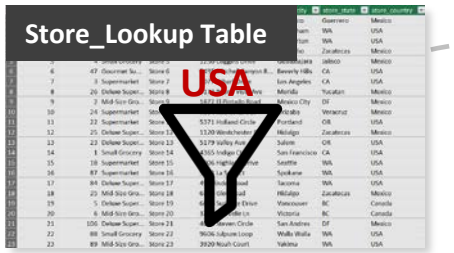
If the measure being evaluated contains a **CALCULATE** function, filter context is modified between **Step 1** & **Step 2**

STEP 1

Detect pivot coordinates & apply filter context

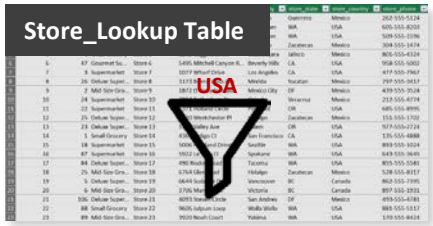
store_country	Total Transactions	USA Transactions
CANADA	16,091	180,823
MEXICO	72,806	180,823
USA	180,823	180,823
Grand Total	**269,720**	**180,823**

Store_Lookup[store_country] = **"MEXICO"**



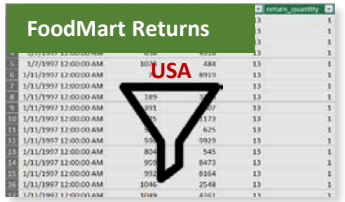
STEP 2

Carry the filters across all table relationships



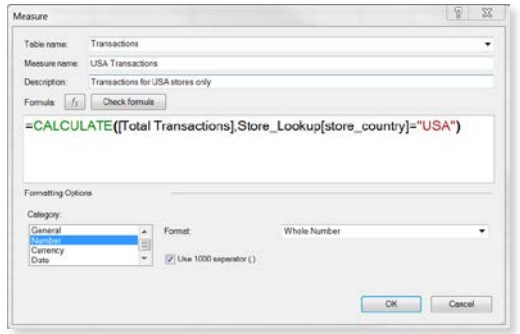
1 1

* *



STEP 3

Evaluate the formula against the filtered table



*Total Transactions where store_country = "**USA**"* = **180,823**

EXCEL MAVEN

FILTER

FILTER()

Returns a table that represents a subset of another table or expression

=**FILTER**(<table>, <filter expression>)

Table to be filtered

Examples:

- *Store_Lookup*
- *Product_Lookup*

A Boolean (True/False) filter expression to be evaluated for each row of the table

Examples:

- *Store_Lookup[store_country]=**"USA"***
- *Calendar[Year]=**1998***
- *[retail_price]>**AVERAGE[retail_price]***

HEY THIS IS IMPORTANT!

FILTER is used to **add filter context** on top of what's already defined by the PivotTable layout.

Since FILTER returns a table (as opposed to a scalar), it's almost always used as an *input* to other functions, **like enabling more complex filtering options within a CALCULATE function** (or passing a filtered table to an iterator like SUMX)

PRO TIP:

*Since FILTER iterates through each row in a table, it can be slow and processor-intensive; **never use FILTER when a normal CALCULATE function will accomplish the same thing!***

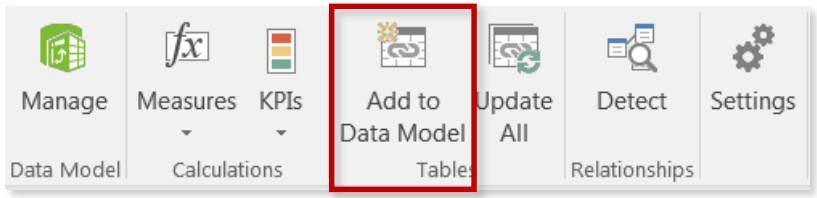
EXCEL MAVEN

PRO TIP: FILTERING WITH DISCONNECTED SLICERS (PART 1)

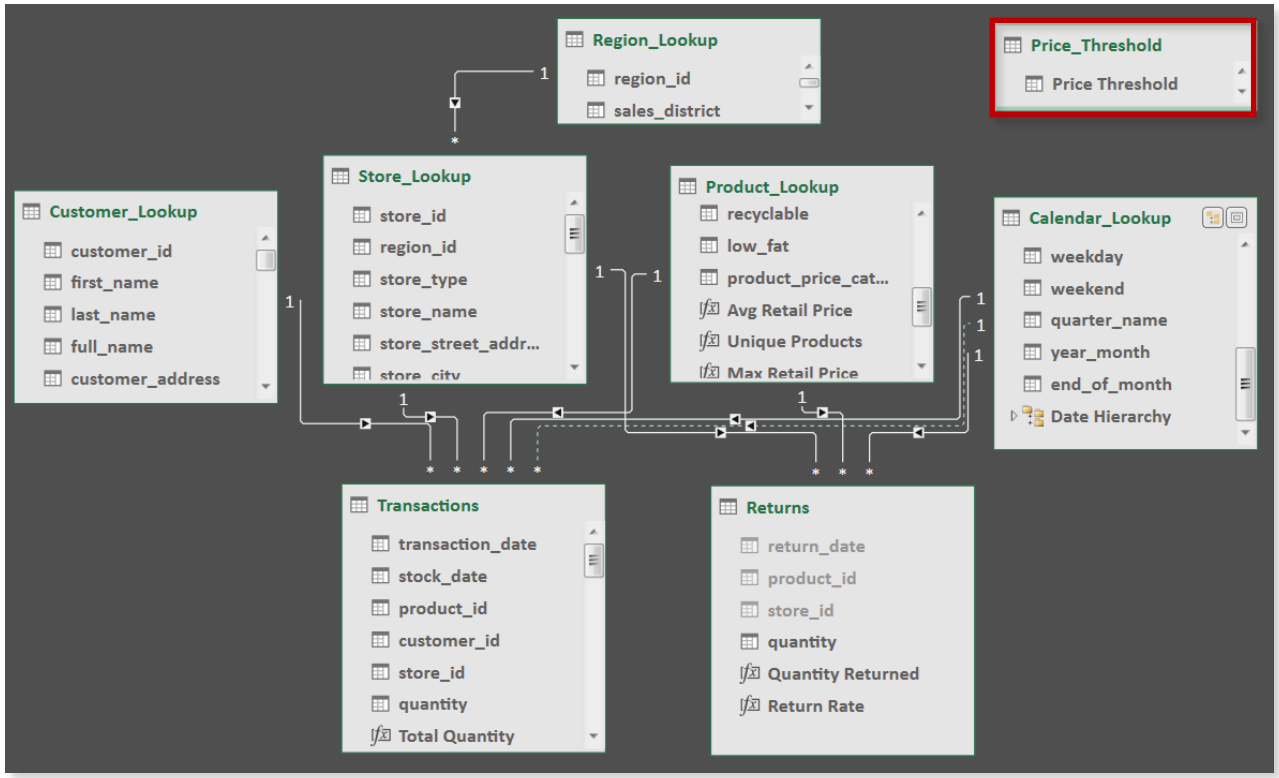
STEP 1: *Create an Excel table containing a list of values to use as thresholds or parameters:*

	A
1	**Price Threshold**
2	1
3	2
4	3
5	4

STEP 2: *Add the table to the **Data Model** (from **Power Pivot** tab):*

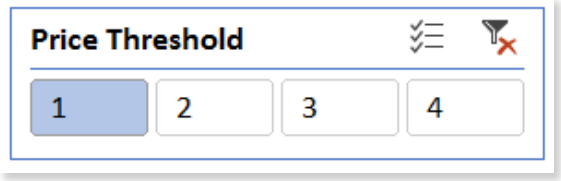


STEP 3: *Make sure that your table loaded, and is NOT connected to any other table in the model:*

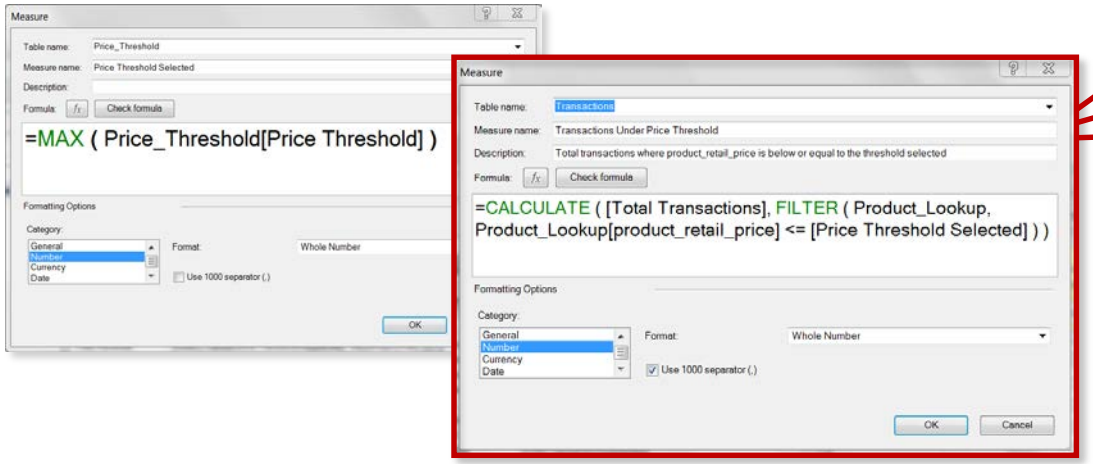


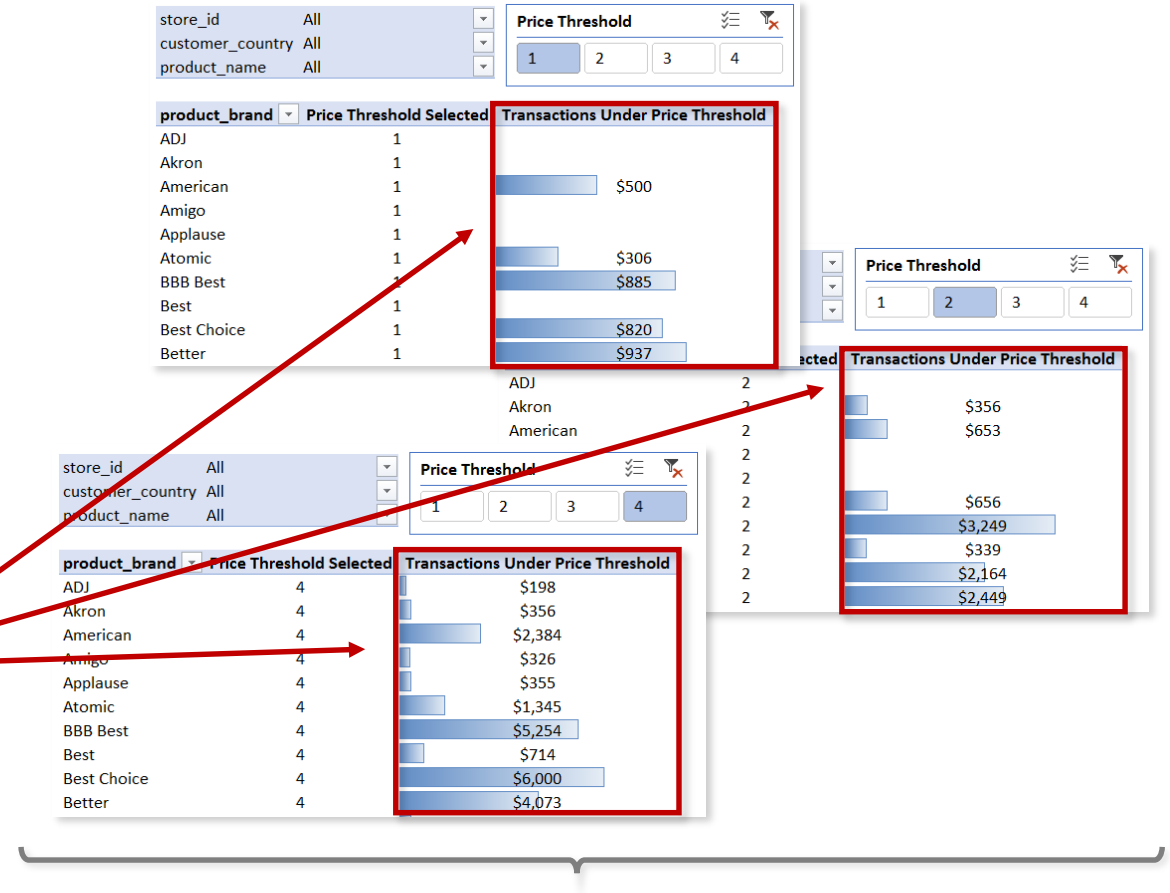
PRO TIP: FILTERING WITH DISCONNECTED SLICERS (PART 2)

STEP 4: *Place your new table on the pivot as a slicer:*



STEP 5: *Create a measure to capture the slicer selection, then reference it in a* ***FILTER*** *statement within* ***CALCULATE****:*

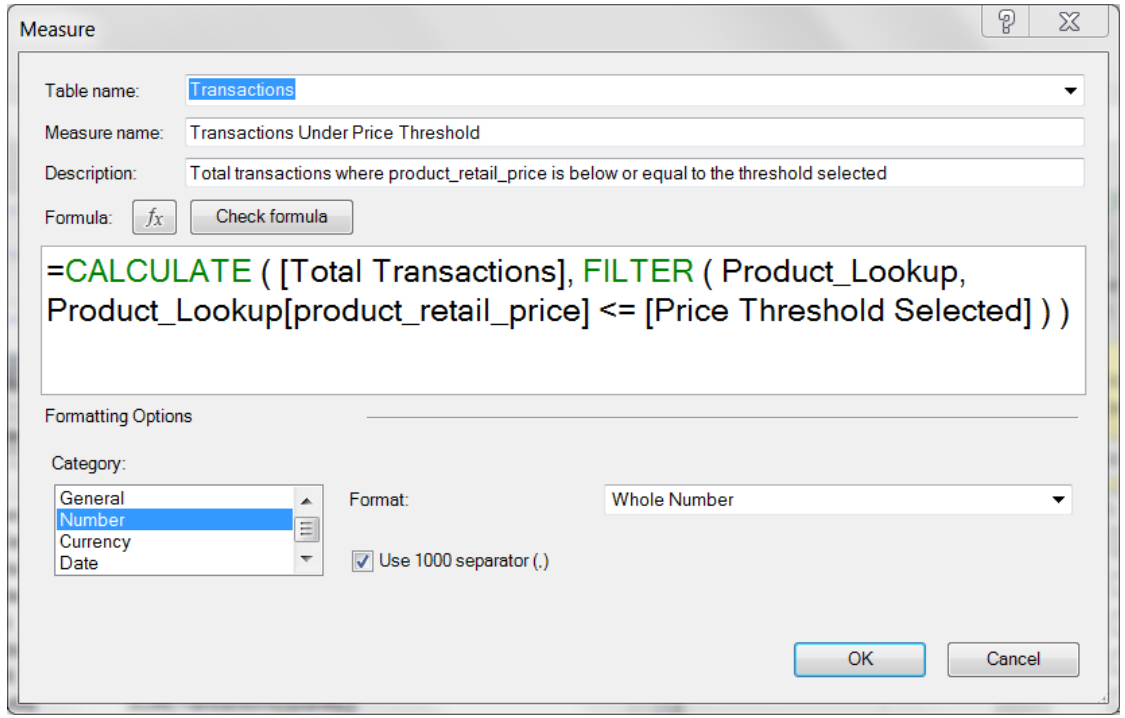




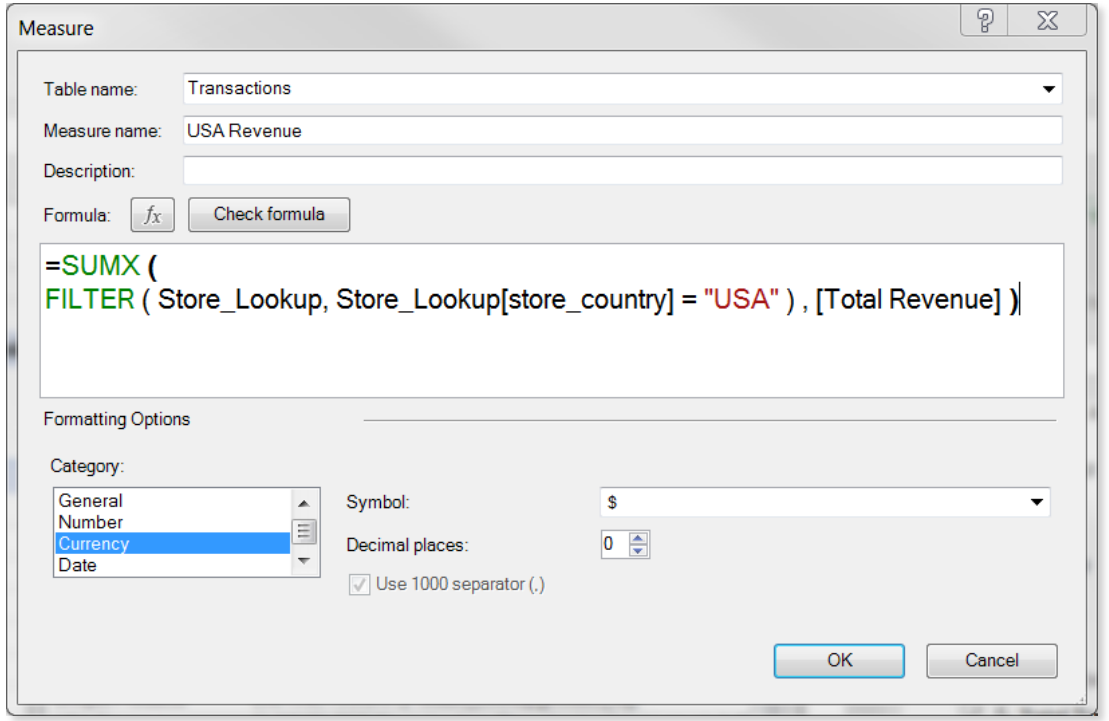
The ***Transactions Under Price Threshold*** *measure calculates Total Transactions* ***when the product price is below the selected threshold***

FILTER (EXAMPLES)

Calculate Total Transactions ***only for cases where the product price is below a selected threshold***



Calculate Total Revenue, ***but only for USA stores***



ALL

ALL() *Returns all rows in a table, or all values in a column, ignoring any filters that have been applied*

=**ALL**(<table> or <column>, [column1], [column2],…)

The table or column that you want to clear filters on

Examples:

- *Transactions*
- *Product_Lookup[product_brand]*

List of columns that you want to clear filters on (optional)

Notes:

- *If your first parameter is a table, you can't specify additional columns*
- *All columns must include the table name, and come from the same table*

Examples:

- *Customer_Lookup[customer_city], Customer_Lookup[customer_country]*
- *Product_Lookup[product_name]*

PRO TIP:

*ALL is like the opposite of FILTER; instead of adding filter context, ALL **removes filter context**. This is often used when you need unfiltered values that won't be skewed by the PivotTable layout (i.e. Category sales as % of Total)*

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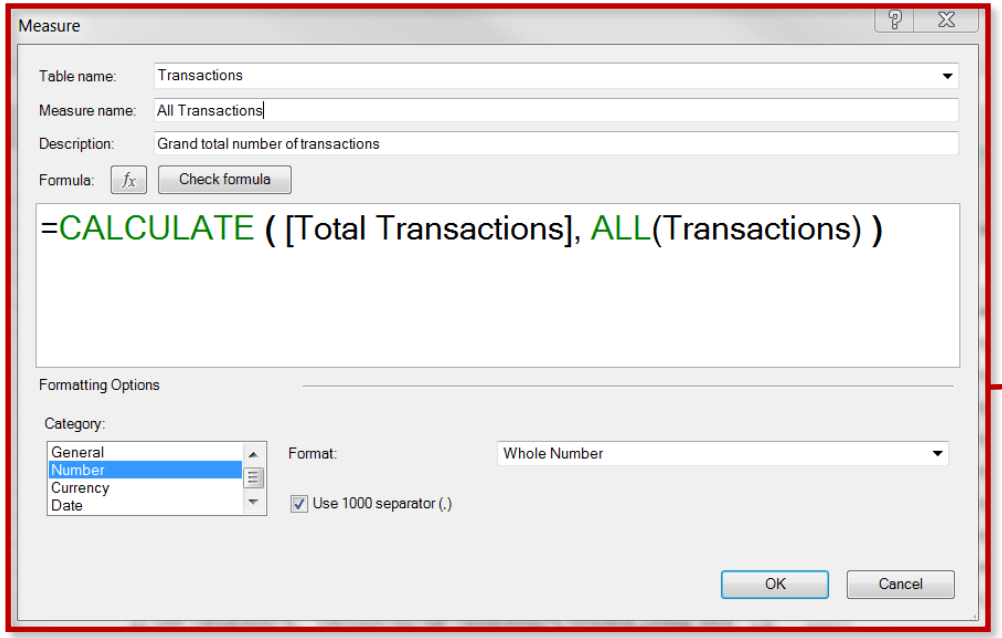
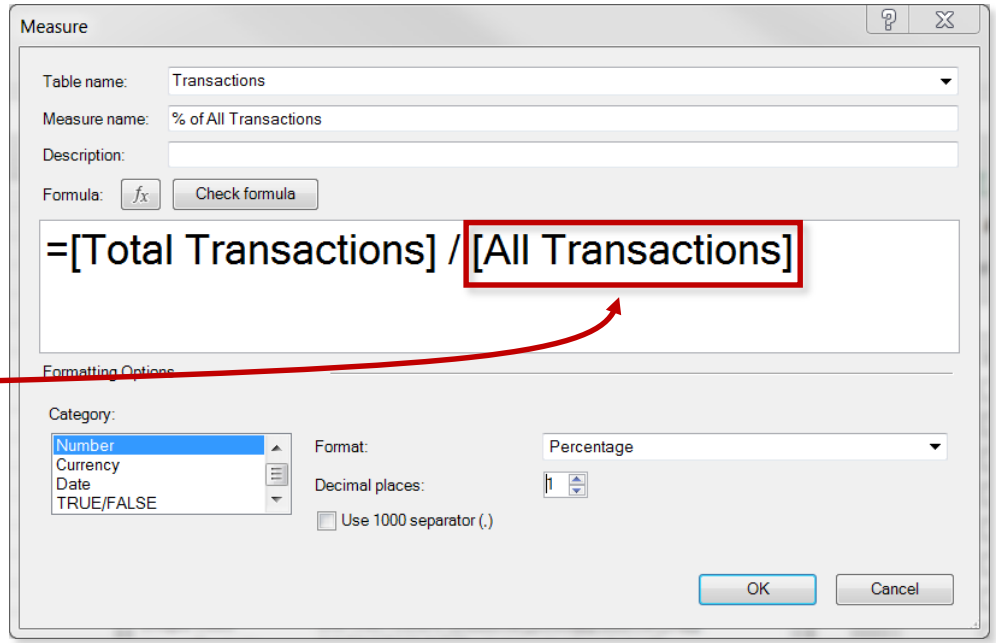
ALL (EXAMPLE)





- In this example, we use **ALL** to calculate total transactions across *all rows* in the Transactions table, **ignoring any filter context from the PivotTable**
  - By dividing the original **[Total Transaction]** measure (which responds to PivotTable filter context as expected) by the new **[All Transactions]** measure, we can correctly calculate the percentage of the total no matter how the PivotTable is filtered

RELATED

RELATED()

Returns related values in each row of a table using relationships with other tables

=**RELATED**(<column>)

The column that contains the values you want to retrieve

Examples:

- *Product_Lookup[product_brand]*
- *Store_Lookup[store_country]*

HEY THIS IS IMPORTANT!

RELATED works almost *exactly* like a **VLOOKUP** function – it uses the relationship between tables (*defined by primary and foreign keys*) to pull values from one table into a new column of another.

Since this function requires row context, it can only be used as a **calculated column** or as part of an **iterator function** that cycles through all rows in a table (FILTER, SUMX, MAXX, etc.)

PRO TIP:

Avoid using RELATED to create redundant calculated columns unless you absolutely need them, since those extra columns increase file size; instead, use RELATED within a measure like FILTER or SUMX

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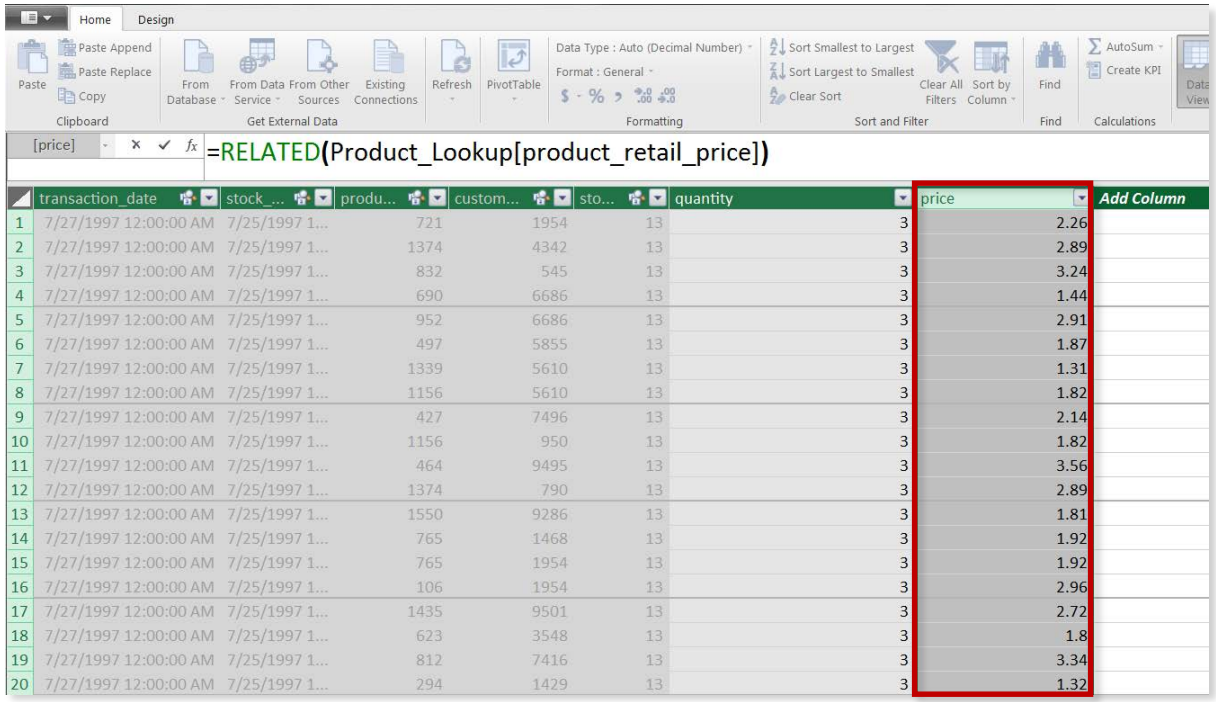
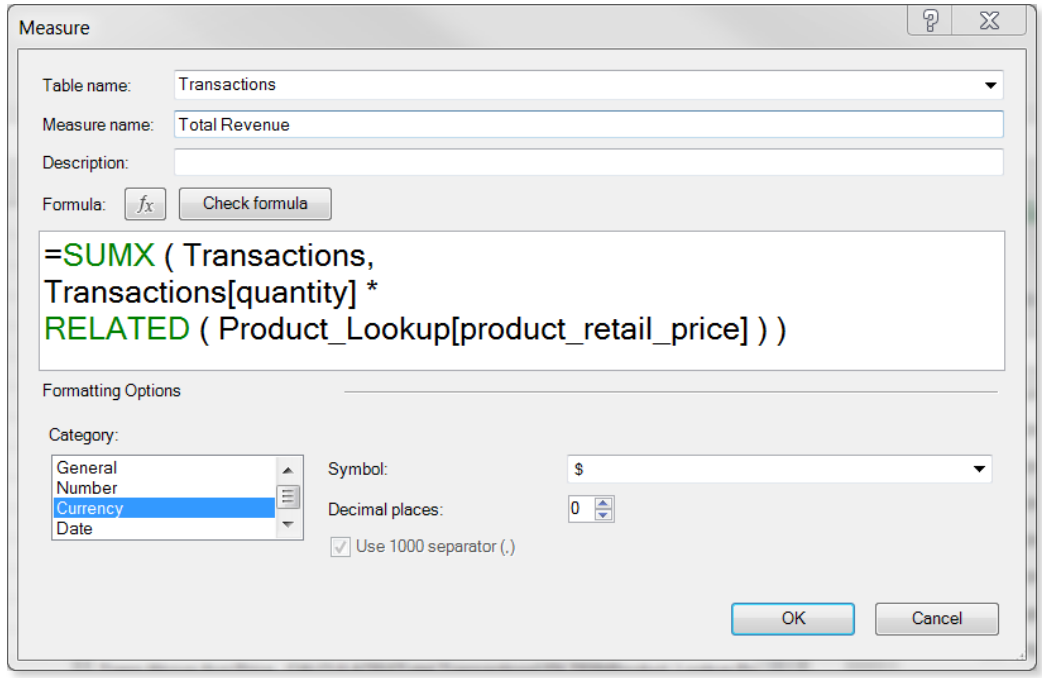
RELATED (EXAMPLES)

*Retrieve the **retail price** from the Product_Lookup table and append it to the Transactions table*



*Multiply the **quantity** in each row of the Transactions table with the related **retail price** from the Product_Lookup table, and sum the results*



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ITERATOR ("X") FUNCTIONS

Iterator (or "**X**") **functions** allow you to loop through the same calculation or expression on *each row of a table*, and then apply some sort of aggregation to the results (SUM, MAX, etc.)

=**SUMX**(<table>, <expression>)

*Aggregation to apply to calculated rows**

Examples:

- *SUMX*
- *COUNTX*
- *AVERAGEX*
- *RANKX*
- *MAXX/MINX*

Table in which the expression will be evaluated

Examples:

- *Transactions*
- *FILTER(Transactions, RELATED(Store_Lookup[country])="USA")*

Expression to be evaluated for each row of the given table

Examples:

- *[Total Transactions]*
- *Transactions[price] * Transactions[quantity]*

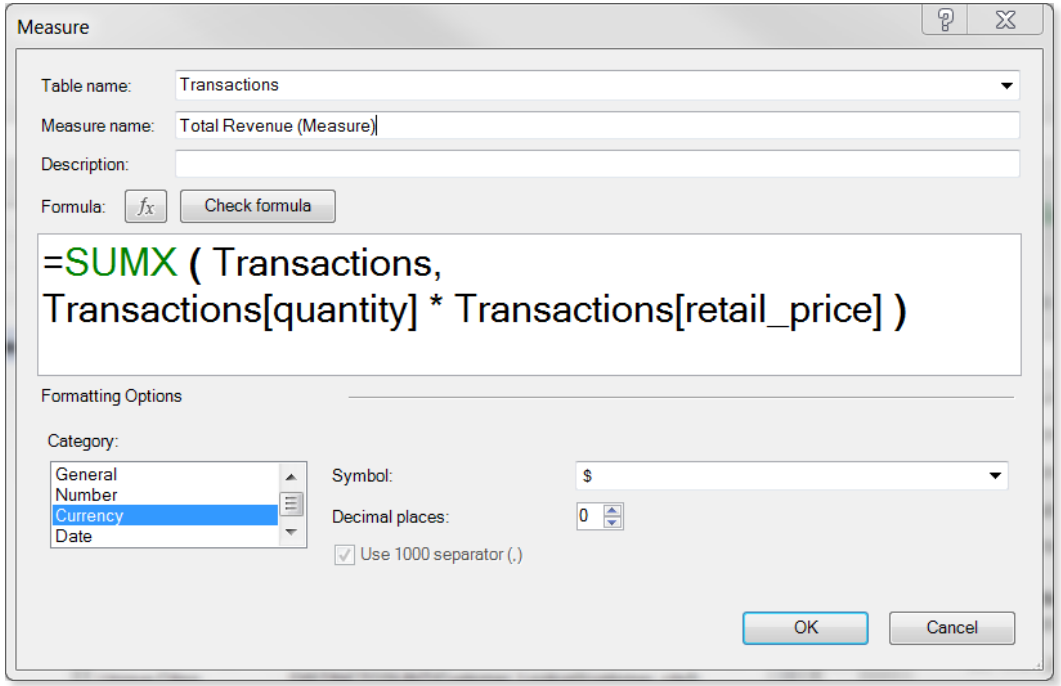
PRO TIP:

*Imagine the function **adding a temporary new column** to the table, calculating the value in each row (based on the expression) and then applying the aggregation to that new column (like SUMPRODUCT)*

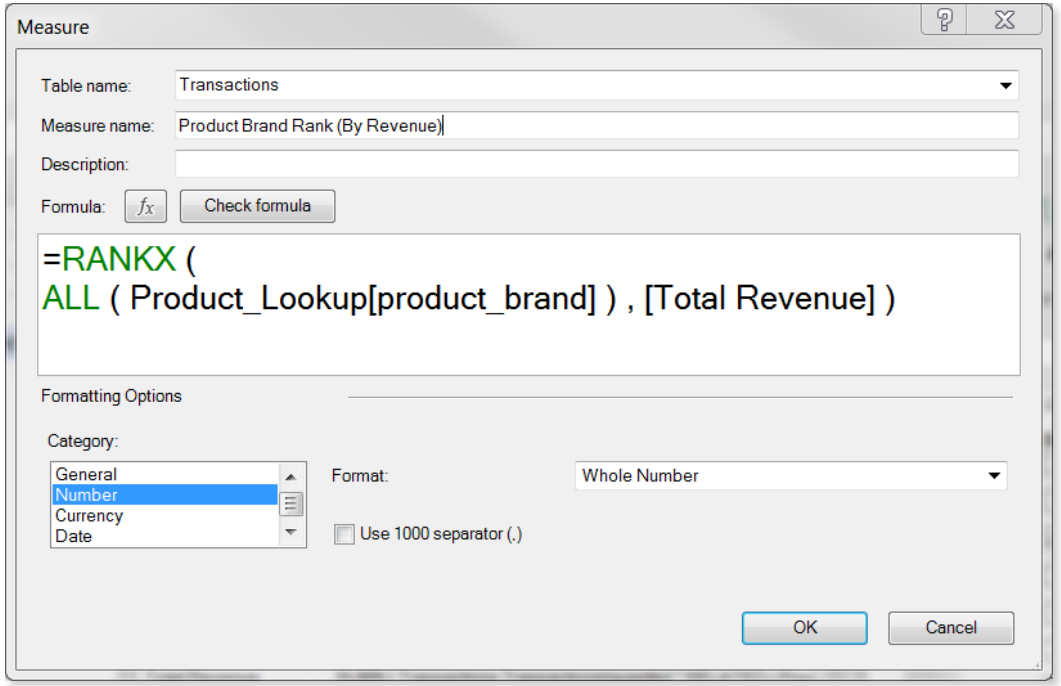
In this example we're looking at **SUMX, but all "X" functions follow a similar syntax*

ITERATOR ("X") FUNCTIONS (EXAMPLES)

*Multiply **quantity** and **retail price** for each row in the Transactions table, and sum the results*



*Calculate the **rank of each product brand**, based on total revenue*



BASIC DATE & TIME FUNCTIONS

DAY/MONTH/ YEAR()	*Returns the day of the month (1-31), month of the year (1-12), or year of a given date*	=**DAY/MONTH/YEAR**(<date>)
HOUR/MINUTE/ SECOND()	*Returns the hour (0-23), minute (0-59), or second (0-59) of a given datetime value*	=**HOUR/MINUTE/SECOND**(<datetime>)
TODAY/NOW()	*Returns the current date or exact time*	=**TODAY/NOW**()
WEEKDAY/ WEEKNUM()	*Returns a weekday number from 1 (Sunday) to 7 (Sunday), or the week # of the year*	=**WEEKDAY/WEEKNUM**(<date>, *<type>*)
EOMONTH()	*Returns the date of the last day of the month, +/- a specified number of months*	=**EOMONTH**(<start_date>, <months>)
DATEDIFF()	*Returns the difference between two dates, based on a selected interval*	=**DATEDIFF**(<start_date>, <end_date>, <interval>)

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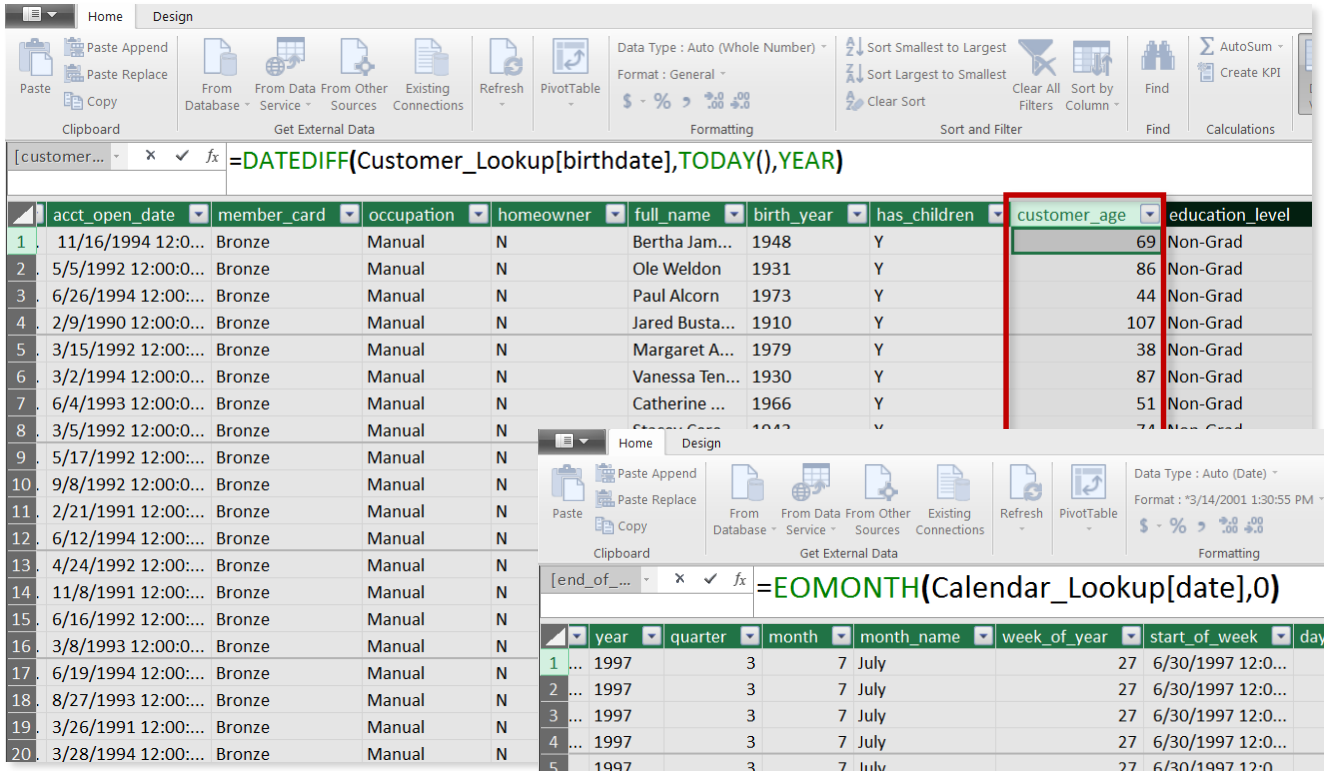
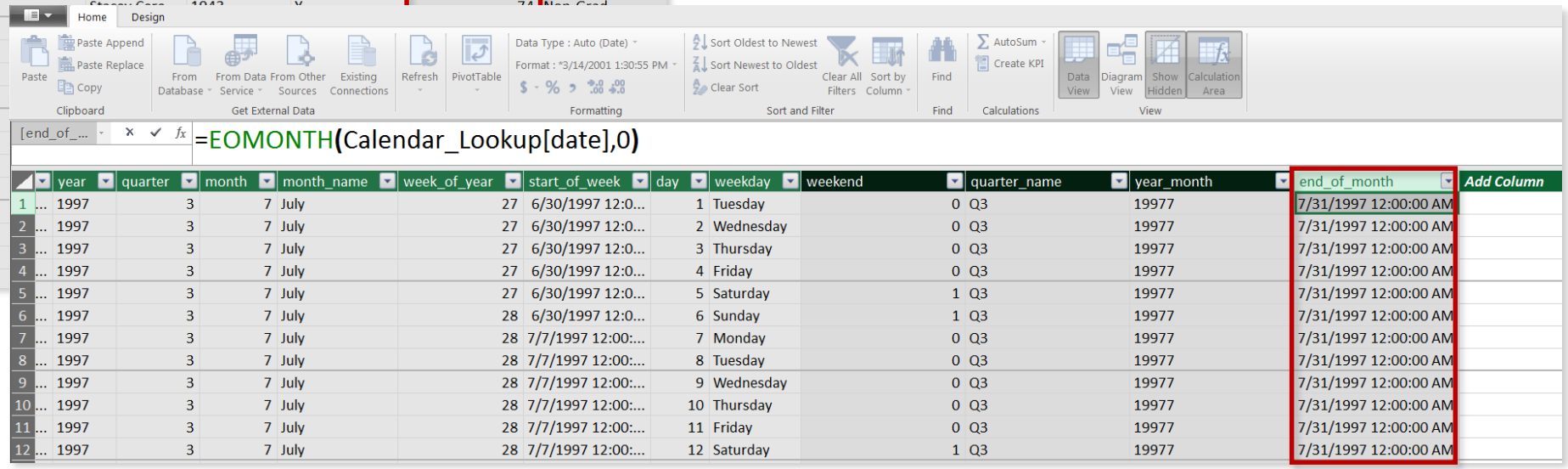
BASIC DATE & TIME FUNCTIONS (EXAMPLES)

*Calculate the **time difference between the customer birthdate and current date**, in years*



	acct_open_date	member_card	occupation	homeowner	full_name	birth_year	has_children	customer_age	education_level
1	11/16/1994 12:0...	Bronze	Manual	N	Bertha Jam...	1948	Y	69	Non-Grad
2	5/5/1992 12:00:0...	Bronze	Manual	N	Ole Weldon	1931	Y	86	Non-Grad
3	6/26/1994 12:00:...	Bronze	Manual	N	Paul Alcorn	1973	Y	44	Non-Grad
4	2/9/1990 12:00:0...	Bronze	Manual	N	Jared Busta...	1910	Y	107	Non-Grad
5	3/15/1992 12:00:...	Bronze	Manual	N	Margaret A...	1979	Y	38	Non-Grad
6	3/2/1994 12:00:0...	Bronze	Manual	N	Vanessa Ten...	1930	Y	87	Non-Grad
7	6/4/1993 12:00:0...	Bronze	Manual	N	Catherine ...	1966	Y	51	Non-Grad
8	3/5/1992 12:00:0...	Bronze	Manual	N					
9	5/17/1992 12:00:...	Bronze	Manual	N					
10	9/8/1992 12:00:0...	Bronze	Manual	N					
11	2/21/1991 12:00:...	Bronze	Manual	N					
12	6/12/1994 12:00:...	Bronze	Manual	N					
13	4/24/1992 12:00:...	Bronze	Manual	N					
14	11/8/1991 12:00:...	Bronze	Manual	N					
15	6/16/1992 12:00:...	Bronze	Manual	N					
16	3/8/1993 12:00:0...	Bronze	Manual	N					
17	6/19/1994 12:00:...	Bronze	Manual	N					
18	8/27/1993 12:00:...	Bronze	Manual	N					
19	3/26/1991 12:00:...	Bronze	Manual	N					
20	3/28/1994 12:00:...	Bronze	Manual	N					

*Calculate the **end date of the month**, for each row in the Calendar_Lookup table*



	year	quarter	month	month_name	week_of_year	start_of_week	day	weekday	weekend	quarter_name	year_month	end_of_month	Add Column
1	1997	3	7	July	27	6/30/1997 12:0...	1	Tuesday	0	Q3	19977	7/31/1997 12:00:00 AM	
2	1997	3	7	July	27	6/30/1997 12:0...	2	Wednesday	0	Q3	19977	7/31/1997 12:00:00 AM	
3	1997	3	7	July	27	6/30/1997 12:0...	3	Thursday	0	Q3	19977	7/31/1997 12:00:00 AM	
4	1997	3	7	July	27	6/30/1997 12:0...	4	Friday	0	Q3	19977	7/31/1997 12:00:00 AM	
5	1997	3	7	July	27	6/30/1997 12:0...	5	Saturday	1	Q3	19977	7/31/1997 12:00:00 AM	
6	1997	3	7	July	28	6/30/1997 12:0...	6	Sunday	1	Q3	19977	7/31/1997 12:00:00 AM	
7	1997	3	7	July	28	7/7/1997 12:00:...	7	Monday	0	Q3	19977	7/31/1997 12:00:00 AM	
8	1997	3	7	July	28	7/7/1997 12:00:...	8	Tuesday	0	Q3	19977	7/31/1997 12:00:00 AM	
9	1997	3	7	July	28	7/7/1997 12:00:...	9	Wednesday	0	Q3	19977	7/31/1997 12:00:00 AM	
10	1997	3	7	July	28	7/7/1997 12:00:...	10	Thursday	0	Q3	19977	7/31/1997 12:00:00 AM	
11	1997	3	7	July	28	7/7/1997 12:00:...	11	Friday	0	Q3	19977	7/31/1997 12:00:00 AM	
12	1997	3	7	July	28	7/7/1997 12:00:...	12	Saturday	1	Q3	19977	7/31/1997 12:00:00 AM	

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TIME INTELLIGENCE FORMULAS

Time Intelligence functions allow you to easily calculate common time comparisons:

Performance To-Date

```
=CALCULATE(<measure>, DATESYTD(Calendar[Date]))
```

Use **DATESQTD** *for Quarters or* **DATESMTD** *for Months*

Previous Period

```
=CALCULATE(<measure>, DATEADD(Calendar[Date],-1,MONTH))
```

*Select an interval (***DAY***,* **MONTH***,* **QUARTER***, or* **YEAR***) and the # of intervals to compare (i.e. previous month, rolling 10-day)*

Running Total

```
=CALCULATE(<measure>,
        DATESINPERIOD(Calendar[Date], MAX(Calendar[Date]),-10,DAY))
```

PRO TIP:

To calculate a ***moving average****, use the running total calculation above and divide by the # of intervals!*

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SPEED & PERFORMANCE CONSIDERATIONS

Avoid using unnecessary slicers, or consider disabling cross-filtering

- *When you use multiple slicers, they "cross-filter" by default; in other words, options in **Slicer B** are automatically grayed out if they aren't relevant given a selected value in **Slicer A***
- *To disable, select **Slicer Tools** > **Slicer Settings** and uncheck "**Visually indicate items with no data**"*

Eliminate redundant columns; keep data tables narrow

- *Data tables should ideally only contain quantitative values and foreign keys; any extra descriptive columns should live in a related lookup table*

Imported columns are better than calculated columns

- *When possible, create calculated columns at the source (i.e. in your raw database) or using Power Query; this is more efficient than processing those calculations in the Data Model/Power Pivot*

Minimize iterator functions (FILTER, SUMX, etc.)

- *Functions that cycle through each row in a table are "expensive", meaning that they take time and consume processing power*

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DAX BEST PRACTICES

Write measures for even the simplest calculations *(i.e. Sum of Sales)*

- *Once you create a measure it can be used anywhere in the workbook and as an input to other, more complex calculations*

Break measures down into simple, component parts

- *DAX is a difficult language to master; focus on practicing and understanding simple components at first, then assemble them into more advanced formulas*

Reference columns with the table name, and measures alone

- *Using "fully qualified" column references (preceeded by the table name) helps make formulas more readable and intuitive, and differentiates them from measure references*

WRAPPING UP

DATA VISUALIZATION OPTIONS

There are several options for building **visuals** and **reports** from a data model:

*Available **within Excel***

1. **PivotCharts & Conditional Formatting**
   - *Check out my **Data Analysis with Excel PivotTables** course for a deep dive*
2. **Spreadsheet-based dashboards built with CUBE functions**
   - *Use CUBE functions to pull values from the data model for custom Excel reports (no pivots)*
3. **Power View, Power Map, etc.**
   - *Excel plug-in with Power Pivot and other BI tools; recommend PowerBI as a better option*

Standalone product (desktop + online)

4. **Microsoft PowerBI**
   - *Brand new (**free!**) self-service BI product for **loading, shaping, modeling,** and **visualizing data***

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SNEAK PEEK: POWERBI

Power BI

PowerBI is a standalone Microsoft business intelligence product, which includes both desktop and web-based applications for loading, modeling, and visualizing data

For info about plans & pricing: **powerbi.microsoft.com**

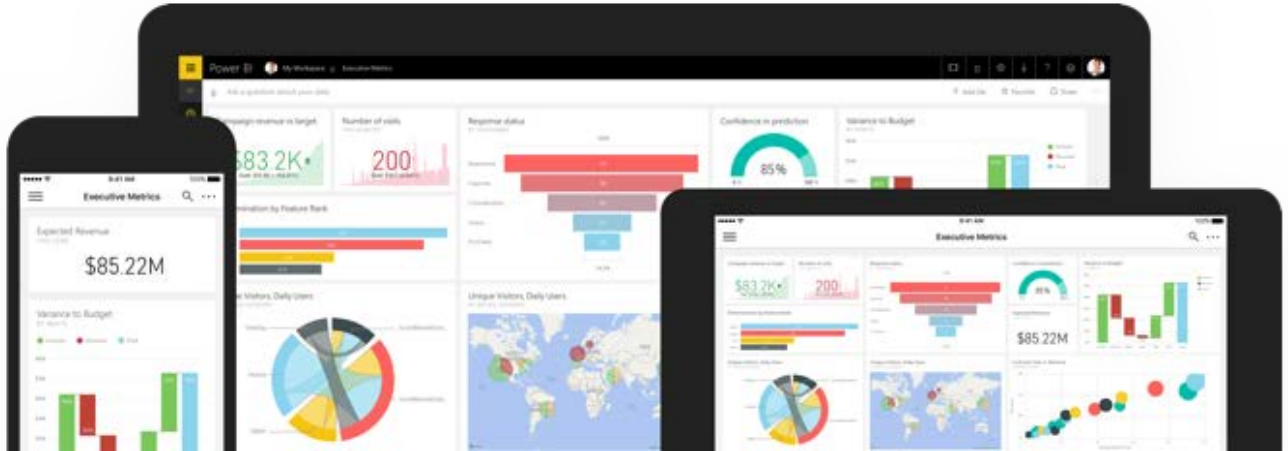

Figure 1. Magic Quadrant for Business Intelligence and Analytics Platforms

Source: Gartner (February 2017)

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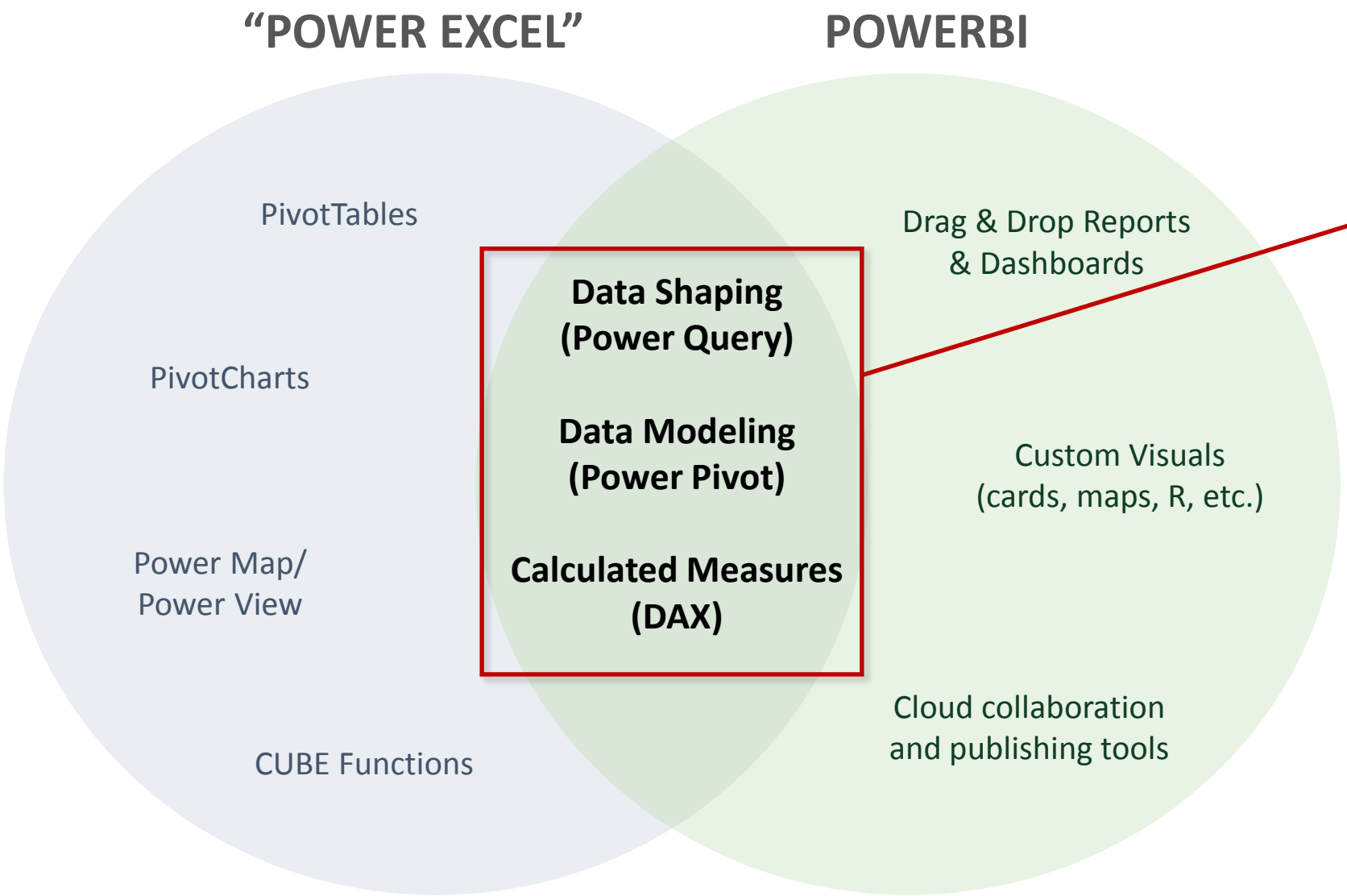
“POWER EXCEL” VS. POWERBI



“Power Excel” and PowerBI are built on top of the ***exact same engine*****!**

PowerBI takes the same data shaping, modeling and analytics capabilities and adds new **reporting and visualization tools**

Transitioning is easy; **you can import an entire data model directly from Excel!**

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RESOURCES & NEXT STEPS

Looking to become an absolute Excel **ROCK STAR**? Try the full stack:

- *Microsoft Excel – **Data Analysis with Excel PivotTables***
- *Microsoft Excel – **Advanced Excel Formulas & Functions***
- *Microsoft Excel – **Data Viz with Excel Charts & Graphs***
- ***Microsoft PowerBI Essentials** (**COMING SOON!**)*

Check out these **awesome resources** for additional support:

- ***msdn.microsoft.com** for DAX documentation and support*
- ***powerpivotpro.com** for blogs, articles, and additional Power Pivot resources*
- ***Power Query & Power BI** by Rob Collie (paperback, available on Amazon)*

Ratings and reviews mean the world to me, so **please** share feedback!

- *Feel free to post to the Q&A section or message me directly if you need any support, or if there's anything I can do to improve your course experience!*

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Jul
Aug
Sep
Oct
Nov
8/9
8/16
8/23
8/30
8/30
Chris Burd
Courtney Lowe
Phil Escott
THANK YOU!
70%
100%