EXPERT INSIGHT

Microsoft Power BI Quick Start Guide

Bring your data to life through data modeling, visualization, digital storytelling, and more

Second Edition

Devin Knight, Mitchell Pearson, Bradley Schacht, Erin Ostrowsky

Packt

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BIRMINGHAM - MUMBAI

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Producers: Aarthi Kumaraswamy, Caitlin Meadows
Acquisition Editor – Peer Reviews: Divya Mudaliar
Content Development Editor: Alex Patterson
Technical Editor: Karan Sonawane
Project Editor: Mrunal Dave
Copy Editor: Safis Editing
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Contributors

About the authors

Devin Knight is a Microsoft Data Platform MVP and the President at Pragmatic Works Training. At Pragmatic Works, Devin determines which courses are created, delivered, and updated for customers, including 15+ Power BI courses. This is the tenth SQL Server and Business Intelligence book that he has authored. Devin often speaks at conferences such as PASS Summit, PASS Business Analytics Conference, SQL Saturdays, and Code Camps. He is also a contributing member to several PASS Virtual Chapters. Making his home in Jacksonville, FL, Devin is a contributor at the local Power BI User Group.

I must give thanks to God; without God in my life, I would not be as blessed as I am daily. Thanks for the amazing team of authors: Mitchell, Brad, and Erin have put in time after hours away from their families to bring this great book together. To my wife, Erin, and three children, Collin, Justin, and Lana, who were all patient during nights that daddy had to spend writing. Finally, I would like to thank Oliver Wood, the best Quidditch coach a rising star like myself could ask for. I know this will be the year we win the Quidditch cup and become champions.

Mitchell Pearson has worked as a Data Platform Consultant and Trainer for the last 8 years. Mitchell has authored books on SQL Server, Power BI, and the Power Platform. His data platform experience includes designing and implementing enterprise-level Business Intelligence solutions with the Microsoft SQL Server stack (T-SQL, SSIS, SSAS, and SSRS), the Power Platform, and Microsoft Azure.

Mitchell is very active in the community:

- Running the local Power BI User Group
- Presenting at user groups locally and virtually
- Writing blogs at `www.mitchellpearson.com` and creating YouTube videos for `MitchellSQL`

First of all, thank you to God for unending grace and mercy. Secondly, thank you to Brian Knight for giving me an incredible opportunity in the Business Intelligence field. Finally, thank you to my wife and kids for their unending encouragement and their sacrifice; without their support, I could not have contributed to this book.

Bradley Schacht is a Senior Cloud Solution Architect (Data Platform) on the Microsoft State and Local Government team based in Jacksonville, FL. Bradley has authored three other SQL Server books. As a former consultant and trainer, he uses his experience on the Microsoft data platform to help customers architect quality end-to-end solutions for every business problem encountered. Bradley gives back to the community through speaking at events such as the PASS Summit, SQL Saturdays, Code Camps, and user groups across the USA, including locally at the **Jacksonville SQL Server User Group** (**JSSUG**). He is a contributor on `www.SQLServerCentral.com` and blogs on his personal site, `www.BradleySchacht.com`.

I give thanks to God, who has blessed me with so many wonderful things in life and whom I would be lost without. Thanks to my amazing wife, Nichole, and our baby boy, Oliver. The support, encouragement, and family time you give me each and every day means more to me than you will ever know. Thanks to my co-authors, Devin, Mitchell, and Erin, who all worked hard and sacrificed to make this book possible. To everyone that has helped me throughout my career, thank you. Finally, I thank the Atlanta Braves for winning their first postseason series since 2001 and proving that dreams do come true. Please don't screw it up. I look forward to reflecting on this postseason with Oliver when he signs with the Braves in 2038.

Erin Ostrowsky is a creative and passionate lifelong learner. She began her career as a business journalist and researcher and found herself drawn to the power of beautifully visualized data analysis. After living overseas, Erin returned to the USA looking to marry her communication background with a technical focus and found a life-changing opportunity to work as a trainer for Pragmatic Works, where she focused on creating new educational materials and delivering Power BI training around the USA. Erin focuses on the Power Platform tools and loves working on teams to build business intelligence solutions that businesses use and enjoy.

Erin is thankful to Jesus Christ for showing her that love is the root of all beauty on Earth. She thanks her family, friends, and colleagues for teaching her about life and being part of the adventure.

About the reviewer

Gilbert Quevauvilliers has 10+ years of experience in delivering data solutions, and has a real passion for Power BI; he's been using Power BI since its inception at the end of 2014. Gilbert has also been using DAX from Excel 2010 when it was created, and has been named a Microsoft MVP from 2017 through to 2020.

Gilbert has hands-on experience assisting organizations of all sizes in successfully implementing Power BI and the Microsoft Data Analytics Platform.

Gilbert is fortunate enough to have spoken at various events (Microsoft Business Applications Summit, SQL Saturday's, Power BI user groups, and more), and is currently consulting through his own company, FourMoo (the name represents his four family members). With FourMoo, Gilbert provides Microsoft Power BI solutions for business challenges by using your data and working with your business users. Gilbert also has an active blog, which can be found at `www.fourmoo.com/blog`.

I would like to say a big thanks to my family, for their endless support and for helping me find the time to review this book.

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Preface

As an experienced BI professional, you may have, at one time, considered your skills irreplaceable. However, while you were tirelessly building the most elegant data warehouse solutions, Microsoft was busy building a new suite of self-service business intelligence and analytics tools called Power BI. Quickly, Power BI has become one of the most popular tools in the market, and users are looking to you for advice on how they should implement best practices and scale their own usage of the tool. While your corporate BI solutions will always be the gold standard for your company's enterprise data strategy, you can no longer ignore your company's hunger for self-service data wrangling.

In this book, you will learn how to bridge the gap between your existing corporate BI skillset and what's possible with Power BI. You will understand how to connect to data sources using both import and direct query options. You will then learn how to effectively use the Power BI Query Editor to perform transformations and data-cleansing processes on your data. This will include using R script and advanced M query transforms. Next, you will learn how to properly design your data model to navigate table relationships and use **Data Analysis Expression** formulas to enhance its usability. Visualizing your data is another key element of this book, as you will learn proper data visualization styles and enhanced digital storytelling techniques. Finally, by the end of this book, you will understand how to administer your company's Power BI environment so that deployment can be made seamless, data refreshes can run properly, and security can be fully implemented.

Who this book is for

This book is intended for business intelligence professionals who have experience with traditional enterprise BI tools, and now need a guide to jumpstart their knowledge of Power BI. Individuals new to business intelligence will also gain a lot from reading this book, but knowledge of some industry terminology will be assumed. The concepts covered in this book can also be helpful for BI managers beginning their companies' self-service BI implementation. Prior knowledge of Power BI is helpful but certainly not required for this book.

What this book covers

Chapter 1, *Getting Started with Importing Data Options*, begins by getting the audience oriented with the Power BI Desktop. Next, they will learn how to connect to various common data sources in Power BI. Once a data source is chosen, the options within will be explored, including the choice between data import, direct query, and live connection.

Chapter 2, *Data Transformation Strategies*, explores the capabilities of the Power Query Editor inside the Power BI Desktop. Using this Power BI Query Editor, the reader will first learn how to do basic transformations, and they will quickly learn more advanced data cleansing practices. By the end of this chapter, the audience will know how to combine queries, use parameters, and read and write basic M queries.

Chapter 3, *Building the Data Model*, discusses one of the most critical parts of building a successful Power BI solution—designing an effective data model. In this chapter, readers will learn that while designing a data model, they are really setting themselves up for success when it comes to building reports. Specifically, this chapter will teach the audience how to establish relationships between tables, how to deal with complex relationship designs, and how to implement usability enhancements for report consumers.

Chapter 4, *Leveraging DAX*, teaches that the DAX language within Power BI is critical to building data models that are valuable to data consumers. While DAX may be intimidating at first, readers will quickly learn that its roots come from the Excel formula engine. This can be helpful at first, but as you find the need to develop more and more complex calculations, readers will learn that having a background in Excel formulas will only take them so far. This chapter will start with an understanding of basic DAX concepts but quickly accelerate into more complex ideas, such as Time Intelligence and Filter Context.

Chapter 5, *Visualizing Data*, describes how to take a finely tuned data model and build reports that properly deliver a message that clearly and concisely tells a story about the data.

Chapter 6, *Digital Storytelling with Power BI*, covers the capability that Power BI has to be much more than just a simple drag-and-drop reporting tool. Using the storytelling features of Drillthrough, Bookmarks, and the Selection pane, you have the ability to design reports that not only display data but also tell engaging stories that make your users crave for more.

Chapter 7, *Using a Cloud Deployment with the Power BI Service*, examines deploying your solution to the Power BI service to share what you have developed with your organization. Once deployed, you can build dashboards, share them with others, and schedule data refreshes. This chapter will cover the essential skills a BI professional would need to know to top off a Power BI solution they have developed.

Chapter 8, *Data Cleansing in the Cloud with Dataflows*, focuses on building reusable data and transform ative logic. Using Power BI dataflows supports large data volumes to perform scalable operations.

Chapter 9, *On-Premises Solutions with Power BI Report Server*, explores how many organizations have decided that they are not yet ready to move to the cloud. Using the Power BI Report Server cloud, wary organizations get the benefit of Power BI reports without compromising their feelings about the cloud. This chapter will cover deploying to the Power BI Report Server cloud, sharing reports with others, and updating data.

To get the most out of this book

After downloading and installing the Power BI Desktop, you will be able to follow the majority of the examples in this book. By subscribing to the Power BI Pro license, you can follow all examples in this book. There are also supplementary files you can download to follow the book's examples.

Download the example code files

The code bundle for the book is hosted on GitHub at `https://github.com/PacktPublishing/Microsoft-Power-BI-Start-Guide-Second-Edition`. We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Download the color images

We also provide a PDF file that has color images of the screenshots/diagrams used in this book. You can download it here: `https://static.packt-cdn.com/downloads/9781800561571_ColorImages.pdf`

Conventions used

There are a number of text conventions used throughout this book.

`CodeInText`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. For example; "Start by connecting to the `FIPS_CountyName.txt` file that is found in the book files using the Text/CSV connector."

A block of code is set as follows:

```
Month Year = RIGHT("0" & 'Date (Order)'[Month Number of Year], 2)
```

Any command-line input or output is written as follows:

```
package 'mice' successfully unpacked and MD5 sums checked.
```

Bold: Indicates a new term, an important word, or words that you see on the screen, for example, in menus or dialog boxes, also appear in the text like this. For example: To now build a set of report visuals on this example, you can click **Close & Apply** under the **Home** ribbon.

Warnings or important notes appear like this.

Tips and tricks appear like this.

Get in touch

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1
Getting Started with Importing Data Options

Power BI may very well be one of the most aptly named tools ever developed by Microsoft, giving analysts and developers a powerful business intelligence and analytics playground while still packaging it in a surprisingly lightweight application. Using Microsoft Power BI, the processes of data discovery, data modeling, data visualization, and sharing are made elegantly simple using a single product. These processes are so commonplace when developing Power BI solutions that this book has adopted sections that follow this pattern. However, from your perspective, the really exciting thing may be that development problems that would previously take you weeks to solve in a corporate BI solution can now be accomplished in only hours.

Power BI is a **Software as a Service** (**SaaS**) offering in the Azure cloud and, as such, the Microsoft product team follows a strategy of *cloud first* as they develop and add new features to the product. However, this does not mean that Power BI is only available in the cloud. Microsoft presents two options for sharing your results with others. The first, most often-utilized, method is the cloud-hosted Power BI service, which is available to users for a low monthly subscription fee. The second option is the on-premises Power BI Report Server, which can be obtained through either your SQL Server Enterprise licensing with Software Assurance or a subscription level known as Power BI Premium. Both solutions require a development tool called Power BI Desktop, which is available for free, and is where you must start to design your solutions.

Using the Power BI Desktop application enables you to define your data discovery and data preparation steps, organize your data model, and design engaging data visualizations based on your reports. In this first chapter, the development environment will be introduced, and the data discovery process will be explored in depth. The topics detailed in this chapter include the following:

- Getting started
- Importing data
- Direct query
- Live connection

Let's first start by learning about what you need on your machine to get started.

Getting started

Power BI Desktop is available for free and can be found via a direct download link at Power BI (`https://powerbi.microsoft.com/`), or by installing it as an app from Microsoft Store. There are several benefits of using the Microsoft Store Power BI app, including automatic updates, no requirement for admin privileges, and making it easier for planned IT rollout of Power BI.

If you are using the on-premises Power BI Report Server for your deployment strategy, then you must download a different Power BI Desktop, which is available by clicking the advanced download options link at `https://powerbi.microsoft.com/en-us/report-server/`. A separate installation is required because updates are released more often to Power BI in the cloud. This book will be written primarily under the assumption that you are using the cloud-hosted Power BI Service as your deployment strategy.

Once you've downloaded, installed, and launched Power BI Desktop, you will likely be welcomed by the start up screen, which is designed to help new users find their way. Close this start up screen so that we can review some of the most commonly used features of the application:

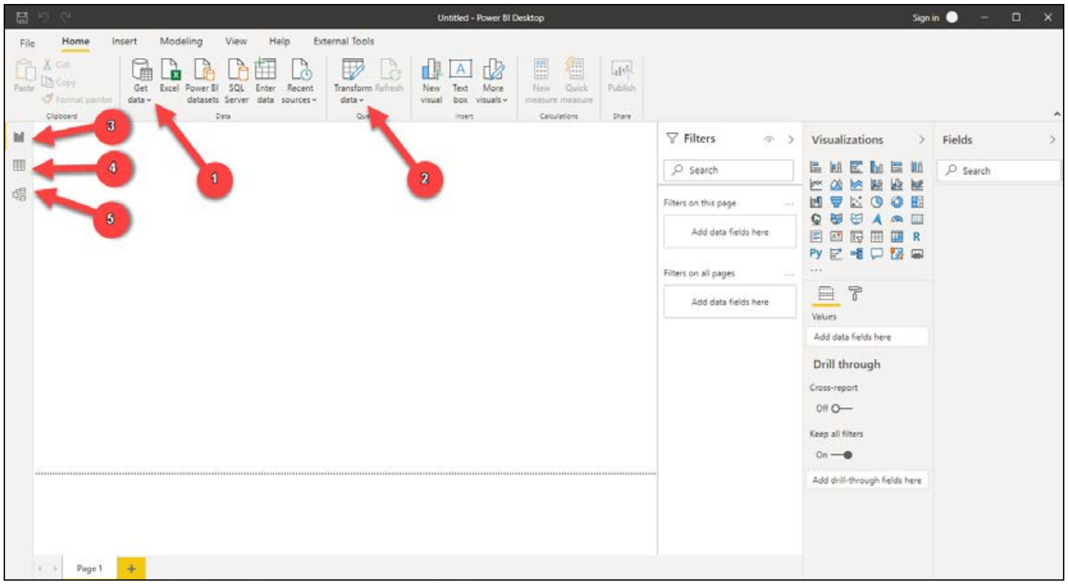


Figure 1.1: First view of Power BI Desktop

Following the preceding screenshot, let's learn the names and purposes of some of the most important features in Power BI Desktop:

- **Get data**: Used for selecting data connectors and configuring data source details.
- **Transform data**: Launches the Power Query Editor, which is used to apply data transformations to incoming data.
- **Report view**: Report canvas used for designing data visualizations. This is the default view that's open when Power BI Desktop is launched.
- **Data view**: Provides a view of the data in your model. This looks similar to a typical Excel spreadsheet, but it is read-only.
- **Model view**: Primarily used when your data model has multiple tables and relationships that need to be defined between them.

Now that you have a little familiarity with the basic controls within Power BI Desktop, let's learn about the options you have for connecting to your various data sources.

Importing data

Power BI is best known for the impressive data visualizations and dashboard capabilities it has. However, before you can begin building reports, you first need to connect to the necessary data sources. Within Power BI Desktop, a developer has more than 130 unique data connectors to choose from, ranging from traditional file types, database engines, big data solutions, cloud sources, data stored on a web page, and other SaaS providers. This book will not cover all 130 connectors that are available, but it will highlight some of the most popular.

When establishing a connection to a data source, you may be presented with one of three different options regarding how your data will be treated: **Import**, **DirectQuery**, or live connection. This section will focus specifically on the Import option.

Choosing to import data, which is the most common option and default behavior, means that Power BI will physically extract rows of data from the selected source and store it in an in-memory storage engine within Power BI. Power BI Desktop uses a special method for storing data, known as xVelocity, which is an in-memory technology that not only increases the performance of your query results, but can also highly compress the amount of space taken up by your Power BI solution. In *some* cases, the compression that takes place can even lower the required disk space by up to one-tenth of the original data source size. The xVelocity engine uses a local unseen instance of **SQL Server Analysis Services** (**SSAS**) to provide these in-memory capabilities.

There are consequences to using the **Import** option within Power BI that you should also consider. These consequences will be discussed later in this chapter, but as you read on, consider the following:

- How does data that has been imported into Power BI get updated?
- What if I need a dashboard to show near real-time analytics?
- How much data can really be imported into an in-memory storage system?

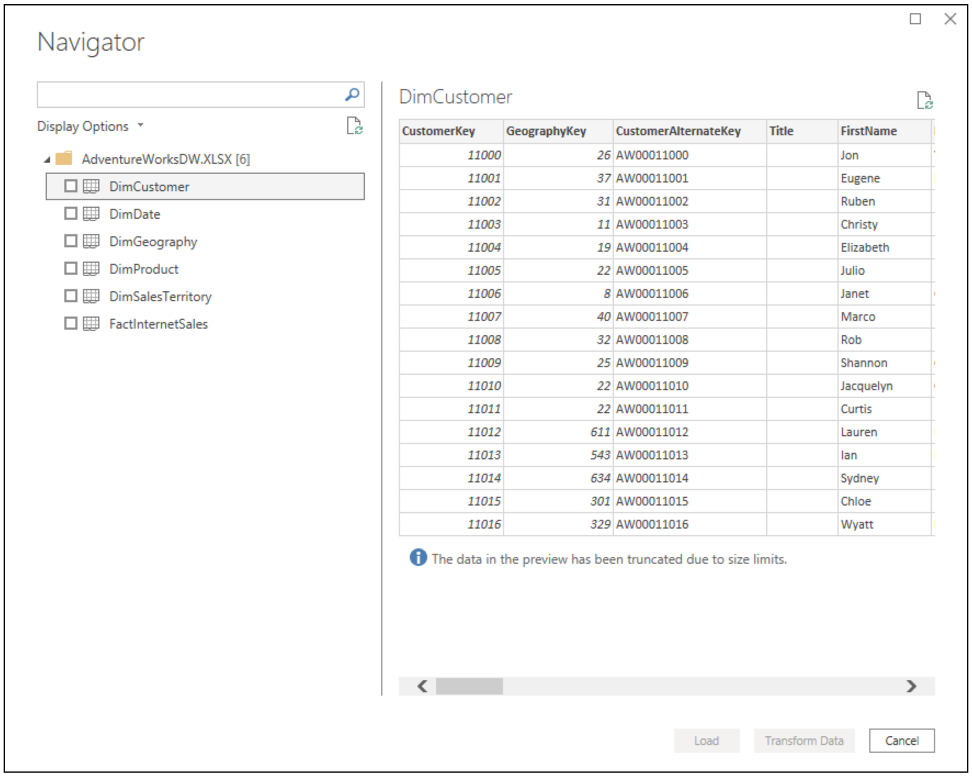
Now that you are familiar with the underlying mechanics of importing data, let's try it out with a few of the most common data source types, starting with Excel.

Excel as a source

Believe it or not, Excel continues to be the most popular application in the world and, as such, you should expect that at some point, you will be using it as a data source:

1. To get started, open Power BI Desktop and close the start up screen if it automatically appears.

2. Under the **Home** ribbon, you will find that **Get data** button, which you already learned is used for selecting and configuring data sources. Selecting the down arrow next to the button will show you the most common data connectors, but selecting the center of the button will launch the full list of all available connectors. Regardless of which way you select the button, you will find Excel at the top of both lists.
3. Navigate to and open the file called `AdventureWorksDW.xlsx` from this book's resources. This will launch the **Navigator** dialog, shown in the following screenshot, which is used for selecting the objects in the Excel workbook you wish to take data from:



AdventureWorksDW.XLSX [6]

- DimCustomer
- DimDate
- DimGeography
- DimProduct
- DimSalesTerritory
- FactInternetSales

DimCustomer

CustomerKey	GeographyKey	CustomerAlternateKey	Title	FirstName
11000	26	AW00011000		Jon
11001	37	AW00011001		Eugene
11002	31	AW00011002		Ruben
11003	11	AW00011003		Christy
11004	19	AW00011004		Elizabeth
11005	22	AW00011005		Julio
11006	8	AW00011006		Janet
11007	40	AW00011007		Marco
11008	32	AW00011008		Rob
11009	25	AW00011009		Shannon
11010	22	AW00011010		Jacquelyn
11011	22	AW00011011		Curtis
11012	611	AW00011012		Lauren
11013	543	AW00011013		Ian
11014	634	AW00011014		Sydney
11015	301	AW00011015		Chloe
11016	329	AW00011016		Wyatt

The data in the preview has been truncated due to size limits.

Figure 1.2: The Navigator dialog is used for selecting spreadsheets or tables

4. In this example, you can see six separate spreadsheets you can choose from. Clicking once on the spreadsheet name will give you a preview of the data it stores, while clicking the checkbox next to the name will include it as part of the data import. For this example, select the checkboxes next to all of the available objects, then notice the options available at the bottom right.

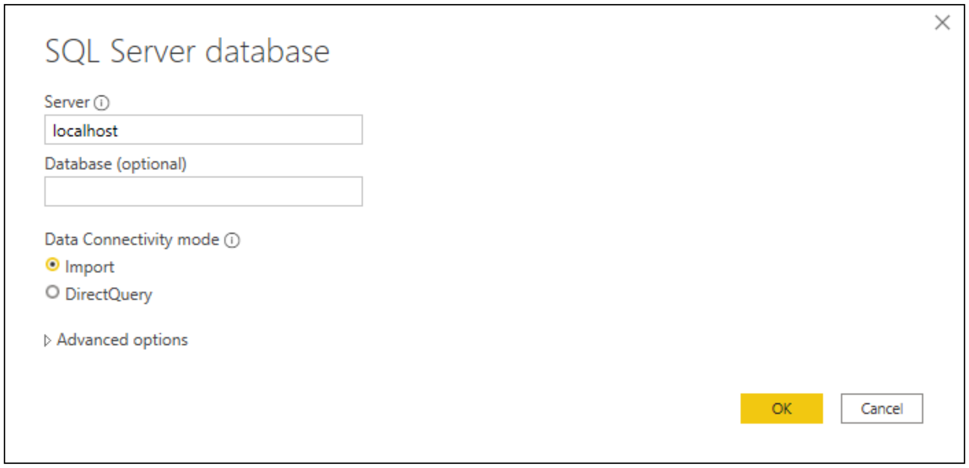
5. Selecting **Load** will immediately take the data from the selected spreadsheets and import them as separate tables into your Power BI data model. Choosing **Transform Data** will launch an entirely new window called Power Query Editor, which allows you to apply business rules or transform to your data prior to importing it. You will learn much more about Power Query Editor in *Chapter 2*, *Data Transformation Strategies*. Since you will learn more about this later, simply select **Load** to end this example.

Another topic you will learn more about in *Chapter 7*, *Using a Cloud Deployment with the Power BI Service*, is the concept of data refreshes. This is important because, when you import data into Power BI, that data remains static until another refresh is initiated. This refresh can either be initiated manually or set on a schedule. This also requires the installation of Data Gateway, the application in charge of securely pushing data into Power BI Service. Feel free to skip to *Chapter 7*, *Using a Cloud Deployment with the Power BI Service*, if configuring a data refresh is a subject you need to know about now.

SQL Server as a source

Another common source designed for relational databases is Microsoft SQL Server:

1. To connect to SQL Server, select the **Get data** button again, but this time choose **SQL Server**. The following screenshot shows that you must provide the server, but the database is optional and can be selected later:



SQL Server database

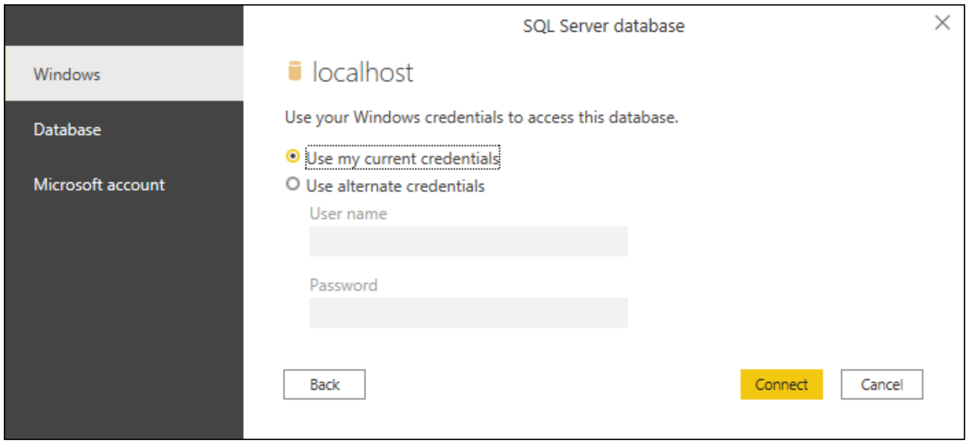
Server: localhost

Database (optional):

Data Connectivity mode: [✓ Import] DirectQuery

Figure 1.3: Establishing a connection to SQL Server

2. On your first use of SQL server, you are asked to choose the type of **Data Connectivity mode** you would like. As mentioned previously, **Import** is the default mode, but you can optionally select **DirectQuery**. DirectQuery will be discussed in greater detail later in this chapter. Expanding the **Advanced** options provides a way to insert a SQL statement that may be used as your source. For the following example, the **Server** name property is the only property populated before you click **OK**:


SQL Server database

localhost

Use your Windows credentials to access this database.

[✓ Use my current credentials]
Use alternate credentials
User name
Password

Figure 1.4: Providing credentials to SQL Server

3. Next, you will be prompted, as shown in the preceding screenshot, to provide the credentials you are using to connect to the database server you provided on the previous screen.
4. Click **Connect** after providing the proper credentials. You may be prompted with a warning stating that Power BI is only able to access the data source using an unencrypted connection. Click **OK** if you encounter this to launch the same **Navigator** dialog that you may remember from when you connected to Excel. Here, you will select the tables, views, or functions within your SQL Server database that you wish to import into your Power BI solution. Once again, the final step in this dialog allows you to choose to either **Load** or **Transform Data**.

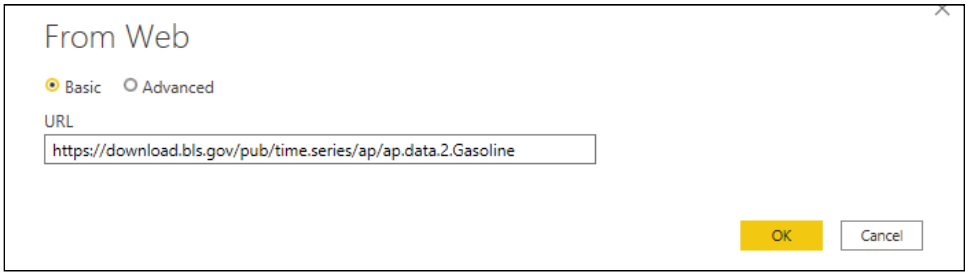
Now that you have a better understanding of how to connect to some of the most common data sources, let's look at one that is rather unique.

Web as a source

One pleasant surprise to many Power BI developers is the availability of a web connector. Using this connection type allows you to source data from files that are stored on a website, or even data that has been embedded into an HTML table on a web page. Using this type of connector can often be helpful when you would like to supplement your internal corporate data sources with information that can be publicly found on the internet.

For this example, imagine you are working for a major automobile manufacturer in the United States. You have already designed a Power BI solution using data internally available within your organization that shows historical patterns in sales trends. However, you would like to determine whether there are any correlations in periods of historically higher fuel prices and lower automobile sales. Fortunately, you found that the United States Department of Labor publicly posts the historical average consumer prices of many commonly purchased items, including fuel prices:

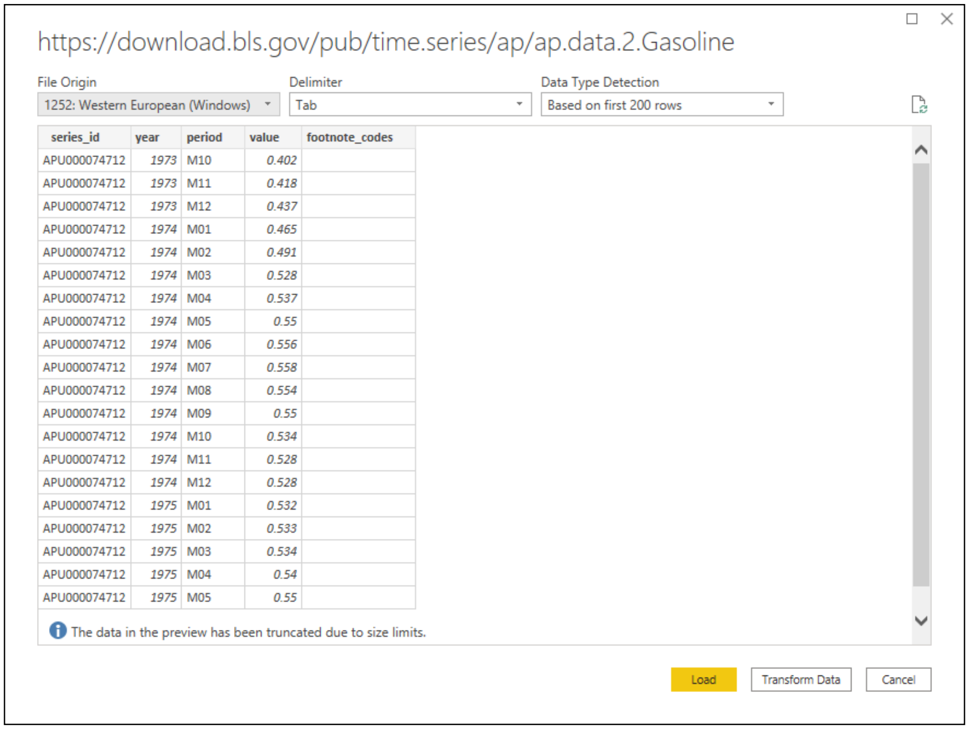
1. Now that you understand the scenario within Power BI Desktop, select the **Get data** button and choose **Web** as your source. You will then be prompted to provide the **URL** where the data can be found. In this example, the data can be found by searching on the website `https://www.data.gov/`. Alternatively, to save you some time, use the direct link: `https://download.bls.gov/pub/time.series/ap/ap.data.2.Gasoline`. Once you provide the **URL**, click **OK**, as shown in the following screenshot:



URL: https://download.bls.gov/pub/time.series/ap/ap.data.2.Gasoline

Figure 1.5: Providing the URL where your data can be found

2. Next, you will likely be prompted with an **Access Web Content** dialog box. This is important when you are using a data source that requires someone to log in to access it. Since this data source does not require a login to find the data, you can simply select anonymous access, which is the default, and then click **Connect**, as shown in the following screenshot:



https://download.bls.gov/pub/time.series/ap/ap.data.2.Gasoline

File Origin: 1252: Western European (Windows)
Delimiter: Tab
Data Type Detection: Based on first 200 rows

series_id	year	period	value	footnote_codes
APU000074712	1973	M10	0.402	
APU000074712	1973	M11	0.418	
APU000074712	1973	M12	0.437	
APU000074712	1974	M01	0.465	
APU000074712	1974	M02	0.491	
APU000074712	1974	M03	0.528	
APU000074712	1974	M04	0.537	
APU000074712	1974	M05	0.55	
APU000074712	1974	M06	0.556	
APU000074712	1974	M07	0.558	
APU000074712	1974	M08	0.554	
APU000074712	1974	M09	0.55	
APU000074712	1974	M10	0.534	
APU000074712	1974	M11	0.528	
APU000074712	1974	M12	0.528	
APU000074712	1975	M01	0.532	
APU000074712	1975	M02	0.533	
APU000074712	1975	M03	0.534	
APU000074712	1975	M04	0.54	
APU000074712	1975	M05	0.55	

The data in the preview has been truncated due to size limits.

Figure 1.6: A preview of the data is shown before you import it into Power BI

3. Notice on the next screen that Power BI Desktop recognizes the URL you provided as a tab-delimited file. This can now easily be added to any existing data model you have designed.

Now that you've learned how to connect to various data sources, it is important to discuss in more depth the different data storage modes.

DirectQuery

Many of you have likely been trying to envision how you may implement these data imports in your environment. You may have asked yourself questions such as the following:

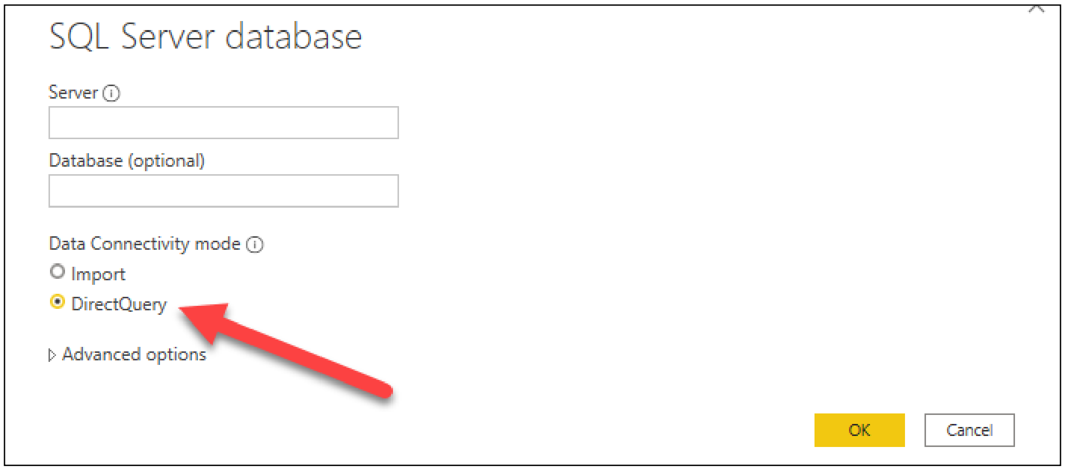
- If data imported into Power BI uses an in-memory technology, did my company provide me with a machine that has enough memory to handle this?

- Am I really going to import my source table with tens of billions of rows into memory?
- How do I handle the requirement of displaying results in real time from the source?

These are all excellent questions that would have many negative answers if the only way to connect to your data was by importing your source into Power BI. Fortunately, there is another way. Using DirectQuery, Power BI allows you to connect directly to a data source so that no data is imported or copied into Power BI Desktop.

Why is this a good thing? Consider the questions that were asked at the beginning of this section. Since no data is imported to Power BI Desktop, this means it is less important how powerful your personal laptop is. This is because all query results are now processed on the source server instead of your laptop. It also means that there is no need to refresh the results in Power BI, since any reports you design are always pointing to a live version of the data source. That's a huge benefit!

The following screenshot shows a connection to a SQL Server database with the **DirectQuery** option selected:



SQL Server database

Server

Database (optional)

Data Connectivity mode

( ) Import

(•) DirectQuery

Figure 1.7: SQL Server Data Connectivity mode allows you to switch to DirectQuery mode

Earlier in this chapter, the Data Gateway application was mentioned as a requirement for scheduling data refreshes for sources that used the **Import** option. This same application is also needed with **DirectQuery** if your data is an on-premises source. Even though there is no scheduled data refresh, the Data Gateway application is still required to push on-premises data into the cloud. Again, this will be discussed in more depth in *Chapter 7, Using a Cloud Deployment with the Power BI Service*.

Limitations

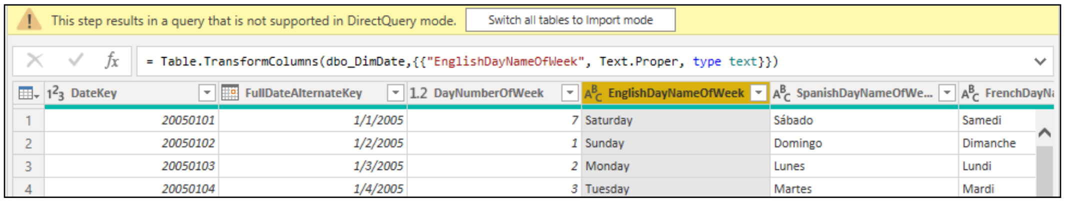
So, if DirectQuery is so great, why not choose it every time? Well, with every great feature, you will also find limitations. The first glaring limitation is that not all data sources support DirectQuery. At the time this book was written, the following data sources support DirectQuery in Power BI:

- Amazon Redshift
- AtScale Cubes
- Azure HDInsight Spark
- Azure SQL Database
- Azure SQL Data Warehouse
- BI Connector
- Denodo
- Dremio
- Essbase
- Exasol
- Google BigQuery
- HDInsight Interactive Query
- IBM DB2
- IBM Netezza
- Impala
- Indexima
- Intersystems IRIS
- Jethro ODBC
- Kyligence Enterprise
- MarkLogic ODBC
- Oracle
- PostgreSQL
- Power BI datasets
- QubolePresto
- SAP Business Warehouse Message Server
- SAP Business Warehouse Server
- SAP HANA

- Snowflake
- Spark
- SQL Server
- Teradata Database
- Vertica

Depending on the data source you choose, there is a chance of slower query performance when using DirectQuery compared to the default data import option. Keep in mind that when the **Import** option is selected, it leverages a highly sophisticated in-memory storage engine. When selecting DirectQuery, performance will depend on the source type you have chosen from the preceding list.

Another limitation worth noting is that not all Power BI features are supported when you choose DirectQuery. For example, depending on the selected source, some of the Power Query Editor features are disabled and could result in the following message: "**This step results in a query that is not supported in DirectQuery mode.**" The following screenshot shows this response:



This step results in a query that is not supported in DirectQuery mode. Switch all tables to Import mode

```
= Table.TransformColumns(dbo_DimDate,{{"EnglishDayNameOfWeek", Text.Proper, type text}})
```

	DateKey	FullDateAlternateKey	DayNumberOfWeek	EnglishDayNameOfWeek	SpanishDayNameOfWe...	FrenchDayNa
1	20050101	1/1/2005	7	Saturday	Sábado	Samedi
2	20050102	1/2/2005	1	Sunday	Domingo	Dimanche
3	20050103	1/3/2005	2	Monday	Lunes	Lundi
4	20050104	1/4/2005	3	Tuesday	Martes	Mardi

Figure 1.8: Certain transforms may force a user out of DirectQuery mode

The reason for this limitation is because DirectQuery automatically attempts to convert any Power Query steps into a query in the data source's native language. So, if the source of this solution was SQL Server, then Power BI would attempt to convert this data transformation into a comparable T-SQL script. Once Power BI realizes Power Query Editor used a function that is not compatible with the source, the error is generated.

Composite models

Occasionally, you may find it helpful for your data model to take a hybrid approach regarding how it stores data. For example, you want sales transactions to be displayed in near real time on your dashboard, so you set your `SalesTransaction` table to use DirectQuery. However, your `Product` table rarely has values that are added or changed. Having values that do not change often make it a great candidate for the imported data storage method to take advantage of the performance benefits.

This describes a perfect scenario for utilizing a feature called composite models. Composite models allow a single Power BI solution to include both DirectQuery and import table connections within one data model. From the Power BI developer's perspective, you can take advantage of the best parts of each data storage mode within your design.

> Another effective use case for composite models is available due to a feature called aggregations. Leveraging aggregations is one of the best ways to manage extremely large datasets in Power BI. You will learn more about designing aggregations in *Chapter 3, Building the Data Model*.

Within Power BI Desktop, it is clear a solution is leveraging composite models if we view the storage mode in the bottom-right corner of the tool. Clicking this corner, shown in the following screenshot, will allow you to switch all tables to **Import** mode instead. Optionally, if you need to change the storage mode of individual tables, this can be accomplished in the **Model** view by selecting individual tables:

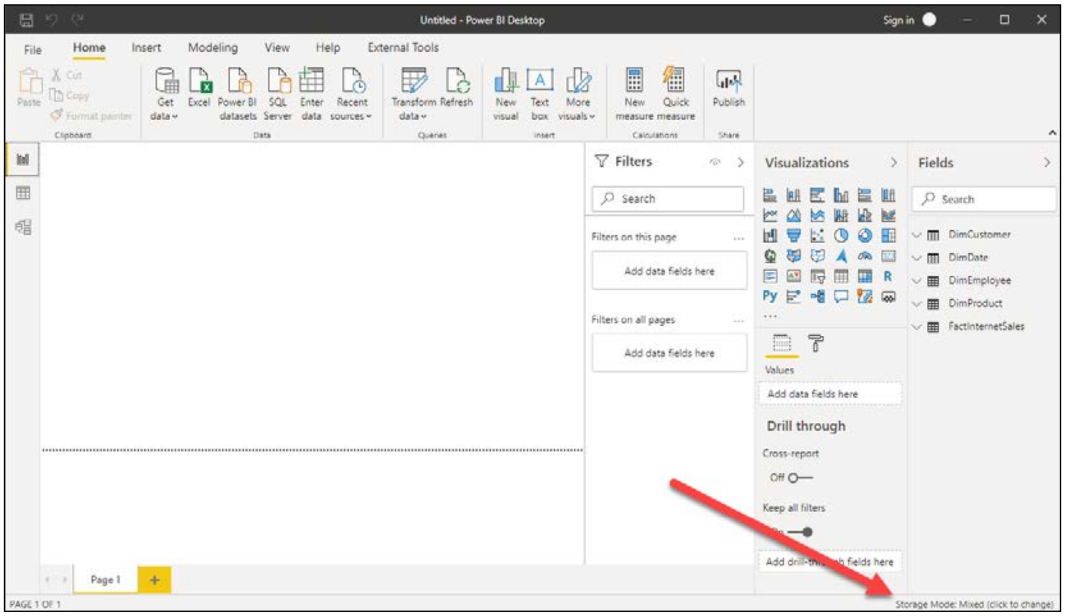


Figure 1.9: The bottom-right corner allows you to switch storage modes for the entire model

While composite models give you the best of DirectQuery and import models, there's a third storage mode that is often used for data sources that are highly groomed by IT.

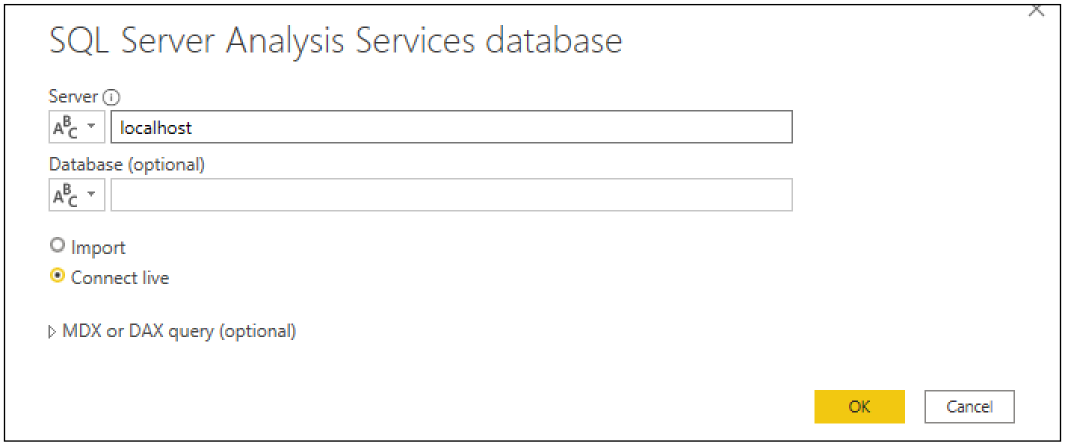
Live connection

The basic concept of live connection is very similar to that of DirectQuery. Just like DirectQuery, when you use a live connection, no data is actually imported into Power BI. Instead, your solution points directly to the underlying data source and leverages Power BI Desktop simply as a data visualization tool. So, if these two things are so similar, why give them different names? The answer is because even though the basic concept is the same, DirectQuery and live connection vary greatly.

One difference that should quickly be noticeable is the query performance experience. It was mentioned in a previous section that DirectQuery can often have poor performance, depending on the data source type. With live connection, you generally will not have any performance problem because it is only supported by the following types of data sources:

- SQL Server Analysis Services database
- Azure Analysis Services database
- Power BI datasets

The reason performance does not suffer with these data sources is because they either use the same xVelocity engine that Power BI does, or another high-performance storage engine. To set up your own live connection to one of these sources, you can choose the **SQL Server Analysis Services database** from the list of connectors after selecting **Get data**. The following screenshot shows that you can specify that the connection should be set to **Connect live**:


SQL Server Analysis Services database

Server: localhost

Database (optional):

Import [✓ Connect live]

Figure 1.10: SQL Server Analysis Services Data Connectivity mode allows you to switch to Connect live mode

If a dataset is configured for a Live connection or DirectQuery, then you can expect automatic refreshes to occur approximately each hour by default. You can manually adjust the refresh frequency in the Scheduled cache refresh option in the Power BI service.

Of course, these benefits don't come without a cost. Let's discuss some of the limitations of Live connection.

Limitations

So far, this sounds great! You have now learned that you can connect directly to your data sources, without importing data into your model, and that you won't have significant performance consequences. Of course, these benefits don't come without giving something up, so what are the limitations of a live connection?

What you will encounter with live connections are limitations that are generally a result of the fact that Analysis Services is an Enterprise BI tool. Thus, if you are going to connect to it, then it has probably already gone through significant data cleansing and modeling by your IT team.

Modeling capabilities such as defining relationships are not available because these would be designed in an Analysis Services Model. Also, Power Query Editor is not available at all against a Live connection source. While, at times, this may be frustrating, it does make sense that it works this way. This is because any of the changes you may desire to make with relationships or in the Power Query Editor should be done in Analysis Services, not Power BI.

Which should I choose?

Now that you have learned about the three different ways to connect to your data, you are left wondering which option is best for you. It's fair to say that the choice you make will really depend on the requirements of each individual project you have.

To summarize, some of the considerations that were mentioned in this chapter are listed in the following table:

Consideration	**Import Data**	**DirectQuery**	**Live connection**
Best performance	Yes	No	Yes
Best design experience	Yes	No	No
Best for keeping data up to date	No	Yes	Yes
Data source availability	Yes	No	No
Most scalable	No	Yes	Yes

Some of the items you'll consider may be more important than others. So, to make this more personal, try using the `Data Connectivity - Decision Matrix` file that is included with this book. In this file, you can rank (from 1 to 10) the importance of each of these considerations to help you choose which option is best for you.

Since the **Import Data** option presents the most available features, going forward, this book primarily uses this option. In *Chapter 2*, *Data Transformation Strategies*, you will learn how to implement data transformation strategies to ensure all the necessary business rules are applied to your data.

Summary

Power BI provides users with a variety of methods for connecting to data sources with natively built-in data connectors. The connector you choose for your solution will depend on where your data is located. Once you've connected to a data source, you can decide on what type of query mode best suits your needs. Some connectors allow for little to no latency in your results with options like DirectQuery or live connection. In this chapter, you learned about the benefits and disadvantages of each query mode, and you were given a method for weighting these options using a decision matrix.

In the next chapter, you will learn more about how data transformations may be applied to your data import process so that incoming data will be properly cleansed.

2

Data Transformation Strategies

Within any BI project, it is essential that the data you are working with has been properly scrubbed to ensure accurate results on your reports and dashboards. Applying data cleansing business rules, also known as transforms, is the primary method for correcting inaccurate or malformed data, but the process can often be the most time-consuming part of any corporate BI solution. However, the data transformation capabilities built into Power BI are both very powerful and user-friendly. Using the Power Query Editor, tasks that would typically be difficult or time-consuming in an enterprise BI tool are as simple as right-clicking on a column and selecting the appropriate transform for the field. While interacting with the user interface, the Power Query Editor automatically writes queries using a language called `M` behind the scenes.

Through the course of this chapter, you will explore some of the most common features of the Power Query Editor that make it so highly regarded by its users. Since one sample dataset cannot provide all the problems you will run into, you will be provided with several small, disparate examples to show you what is possible. This chapter will detail the following topics:

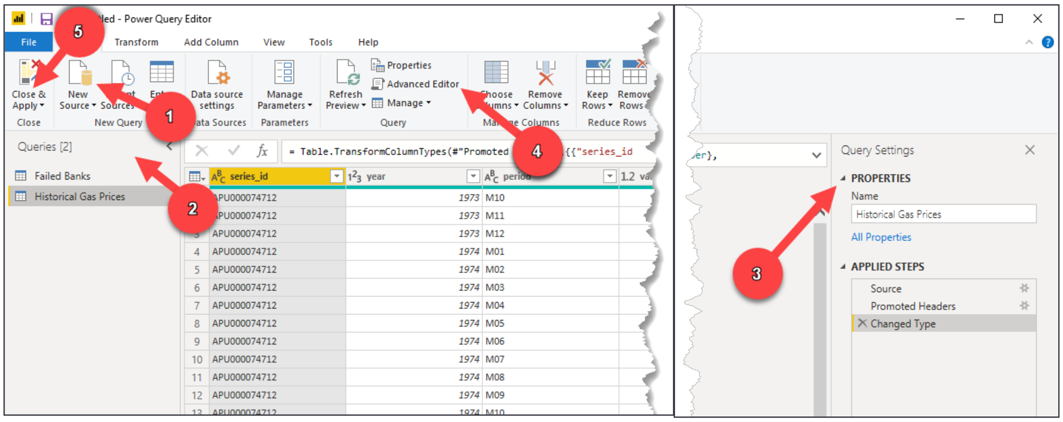
- The Power Query Editor
- Transform basics
- Advanced data transformation options
- Leveraging R

- AI Insights
- The M formula language

To get started, let's get familiar with the interface known as the Power Query Editor.

The Power Query Editor

The **Power Query Editor** is the primary tool that you will utilize for applying transformations and cleansing processes to your data. This editor can be launched as part of establishing a connection to your data, or by simply clicking **Transform Data** on the **Home** ribbon of the Power BI Desktop. When the Power Query Editor is opened, you will notice that it has its own separate environment for you to work in. The environment encapsulates a user-friendly method for working with all of the queries that you will define. Before you dive deep into the capabilities of the Power Query Editor, let's first start by reviewing the key areas of the Power Query Editor interface, as shown in *Figure 2.1*:



```
= Table.TransformColumnTypes(#"Promoted ... {{"series_id
```

	series_id	year	period
1	APU000074712	1973	M10
2	APU000074712	1973	M11
3	APU000074712	1973	M12
4	APU000074712	1974	M01
5	APU000074712	1974	M02
6	APU000074712	1974	M03
7	APU000074712	1974	M04
8	APU000074712	1974	M05
9	APU000074712	1974	M06
10	APU000074712	1974	M07
11	APU000074712	1974	M08
12	APU000074712	1974	M09
13	APU000074712	1974	M10

Name: Historical Gas Prices

Figure 2.1: First view of the Power Query Editor

Following the numbered figures, let's review some of the most important features of the Power Query Editor:

1. **New Source**: This launches the interface to establish your connection details, which is the same interface as the **Get data** button that you learned about in *Chapter 1, Getting Started with Importing Data Options*.
2. The **Queries** pane: A list of all the queries that you have connected to. From here, you can rename a query, disable the load and modify report refresh capabilities, and organize your queries into groups.

3. **Query Settings**: Within this pane, you can rename the query, but more importantly, you can see and change the list of steps, or transforms, that have been applied to your query. If you ever accidentally close this pane, you can relaunch it from the **View** menu.
4. **Advanced Editor**: By launching the **Advanced Editor**, you can see the `M` query that is automatically written for you by the Power Query Editor.
5. **Close & Apply**: Choosing this option will close the Power Query Editor and load the results into the data model.

With this basic navigation understood, let's start to discuss some of the basics of working with various transforms.

Transform basics

Applying data transformations within the Power Query Editor can be a surprisingly simple thing to do. However, there are a few things to consider as we begin this process. The first is that there are multiple ways to solve a problem. As you work your way through this book, the authors have tried to show you the fastest and easiest methods of solving the problems that are presented, but these solutions will certainly not be the only ways to reach your goals.

The next thing you should understand is that every click you do inside the Power Query Editor is automatically converted into a formula language called M. Virtually all the basic transforms you will need can be accomplished by simply interacting with the Power Query Editor user interface, but for more complex business problems there is a good chance you may have to modify the M queries that are written for you by the editor. You will learn more about M later in this chapter.

Finally, the last important consideration to understand is that all transforms that are created within the editor are stored in the **Query Settings** pane under a section called **Applied Steps**. Why is this important to know? The **Applied Steps** section has many features, but here are some of the most critical to know for now:

- **Deleting transforms**: If you make a mistake and need to undo a step, you can click the **Delete** button next to a step.
- **Modifying transforms**: This can be done with any step that has a gear icon next to it.
- **Changing the order of transforms**: If you realize that it is better for one step to execute before another one, you can change the order of how the steps are executed.

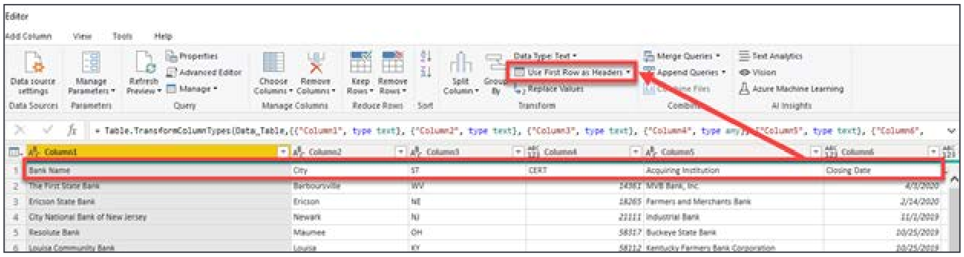
- **Selecting previous steps**: Clicking on any step prior to the current one will allow you to see how your query results would change one step earlier in the process.

With this understanding, you will now get hands-on with applying several basic transforms inside the Power Query Editor. The goal of these first sets of examples is to get you comfortable with the Power Query Editor user interface before the more complex use cases are covered.

Use First Row as Headers

Organizing column names or headers is often an important first task when managing your dataset. Providing relevant column names makes many of the downstream processes, such as building reports, much easier. Often, column headers are automatically imported from your data source, but sometimes you may be working with a more unique data source that makes it difficult for Power BI to capture the column header information. This walkthrough will show how to deal with such a scenario:

1. Launch Power BI Desktop, and click **Get data** on the **Home** ribbon.
2. Choose **Excel**, then navigate to and select **Open** on the `Failed Bank List.xlsx` file that is available in the book source files.
3. In the **Navigator** window, select the table called **Data**, then choose **Transform Data**. When the Power Query Editor launches, you should notice that the column headers are not automatically imported. In fact, the column headers are in the first row of the data.
4. To push the column names that are in the first row of data to the header section, select the transform called **Use First Row as Headers** from the **Home** ribbon as shown in *Figure 2.2*:



```
= Table.TransformColumnTypes(Data_Table,{{"Column1", type text}, {"Column2", type text}, {"Column3", type text}, {"Column4", type any}, {"Column5", type text}, {"Column6",
```

	Column1	Column2	Column3	Column4	Column5	Column6
1	Bank Name	City	ST	CERT	Acquiring Institution	Closing Date
2	The First State Bank	Barboursville	WV	14361	MVB Bank, Inc	4/3/2020
3	Ericson State Bank	Ericson	NE	18265	Farmers and Merchants Bank	2/14/2020
4	City National Bank of New Jersey	Newark	NJ	21111	Industrial Bank	11/1/2019
5	Resolute Bank	Maumee	OH	58317	Buckeye State Bank	10/25/2019
6	Louisa Community Bank	Louisa	KY	58112	Kentucky Farmers Bank Corporation	10/25/2019

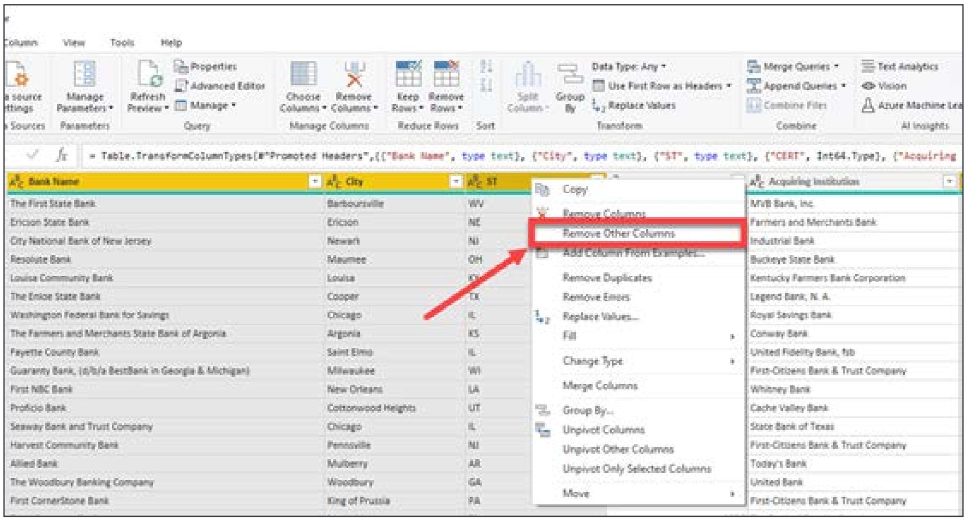
Figure 2.2: Leveraging the Use First Row as Headers transform

Once complete, you will see the first row of the dataset has been promoted to the column header area. This is a very common transform that you can expect to use often with flat files. Next, let's look at another commonly used transform, **Remove Columns**.

Remove Columns

Often, the data sources you will connect to will include many columns that are not necessary for the solution you are designing. It is important to remove these unnecessary columns from your dataset because these unused columns needlessly take up space inside your data model. There are several different methods for removing columns in the Power Query Editor. This example will show one of these methods using the same dataset from the previous demonstration:

1. Multi-select (*Ctrl* + click) the column headers of the columns you wish to keep as part of your solution. In this scenario, select the columns **Bank Name**, **City**, **ST**, and **Closing Date**.
2. With these four columns selected, right-click on any of the selected columns and choose **Remove Other Columns**, as shown in *Figure 2.3*:



```
= Table.TransformColumnTypes(#"Promoted Headers",{{"Bank Name", type text}, {"City", type text}, {"ST", type text}, {"CERT", Int64.Type}, {"Acquiring
```

Bank Name	City	ST	Acquiring Institution
The First State Bank	Barboursville	WV	MVB Bank, Inc.
Ericson State Bank	Ericson	NE	Farmers and Merchants Bank
City National Bank of New Jersey	Newark	NJ	Industrial Bank
Resolute Bank	Maumee	OH	Buckeye State Bank
Louisa Community Bank	Louisa	KY	Kentucky Farmers Bank Corporation
The Enloe State Bank	Cooper	TX	Legend Bank, N. A.
Washington Federal Bank for Savings	Chicago	IL	Royal Savings Bank
The Farmers and Merchants State Bank of Argonia	Argonia	KS	Conway Bank
Fayette County Bank	Saint Elmo	IL	United Fidelity Bank, fsb
Guaranty Bank, (d/b/a BestBank in Georgia & Michigan)	Milwaukee	WI	First-Citizens Bank & Trust Company
First NBC Bank	New Orleans	LA	Whitney Bank
Proficio Bank	Cottonwood Heights	UT	Cache Valley Bank
Seaway Bank and Trust Company	Chicago	IL	State Bank of Texas
Harvest Community Bank	Pennsville	NJ	First-Citizens Bank & Trust Company
Allied Bank	Mulberry	AR	Today's Bank
The Woodbury Banking Company	Woodbury	GA	United Bank
First CornerStone Bank	King of Prussia	PA	First-Citizens Bank & Trust Company

Figure 2.3: Selecting the Remove Other Columns transform

Once this transform is completed, you should be left with only the columns you need.

Another popular method for removing columns is clicking the **Choose Columns** button on the **Home** ribbon of the Power Query Editor. This option provides a list of all the columns, and you can choose the columns you wish to keep or exclude.

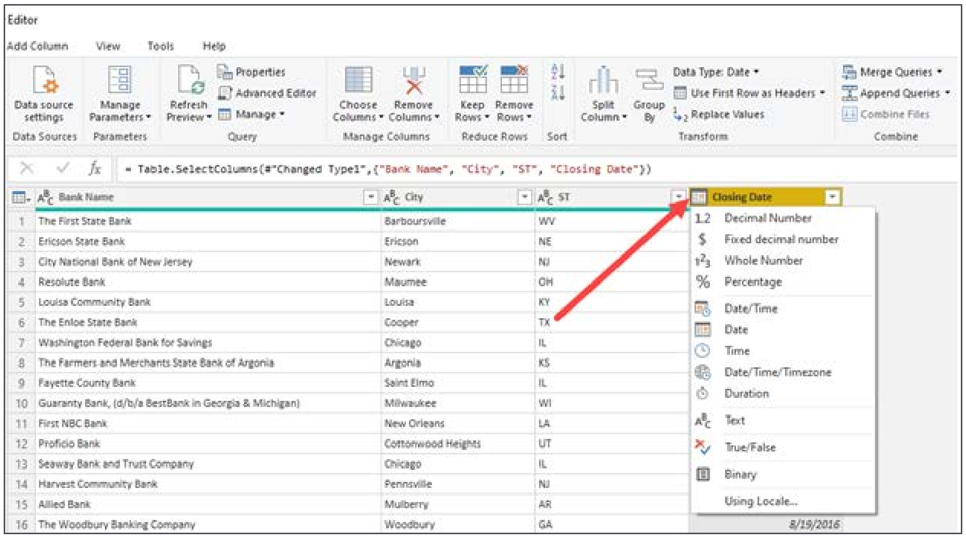
> You can also select the columns you wish to remove; right-click on one of the selected columns and click **Remove**. This seems like the more obvious method. However, this option is not as user-friendly in the long run because it does not provide an option to edit the transform in the **Applied Steps** section like the first two methods do.

With any data cleansing tool, data type manipulation is critical and can help save you from many headaches later in the development of your solution. In the next section, you will learn about how to change data types.

Change Type

Defining column data types properly early on in your data scrubbing process can help to ensure proper business rules can be applied and data is presented properly in reports. The Power Query Editor has various numeric, text, and date-time data types for you to choose from. In our current example, all of the data types were automatically interpreted correctly by the Power Query Editor, but let's look at where you could change this if necessary:

1. Locate the data type indicator on the column header to the left of the column name.
2. Click the data type icon, and a menu will open that allows you to choose whichever data type you desire, as shown in *Figure 2.4*:



```
= Table.SelectColumns(#"Changed Type1",{"Bank Name", "City", "ST", "Closing Date"})
```

	Bank Name	City	ST	Closing Date
1	The First State Bank	Barboursville	WV	
2	Ericson State Bank	Ericson	NE	
3	City National Bank of New Jersey	Newark	NJ	
4	Resolute Bank	Maumee	OH	
5	Louisa Community Bank	Louisa	KY	
6	The Enloe State Bank	Cooper	TX	
7	Washington Federal Bank for Savings	Chicago	IL	
8	The Farmers and Merchants State Bank of Argonia	Argonia	KS	
9	Fayette County Bank	Saint Elmo	IL	
10	Guaranty Bank, (d/b/a BestBank in Georgia & Michigan)	Milwaukee	WI	
11	First NBC Bank	New Orleans	LA	
12	Proficio Bank	Cottonwood Heights	UT	
13	Seaway Bank and Trust Company	Chicago	IL	
14	Harvest Community Bank	Pennsville	NJ	
15	Allied Bank	Mulberry	AR	
16	The Woodbury Banking Company	Woodbury	GA	8/19/2016

Figure 2.4: Choosing a different data type

Another method you can use for changing column data types is to right-click on the column you wish to change, then select **Change Type** and choose the new data type. You should always be careful when changing data types to ensure your data supports the change. For instance, if you change a column data type to a Whole Number while it has letters stored in it, Power BI will produce an error.

> If you want to change multiple column data types at once, you can multi-select the necessary columns, then select the new data type from the **Data Type** property on the **Home** ribbon.

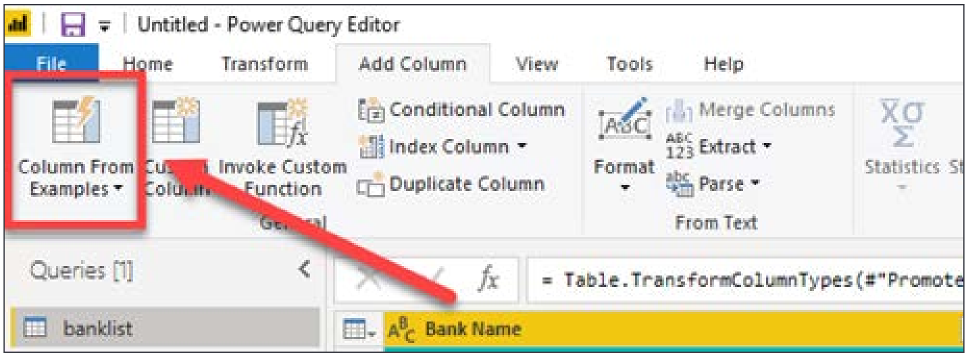
Many of the transforms you will encounter in the future are contextually based on the column data types you are working with. For example, if you have a column that is a date, then you will be provided with special transforms that can only be executed against a date data type, such as extracting the month name from a date column.

Understanding how to properly set data types in Power BI is often the first step to using more exciting transforms. In the next section, you will learn how Power BI can read from an example you provide to automatically create transform rules.

Column From Examples

One option that can make complex data transformations seem simple is the feature called **Add Column From Examples**. Using **Add Column From Examples**, you can provide the Power Query Editor with a sample of what you would like your data to look like, and it can then automatically determine which transforms are required to accomplish your goal. Continuing with the same failed banks example, let's walk through a simple example of how to use this feature:

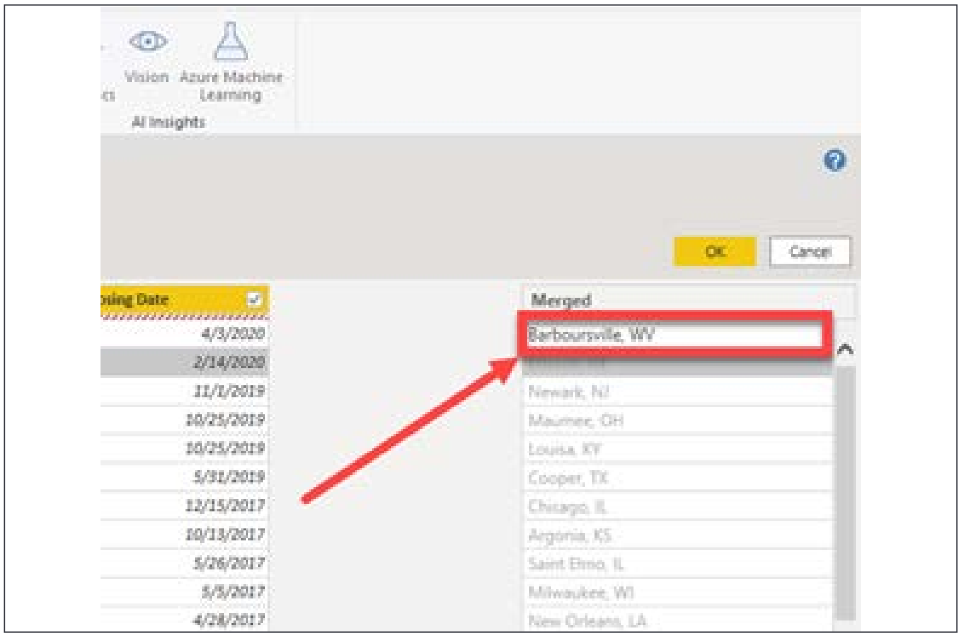
1. Find and select the **Add Column** tab in the Power Query Editor ribbon.
2. Select the **Column From Examples** button and, if prompted, choose **From All Columns**. This will launch a new **Add Column From Examples** interface:



```
= Table.TransformColumnTypes(#"Promote
```

Figure 2.5: Choosing the Column from Examples transform

3. Our goal is to leverage this feature to combine the `City` and `ST` columns together. In the first empty cell, type `Barboursville, WV` and then hit *Enter*. In *Figure 2.5* you will notice that the text you typed has automatically been translated into an M query and applied for every row in the dataset.
4. Once you click **OK**, the transform is finalized and automatically added to the overall `M` query that has been built through the user interface. The newly merged column will be added with the rest of your columns and you can optionally rename the column something more appropriate by double-clicking on the column header:



sing Date	Merged
4/3/2020	Barboursville, WV
2/14/2020	
11/1/2019	Newark, NJ
10/25/2019	Maumee, OH
10/25/2019	Louisa, KY
5/31/2019	Cooper, TX
12/15/2017	Chicago, IL
10/13/2017	Argonia, KS
5/26/2017	Saint Elmo, IL
5/5/2017	Milwaukee, WI
4/28/2017	New Orleans, LA

Figure 2.6: Adding Column from Examples

As you can see, the **Add Column from Examples** feature is great because you don't have to be an expert in which transforms are appropriate because Power BI will automatically choose them for you!

> Sometimes, you may encounter scenarios where the **Add Column From Examples** feature needs more than one example to properly translate your example into an M query function that accomplishes your goal. If this happens, simply provide additional examples of how you would like the data to appear in different rows, and the Power Query Editor should adjust to account for outliers.

Now that you have learned some basic transforms, let's explore some more complex design patterns that are still used quite frequently.

Advanced data transformation options

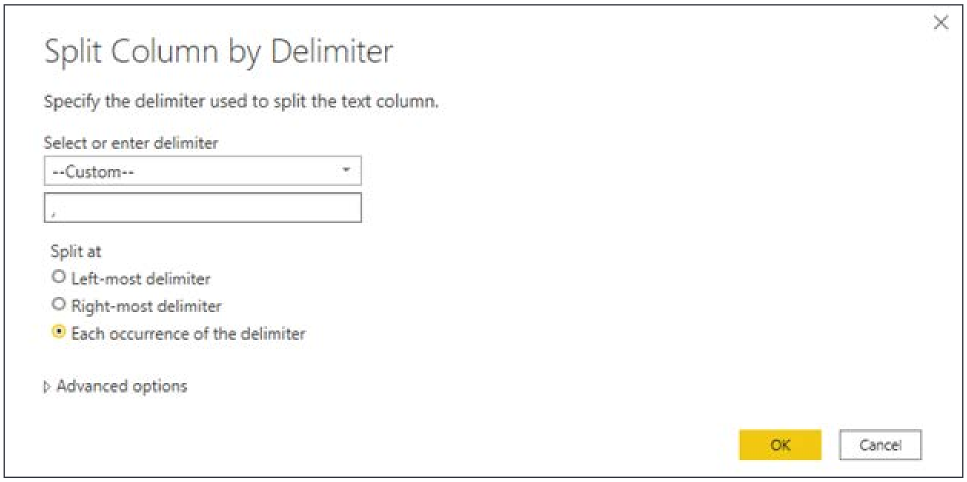
Now that you should be more comfortable working within the Power Query Editor, let's take the next step and discuss more advanced options. Often, you will find the need to go beyond these basic transforms when dealing with data that requires more care. In this section, you will learn about some common advanced transforms that you may have a need for, which include **Conditional Columns**, **Fill Down**, **Unpivot**, **Merge Queries**, and **Append Queries**.

Conditional Columns

Using the Power Query Editor **Conditional Columns** functionality is a great way to add new columns to your query that follow logical `if/then/else` statements. This concept of `if/then/else` is common across many programming languages, including Excel formulas. Let's review a real-world scenario where you would be required to do some data cleansing on a file before it could be used. In this example, you will be provided with a file of all the counties in the United States, and you must create a new column that extracts the state name from the county column and places it in its own column:

1. Start by connecting to the `FIPS_CountyName.txt` file that is found in the book files using the **Text/CSV** connector.
2. Launch the Power Query Editor by selecting **Transform Data**, then start by changing the data type of `Column1` to **Text**. When you do this, you will be prompted to replace an existing type conversion. You can accept this by clicking **Replace current**.

3. Now, on `Column2`, filter out the value **UNITED STATES** from the column by clicking the arrow next to the column header and unchecking **UNITED STATES**. Then, click **OK**.
4. Remove the state abbreviation from `Column 2` by right-clicking on the column header and selecting **Split Column | By Delimiter**. Choose **-- Custom --** for the delimiter type, and type **,** before then clicking **OK**, as shown in *Figure 2.7*:



Split Column by Delimiter

Specify the delimiter used to split the text column.

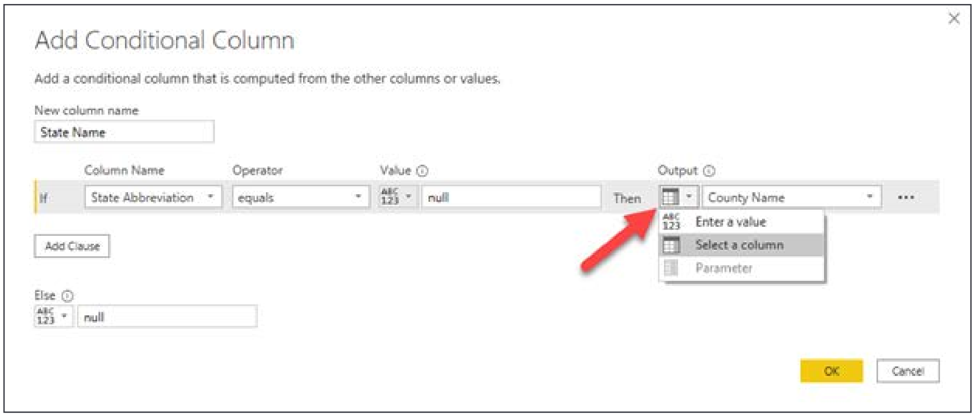
Select or enter delimiter: --Custom--

,

Split at
- Left-most delimiter
- Right-most delimiter
- [✓ Each occurrence of the delimiter]

Figure 2.7: Splitting a column based on a delimiter

5. Next, rename the column names `Column1`, `Column2.1`, and `Column 2.2`, to `County Code`, `County Name`, and `State Abbreviation`, respectively.
6. To isolate the full state name into its own column, you will need to implement **Conditional Column**. Go to the **Add Column** ribbon and select **Conditional Column**.
7. Change the **New column name** property to `State Name` and implement the logic `If State Abbreviation equals null Then return County Name Else return null` as shown in *Figure 2.8*. To return the value from another column, you must select the icon in the **Output** property, then choose **Select a column**. Once this is complete, click **OK**:



Add Conditional Column

Add a conditional column that is computed from the other columns or values.

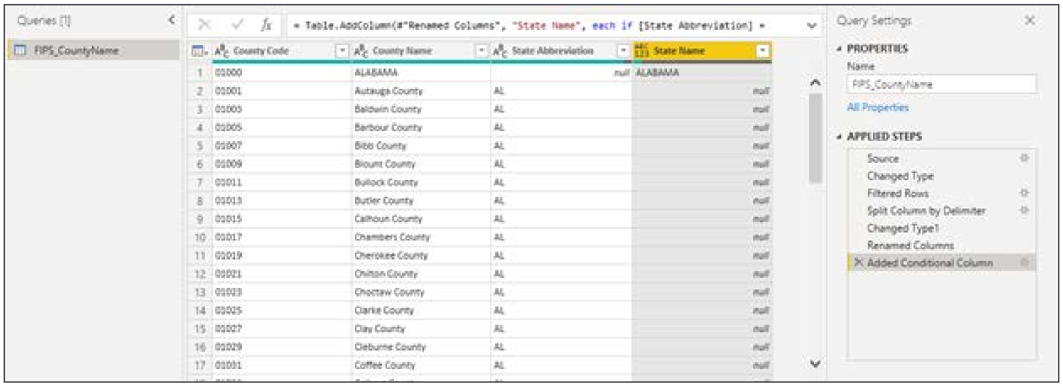
New column name: State Name

	Column Name	Operator	Value		Output
If	State Abbreviation	equals	null	Then	County Name

Else: null

Figure 2.8: Adding a conditional column

This results in a new column called **State Name**, which has the fully spelled-out state name only appearing on rows where the `State Abbreviation` is `null`:



```
= Table.AddColumn(#"Renamed Columns", "State Name", each if [State Abbreviation] =
```

	County Code	County Name	State Abbreviation	State Name
1	01000	ALABAMA	null	ALABAMA
2	01001	Autauga County	AL	null
3	01003	Baldwin County	AL	null
4	01005	Barbour County	AL	null
5	01007	Bibb County	AL	null
6	01009	Blount County	AL	null
7	01011	Bullock County	AL	null
8	01013	Butler County	AL	null
9	01015	Calhoun County	AL	null
10	01017	Chambers County	AL	null
11	01019	Cherokee County	AL	null
12	01021	Chilton County	AL	null
13	01023	Choctaw County	AL	null
14	01025	Clarke County	AL	null
15	01027	Clay County	AL	null
16	01029	Cleburne County	AL	null
17	01031	Coffee County	AL	null

Query Settings

PROPERTIES

Name: FIPS_CountyName

APPLIED STEPS

- Source
- Changed Type
- Filtered Rows
- Split Column by Delimiter
- Changed Type1
- Renamed Columns
- Added Conditional Column

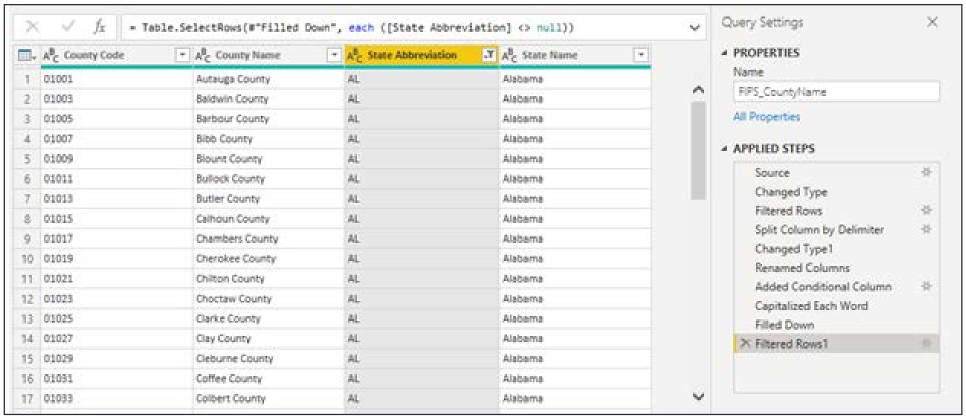
Figure 2.9: End result of following these steps

This is only setting the stage to fully scrub this dataset. To complete the data cleansing process for this file, read on to the next section about **Fill Down**. However, for the purposes of this example, you have now learned how to leverage the capabilities of the **Conditional Column** transform in the Power Query Editor.

Fill Down

Fill Down is a rather unique transform in how it operates. By selecting **Fill Down** on a particular column, a value will replace all `null` values below it until another non-null appears. When another non-null value is present, that value will then fill down to all subsequent `null` values. To examine this transform, you will pick up from where you left off in the **Conditional Column** example in the previous section:

1. Right-click on the **State Name** column header and select **Transform | Capitalize Each Word**. This transform should be self-explanatory.
2. Next, select the **State Name** column and, in the **Transform** ribbon, select **Fill | Down**. This will take the value in the **State Name** column and replace all non-null values until there is another **State Name** value that it can switch to. After performing this transform, scroll through the results to ensure that the value of `Alabama` switches to `Alaska` when appropriate.
3. To finish this example, filter out any `null` values that appear in the **State Abbreviation** column. The final result should look like *Figure 2.10*, as follows:



```
= Table.SelectRows(#"Filled Down", each ([State Abbreviation] <> null))
```

	County Code	County Name	State Abbreviation	State Name
1	01001	Autauga County	AL	Alabama
2	01003	Baldwin County	AL	Alabama
3	01005	Barbour County	AL	Alabama
4	01007	Bibb County	AL	Alabama
5	01009	Blount County	AL	Alabama
6	01011	Bullock County	AL	Alabama
7	01013	Butler County	AL	Alabama
8	01015	Calhoun County	AL	Alabama
9	01017	Chambers County	AL	Alabama
10	01019	Cherokee County	AL	Alabama
11	01021	Chilton County	AL	Alabama
12	01023	Choctaw County	AL	Alabama
13	01025	Clarke County	AL	Alabama
14	01027	Clay County	AL	Alabama
15	01029	Cleburne County	AL	Alabama
16	01031	Coffee County	AL	Alabama
17	01033	Colbert County	AL	Alabama

Query Settings

PROPERTIES

Name: FIPS_CountyName

All Properties

APPLIED STEPS

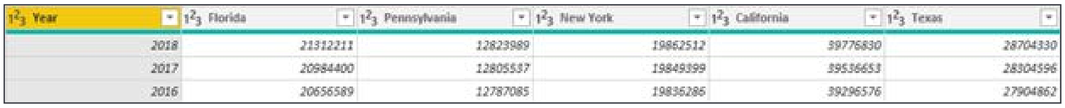
- Source
- Changed Type
- Filtered Rows
- Split Column by Delimiter
- Changed Type1
- Renamed Columns
- Added Conditional Column
- Capitalized Each Word
- Filled Down
- Filtered Rows1

Figure 2.10: End result of following these steps

In this example, you learned how you can use **Fill Down** to replace all of the `null` values below a non-null value. You can also use **Fill Up** to do the opposite, which would replace all the `null` values above a non-null value. One important thing to note is that the data must be sorted properly for **Fill Down** or **Fill Up** to be successful. In the next section, you will learn about another advanced transform, known as **Unpivot**.

Unpivot

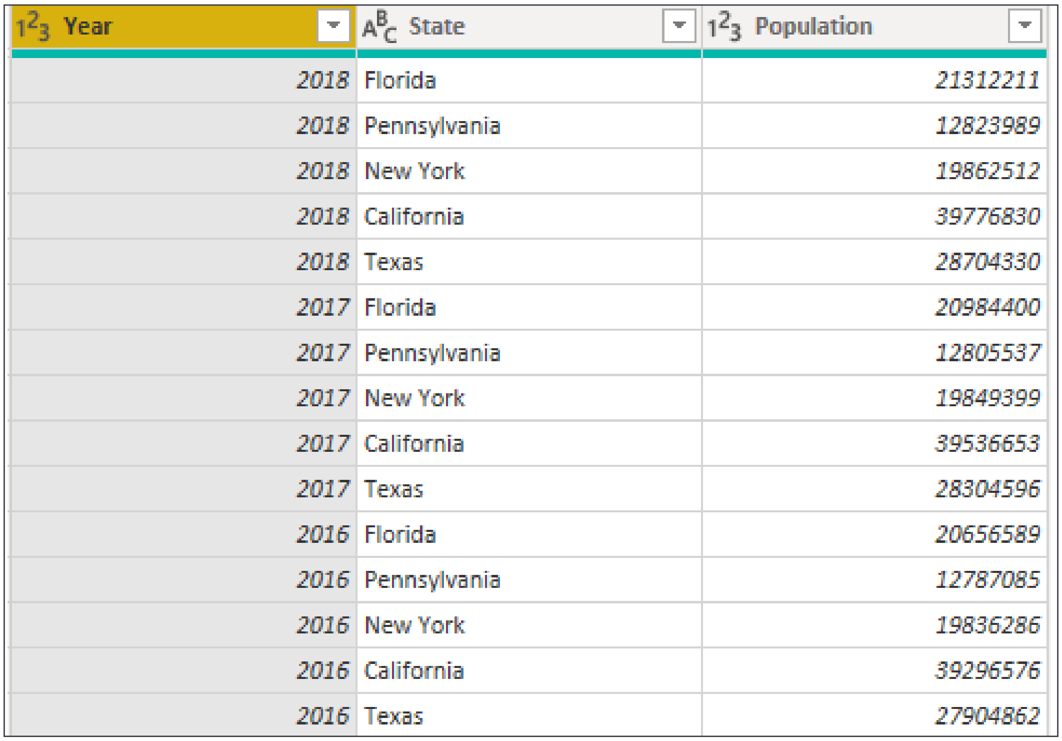
The **Unpivot** transform is an incredibly powerful transform that allows you to reorganize your dataset into a more structured format best suited for BI. Let's discuss this by visualizing a practical example to help understand the purpose of **Unpivot**. Imagine you are provided with a file that contains the populations of US states over the last three years, and looks as in *Figure 2.11*:



Year	Florida	Pennsylvania	New York	California	Texas
2018	21312211	12823989	19862512	39776830	28704330
2017	20984400	12805537	19849399	39536653	28304596
2016	20656589	12787085	19836286	39296576	27904862

Figure 2.11: Example data that will cause problems in Power BI

The problem with data stored like this is you cannot very easily answer simple questions. For example, how would you answer questions like, *What was the total population for all states in the US in 2018?* or *What was the average state population in 2016?* With the data stored in this format, simple reports are made rather difficult to design. This is where the **Unpivot** transform can be a lifesaver. Using **Unpivot**, you can change this dataset into something more acceptable for an analytics project, as shown in *Figure 2.12*:



Year	State	Population
2018	Florida	21312211
2018	Pennsylvania	12823989
2018	New York	19862512
2018	California	39776830
2018	Texas	28704330
2017	Florida	20984400
2017	Pennsylvania	12805537
2017	New York	19849399
2017	California	39536653
2017	Texas	28304596
2016	Florida	20656589
2016	Pennsylvania	12787085
2016	New York	19836286
2016	California	39296576
2016	Texas	27904862

Figure 2.12: Results of unpivoted data

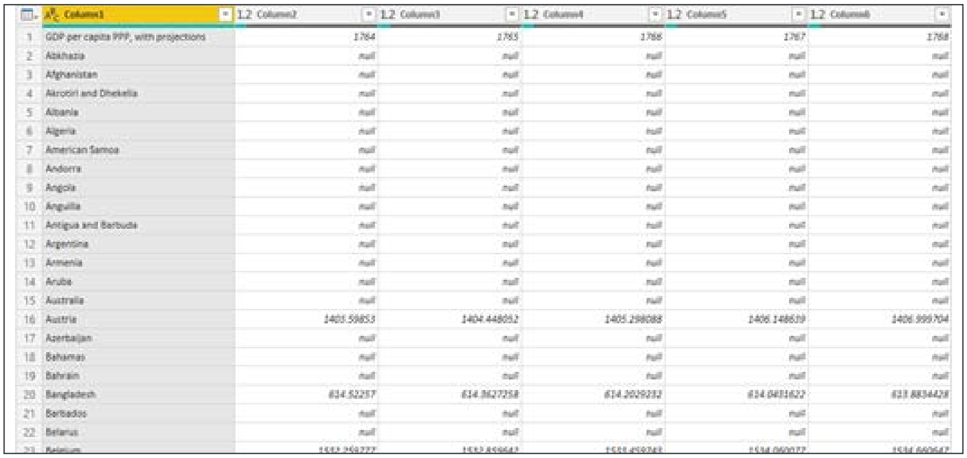
Data stored in this format can now easily answer the questions posed earlier by simply dragging a few columns into your visuals. To accomplish this in other programming languages would often require fairly complex logic, while the Power Query Editor does it in just a few clicks.

There are three different methods for selecting the **Unpivot** transform that you should be aware of, and they include the following options:

- **Unpivot Columns**: Turns any selected columns, headers into row values and the data in those columns into a corresponding row. With this selection, any new columns that may get added to the data source *will* automatically be included in the **Unpivot** transform.
- **Unpivot Other Columns**: Turns all column headers that *are not* selected into row values and the data in those columns into a corresponding row. With this selection, any new columns that may get added to the data source *will* automatically be included in the **Unpivot** transform.
- **Unpivot Only Selected Columns**: Turns any selected columns' headers into row values and the data in those columns into a corresponding row. With this selection, any new columns that may get added to the data source *will not* be included in the **Unpivot** transform.

Let's walk through two examples of using the **Unpivot** transform to show you the first two of these methods, and provide an understanding of how this complex problem can be solved with little effort in Power BI. The third method mentioned for doing **Unpivot** will not be shown since it's so similar to the first option:

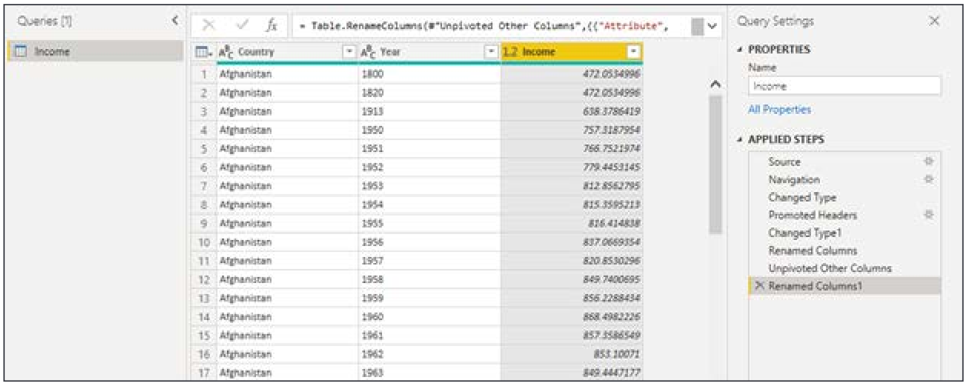
1. Launch a new instance of the Power BI Desktop, and use the Excel connector to import the workbook called `Income Per Person.xlsx` found in the book source files. Once you select this workbook, choose the spreadsheet called **Data** in the **Navigator** window, and then select **Transform Data** to launch the Power Query Editor. *Figure 2.13* shows what our data looks like before the **Unpivot** operation:



	Column1	Column2	Column3	Column4	Column5	Column6
1	GDP per capita PPP, with projections	1764	1765	1766	1767	1768
2	Abkhazia	null	null	null	null	null
3	Afghanistan	null	null	null	null	null
4	Akrotiri and Dhekelia	null	null	null	null	null
5	Albania	null	null	null	null	null
6	Algeria	null	null	null	null	null
7	American Samoa	null	null	null	null	null
8	Andorra	null	null	null	null	null
9	Angola	null	null	null	null	null
10	Anguilla	null	null	null	null	null
11	Antigua and Barbuda	null	null	null	null	null
12	Argentina	null	null	null	null	null
13	Armenia	null	null	null	null	null
14	Aruba	null	null	null	null	null
15	Australia	null	null	null	null	null
16	Austria	1403.59853	1404.448052	1405.298088	1406.148639	1406.999704
17	Azerbaijan	null	null	null	null	null
18	Bahamas	null	null	null	null	null
19	Bahrain	null	null	null	null	null
20	Bangladesh	614.52257	614.3627258	614.2029232	614.0431622	613.8834428
21	Barbados	null	null	null	null	null
22	Belarus	null	null	null	null	null
23	Belgium	1532.259277	1532.859642	1533.459743	1534.060077	1534.660647

Figure 2.13: Example before Unpivot is performed

2. Now, make the first row of data into column headers by selecting the transform called **Use First Row as Headers** on the **Home** ribbon.
3. Rename the **GDP per capita PPP, with projections** column to **Country**.
4. If you look closely at the column headers, you can tell that most of the column names are actually years and the values inside those columns are the income for those years. This is not the ideal way to store this data because it would be incredibly difficult to answer a question like, *What is the average income per person for Belgium?* To make it easier to answer this type of question, right-click on the **Country** column and select **Unpivot Other Columns**.
5. Rename the columns `Attribute` and `Value` to `Year` and `Income`, respectively.
6. To finish this first example, you should also rename this query **Income**. The results of these first steps can be seen in *Figure 2.14*:



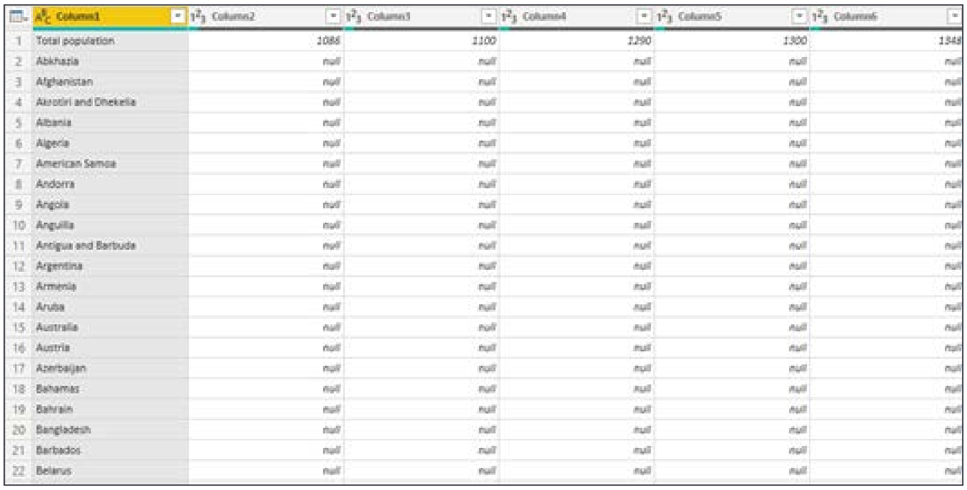
```
= Table.RenameColumns(#"Unpivoted Other Columns",{{"Attribute",
```

	Country	Year	Income
1	Afghanistan	1800	472.0534996
2	Afghanistan	1820	472.0534996
3	Afghanistan	1913	638.3786419
4	Afghanistan	1950	757.3187954
5	Afghanistan	1951	766.7521974
6	Afghanistan	1952	779.4453145
7	Afghanistan	1953	812.8562795
8	Afghanistan	1954	815.3595213
9	Afghanistan	1955	816.414838
10	Afghanistan	1956	837.0669354
11	Afghanistan	1957	820.8530296
12	Afghanistan	1958	849.7400695
13	Afghanistan	1959	856.2288434
14	Afghanistan	1960	868.4982226
15	Afghanistan	1961	857.3586549
16	Afghanistan	1962	853.10071
17	Afghanistan	1963	849.4447177

Figure 2.14: Results of unpivoted data

This first method walked you through what can often be the fastest method for performing an **Unpivot** transform, which is by using the **Unpivot Other Columns** option. In this next example, you will learn how to use the **Unpivot Columns** method as well:

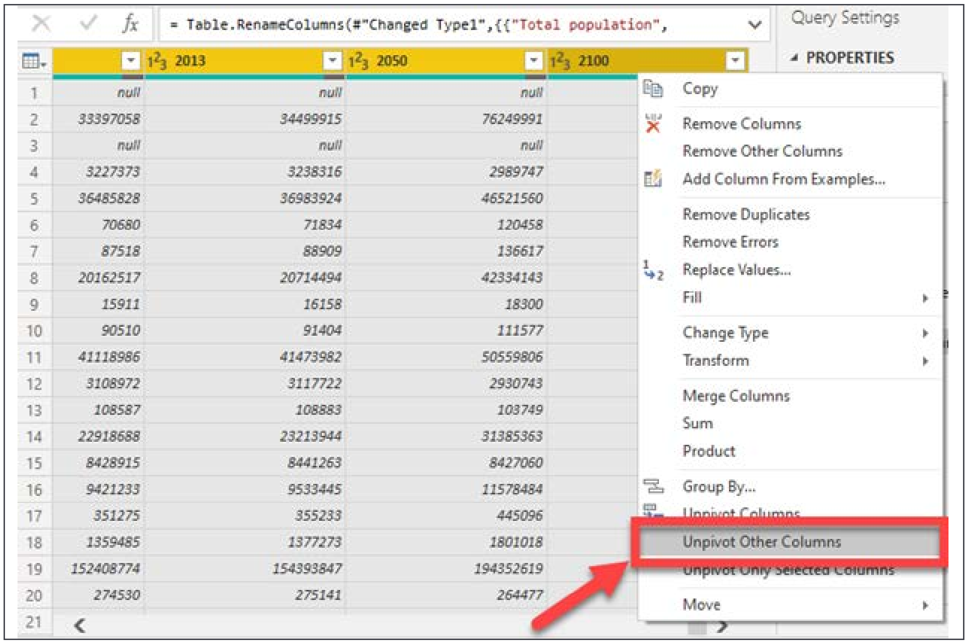
1. Remain in the Power Query Editor, and select **New Source** from the **Home** ribbon. Use the Excel connector to import the `Total Population.xlsx` workbook from the book source files. Once you select this workbook, choose the spreadsheet called **Data** in the **Navigator** window, and then select **OK**. *Figure 2.15* shows the dataset before **Unpivot** has been added:



	Column1	Column2	Column3	Column4	Column5	Column6
1	Total population	1086	1100	1290	1300	1348
2	Abkhazia	null	null	null	null	null
3	Afghanistan	null	null	null	null	null
4	Akrotiri and Dhekelia	null	null	null	null	null
5	Albania	null	null	null	null	null
6	Algeria	null	null	null	null	null
7	American Samoa	null	null	null	null	null
8	Andorra	null	null	null	null	null
9	Angola	null	null	null	null	null
10	Anguilla	null	null	null	null	null
11	Antigua and Barbuda	null	null	null	null	null
12	Argentina	null	null	null	null	null
13	Armenia	null	null	null	null	null
14	Aruba	null	null	null	null	null
15	Australia	null	null	null	null	null
16	Austria	null	null	null	null	null
17	Azerbaijan	null	null	null	null	null
18	Bahamas	null	null	null	null	null
19	Bahrain	null	null	null	null	null
20	Bangladesh	null	null	null	null	null
21	Barbados	null	null	null	null	null
22	Belarus	null	null	null	null	null

Figure 2.15: Example before Unpivot is performed

2. Like the last example, you will again need to make the first row of data into column headers by selecting the transform called **Use First Row as Headers** on the **Home** ribbon.
3. Then, rename the column **Total population** to **Country**.
4. This time, multi-select all the columns except **Country**, then right-click on one of the selected columns and choose **Unpivot Other Columns** as shown in *Figure 2.16*. The easiest way to multi-select these columns is to select the first column then hold *Shift* before clicking the last column:

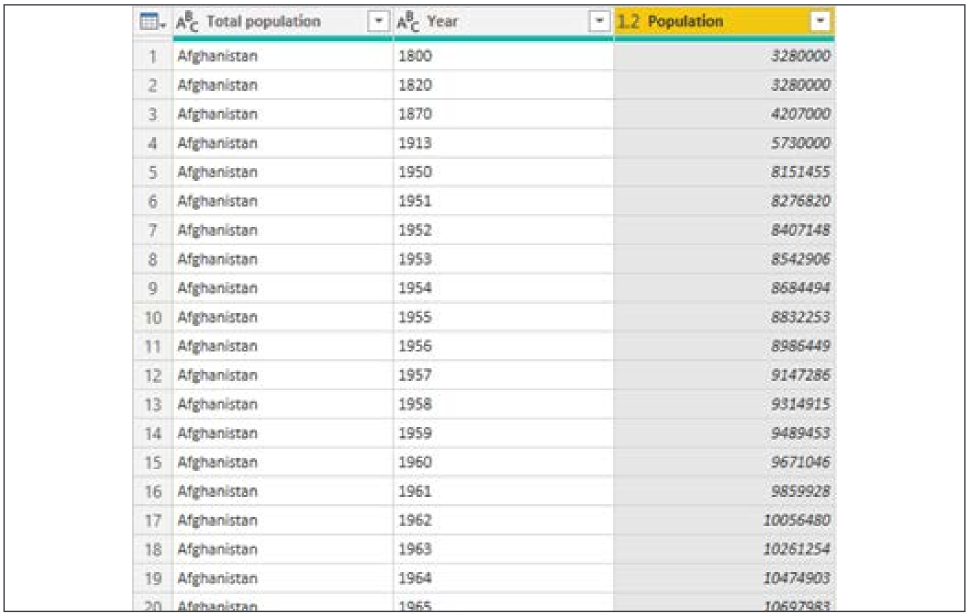


```
= Table.RenameColumns(#"Changed Type1",{{"Total population",
```

		2013	2050	2100
1	null	null	null	
2	33397058	34499915	76249991	
3	null	null	null	
4	3227373	3238316	2989747	
5	36485828	36983924	46521560	
6	70680	71834	120458	
7	87518	88909	136617	
8	20162517	20714494	42334143	
9	15911	16158	18300	
10	90510	91404	111577	
11	41118986	41473982	50559806	
12	3108972	3117722	2930743	
13	108587	108883	103749	
14	22918688	23213944	31385363	
15	8428915	8441263	8427060	
16	9421233	9533445	11578484	
17	351275	355233	445096	
18	1359485	1377273	1801018	
19	152408774	154393847	194352619	
20	274530	275141	264477	
21				

Figure 2.16: Using the Unpivot Other Columns transform

5. Rename the columns from **Attribute** and **Value** to **Year** and **Population**, respectively, to see the result showing in *Figure 2.17*:



	Total population	Year	Population
1	Afghanistan	1800	3280000
2	Afghanistan	1820	3280000
3	Afghanistan	1870	4207000
4	Afghanistan	1913	5730000
5	Afghanistan	1950	8151455
6	Afghanistan	1951	8276820
7	Afghanistan	1952	8407148
8	Afghanistan	1953	8542906
9	Afghanistan	1954	8684494
10	Afghanistan	1955	8832253
11	Afghanistan	1956	8986449
12	Afghanistan	1957	9147286
13	Afghanistan	1958	9314915
14	Afghanistan	1959	9489453
15	Afghanistan	1960	9671046
16	Afghanistan	1961	9859928
17	Afghanistan	1962	10056480
18	Afghanistan	1963	10261254
19	Afghanistan	1964	10474903
20	Afghanistan	1965	10697983

Figure 2.17: Shows the final result of these steps

In this section, you learned about two different methods for performing an **Unpivot**. To complete the data cleansing process on these two datasets, it's recommended that you continue through the next section on merging queries.

Merge Query

Another common requirement when building BI solutions is the need to join two tables together to form a new outcome that includes some columns from both tables in the result. Fortunately, Power BI makes this task very simple with the **Merge Queries** feature. Using this feature requires that you select two tables and then determine which column or columns will be the basis of how the two queries are merged. After determining the appropriate columns for your join, you will select a join type. The join types are listed here with the description that is provided within the product:

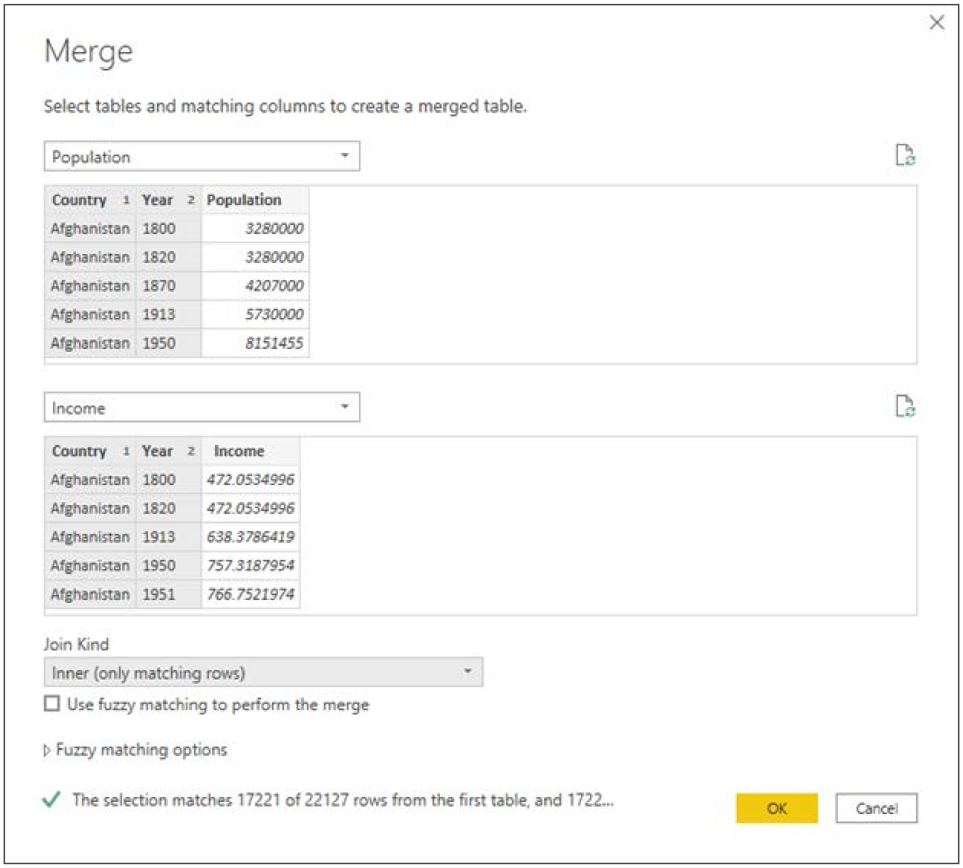
- **Left Outer** (all rows from the first table, only matching rows from the second)
- **Right Outer** (all rows from the second table, only matching rows from the first)
- **Full Outer** (all rows from both tables)
- **Inner** (only matching rows from both tables)
- **Left Anti** (rows only in the first table)
- **Right Anti** (rows only in the second table)

Many of you may already be very familiar with these different join terms from SQL programming you have learned in the past. However, if these terms are new to you, I recommend reviewing *Visualizing Merge Join Types in Power BI*, courtesy of Jason Thomas in the *Power BI Data Story Gallery*: `https://community.powerbi.com/t5/Data-Stories-Gallery/Visualizing-Merge-Join-Types-in-Power-BI/m-p/219906`. This visual aid is a favorite of many users that are new to these concepts.

To examine the **Merge Queries** option, you will pick up from where you left off with the **Unpivot** examples in the previous section:

1. With the **Population** query selected, find and select **Merge Queries** | **Merge Queries as New** on the **Home** ribbon.
2. In the **Merge** dialog box, select the **Income** query from the drop-down selection in the middle of the screen.

3. Then, multi-select the **Country** and **Year** columns on the **Population** query, and do the same under the **Income** query. This defines which columns will be used to join the two queries together. Ensure that the number indicators next to the column headers match, as demonstrated in *Figure 2.18*. If they don't, you could accidentally attempt to join on the incorrect columns.
4. Next, select **Inner** (**only matching rows**) for **Join Kind**. This join type will return rows only when the columns you chose to join on have values that exist in both queries. Before you click **OK**, confirm that your screen matches *Figure 2.18*:


Merge

Select tables and matching columns to create a merged table.

Population

Country 1	Year 2	Population
Afghanistan	1800	3280000
Afghanistan	1820	3280000
Afghanistan	1870	4207000
Afghanistan	1913	5730000
Afghanistan	1950	8151455

Income

Country 1	Year 2	Income
Afghanistan	1800	472.0534996
Afghanistan	1820	472.0534996
Afghanistan	1913	638.3786419
Afghanistan	1950	757.3187954
Afghanistan	1951	766.7521974

Join Kind

Inner (only matching rows)

☐ Use fuzzy matching to perform the merge

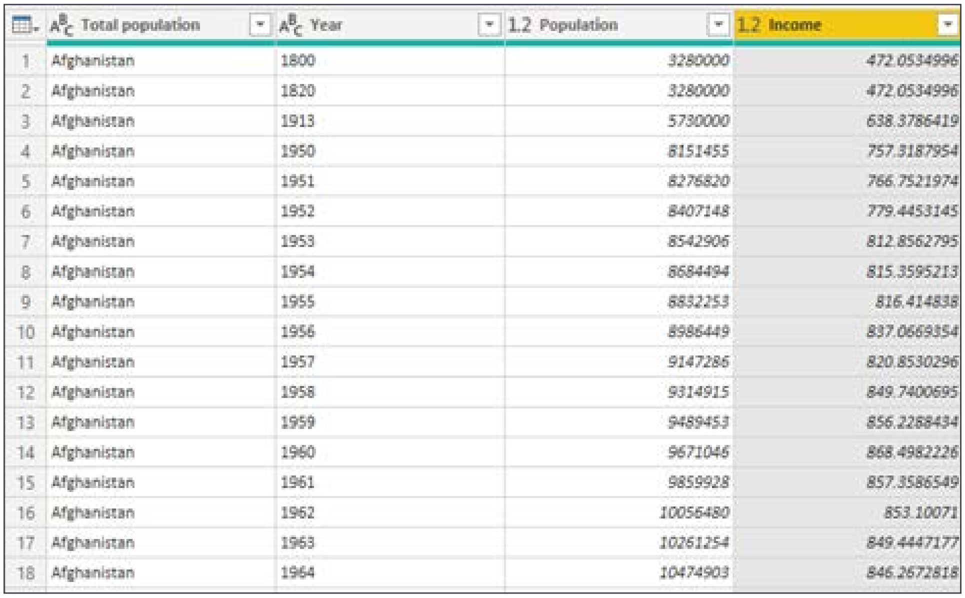
▷ Fuzzy matching options

✓ The selection matches 17221 of 22127 rows from the first table, and 1722...

Figure 2.18: Configuring a merge between two queries

5. Once you select **OK**, this will create a new query called `Merge1` that combines the results of the two queries. Go ahead and rename this query `Country Stats`.

6. You will also notice that there is a column called `Income` that has a value of `Table` for each row. This column is actually representative of the entire `Income` query that you joined to. To choose which columns you want from this query, click the **Expand** button on the column header. After clicking the **Expand** button, uncheck **Country**, **Year**, and **Use original column name as prefix**, then click **OK**.
7. Rename the column called `Income.1` to `Income`. *Figure 2.19* shows this step completed:



	Total population	Year	Population	Income
1	Afghanistan	1800	3280000	472.0534996
2	Afghanistan	1820	3280000	472.0534996
3	Afghanistan	1913	5730000	638.3786419
4	Afghanistan	1950	8151455	757.3187954
5	Afghanistan	1951	8276820	766.7521974
6	Afghanistan	1952	8407148	779.4453145
7	Afghanistan	1953	8542906	812.8562795
8	Afghanistan	1954	8684494	815.3595213
9	Afghanistan	1955	8832253	816.414838
10	Afghanistan	1956	8986449	837.0669354
11	Afghanistan	1957	9147286	820.8530296
12	Afghanistan	1958	9314915	849.7400695
13	Afghanistan	1959	9489453	856.2288434
14	Afghanistan	1960	9671046	868.4982226
15	Afghanistan	1961	9859928	857.3586549
16	Afghanistan	1962	10056480	853.10071
17	Afghanistan	1963	10261254	849.4447177
18	Afghanistan	1964	10474903	846.2672818

Figure 2.19: Configuring a merge between two queries

8. Finally, since you chose the option **Merge Queries as New** in *Step 1*, you can disable the load option for the original queries that you started with. To do this, right-click on the **Income** query in the **Queries** pane and click **Enable load** to disable it. Do the same thing for the **Population** query as shown in *Figure 2.20*. Disabling these queries means that the only query that will be loaded into your Power BI data model is the new one, called **Country Stats**:

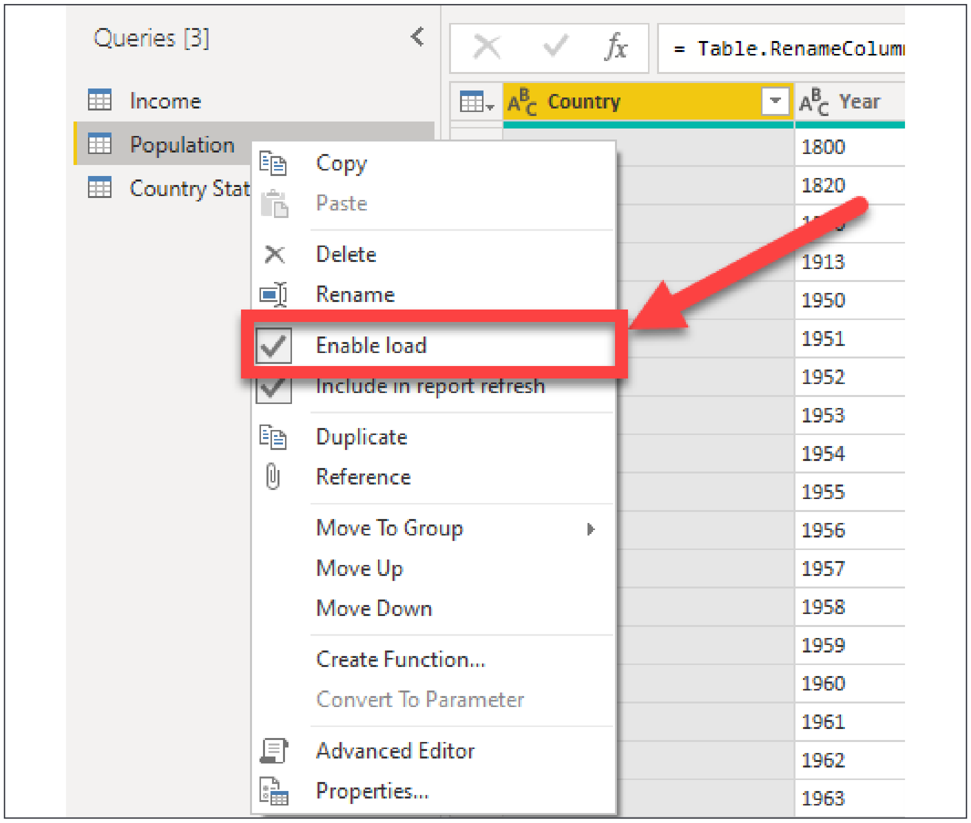


Figure 2.20: Uncheck to disable the loading of this query into the data model

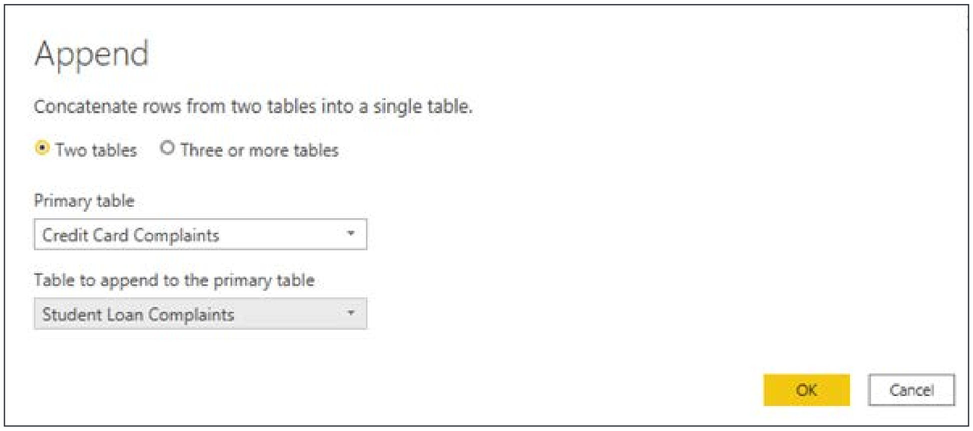
To begin using this dataset in a report, you would click **Close & Apply**. You will learn more about building reports in *Chapter 5*, *Visualizing Data*.

By default, merging queries together relies on exact matching values between your join column(s). However, you may work with data that does not always provide perfect matching values. For example, a user enters data and misspells their country as "Unite States" instead of `United States`. In those cases, you may consider the more advanced feature called Fuzzy Matching. With Fuzzy Matching, Power BI can perform an approximate match and still join on these two values based on the similarity of the values. In this section, you learned how the **Merge Queries** option is ideal for joining two queries together. In the next section, you will learn how you could solve the problem of performing a union of two or more queries.

Append Query

Occasionally, you will work with multiple datasets that need to be appended to each other. Here's a scenario: you work for a customer service department for a company that provides credit or loans to customers. You are regularly provided with `.csv` and `.xlsx` files that give summaries of customer complaints regarding credit cards and student loans. You would like to analyze both of these data extracts at the same time but, unfortunately, the credit card and student loan complaints are provided in two separate files. In this example, you will learn how to solve this problem by performing an append operation on these two different files:

1. Launch a new instance of the Power BI Desktop, and use the Excel connector to import the workbook called `Student Loan Complaints.xlsx` found in the book source files. Once you select this workbook, choose the spreadsheet called **Student Loan Complaints** in the **Navigator** window, and then select **Transform Data** to launch the Power Query Editor.
2. Next, import the credit card data by selecting **New Source | Text/CSV**, then choose the file called `Credit Card Complaints.csv` found in the book source files. Click **OK** to bring this data into the Power Query Editor.
3. With the `Credit Card Complaints` query selected, find and select **Append Queries | Append Queries as New** on the **Home** ribbon.
4. Select **Student Loan Complaints** as the table to append to, then select **OK** as shown in *Figure 2.21*:



Append

Concatenate rows from two tables into a single table.

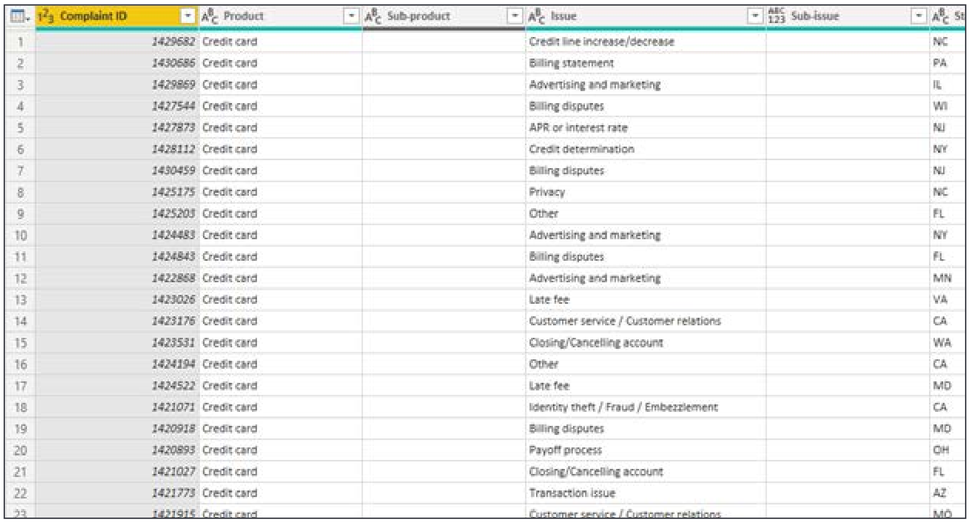
[● Two tables] ○ Three or more tables

Primary table: Credit Card Complaints

Table to append to the primary table: Student Loan Complaints

Figure 2.21: Configuring an append between two queries

5. Rename the newly created query **All Complaints** and view the results as seen in *Figure 2.22*:



	Complaint ID	Product	Sub-product	Issue	Sub-issue	St
1	1429682	Credit card		Credit line increase/decrease		NC
2	1430686	Credit card		Billing statement		PA
3	1429869	Credit card		Advertising and marketing		IL
4	1427544	Credit card		Billing disputes		WI
5	1427873	Credit card		APR or interest rate		NJ
6	1428112	Credit card		Credit determination		NY
7	1430459	Credit card		Billing disputes		NJ
8	1425175	Credit card		Privacy		NC
9	1425203	Credit card		Other		FL
10	1424483	Credit card		Advertising and marketing		NY
11	1424843	Credit card		Billing disputes		FL
12	1422868	Credit card		Advertising and marketing		MN
13	1423026	Credit card		Late fee		VA
14	1423176	Credit card		Customer service / Customer relations		CA
15	1423531	Credit card		Closing/Cancelling account		WA
16	1424194	Credit card		Other		CA
17	1424522	Credit card		Late fee		MD
18	1421071	Credit card		Identity theft / Fraud / Embezzlement		CA
19	1420918	Credit card		Billing disputes		MD
20	1420893	Credit card		Payoff process		OH
21	1421027	Credit card		Closing/Cancelling account		FL
22	1421773	Credit card		Transaction issue		AZ
23	1421915	Credit card		Customer service / Customer relations		MO

Figure 2.22: Configuring an append between two queries

6. Similar to the previous example, you would likely want to disable the load option for the original queries that you started with. To do this, right-click on the **Student Load Complaints** query in the **Queries** pane and click **Enable load** to disable it.
7. Do the same to the **Credit Card Complaints** query, and then select **Close & Apply**.

Now that you have learned about the various methods for combining data, the next section will discuss a more advanced method of working with data using the R programming language.

Leveraging R

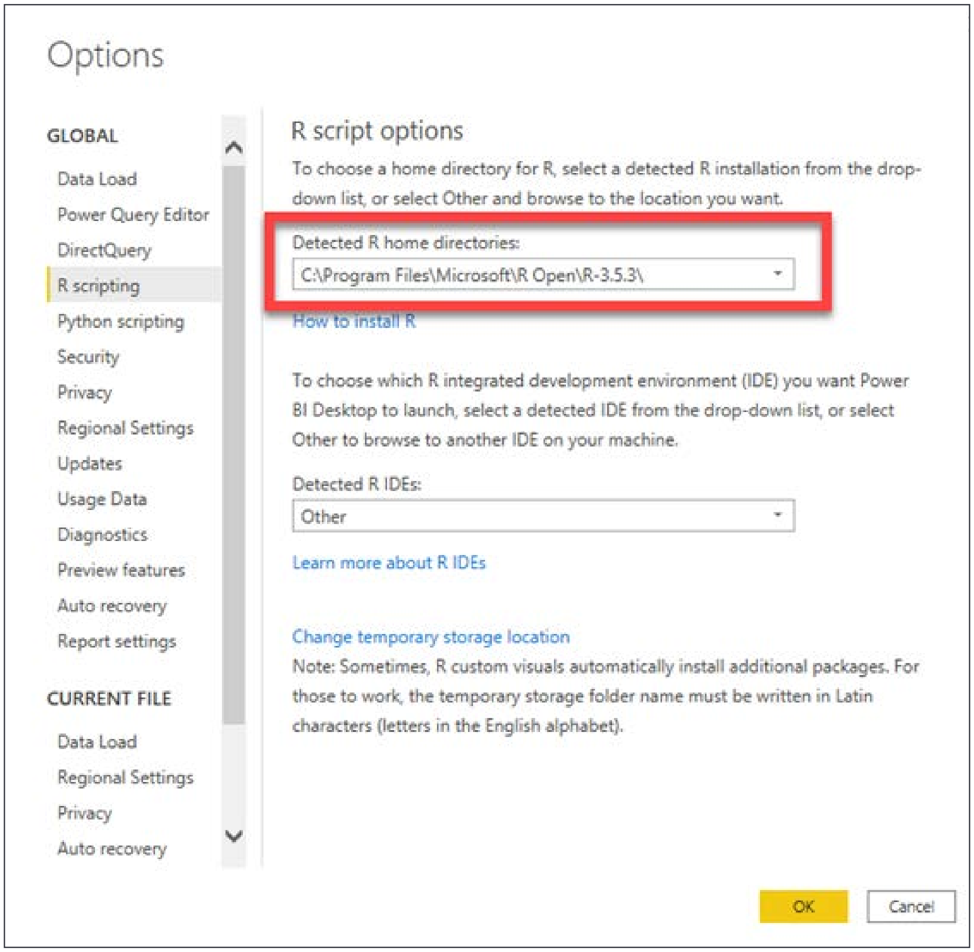
R is a very powerful scripting language that is primarily used for advanced analytics tools, but also has several integration points within Power BI. One such integration is the ability to apply business rules to your data with the R language. Why is that important? Well, with this capability you can extend beyond the limits of the Power Query Editor and call functions and libraries from R to do things that would not normally be possible. In the next two sections, you will explore how to set up your machine to leverage R within Power BI and then walk through an example of using an `R` script transform.

There are many additional books and references you can read to learn more about the R scripting language, but for the purposes of this book, our goal is to inform you of what is possible when R and Power BI are combined.

Installation and configuration

To use R within Power BI, you must first install an `R` distribution for you to run and execute scripts against. In this book, we will leverage Microsoft's distribution, Microsoft R Open. It is an open source project and free for anyone to use. Once Microsoft R Open has been installed, you can then configure Power BI to recognize the home directory where `R` libraries may be installed. Let's walk through these setup steps together:

1. Navigate to the website `https://mran.microsoft.com/download/` to download and install Microsoft R Open.
2. For the purposes of our example, you will select **Download** next to **Windows**.
3. Once the download has completed, run the installation and accept all default settings and user agreements.
4. Next, launch a new instance of Power BI Desktop to set up the R integration with Power BI. Click the menu options **File | Options and settings | Options**.
5. Choose the **R scripting** section and ensure that the **Detected R home directories** property is filled with the R instance you just installed, as shown in *Figure 2.23*:



R script options

To choose a home directory for R, select a detected R installation from the drop-down list, or select Other and browse to the location you want.

Detected R home directories:
C:\Program Files\Microsoft\R Open\R-3.5.3\

How to install R

To choose which R integrated development environment (IDE) you want Power BI Desktop to launch, select a detected IDE from the drop-down list, or select Other to browse to another IDE on your machine.

Detected R IDEs:
Other

Learn more about R IDEs

Change temporary storage location

Note: Sometimes, R custom visuals automatically install additional packages. For those to work, the temporary storage folder name must be written in Latin characters (letters in the English alphabet).

Figure 2.23: Mapping the R home directories in Power BI

6. Once this is completed, click **OK**.

With this setup now complete, let's see how we can take advantage of R within Power BI.

The R script transform

With the R distribution now installed and configured to integrate with Power BI, you are now ready to see what's possible with these new capabilities. In this example, you will be looking at data from the European stock market. The problem with this dataset, which calls for it to be corrected with R, is that the file provided to you has missing values for certain days. So, to get a more accurate reading of the stock market, you will use an `R` package called `MICE` to impute the missing values:

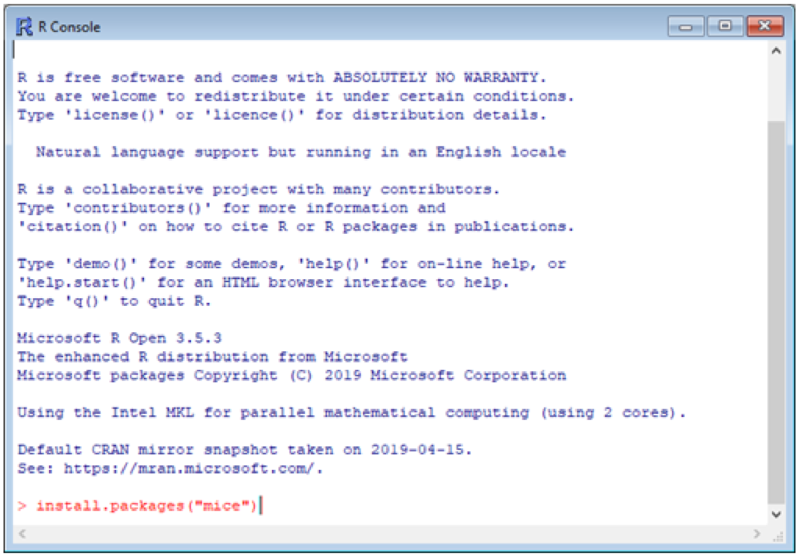
1. Before beginning in Power BI, you should ensure that the `MICE` library is installed and available in the R distribution you set up in the last section. To do this, launch Microsoft R Open from your device. This is the basic RGui that was installed for you to run `R` scripts with.

   For many developers, the preferred method for writing `R` scripts is a free open source tool called RStudio. RStudio includes a code editor, debugging, and visualization tools that many find easier to work with. You can download RStudio from `https://www.rstudio.com/`.

2. Type the following script in the **R Console** window, and then hit *Enter*:

   ```
   install.packages("mice")
   ```

   This input is illustrated in the following screenshot:



```
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

Microsoft R Open 3.5.3
The enhanced R distribution from Microsoft
Microsoft packages Copyright (C) 2019 Microsoft Corporation

Using the Intel MKL for parallel mathematical computing (using 2 cores).

Default CRAN mirror snapshot taken on 2019-04-15.
See: https://mran.microsoft.com/.

> install.packages("mice")
```

Figure 2.24: Running the library install in RGui

3. You can close the **R Console** window and return to Power BI Desktop after it returns an output like the following:

```
package 'mice' successfully unpacked and MD5 sums checked.
```

4. In Power BI Desktop, start by connecting to the required data source called `EuStockMarkets_NA.csv` from the book source files. Once you connect to the file, click **Transform Data** to launch the Power Query Editor.
5. You will notice that there are a few days missing values in the **SMI** (**Stock Market Index**) column. We would like to replace values that show **NA** with approximate values using an R script. Go to the **Transform** ribbon, and select the **Run R Script** button on the far right.
6. Use the following R script to call the `MICE` library that you recently installed to detect what the missing values in this dataset should be:

```
    # 'dataset' holds the input data for this script
    library(mice)
    tempData <- mice(dataset,m=1,maxit=50,meth='pmm',seed=100)
    completedData <- complete(tempData,1)
    output <- dataset
    output$completedValues <- completedData$"SMI missing values"
```

7. Click **OK**. If you are prompted with a warning indicating **Information is required about data privacy** click **Continue**.
8. Next, click on the hyperlink on the table value next to the `completedData` row to see the result of the newly implemented transform for detecting missing values.

This new output has replaced the missing values with new values that were detected based on the algorithm used within the R script. To now build a set of report visuals on this example, you can click **Close & Apply** on the **Home** ribbon.

This is just one simple way that R can be used with Power BI. You should note that in addition to using R as a transform, it can also be used as a data source and as a visual within Power BI.

While this book highlights the programming language `R` to extend the capabilities of Power BI, some might prefer Python. Python is another programming language that allows for extensibility into Power BI to create new data connectors, transforms, and visuals. So, should you choose R or Python? That depends on which you are more comfortable with. If you have already spent time learning `Python`, then stick with that! In the next section of this chapter, you will learn about Power BI's AI integration features, which give you the ability to call on components of Azure Cognitive Services with the Power Query Editor.

AI Insights

As you learned in the previous section, Power BI integrates and takes advantage of outside tools to enhance the capabilities within itself. That continues to be the case with the AI Insights features. Leveraging the AI Insights capabilities gives you the ability to tap into core features and algorithms within Azure Cognitive Services and expose them within Power BI. So how can this be useful to you?

Imagine you work for a company that runs a vacation rentals website. Customers can book travel and post reviews of their trips on your website. With thousands of customers and hundreds of rental homes, it can be difficult to manage all the reviews that come in to make sure your locations are all meeting the standards your customers expect. With AI Insights you can run algorithms that can perform sentiment analysis, key phrase extraction, language detection, and even image tagging. So, if you have international customers that post reviews, you can use language detection to understand what language the post was written in. Then you can use sentiment analysis to capture whether the review was positive or negative. Finally, using phrase extraction, you can pull out key terms in the reviews to see if the same locations continue to receive feedback regarding similar problems. Furthermore, if your feedback system allows photos to be posted in the reviews, the image tagging capabilities can return a list of characteristics found in the images posted. This would allow for automated categorization of images using AI.

As you can see, these are very powerful features that take your analytics processing to the next level. There are limitations, however, that you should be aware of before exploring these features. As of the time that this book was published, Cognitive Services integration is only supported for Power BI Premium capacity nodes `EM2`, `A2`, or `P1` and above. This means if your company is not currently leveraging Power BI Premium, then these features are not available to you.

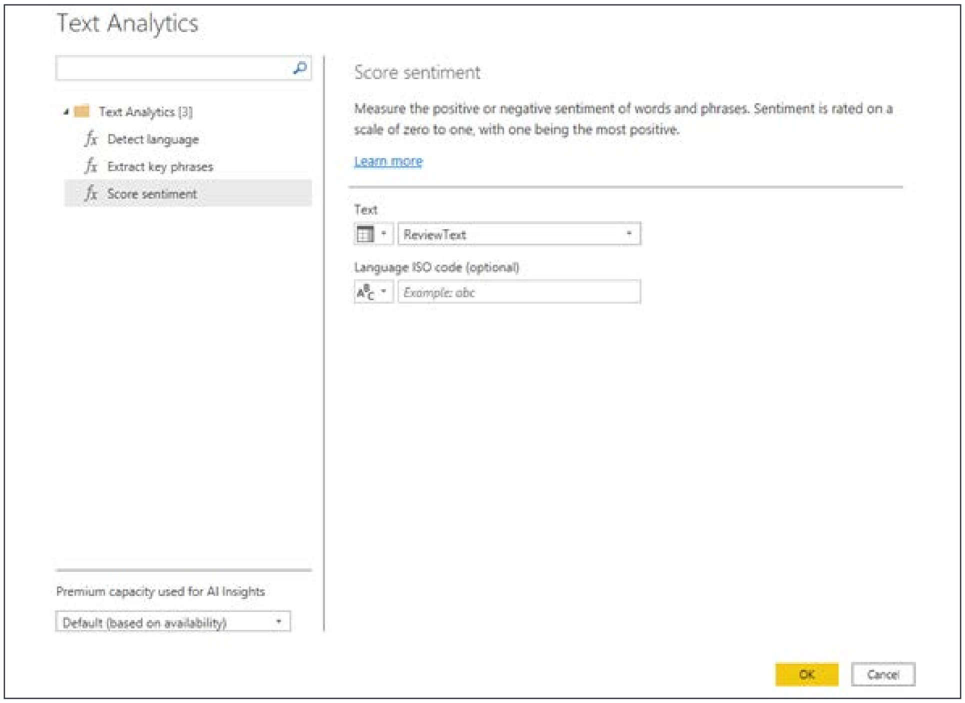
> Before using the AI Insights features in Power BI, you will need to change the capacity settings in the Power BI admin portal to enable the AI workload. After turning on the AI workload setting, you can also set the maximum amount of memory you would like to give the workload. The general recommendation is a memory limit of 20%.

In the next section, you will learn how to leverage an AI Insights Text Analytics feature called Sentiment Analysis.

Sentiment Analysis with Text Analytics

The Text Analytics features within the AI Insights features can be incredible time-savers. Imagine having to read paragraphs of information and conclude what was important or whether it was written in a positive or negative light. These are exactly the type of things that this feature can do for you. In this next example, you are going to test out one of these features by running a sentiment analysis algorithm on hotel reviews to see how customers feel about staying at your hotel locations:

1. Launch a new instance of Power BI Desktop, and use the Excel connector to import the workbook called `Hotel Ratings.xlsx` found in the book source files. Once you select this workbook, choose the spreadsheet called **Reviews** in the **Navigator** window, and then select **Transform Data** to launch the Power Query Editor.
2. Select **Text Analytics** on the **Home** ribbon of the Power Query Editor. If this is your first time using this feature, you may be prompted to sign into a Power BI account that has Power BI Premium capacity assigned to it.
3. Next, you will be prompted to choose which Text Analytics algorithm you would like to use. Select **Score sentiment**, as shown in *Figure 2.25*, and ensure the **ReviewText** field is the **Text** that will be analyzed. Then click **OK**:


Text Analytics

Score sentiment

Measure the positive or negative sentiment of words and phrases. Sentiment is rated on a scale of zero to one, with one being the most positive.

Learn more

Text: ReviewText

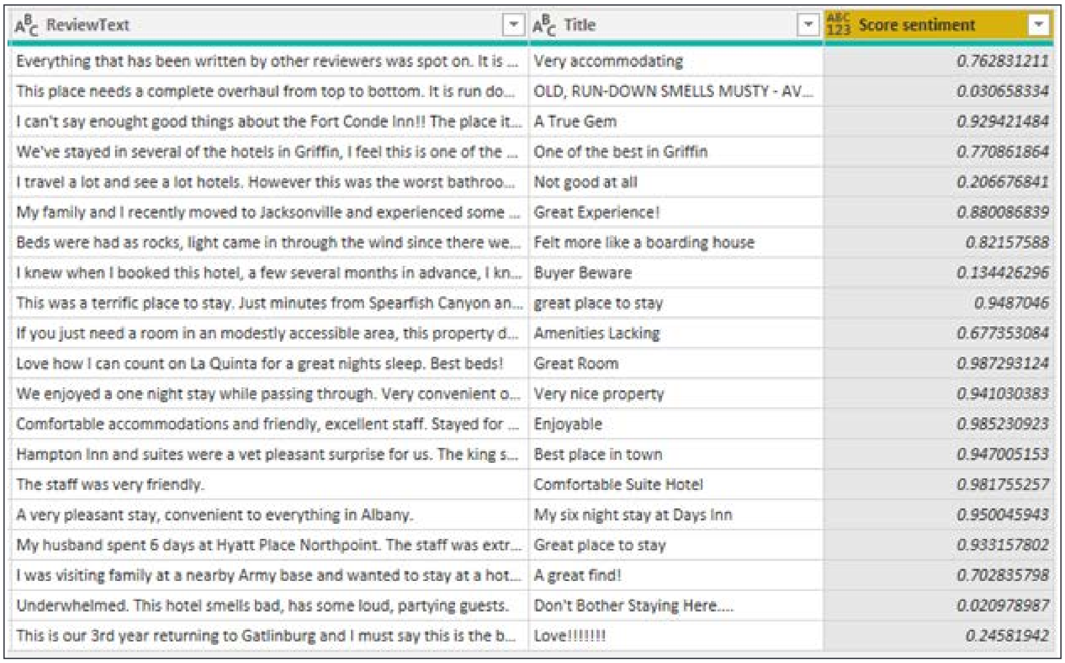
Language ISO code (optional): Example: abc

Premium capacity used for AI Insights: Default (based on availability)

Figure 2.25: Using the Text Analytics feature

4. If prompted with a data privacy warning, click **Continue** and then select **Ignore Privacy Levels check** for this file before clicking **Save**. This type of warning can occur when you combine two disparate sources or services together and is to ensure it is OK for these data sources to be combined.

This transform will produce a new numeric column with a value between `0` and `1` for every row in the dataset. A sentiment score of `.50` is considered neutral, while any score lower is negative and any score higher is generally positive:



ReviewText	Title	Score sentiment
Everything that has been written by other reviewers was spot on. It is ...	Very accommodating	0.762831211
This place needs a complete overhaul from top to bottom. It is run do...	OLD, RUN-DOWN SMELLS MUSTY - AV...	0.030658334
I can't say enought good things about the Fort Conde Inn!! The place it...	A True Gem	0.929421484
We've stayed in several of the hotels in Griffin, I feel this is one of the ...	One of the best in Griffin	0.770861864
I travel a lot and see a lot hotels. However this was the worst bathroo...	Not good at all	0.206676841
My family and I recently moved to Jacksonville and experienced some ...	Great Experience!	0.880086839
Beds were had as rocks, light came in through the wind since there we...	Felt more like a boarding house	0.82157588
I knew when I booked this hotel, a few several months in advance, I kn...	Buyer Beware	0.134426296
This was a terrific place to stay. Just minutes from Spearfish Canyon an...	great place to stay	0.9487046
If you just need a room in an modestly accessible area, this property d...	Amenities Lacking	0.677353084
Love how I can count on La Quinta for a great nights sleep. Best beds!	Great Room	0.987293124
We enjoyed a one night stay while passing through. Very convenient o...	Very nice property	0.941030383
Comfortable accommodations and friendly, excellent staff. Stayed for ...	Enjoyable	0.985230923
Hampton Inn and suites were a vet pleasant surprise for us. The king s...	Best place in town	0.947005153
The staff was very friendly.	Comfortable Suite Hotel	0.981755257
A very pleasant stay, convenient to everything in Albany.	My six night stay at Days Inn	0.950045943
My husband spent 6 days at Hyatt Place Northpoint. The staff was extr...	Great place to stay	0.933157802
I was visiting family at a nearby Army base and wanted to stay at a hot...	A great find!	0.702835798
Underwhelmed. This hotel smells bad, has some loud, partying guests.	Don't Bother Staying Here....	0.020978987
This is our 3rd year returning to Gatlinburg and I must say this is the b...	Love!!!!!!!	0.24581942

Figure 2.26: Results of Score sentiment

Looking at *Figure 2.26*, it looks like the AI integration, with a few exceptions, did a good job determining how to rate each review.

Next, in the final section of this chapter, you will be introduced to the M formula language.

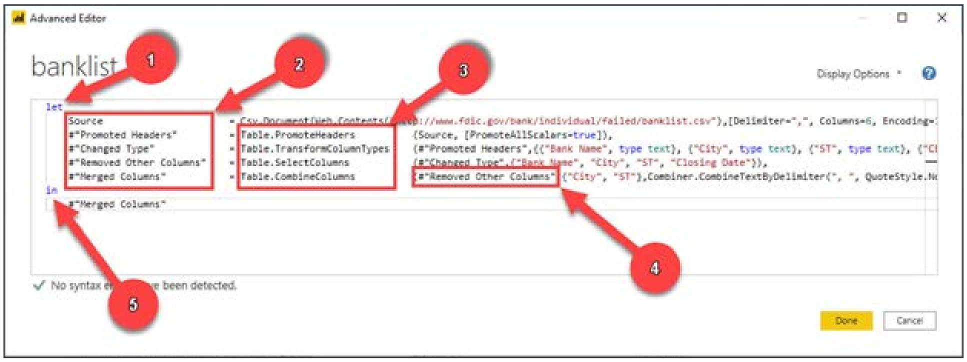
The M formula language

The Power Query Editor is the user interface that is used to design and build data imports. However, you should also know that every transform you apply within this editor is actually, quietly and behind the scenes, writing an M query for you. The letter M here is a reference to the language's data mashup capabilities.

For simple solutions, it is unlikely that you will ever need to even look at the M query that is being written, but there are some more complex cases where it's helpful to understand how to read and write your own M. For the purposes of this book, covering just the Power BI essentials, you will learn how to find the M query editor within your solution and then understand how to read what it is doing for you.

For the purposes of this example, you can open up any previously built example, however, the screenshot used here is from the very first example in this chapter on basic transforms:

1. Using any Power BI solution you have designed, launch the Power Query Editor.
2. On the **Home** ribbon, select **Advanced Editor** to see the M query that has been written by the user interface. *Figure 2.27* shows an example of what your **Advanced Editor** might show:



```
let
    Source                    = Csv.Document(Web.Contents("http://www.fdic.gov/bank/individual/failed/banklist.csv"),[Delimiter=",", Columns=6, Encoding=
    #"Promoted Headers"       = Table.PromoteHeaders      (Source, [PromoteAllScalars=true]),
    #"Changed Type"           = Table.TransformColumnTypes (#"Promoted Headers",{{"Bank Name", type text}, {"City", type text}, {"ST", type text}, {"Cl
    #"Removed Other Columns"  = Table.SelectColumns       (#"Changed Type",{"Bank Name", "City", "ST", "Closing Date"}),
    #"Merged Columns"         = Table.CombineColumns      (#"Removed Other Columns",{"City", "ST"},Combiner.CombineTextByDelimiter(", ", QuoteStyle.No
in
    #"Merged Columns"
```

Figure 2.27: Understanding the elements of M

This query has been formatted to make it easier to read. Let's review the key elements that are present here:

1. **The let expression**: Encapsulates a set of values or named expressions to be computed.
2. **Named expressions or variables**: The name given to a set of operations in a step. These names can be anything, but you should note that if you wish to have a space in the name of a step then it must be surrounded by `#""`. For example, if I wanted something to be called *Step 1*, then I would have to name an expression `#"Step 1"`. If a space is not required in the name of your step then the double quotes are not required.
3. **M functions**: The operations that are used to manipulate the data source.

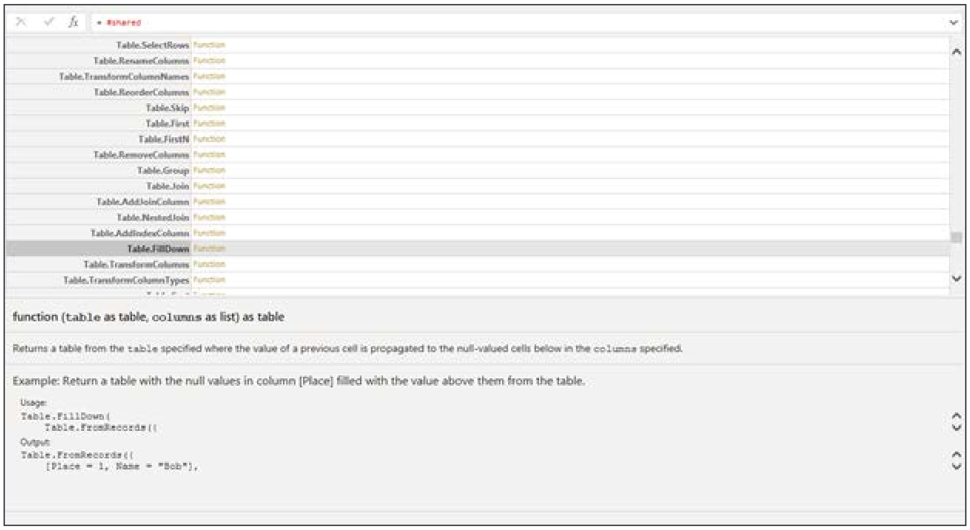
4. **Prior step reference**: The M query language generally executes its functions as serial operations, meaning each operation is executed one after the other sequentially. You can see this when you look at a query because each call to an M function always references the prior-named expression, to pick up where it left off.
5. **The in expression**: Oddly, the `in` expression is actually a reference to what the query will output. Whichever named expression is referenced in the `in` expression will be what is returned back in the `Power Query Editor` preview.

It is important to realize that M is case-sensitive. That means if you ever make a change to a query or write one from scratch, you should be careful because there is a difference between "a" and "A."

#shared

As mentioned previously, this book will not dive deep into writing your own M queries since that would be far beyond the essentials of Power BI. However, there is a great method for exploring the M functions that are available, and how to use them. Within the Power Query Editor, you can use the `#shared` function to return documentation on every available function in the M library. Let's walk through how you can leverage this tool:

1. In a new instance of Power BI Desktop, select **Get data** and then choose **Blank Query**. This will launch the Power Query Editor with an empty formula bar waiting for you to provide your own M.
2. In this formula bar, type `= #shared`, then hit *Enter*. Remember that M is case-sensitive so you must use a lowercase `s` when typing `shared`.
3. This will return a list of all the available `M` functions. By selecting the cell that has the hyperlink text of a certain function, you can see documentation on how to use each function. *Figure 2.28* shows an example of this:



```
= #shared
```

Table.SelectRows	Function
Table.RenameColumns	Function
Table.TransformColumnNames	Function
Table.ReorderColumns	Function
Table.Skip	Function
Table.First	Function
Table.FirstN	Function
Table.RemoveColumns	Function
Table.Group	Function
Table.Join	Function
Table.AddJoinColumn	Function
Table.NestedJoin	Function
Table.AddIndexColumn	Function
Table.FillDown	Function
Table.TransformColumns	Function
Table.TransformColumnTypes	Function

function (`table` as table, `columns` as list) as table

Returns a table from the `table` specified where the value of a previous cell is propagated to the null-valued cells below in the `columns` specified.

Example: Return a table with the null values in column [Place] filled with the value above them from the table.

Usage:

```
Table.FillDown(
    Table.FromRecords({
```

Output:

```
Table.FromRecords({
    [Place = 1, Name = "Bob"],
```

Figure 2.28: Example of function documentation

This is a great method for learning what M functions are available, and how each may be used. If you are stumped on how to solve a problem using M then make this your first stop to explore what options you have.

Summary

In this chapter, you learned that the Power Query Editor is an extremely powerful tool for applying business rules to incoming data. Implementing data cleansing techniques can be as simple as right-clicking on a column, or more complex, such as when building a conditional column. While the Power Query Editor does have a vast library of transforms available, you also learned that you can tap into the capabilities of R to extend what's possible when designing queries. Finally, this chapter discussed the AI capabilities within the Power Query Editor that allow you to leverage several algorithms available within Azure Cognitive Services. In the next chapter, on building the data model, you will learn about proper techniques for building a well-designed Power BI data model to ensure your solutions can solve all your reporting needs.

3
Building the Data Model

In this chapter, you are now going to create a coherent and intelligent data model. Creating a data model is primarily the process of creating necessary relationships between the different data sources that are leveraged in your model.

Self-service BI would not be possible without a functional data model. Historically, BI projects focused on building data models could take months and even years to develop when working within the rigid structure and constraints of a corporate business intelligence environment. Unfortunately, studies show that about 50 percent of all enterprise BI projects fail. These projects fail because the costs are often too high; these projects can cost anywhere from hundreds of thousands of dollars to millions of dollars due to the costs associated with the infrastructure, licensing, and labor. Another reason for the low success rate is that the business and end users often won't see any results for many months and can grow frustrated with the lack of visibility in key business areas. These longer project timelines are a result of the time it takes to work through the gathering of requirements, architecting a complex data model, and cleaning up the original data sources. For the enterprise BI projects that do make it all the way to completion, they will often not deliver on promised deliverables and lack the components needed to perform the analytical tasks requested by the business.

Fortunately, Power BI Desktop removes all of the barriers that have resulted in the high failure rate of traditional enterprise BI projects. Power BI Desktop provides you with a much more agile approach to building your data model. Therefore, project completion is measured in days not months or years, the cost is exponentially cheaper, and any missing components can easily be added as needed. The topics detailed in this chapter are as follows:

- Building relationships
- Working with complex relationships
- Usability enhancements
- Data model performance

Power BI Desktop and the self-service agile approach greatly improve the success of BI projects and this is due to the flexibility of Power BI. Power BI allows you to easily and quickly create meaningful relationships with the different tables that have been imported into your data model. In this section, you will learn how to build relationships in Power BI Desktop.

Building relationships

A relationship in Power BI simply defines how different tables are related to one another. For example, your customer table may be related to your sales table on the customer key column. You could argue that the building of relationships is the most important aspect of Power BI Desktop. It is this process, the building of relationships, that makes everything else work like magic in Power BI. The automatic filtering of visuals and reports, the ease with which you can author measures with **Data Analysis Expressions** (**DAX**), and the ability to quickly connect disparate data sources are all made possible through properly built relationships in the data model.

Sometimes, Power BI Desktop will create the relationships for you automatically. It is important to verify these *auto-detected relationships* to ensure accuracy.

There are a few characteristics of relationships that you should be aware of, which will be discussed in this section:

- Auto-detected relationships
- There may be only one active relationship between two tables
- There may be an unlimited number of inactive relationships between two tables
- Relationships may only be built on a single column, not multiple columns
- Relationships automatically filter from the *one side* of the relationship to the *many side*

Now, to examine some of the key elements of relationships in Power BI, open up the `pbix` file `Chapter 3 - Building the Data Model.pbix` found in your class files:

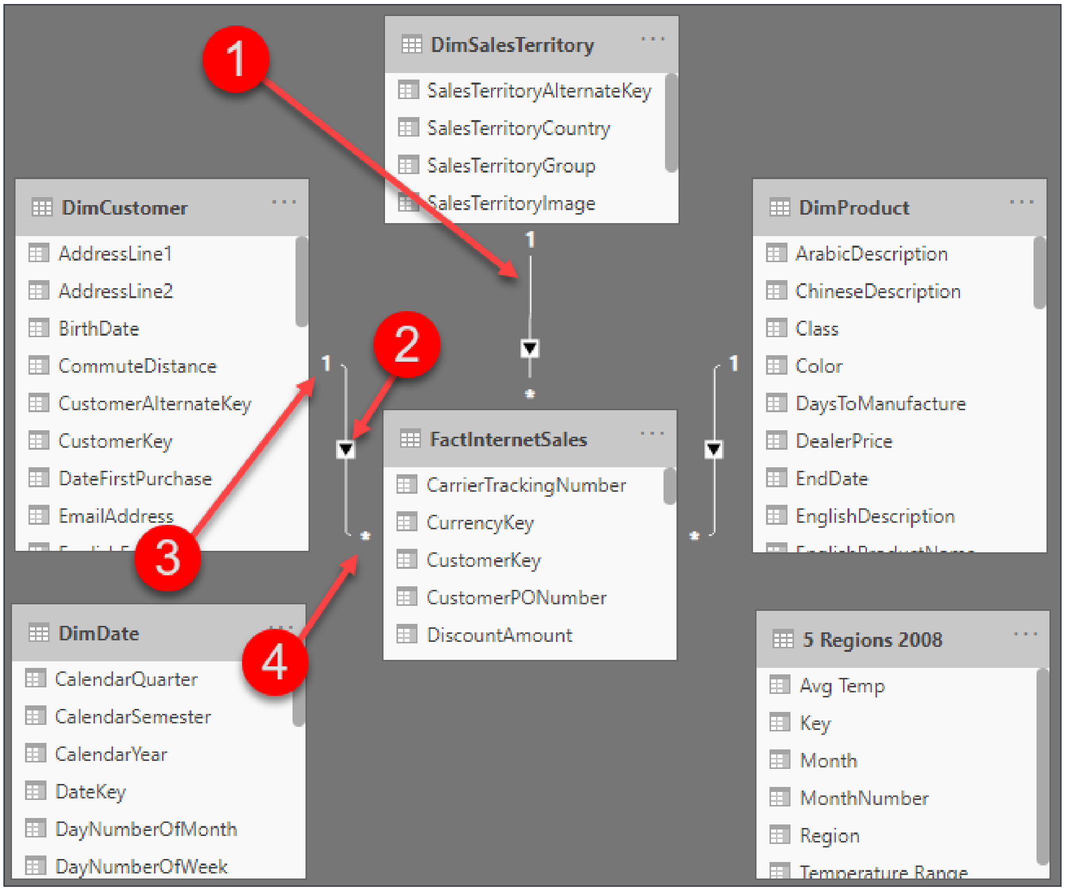


Figure 3.1: Reviewing relationships

Following the numbering, let's take a closer look at each of the four items highlighted in the preceding *Figure 3.1*:

1. **Relationship**: The line between two tables represents that a relationship exists.
2. **Direction**: The arrow indicates in which direction filtering will occur.
3. **One side**: The `1` indicates the `Customer` table as the *one side* of the relationship. This means the key from the *one side* of the relationship is always unique in that table.
4. **Many side**: The * indicates that the **FactInternetSales** table is the *many side* of the relationship. The key will appear in the sales table for each transaction; therefore, the key appears many times.

The first thing you should do after importing data is verify that all auto-detected relationships have been created correctly. From the **Home** ribbon, select **Manage relationships**, as seen in *Figure 3.2*. When in the **report** view, **Manage relationships** will appear on the **Modeling** ribbon. When in the **data** view, **Manage relationships** appears on the **Table tools** ribbon, and when in the **Model** view, **Manage relationships** appears on the **Home** ribbon:

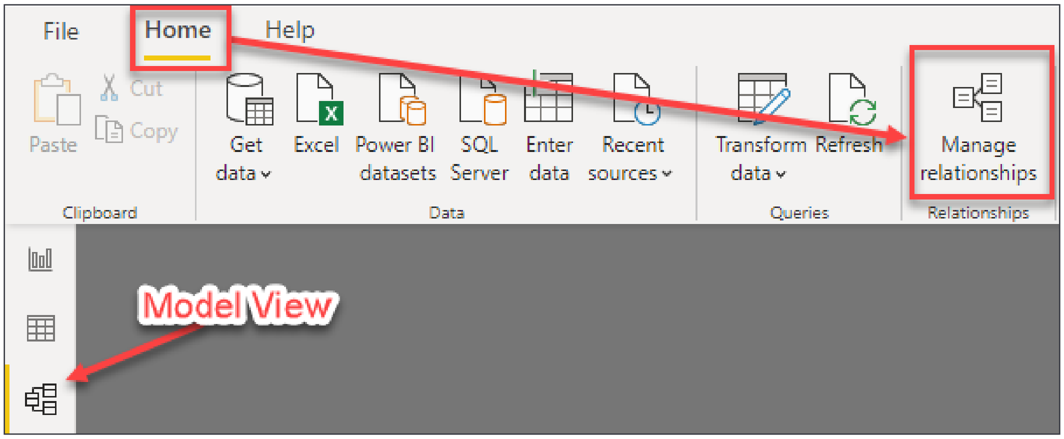
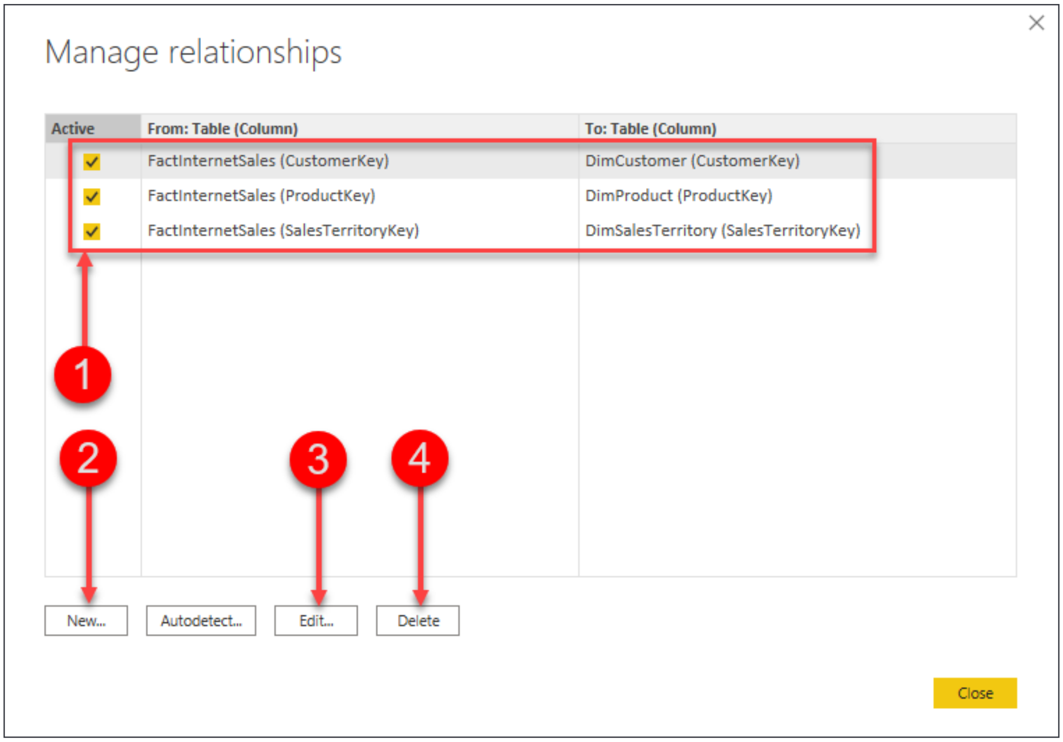


Figure 3.2: Launch the Manage relationships editor

This will open up the **Manage relationships** editor. The relationship editor is one of two places where you will go to create new relationships and edit or delete existing relationships. In this demo, the relationship editor will be used to verify the relationships that were automatically created by Power BI Desktop.

Figure 3.3 provides a view of the **Manage relationships** editor:



Manage relationships

Active	From: Table (Column)	To: Table (Column)
✓	FactInternetSales (CustomerKey)	DimCustomer (CustomerKey)
✓	FactInternetSales (ProductKey)	DimProduct (ProductKey)
✓	FactInternetSales (SalesTerritoryKey)	DimSalesTerritory (SalesTerritoryKey)

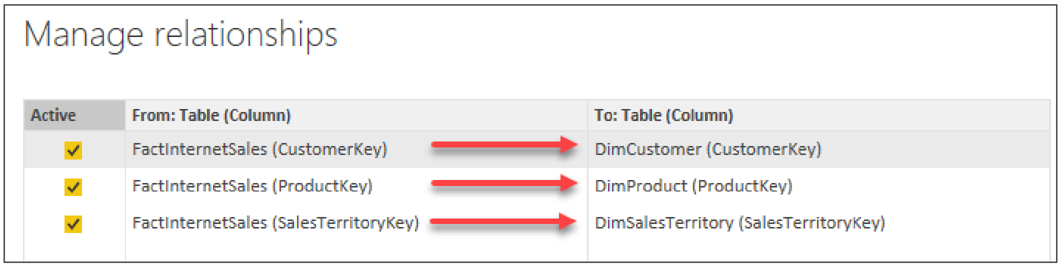
Figure 3.3: Manage relationships editor

Let's break down the editor using the numbered figure:

1. Current relationships in the data model
2. Create a new relationship
3. Edit existing relationships
4. Delete a relationship

First, you need to verify auto-detected relationships. In *Figure 3.3*, the top half of the relationship editor gives you a quick and easy way to see what tables have relationships between them, what columns the relationships have been created on, and if the relationship is an active relationship. We will discuss active and inactive relationships later in this chapter.

Take a look at *Figure 3.4*; you will see that there are currently three relationships, and all three relationships are currently active:



Manage relationships

Active	From: Table (Column)	To: Table (Column)
✓	FactInternetSales (CustomerKey)	DimCustomer (CustomerKey)
✓	FactInternetSales (ProductKey)	DimProduct (ProductKey)
✓	FactInternetSales (SalesTerritoryKey)	DimSalesTerritory (SalesTerritoryKey)

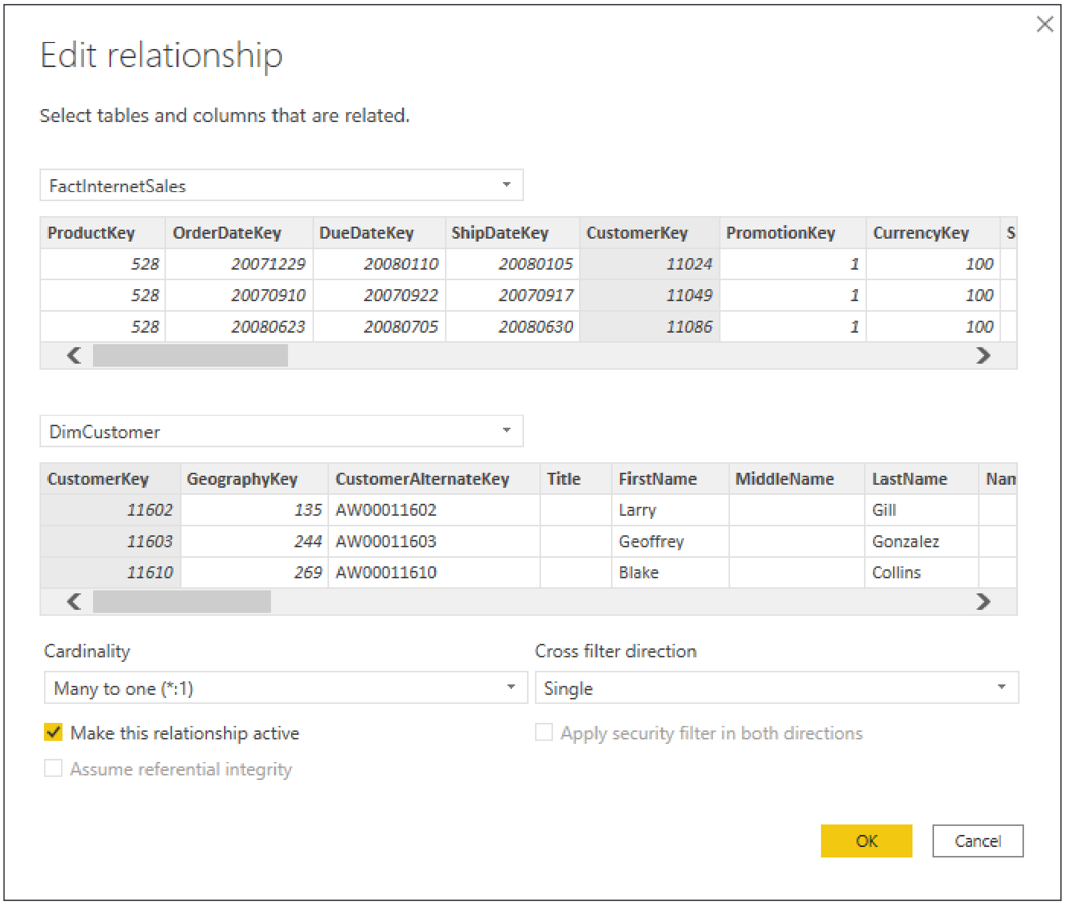
Figure 3.4: Verifying relationships

The first row in *Figure 3.4* displays the relationship between the **FactInternetSales** table and the **DimCustomer** table. The relationship between these two tables was created automatically by Power BI on the **CustomerKey** column from each table. In this scenario, Power BI has correctly chosen the correct column names. However, if the relationship was created in error, then you would need to edit that relationship.

Now, let's take a look at how to edit an existing relationship.

Editing relationships

In this example, you will edit the relationship between **FactInternetSales** and **DimCustomer**. To edit an existing relationship, select that relationship and then click on **Edit...**:



Edit relationship

Select tables and columns that are related.

FactInternetSales

ProductKey	OrderDateKey	DueDateKey	ShipDateKey	CustomerKey	PromotionKey	CurrencyKey	S
528	20071229	20080110	20080105	11024	1	100	
528	20070910	20070922	20070917	11049	1	100	
528	20080623	20080705	20080630	11086	1	100	

DimCustomer

CustomerKey	GeographyKey	CustomerAlternateKey	Title	FirstName	MiddleName	LastName	Nan
11602	135	AW00011602		Larry		Gill	
11603	244	AW00011603		Geoffrey		Gonzalez	
11610	269	AW00011610		Blake		Collins	

Cardinality: Many to one (*:1)

Cross filter direction: Single

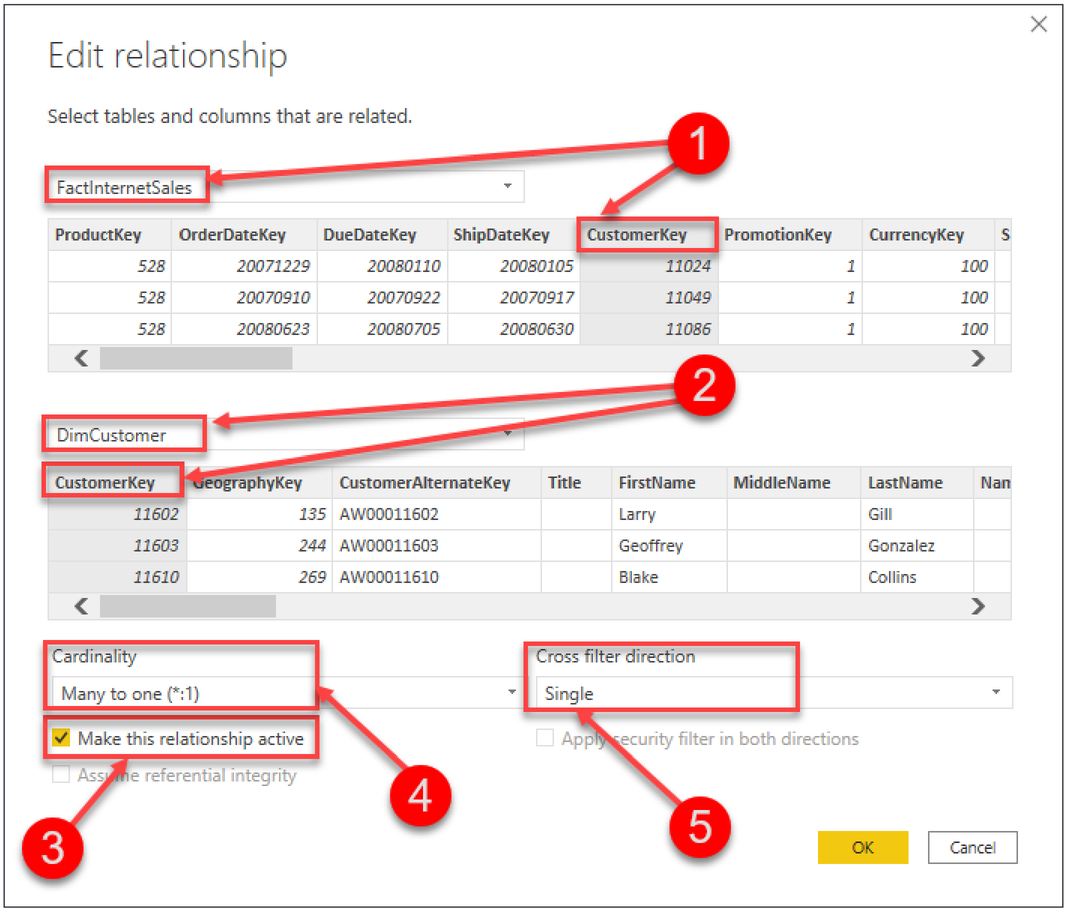
☑ Make this relationship active

☐ Apply security filter in both directions

☐ Assume referential integrity

Figure 3.5: Editing a relationship

Once you select **Edit...** you will receive a new dialog box; this is the **Edit relationship** editor. In this view, you will see how to change an existing relationship, how to change a relationship to active or inactive, and the cardinality of the current relationship; this is also where you can change the **Cross filter direction**:


Edit relationship

Select tables and columns that are related.

FactInternetSales

ProductKey	OrderDateKey	DueDateKey	ShipDateKey	CustomerKey	PromotionKey	CurrencyKey	S
528	20071229	20080110	20080105	11024	1	100	
528	20070910	20070922	20070917	11049	1	100	
528	20080623	20080705	20080630	11086	1	100	

DimCustomer

CustomerKey	GeographyKey	CustomerAlternateKey	Title	FirstName	MiddleName	LastName	Nan
11602	135	AW00011602		Larry		Gill	
11603	244	AW00011603		Geoffrey		Gonzalez	
11610	269	AW00011610		Blake		Collins	

Cardinality: Many to one (*:1)

Cross filter direction: Single

[✓] Make this relationship active

[ ] Assume referential integrity

[ ] Apply security filter in both directions

Figure 3.6: Editing a relationship

There are five numbered items we will review from *Figure 3.6*:

1. This identifies the **FactInternetSales** table and the column that the relationship was built on.
2. This identifies the **DimCustomer** table and the column that the relationship was built on.
3. This checkbox identifies whether the relationship is active or inactive.

4. This is the current cardinality between the two tables. Here we see that there is a *many-to-one* relationship between **FactInternetSales** and **DimCustomer**. Power BI does an excellent job of identifying the correct cardinality, but it is important to always verify that the cardinality is correct.
5. The cross filter direction can be single or both. The *one side* of a relationship always filters the *many side* of the relationship, and this is the default behavior in Power BI. The cross filter option allows you to change this behavior. Cross filtering will be discussed later in this chapter.

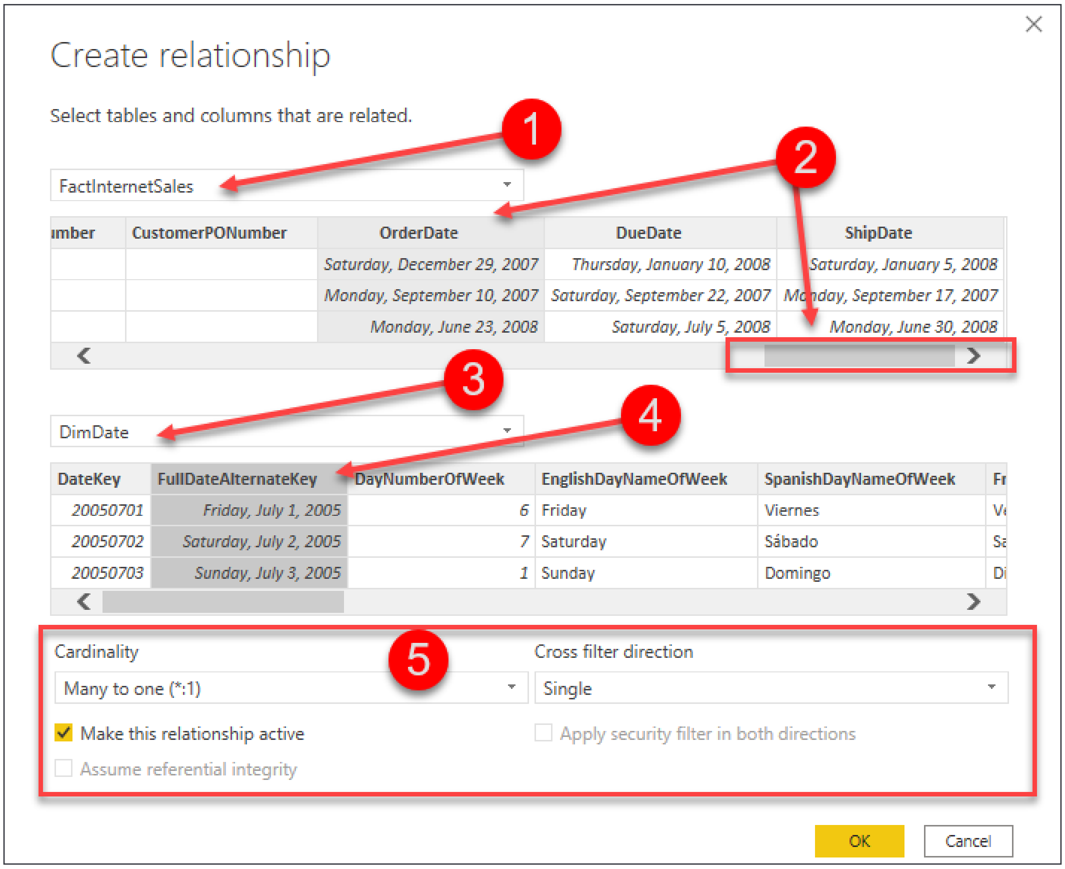
If you need to change the relationship of an existing relationship, then you would do that in the relationship editor seen in *Figure 3.6*. To change the column that a relationship has been created on, simply select a different column. It is important to point out that a relationship between two tables may only be created on a single column. Therefore, if you have a relationship that needs to be defined on multiple columns, also known as a composite key, then you would need to first combine those keys into a single column before creating your relationship. You saw how to combine columns in *Chapter 2*, *Data Transformation Strategies*.

Creating a new relationship

In the previous section, you saw how to verify existing relationships, and even how to edit them. In this section, you are going to learn how to create a new relationship. There are six tables in the data model thus far, and Power BI automatically created a relationship for all the tables, except for two. Let's begin by creating a relationship between the `FactInternetSales` and `DimDate` tables.

The `FactInternetSales` table stores three different dates: `OrderDate`, `ShipDate`, and `DueDate`. There can be only one active relationship between tables in Power BI, and all filtering occurs through the active relationship. In other words, which date do you want to see your total sales, profit, and profit margin calculations on? If it's `OrderDate`, then your relationship will be on the `OrderDate` column from the `FactInternetSales` table to the `FullDateAlternateKey` column in the `DimDate` table. To create a new relationship, open **Manage relationships** from the **Home** ribbon.

Now, let's create a relationship from the **OrderDate** column in **FactInternetSales** to the **FullDateAlternateKey** column in **DimDate**. With the **Manage relationships** editor open, click on **New...** to open the **Create relationship** editor:



Create relationship

Select tables and columns that are related.

FactInternetSales

ımber	CustomerPONumber	OrderDate	DueDate	ShipDate
		Saturday, December 29, 2007	Thursday, January 10, 2008	Saturday, January 5, 2008
		Monday, September 10, 2007	Saturday, September 22, 2007	Monday, September 17, 2007
		Monday, June 23, 2008	Saturday, July 5, 2008	Monday, June 30, 2008

DimDate

DateKey	FullDateAlternateKey	DayNumberOfWeek	EnglishDayNameOfWeek	SpanishDayNameOfWeek	Fr
20050701	Friday, July 1, 2005	6	Friday	Viernes	Vi
20050702	Saturday, July 2, 2005	7	Saturday	Sábado	Sa
20050703	Sunday, July 3, 2005	1	Sunday	Domingo	Di

Cardinality: Many to one (*:1)

Cross filter direction: Single

☑ Make this relationship active

☐ Apply security filter in both directions

☐ Assume referential integrity

Figure 3.7: Creating a new relationship

Complete the following steps to create a new relationship:

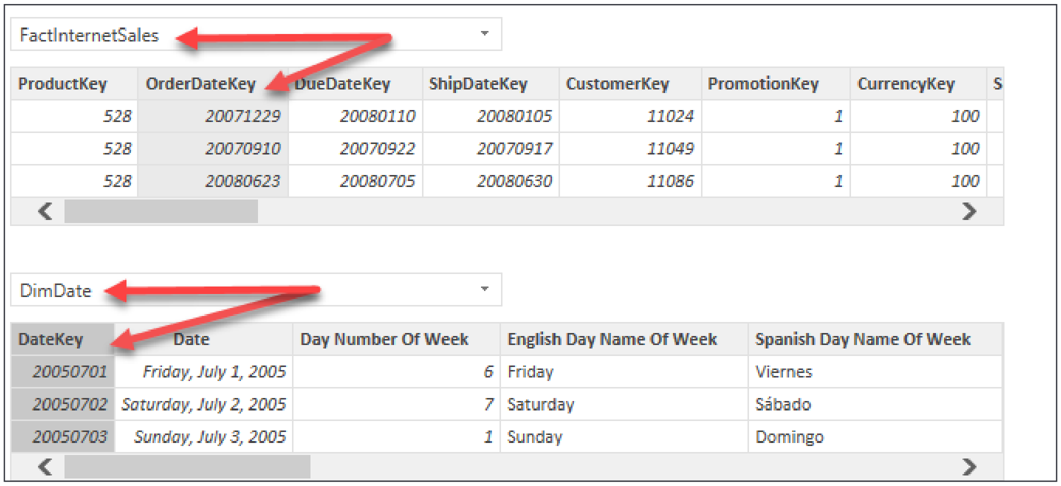
1. Select **FactInternetSales** from the list of tables in the dropdown.
2. Select **OrderDate** from the list of columns, and use the scroll bar to scroll all the way to the right.
3. Select **DimDate** from the next drop-down list.
4. Select **FullDateAlternateKey** from the list of columns.
5. **Cardinality**, **Cross filter direction**, and whether the relationship is active or inactive is updated automatically by Power BI; remember to always verify these items.
6. Click **OK** to close the editor.

Now, let's take a look at creating the relationship on the date key rather than the `Date` column.

Creating a relationship on the date key

The astute reader may have noticed that the previous demo used the actual date columns from each table instead of the date keys. This is because most Power BI models will not contain a date key. However, if you are retrieving your data from a relational database or from a data warehouse, then a date key will most likely exist on both tables, and the relationship can be created on the date key.

In *Figure 3.8*, you see an example of creating a relationship on the date keys in each table:



FactInternetSales

ProductKey	OrderDateKey	DueDateKey	ShipDateKey	CustomerKey	PromotionKey	CurrencyKey	S
528	20071229	20080110	20080105	11024	1	100	
528	20070910	20070922	20070917	11049	1	100	
528	20080623	20080705	20080630	11086	1	100	

DimDate

DateKey	Date	Day Number Of Week	English Day Name Of Week	Spanish Day Name Of Week
20050701	Friday, July 1, 2005	6	Friday	Viernes
20050702	Saturday, July 2, 2005	7	Saturday	Sábado
20050703	Sunday, July 3, 2005	1	Sunday	Domingo

Figure 3.8: Creating a new relationship using the date keys

The date table in the Power BI data model is important for developing time intelligence calculations. When you define your relationship on the date key, rather than the date column, it is important to also mark your date table as a `date table`! If this step is not performed, the built-in time intelligence functions will not work properly.

Time intelligence is discussed in further detail in *Chapter 4, Leveraging DAX*.

At the time of writing, marking a table as a date table can only be accomplished in the **Report** view or **Data** view. There are two ways to mark the table as a date table. First, you can right-click on the date table and choose **Mark as date table | Mark as date table**:

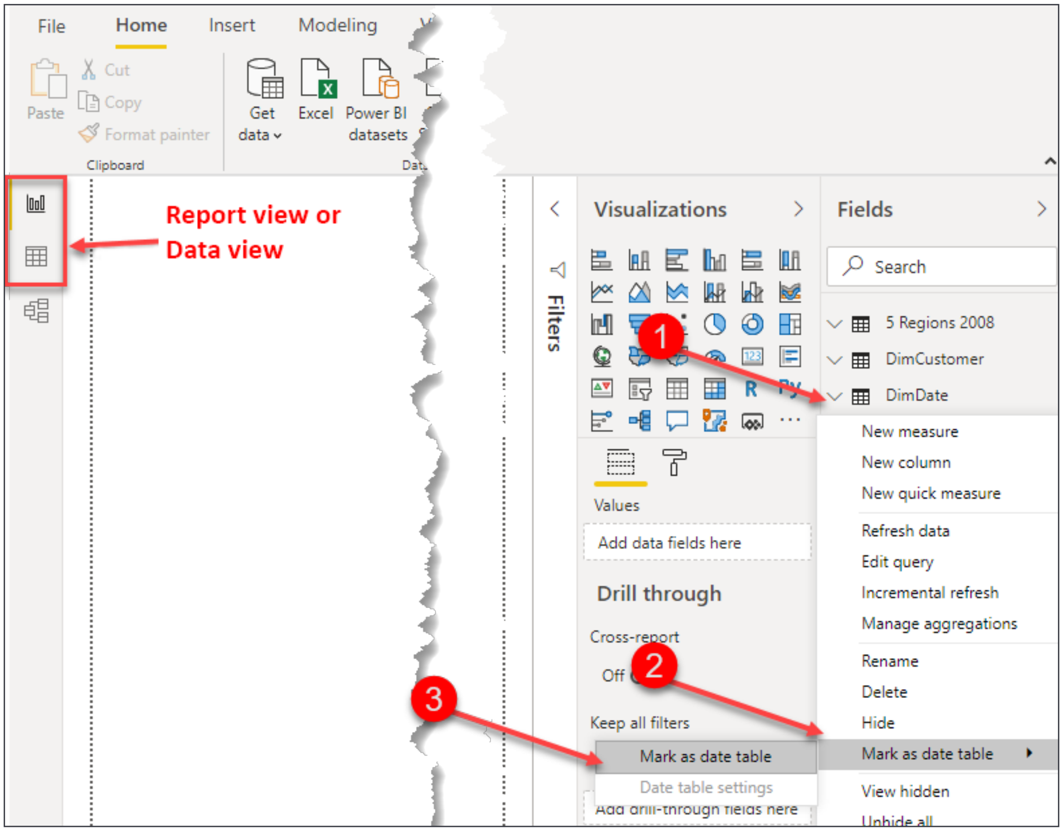


Figure 3.9: Mark as date table

Secondly, you can select the date table; go to the **Table tools** ribbon and select **Mark as date table**:

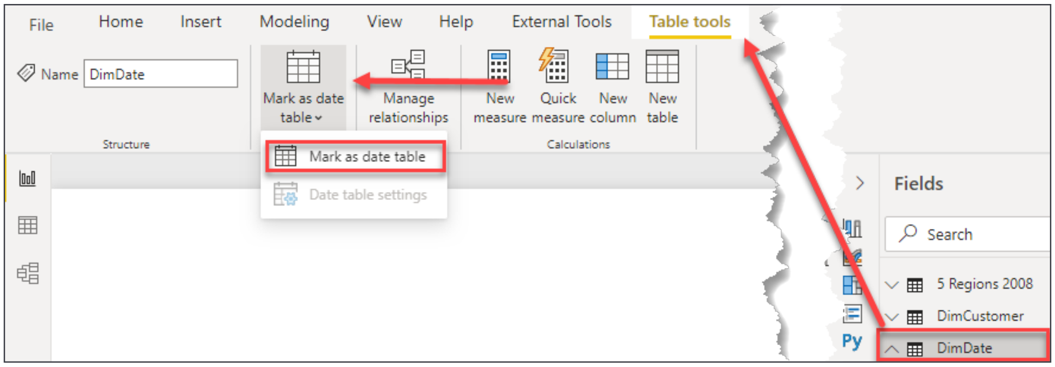
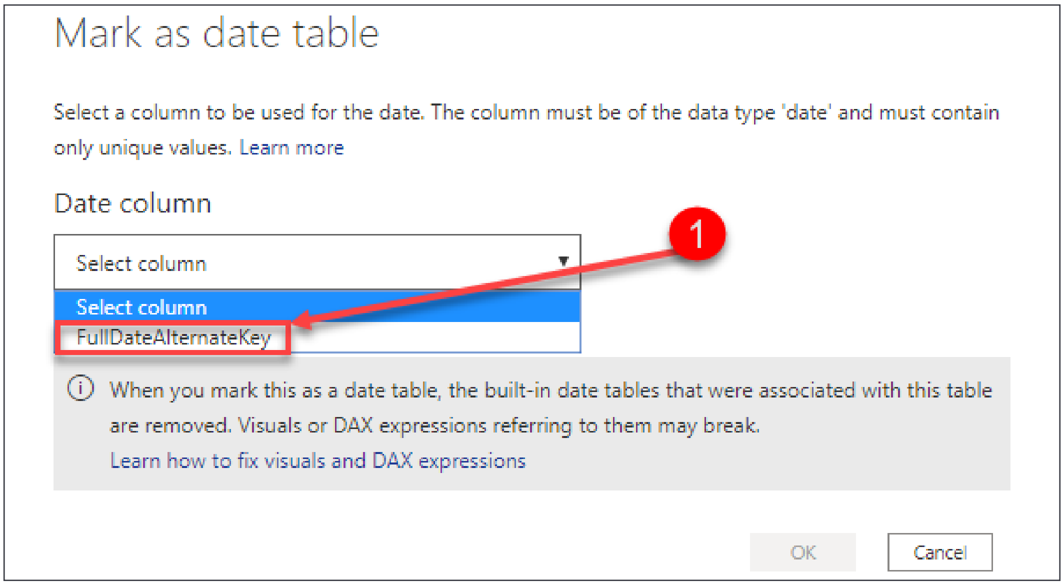


Figure 3.10: Mark as date table, alternate method

Once **Mark as date table** is selected, you will then be prompted to select the **Date column** from your date table:


Mark as date table

Select a column to be used for the date. The column must be of the data type 'date' and must contain only unique values. Learn more

Date column

Select column

Select column
FullDateAlternateKey

When you mark this as a date table, the built-in date tables that were associated with this table are removed. Visuals or DAX expressions referring to them may break.
Learn how to fix visuals and DAX expressions

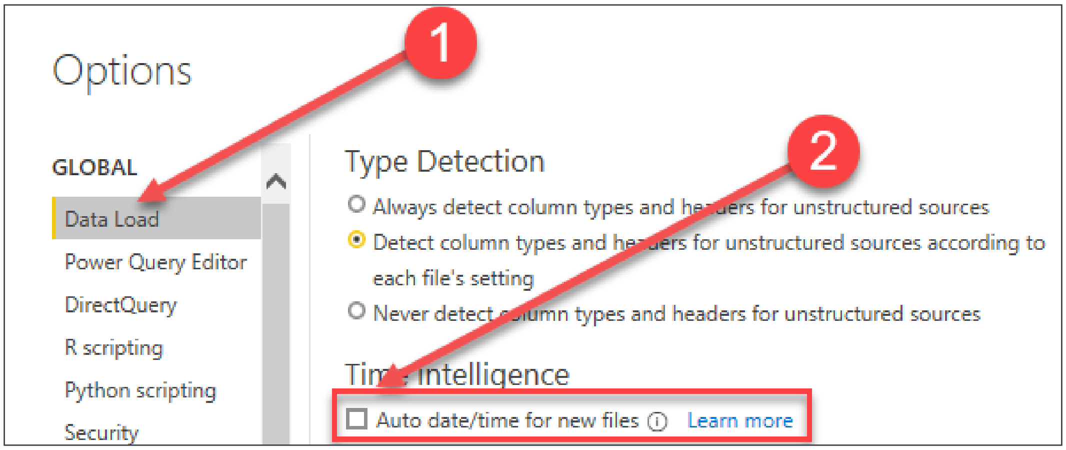
Figure 3.11: Select valid date column from date table

Power BI will automatically limit the list of available options to columns that are set to a `date` type and have only unique values.

There is one other important thing to note on this configuration screen: the built-in date tables that were associated with this table are removed. In the background, Power BI creates a hidden date table for each field that has a `date` or `date/time` field. Depending on the number of date fields in your data model, this can create a lot of extra objects and will consume more memory in your data model! As a best practice, we recommend disabling this functionality. We'll cover this process in the next section.

Disabling automatically created date tables

As mentioned previously, Power BI automatically creates hidden date tables for each `date` or `date/time` field in your data model. The date tables created by Power BI can be disabled from the **Options** menu. To open the **Options** menu, in Power BI Desktop, go to **File** | **Options and Settings** | **Options**. Once the **Options** window has been opened, complete the following steps as seen in *Figure 3.12*:



Type Detection
Always detect column types and headers for unstructured sources
(●) Detect column types and headers for unstructured sources according to each file's setting
Never detect column types and headers for unstructured sources

Time intelligence
☐ Auto date/time for new files ⓘ Learn more

Figure 3.12: Disable automatically created hidden date tables

1. Under **GLOBAL**, choose **Data Load**.
2. Uncheck **Auto date/time for new files**.

In this section, you learned how to verify automatically created relationships and how to create new relationships in Power BI Desktop. In the next section, you will learn about working with complex relationships.

Working with complex relationships

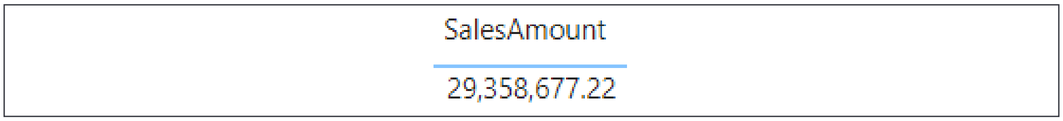
There are many complex scenarios that need to be addressed when building a data model, and Power BI is no different in this regard. In this section, you will learn how to handle many-to-many relationships and role-playing tables in Power BI.

Many-to-many relationships

Before we discuss how to build a relationship between two tables that have a many-to-many relationship, let's discuss specifically what a many-to-many relationship is. Basically a many-to-many relationship is when multiple rows in one table are associated with multiple rows in another table. An example of a many-to-many relationship can be observed in the relationship between products and customers. A product can be sold to many customers, likewise, a customer can purchase many products. This relationship between products and customers is a many-to-many relationship. In a one-to-many relationship, a relationship can be created directly between the two tables. However, in a many-to-many relationship, an indirect relationship is often created through a bridge table. This section will focus on how to set up a many-to-many relationship and how to gain analytical value from such relationships!

In the previous section, you learned how to create a relationship between two tables that had a one-to-many relationship. Immediately, once a one-to-many relationship has been defined in your data model, filtering occurs automatically. This adds a tremendous amount of value to Power BI. However, the analytical value achieved through many-to-many relationships does not happen automatically and requires an extra step. Let's take a look at filtering in general and then how to effectively develop for many-to-many relationships in Power BI.

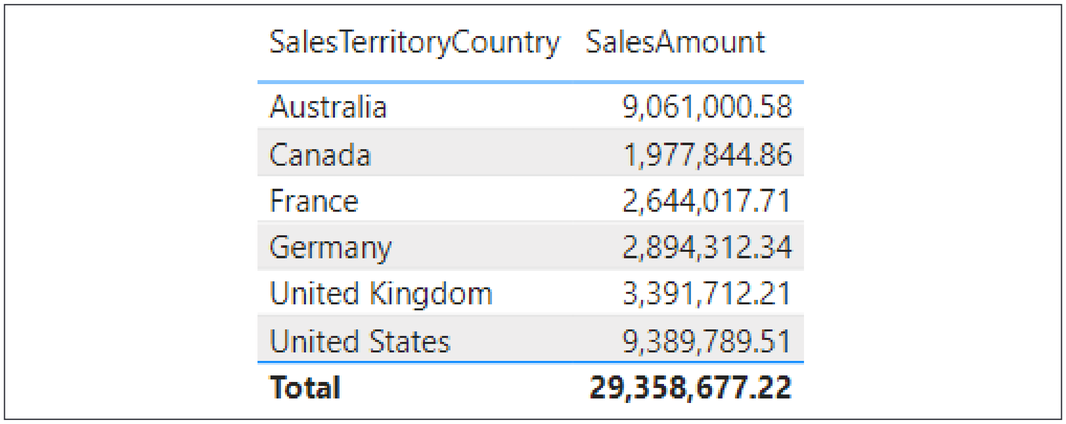
Before you can learn how to handle many-to-many relationships in Power BI, you must first understand the basic behavior of filtering. Filtering will be discussed in more detail in the next chapter, but now let's take a look at a minor detour to explain how filtering works in this context. In *Figure 3.13*, the total **SalesAmount** of all transactions is `$29,358,677.22`. The table visual you see in *Figure 3.13* is simply the sum of the column `SalesAmount` from the `FactInternetSales` table:



SalesAmount
29,358,677.22

Figure 3.13: Total unfiltered SalesAmount

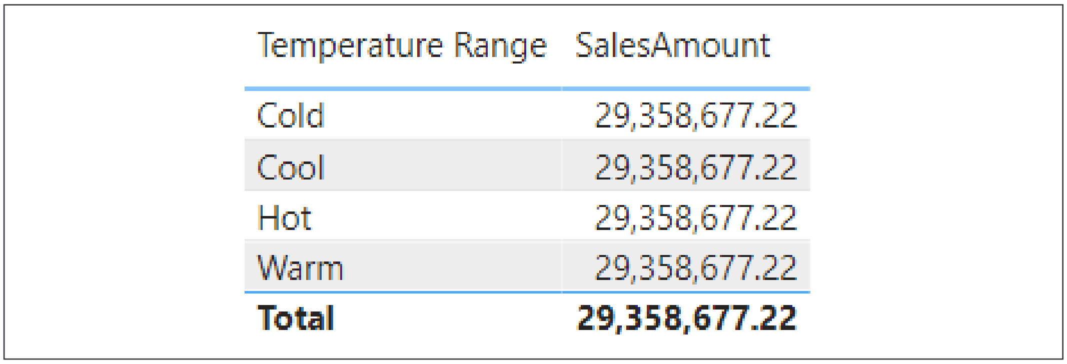
To view the total `SalesAmount` for all transactions broken down by country, all you would need to do is simply add the **SalesTerritoryCountry** column from the `DimSalesTerritory` table. This behavior in Power BI is awesome, and this is automatic filtering at work. Take a look at *Figure 3.14*:



SalesTerritoryCountry	SalesAmount
Australia	9,061,000.58
Canada	1,977,844.86
France	2,644,017.71
Germany	2,894,312.34
United Kingdom	3,391,712.21
United States	9,389,789.51
Total	**29,358,677.22**

Figure 3.14: SalesAmount filtered by Country

Please note that this only works because a valid relationship exists between the `FactInternetSales` and `DimSalesTerritory` tables. If a relationship had not been created, or if the relationship created was invalid, then you would get entirely different results and they would be confusing. Let's take a look at what would happen if no relationship had previously existed. In *Figure 3.15*, the **SalesTerritoryCountry** has been removed and replaced with the **Temperature Range** column from the `5 Regions 2008` table:



Temperature Range	SalesAmount
Cold	29,358,677.22
Cool	29,358,677.22
Hot	29,358,677.22
Warm	29,358,677.22
Total	**29,358,677.22**

Figure 3.15: Replacing Country with Temperature Range

Notice how the total sales amount is repeated for each temperature range. This behavior indicates that the `5 Regions 2008` table is unable to filter the `FactInternetSales` table. This inability to filter can happen for a number of different reasons, and here are a few:

- Because a relationship does not exist between the tables.
- Because an existing relationship is invalid.
- Because an existing relationship does not allow the filtering to pass through an intermediate table.

If you see the repeated value behavior demonstrated in *Figure 3.15*, then go back to the relationship view and verify that all relationships have been created and are valid.

Cross-filtering direction

Now that you understand the basics of automatic filtering in Power BI, let's take a look at an example of a many-to-many relationship. In this data model, `DimProduct` and `DimCustomer` have a many-to-many relationship. A product can be sold to many customers. For example, bread can be sold to Jessica, Kim, and Tyrone. A customer can purchase many products. Kim could purchase bread, milk, and cheese.

A bridge table can be used to store the relationship between two tables that have a many-to-many relationship, just like tools you have worked with in the past.

The relationship between `DimProduct` and `DimCustomer` is stored in the `FactInternetSales` table. The `FactInternetSales` table is a large, many-to-many bridge table:

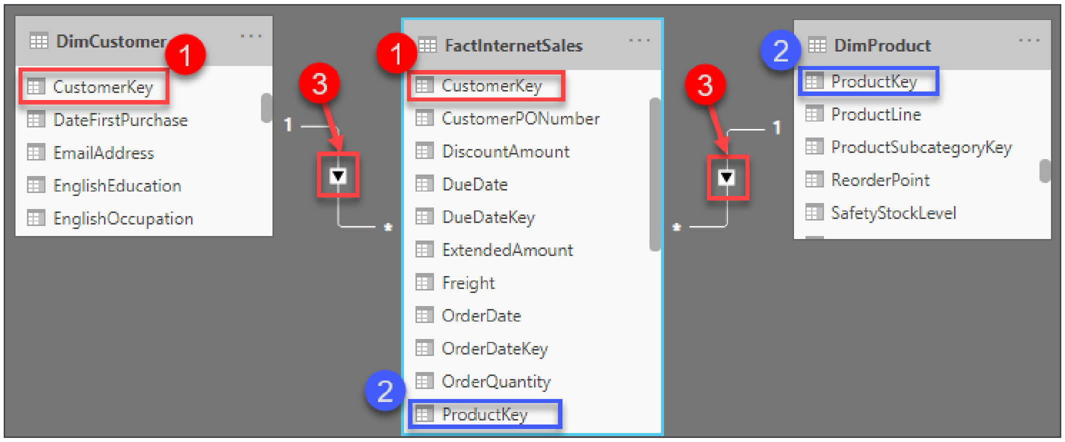
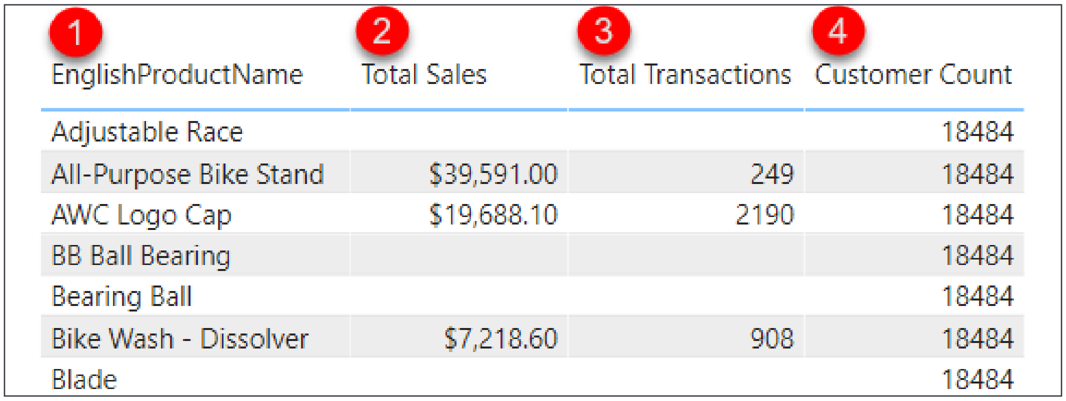


Figure 3.16: Relationship between DimCustomer and FactInternetSales

Figure 3.16 shows the relationship between these two tables; see the following explanation for the numbered points:

1. The relationship between **DimCustomer** and **FactInternetSales**.
2. The relationship between **DimProduct** and **FactInternetSales**.
3. The cross filter direction is set to single.

The following report in *Figure 3.17*, displays the total sales, total transactions, and customer count for each product:



EnglishProductName	Total Sales	Total Transactions	Customer Count
Adjustable Race			18484
All-Purpose Bike Stand	$39,591.00	249	18484
AWC Logo Cap	$19,688.10	2190	18484
BB Ball Bearing			18484
Bearing Ball			18484
Bike Wash - Dissolver	$7,218.60	908	18484
Blade			18484

Figure 3.17: Customer count for each product

Let's take a closer look at *Figure 3.17*, and note the numbered points:

1. **EnglishProductName** from the `DimProduct` table.
2. **Total Sales** is the `SUM` of the `SalesAmount` column from the `FactInternetSales` table.
3. **Total Transactions** is the `COUNT` of associated rows from the `FactInternetSales` table.
4. **Customer Count** is the `COUNT` of the `CustomerKey` column from the `DimCustomer` table.

`Total Sales` and `Total Transactions` are returning the correct results for each product. `Customer Count` is returning the same value for all products (`18,484`). This is due to the way that filtering works. The calculations for `Total Sales` and `Total Transactions` are derived from columns or rows that come from the `FactInternetSales` table. The `Product` table has a one-to-many relationship with `Internet Sales`, and therefore filtering occurs automatically. This explains why those two calculations are being filtered properly, but it does not explain why the count of customers is returning the same repeated value for all products, not entirely anyway.

Let's take another look at the relationship between `DimProduct` and `DimCustomer`. Notice in *Figure 3.18* that the relationship between these two tables flows through the `FactInternetSales` table. This is because they have a many-to-many relationship. In this scenario, the table `FactInternetSales` is acting as a large, many-to-many bridge table. `DimProduct` filters `FactInternetSales`. `DimCustomer` also filters `FactInternetSales`, and `FactInternetSales` is currently unable to filter the customer table:

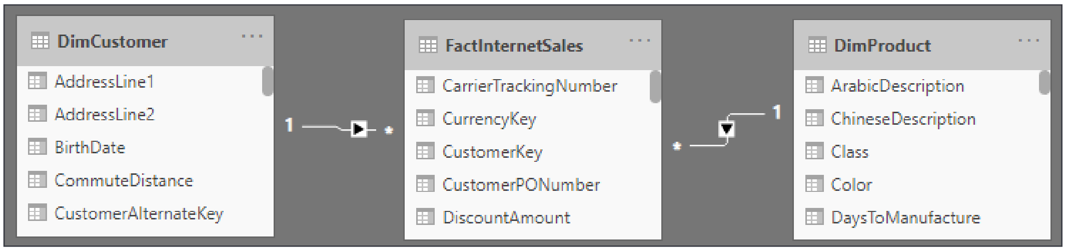


Figure 3.18: Filtering behavior in Power BI

The repeated value for customer count occurs because `FactInternetSales` is unable to filter the `DimCustomer` table. `DimProduct` filters `FactInternetSales`, and a list of transactions are returned for each product. Unfortunately, the filtering does not pass from `FactInternetSales` to `DimCustomer`. This is because `FactInternetSales` is on the many side of the relationship with `DimCustomer`. Therefore, when our calculation performs a count on the customer key, the table is not filtered and the calculation sees every customer key in the `DimCustomer` table (`18,484`).

Do you remember the cross-filter direction property that was briefly covered earlier in this chapter? That little property is there to provide many-to-many support. By simply enabling cross-filtering in both directions, the `FactInternetSales` table will be able to filter the customer table and the customer count will work.

Enabling filtering from the many side of a relationship

To enable cross-filtering, open the relationship editor. Remember, the **Manage relationships** option can be found from the **Report View**, **Data View**, or **Model View** from different ribbons as discussed at the beginning of this chapter. When in **Report View**, **Manage relationships** will appear on the modeling ribbon, when in **Data View**, **Manage relationships** appears on the **Table tools** ribbon, and when in **Model View**, **Manage relationships** appears on the **Home** ribbon.

See *Figure 3.19* for a refresher on where to find it:

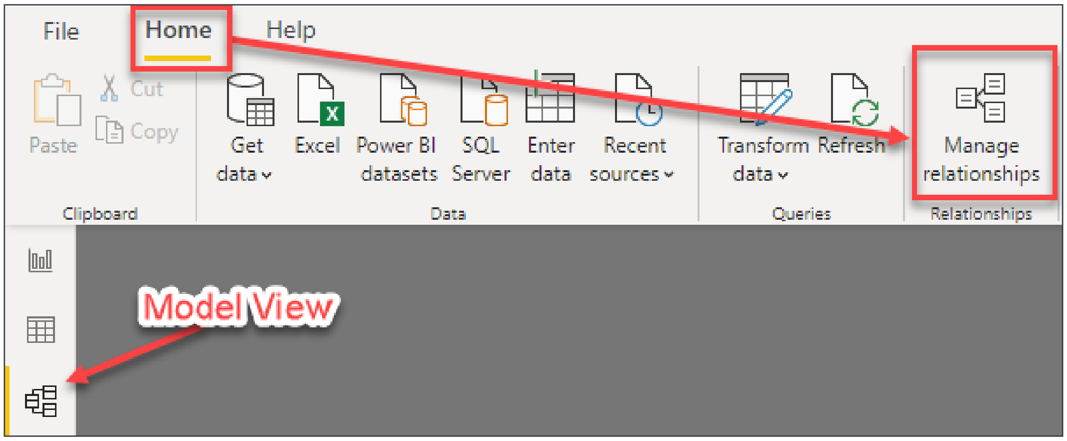
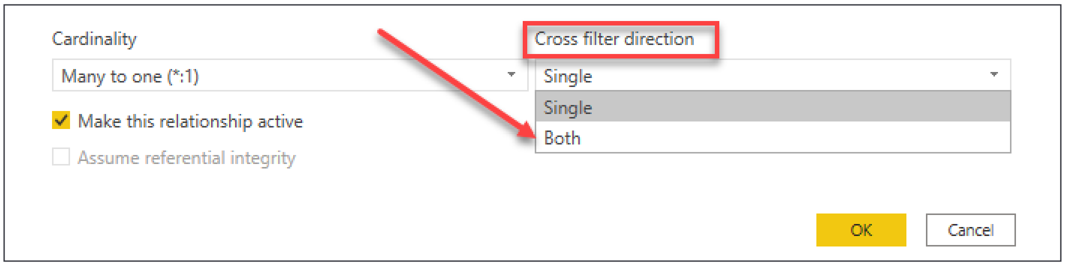


Figure 3.19: Open the relationship editor

Select the relationship between `FactInternetSales` and `DimCustomer`, and then click **Edit**.

Once the relationship editor has launched, change the **Cross filter direction** from **Single** to **Both**:



Cardinality: Many to one (*:1)

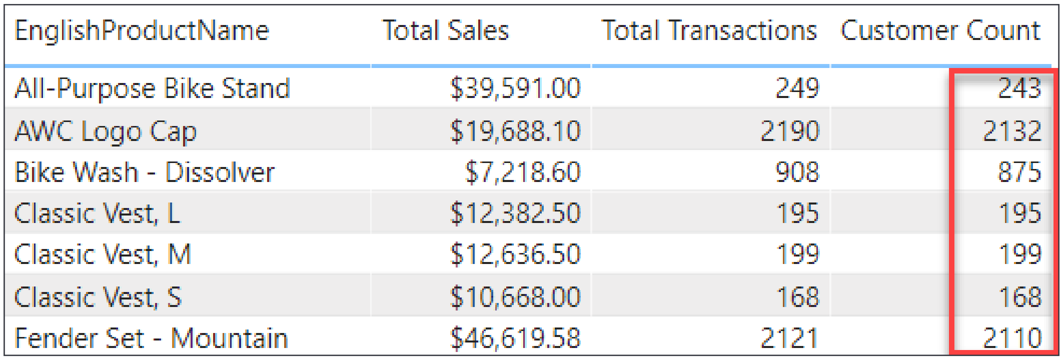
Cross filter direction: Single

- Single
- Both

- [x] Make this relationship active
- [ ] Assume referential integrity

Figure 3.20: Enabling cross filtering

Back in the **Report View**, you will now see the correct `Customer Count` for each product, as shown in *Figure 3.21*:



EnglishProductName	Total Sales	Total Transactions	Customer Count
All-Purpose Bike Stand	$39,591.00	249	243
AWC Logo Cap	$19,688.10	2190	2132
Bike Wash - Dissolver	$7,218.60	908	875
Classic Vest, L	$12,382.50	195	195
Classic Vest, M	$12,636.50	199	199
Classic Vest, S	$10,668.00	168	168
Fender Set - Mountain	$46,619.58	2121	2110

Figure 3.21: Customer Count for each product

> As a best practice, we recommend *not* enabling cross filtering for your date table. In order for some Time Intelligence functions to work properly, the date table must have a contiguous range of dates and therefore cannot be filtered by other tables.

Now that you have learned how to handle many-to-many relationships in Power BI desktop, let's take a look at how to handle another type of complex relationship. In this section, you will learn what role-playing tables are and how to handle them in Power BI Desktop.

Role-playing tables

A role-playing table is a table that can play multiple roles, which helps to reduce data redundancy. Most often, the date table is a role-playing table. For example, the `FactInternetSales` table has three dates to track the processing of an order. There is the `Order Date`, `Ship Date`, and `Due Date` and, without role-playing tables, you would need to have three separate date tables instead of just one. The additional tables take up valuable resources, such as memory, as well as adding an extra layer of administrative upkeep.

Each of these dates is very important to different people and different departments within an organization. For example, the finance department may wish to see total sales and profit by the date that a product was purchased, the order date. However, your shipping department may wish to see product quantity based on the ship date. How do you accommodate requests from different departments in a single data model?

One of the things I loved about working with SQL Server Analysis Services multidimensional was the ease with which it handled role-playing tables; perhaps you also come from a background where you have worked with tools that had built-in support for role-playing tables. Unfortunately, role-playing tables are not natively supported in Power BI; this is because all filtering in Power BI occurs through the active relationship and you can only have one active relationship between two tables.

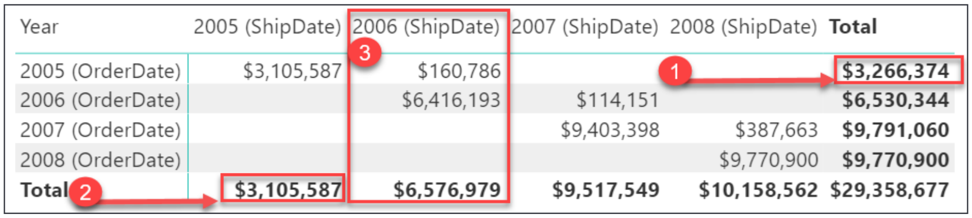
There are generally two ways you can handle role-playing tables in Power BI:

- Import the table multiple times and create an active relationship for each table.
- Using DAX and inactive relationships to create calculations that show calculations by different dates.

The first way, and the method we will show here, is importing the table multiple times. Yes, this means that it will take up more resources. The data model will have three date tables, one table to support each date in the `FactInternetSales` table. Each date table will have a single active relationship to the `FactInternetSales` table.

Some of the benefits of importing the table multiple times are as follows:

- It is easier to train and acclimate end users with the data model. For example, if you want to see sales and profit by the ship date, then you would simply use the date attributes from the ship date table in your reports.
- Most, if not all, DAX measures will work across all date tables, so there is no need to create new measures.
- The analytical value of putting different dates in a matrix. For example, sales ordered and sales shipped by date. For clarification, see *Figure 3.22*:



Year	2005 (ShipDate)	2006 (ShipDate)	2007 (ShipDate)	2008 (ShipDate)	**Total**
2005 (OrderDate)	$3,105,587	$160,786			**$3,266,374**
2006 (OrderDate)		$6,416,193	$114,151		**$6,530,344**
2007 (OrderDate)			$9,403,398	$387,663	**$9,791,060**
2008 (OrderDate)				$9,770,900	**$9,770,900**
Total	**$3,105,587**	**$6,576,979**	**$9,517,549**	**$10,158,562**	**$29,358,677**

Figure 3.22: Sales by ShipDate and OrderDate

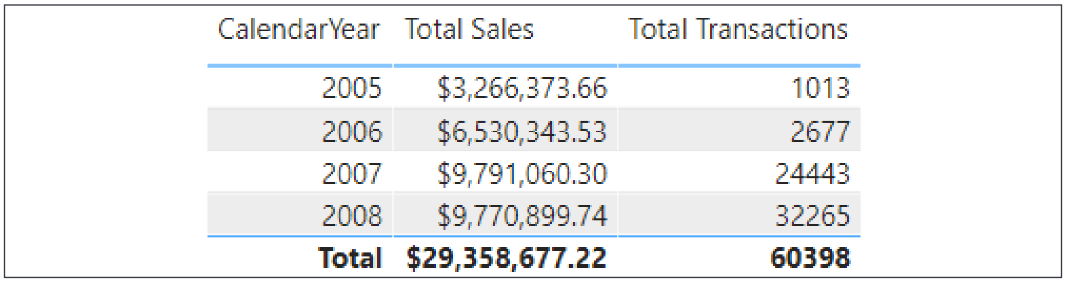
In *Figure 3.22* you can observe the analytical benefit of having a shipping date table and an order date table in the same data model. In this example, the total sales are being displayed in a matrix visual with the year from the order date table on the rows and the year from the shipping date table on the columns:

1. The value of `$3,266,374` is the amount of total sales that were sold in the year `2005`.
2. The value of `$3,105,587` is the amount of total sales that were shipped in the year `2005`.
3. If you take a look at the column `2006 (ShipDate)` you will notice that `$6,576,979` of sales shipped in `2006`. Upon closer inspection, `$160,786` of what shipped in `2006` was actually ordered in `2005` and the remaining `$6,416,193` was ordered in `2006`.

Some of the cons of importing the table multiples times are:

- **Resources**: Additional memory and space will be used.
- **Administrative changes**: Any modifications made to one table will need to be repeated for all tables, as these tables are not linked. For example, if you create a hierarchy in one table, then you would need to create a hierarchy in all date tables.

The report in *Figure 3.23* shows total sales and total transactions by year, but which year? Is this the year that a product was purchased or the year a product was shipped? The active relationship is on the order date, so the report is displaying the results based on when the product was purchased:



CalendarYear	Total Sales	Total Transactions
2005	$3,266,373.66	1013
2006	$6,530,343.53	2677
2007	$9,791,060.30	24443
2008	$9,770,899.74	32265
Total	**$29,358,677.22**	**60398**

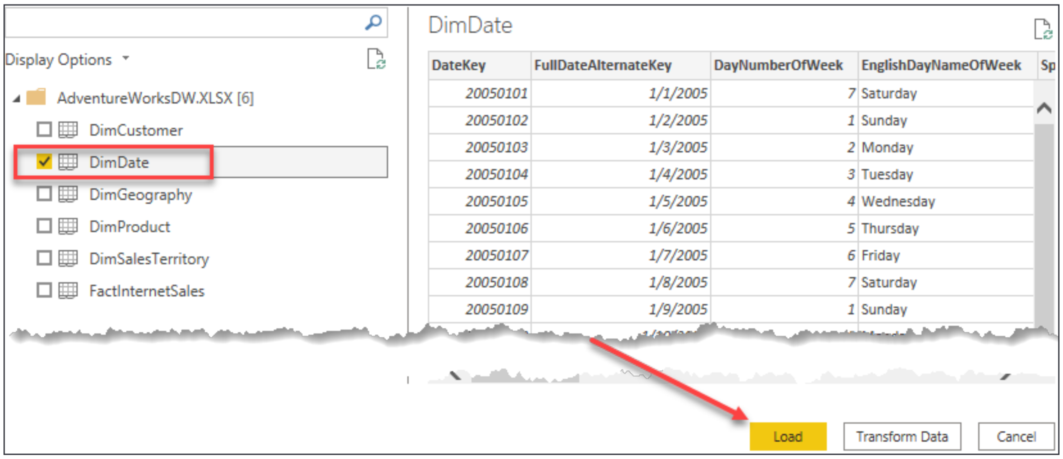
Figure 3.23: Total sales and total transactions by year

The previous visualization is correct but it is ambiguous. To remove any uncertainty from our reports, the data model can be further improved by the renaming of columns. In this next section, you will learn how to make small changes in your data model so that the visuals are more specific.

Importing the date table

In this section, we are going to import a date table to support the analysis of data based on when an order shipped. From the **Get data** option, select **Excel** and open the `AdventureWorksDW` Excel file; the file can be found in the directory location `Microsoft-Power-BI-Start-Guide-Second-Edition-main\Data Sources`.

Next, select **DimDate** from the list of tables, and then click **Load** as seen in *Figure 3.24*:



AdventureWorksDW.XLSX [6]
- ☐ DimCustomer
- ☑ DimDate
- ☐ DimGeography
- ☐ DimProduct
- ☐ DimSalesTerritory
- ☐ FactInternetSales

DimDate

DateKey	FullDateAlternateKey	DayNumberOfWeek	EnglishDayNameOfWeek	Sp
20050101	1/1/2005	7	Saturday	
20050102	1/2/2005	1	Sunday	
20050103	1/3/2005	2	Monday	
20050104	1/4/2005	3	Tuesday	
20050105	1/5/2005	4	Wednesday	
20050106	1/6/2005	5	Thursday	
20050107	1/7/2005	6	Friday	
20050108	1/8/2005	7	Saturday	
20050109	1/9/2005	1	Sunday	

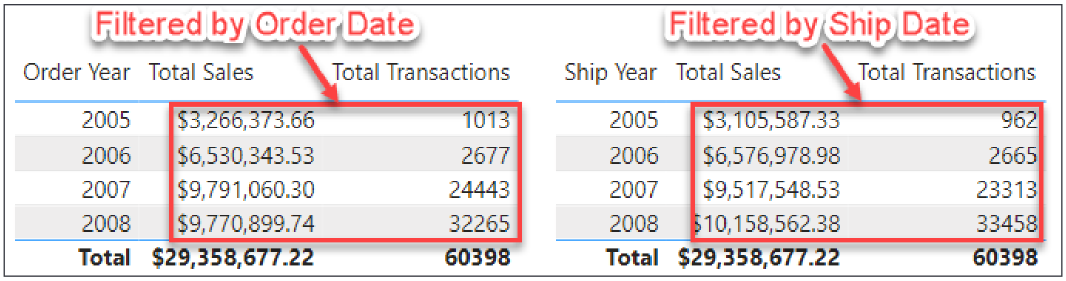
Figure 3.24: Importing DimDate into Power BI

Now that the data has been imported, the next step is creating a valid relationship. Open **Manage relationships** from either the **Home** or **Modeling** ribbon, depending on which view you are currently in. From the relationship editor, click **New** to create a new relationship. For a reminder on how to create a new relationship, refer to *Figure 3.7*. Complete the following steps:

1. Select **FactInternetSales** from the drop-down list.
2. Select the **ShipDate** column; use the scroll bar to scroll all the way to the right.
3. Select **DimDate (2)** from the drop-down list.
4. Select the **FullDateAlternateKey** column.
5. Click **OK** to close the **Create relationship** window.

I took the liberty of changing the table and column names here, for clarity. You will learn how to rename tables and columns in the following *Usability enhancements* section. `DimDate` has been renamed `Date (Order)`. `DimDate (2)` has been renamed `Date (Ship)`.

The data model now has two date tables, each with an active relationship to the `FactInternetSales` table. If you wish to see sales by `Order Year`, then you would bring in the year column from the `Order Date` table, and if you wish to see sales by the `Ship Year`, then you would bring in the year column from the `Ship Date` table; see *Figure 3.25*:


Filtered by Order Date
Filtered by Ship Date

Order Year	Total Sales	Total Transactions
2005	$3,266,373.66	1013
2006	$6,530,343.53	2677
2007	$9,791,060.30	24443
2008	$9,770,899.74	32265
Total	**$29,358,677.22**	**60398**

Ship Year	Total Sales	Total Transactions
2005	$3,105,587.33	962
2006	$6,576,978.98	2665
2007	$9,517,548.53	23313
2008	$10,158,562.38	33458
Total	**$29,358,677.22**	**60398**

Figure 3.25: Displaying the ship year column

Importing the same table multiple times is generally the preferred method when two tables have multiple relationships between them. This method is easy to explain to end users and allows you to reuse most, if not all, of your existing DAX calculations.

The alternative method is to create inactive relationships and then create new calculations (measures) using the DAX language. This method of leveraging inactive relationships can become overwhelming from an administrative point of view. Imagine having to create copies of the existing measures in the data model for each relationship between two tables. In the current data model, `FactInternetSales` stores three dates, and this would possibly mean having to create and maintain three copies of each measure, one to support each date.

In this section, you learned how to rename a column to provide clarity; this is an important step. Now let's take a look at other usability enhancements that can improve your data model.

Usability enhancements

Usability enhancements are those enhancements that can significantly improve the overall user experience when interacting with the data model. In order to ensure a successful handoff and adoption of the work you have done, it is important to not overlook these rather basic improvements.

In this section, we are going to cover the following usability enhancements:

- Hiding tables and columns
- Renaming tables and columns
- Changing the default summarization property
- Displaying one column but sorting by another
- Setting the data category of fields
- Creating hierarchies

Let's begin by considering how to hide tables and columns.

Hiding tables and columns

Some tables are available in the data model simply in a support capacity and would never be used in a report. For example, you may have a table to support many-to-many relationships, weighted allocation, or even dynamic security. Likewise, some columns are necessary for creating relationships in the data model but would not add any analytical value to the reports. Tables or columns that will not be used for reporting purposes should be hidden from **Report View** to reduce complexity and improve the user experience.

To hide a column or table, simply right-click on the object you wish to hide, and then select **Hide in report view**. If you are in the report view already, the available option will simply say **Hide**.

Navigate to **Model View**, find the `FactInternetSales` table, and right-click on `CurrencyKey`, then select **Hide in report view** as seen in *Figure 3.26*:

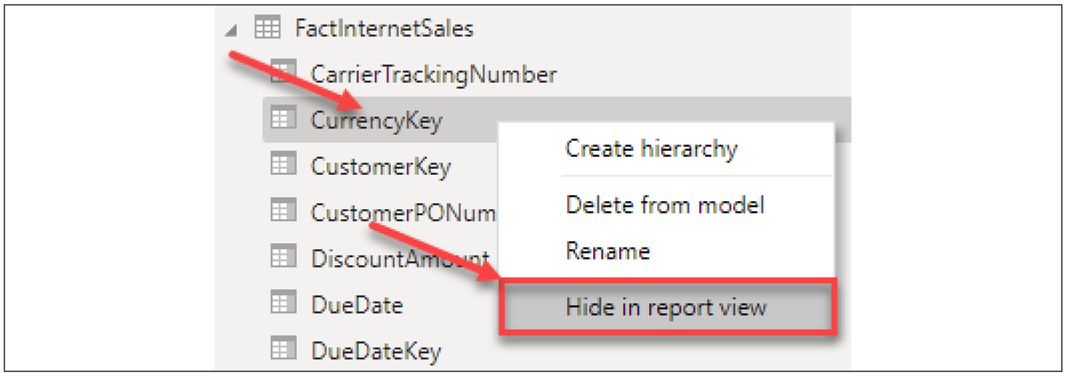


Figure 3.26: Select Hide in report view

Columns that are hidden are still visible in the data and relationship views. Hidden columns can be identified in two ways. First, they have slightly lighter text than columns that are not hidden, and secondly, they have a visibility icon that appears to the left of the column name, as seen in *Figure 3.27*:

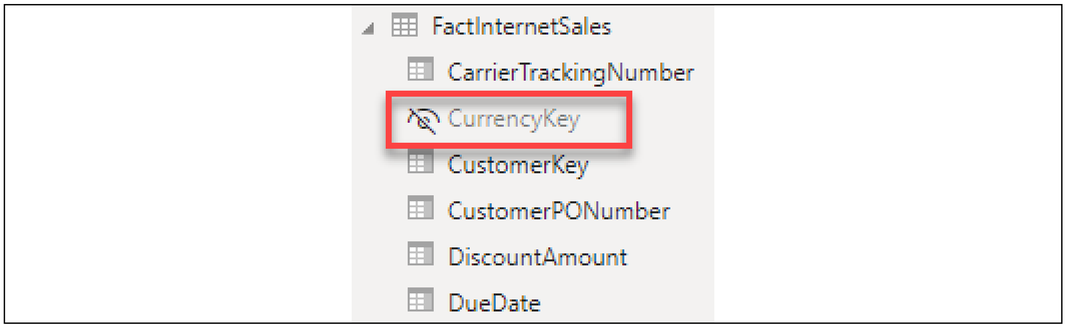


Figure 3.27: Hidden columns

Next, go to each table and hide all remaining key columns, except for `FullDateAlternateKey`.

When working in the **Model View**, you can multi-select columns by holding down the *Ctrl* key while selecting columns. Therefore, you can select all columns that need to be hidden first, then hide them all in a single action.

Renaming tables and columns

The renaming of tables and columns is an important step in making your data model easy to use. Different departments often have different terms for the same entity, therefore it is important to consider multiple departments when renaming objects. For example, you may have a column with a list of customer names and you decide to name this column `Customer`. However, the sales team may have named that column `Prospect` or `Client`, or any number of other terms. Remember to keep your end users and consumers of your reports in mind when renaming tables and columns.

You may rename tables or columns in the **Report**, **Data**, or **Model View**. Navigate to the **Model View** and right-click on **FactInternetSales**, then select **Rename**, as seen in *Figure 3.28*. Rename the table `Internet Sales`:

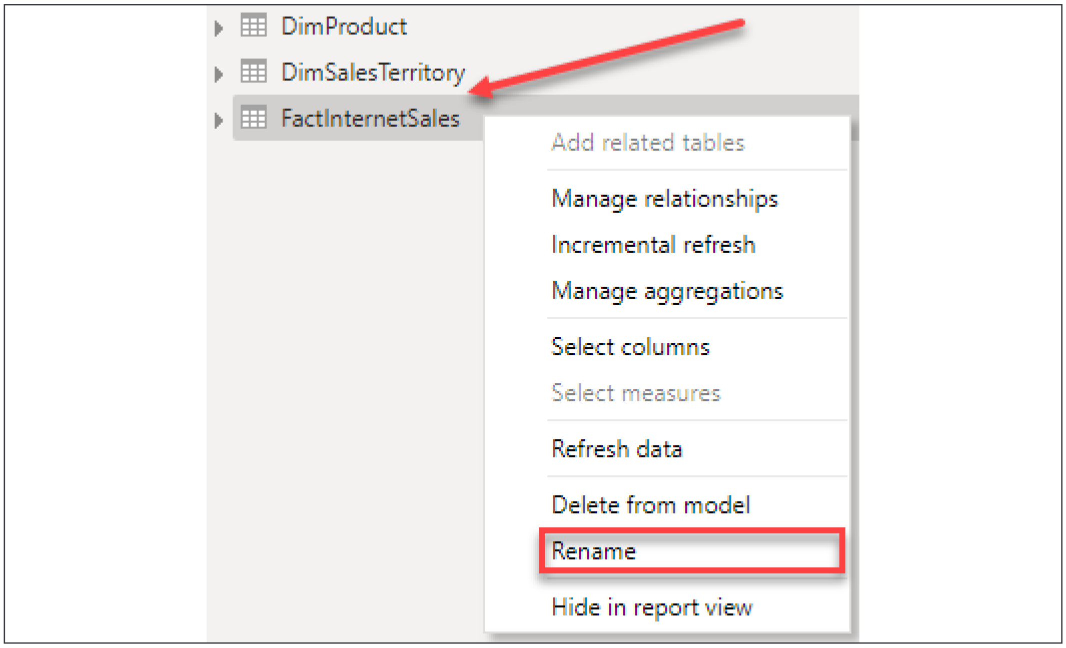


Figure 3.28: Renaming FactInternetSales

Next, rename the remaining tables, removing the `Dim` prefix and adding spaces where applicable. The table below is provided for reference:

FactInternetSales	**Internet Sales**
DimDate	Date (Order)
DimDate (2)	Date (Ship)
DimProduct	Product
DimCustomer	Customer
DimSalesTerritory	Sales Territory
5 Regions 2008	Temperature

The next step is necessary, but could be a somewhat tedious process. If you come from a programming or development background, then you will be used to eliminating spaces in table and column names. End users and consumers of reports will expect to see spaces and, for that reason, it is recommended to add spaces where applicable. Spaces need to be added to any column that is visible, not hidden, in the Report View. To rename a column, right-click on it and then select **Rename**. In *Figure 3.29*, spaces have been added to **CarrierTrackingNumber** and **CustomerPONumber**:

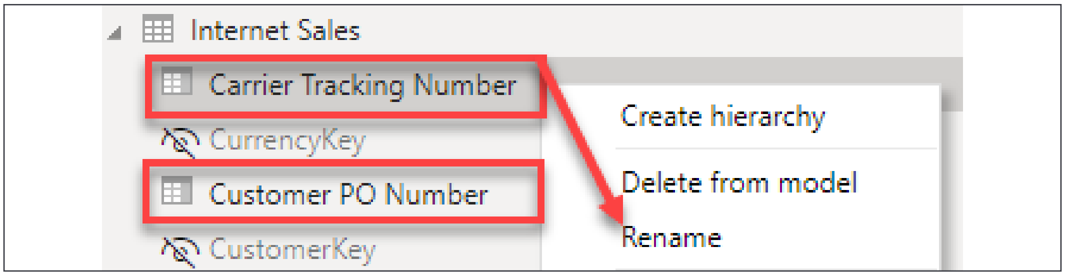


Figure 3.29: Renaming columns

Complete the following steps to rename the rest of your columns:

1. Repeat this process of adding spaces for the remaining columns in each table.
2. Rename `FullDateAlternateKey` to simply `Date`.

Renaming columns is a simple, yet effective step for improving user experience! Now, let's take a look at another important usability enhancement for your data model, changing the default summarization on numeric columns.

Default summarization

By default, Power BI assigns a default summarization to numeric columns that do not have a relationship or appear on the one side of a relationship. This default summarization is usually a sum operation. Columns that have been assigned a default summarization are denoted by Power BI with a Sigma symbol (Σ), as seen in the **Report** View. This default summarization behavior can be observed in the **Temperature** table. In *Figure 3.30*, the columns **Avg Temp** and **Month Number** have been assigned a default summarization by Power BI:

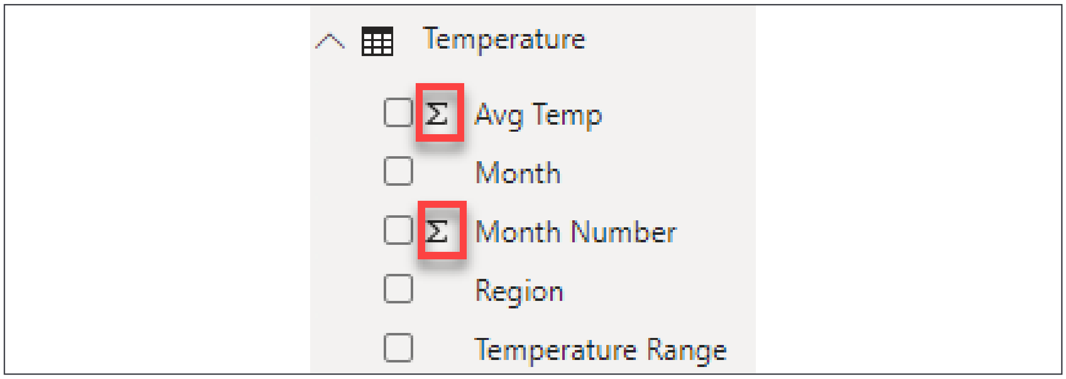
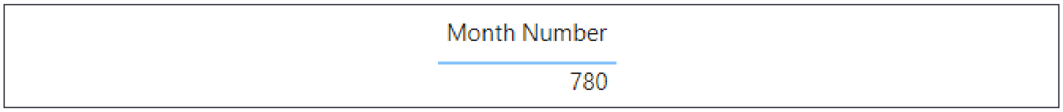


Figure 3.30: Default aggregations assigned to columns

This automatic assignment of default summarizations has pros and cons. The benefit is that fields like `Sales Amount` or `Total Cost` will be automatically aggregated when they are added to a report, thus making the report building process a little easier. The downside is that very commonly a data model will contain numeric columns that are descriptive in nature and it could cause confusion for report developers in Power BI when these columns are automatically aggregated when added to a report. The columns identified in *Figure 3.30* are descriptive attributes that help to explain the data; these columns should not be aggregated. Take a look at the following screenshot:



Month Number
780

Figure 3.31: Sum of months from the Temperature table

In *Figure 3.31*, the `Month Number` column from the date table has been added into a table visual, and the expected behavior is to see a distinct list of the month numbers (`1`, `2`, `3`, `4`, `5`, `6`, `7`, `8`, `9`, `10`, `11`, `12`). Instead of returning a distinct list, the report returns a sum of all records from the `Month Number` column in the `Temperature` table resulting in a final value of `780`. Fortunately, the default aggregation can be changed. See *Figure 3.32* and the accompanying steps:

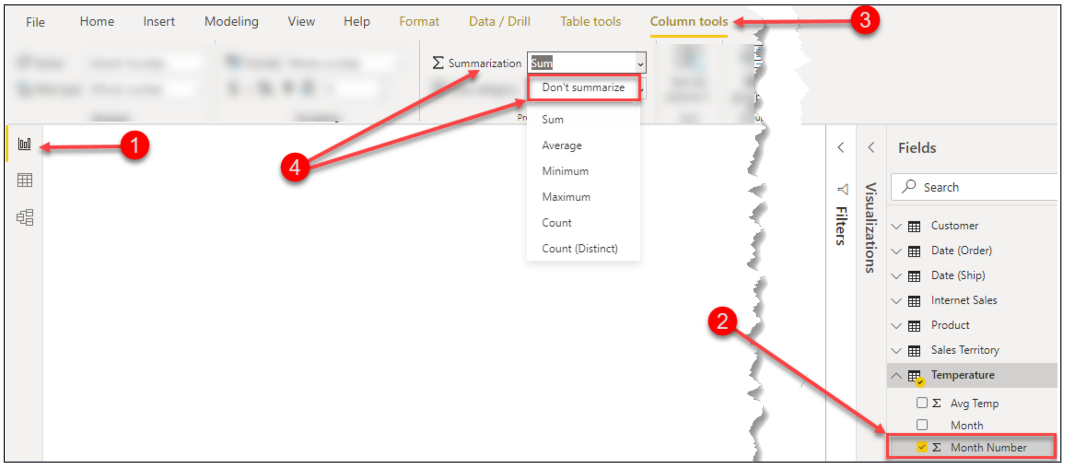


Figure 3.32: Adjust the default summarization

Let's take a look at the numbered items in *Figure 3.32* to learn how to change the default summarization:

1. Select the **Report View** from the left navigation bar.

2. Expand the date table and select the **Month Number** column. Make sure to click on the column name here, not the checkbox. Once the column has been selected, the **Column tools** ribbon will appear across the top of Power BI Desktop.
3. Select the **Column tools** ribbon.
4. Click the dropdown for **Summarization**, and select **Don't summarize**.

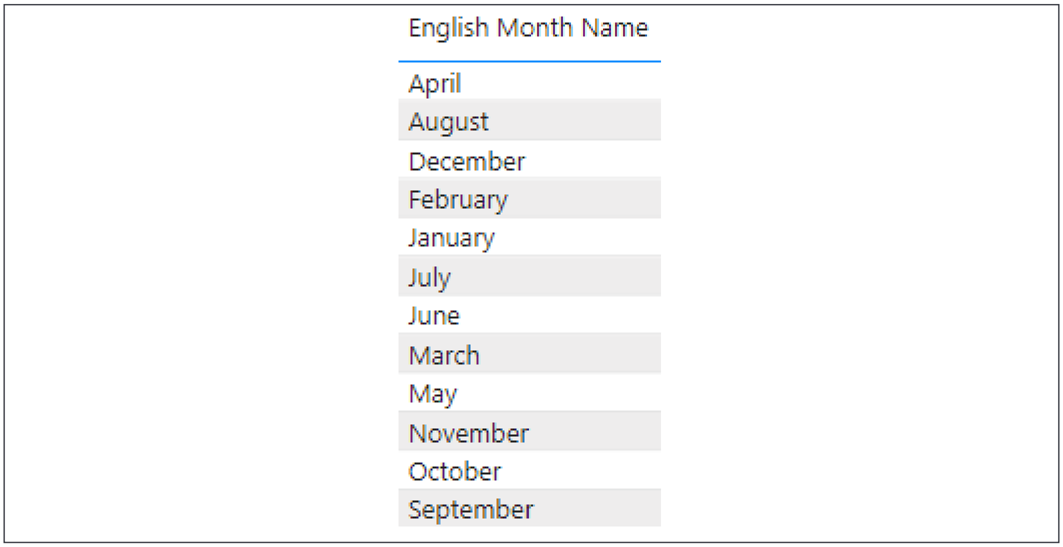
Repeat the above process for each column in your data model that has been assigned a default aggregation but should not be summarized.

Columns that are in tables on the one side of a relationship will automatically have a default summarization of `Don't summarize`! Take a look at the date table and you will notice that each of the numeric columns, like `Calendar Year` and `Month Number`, have a default summarization of `Don't summarize`. This is yet another benefit of properly defining relationships in Power BI.

Now that you have learned how to update the default summarization, let's take a look at yet another important usability enhancement. In this section, you will learn how to configure columns in your data model so that the data is properly sorted in visualizations.

How to display one column but sort by another

Oftentimes, you want to display the name of one column but sort by another. For example, the month name is sorted alphabetically when added to a report visual; see *Figure 3.33*:



English Month Name
April
August
December
February
January
July
June
March
May
November
October
September

Figure 3.33: Month names sorted alphabetically when added to a report visual

The desired behavior is for the month to be sorted chronologically instead. Therefore, the report should display the month name but sort by the month number of the year. Take a look at the numbered items in *Figure 3.34* and the accompanying steps:

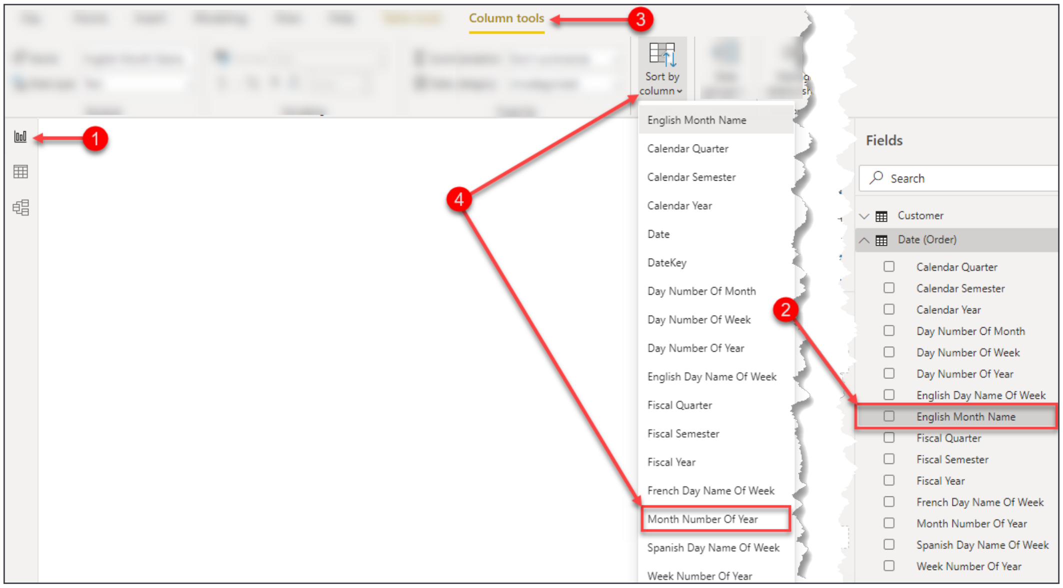


Figure 3.34: Changing the sort order of a column

In order to change the sort order of a column, complete the following steps:

1. Select the **Report** View from the left navigation bar.
2. Expand the **Date** table and select **English Month Name**, as seen in *Figure 3.34*.
3. Select the **Column tools** ribbon.
4. Click the dropdown for **Sort by column** and select **Month Number Of Year**.

Now, let's take a look at how to categorize columns to further improve the report consumer experience.

Data categorization

Power BI makes some assumptions about your columns based on data types, column names, and relationships in the data model. These assumptions are used in the **Report** View when building visualizations to improve your default experience with the tool. Once you start building visualizations, you will notice that Power BI selects different types of visuals for different columns; this is by design. Power BI also decides column placement within the **fields** section of a visual, and you will learn more about the creation of visuals in *Chapter 5*, *Visualizing Data*. As you saw previously in this chapter, when Power BI detects a column that has numeric values on the *many* side of a relationship, a default aggregation is assigned. Power BI assumes you will want to aggregate that data, and will automatically place these numeric columns into the `Values` area of a report visual.

The classification of data allows you to improve the user experience as well as improving accuracy. There are thirteen different options available for data categorization at the time of writing.

Figure 3.35 provides a full list of the data categories available in Power BI:

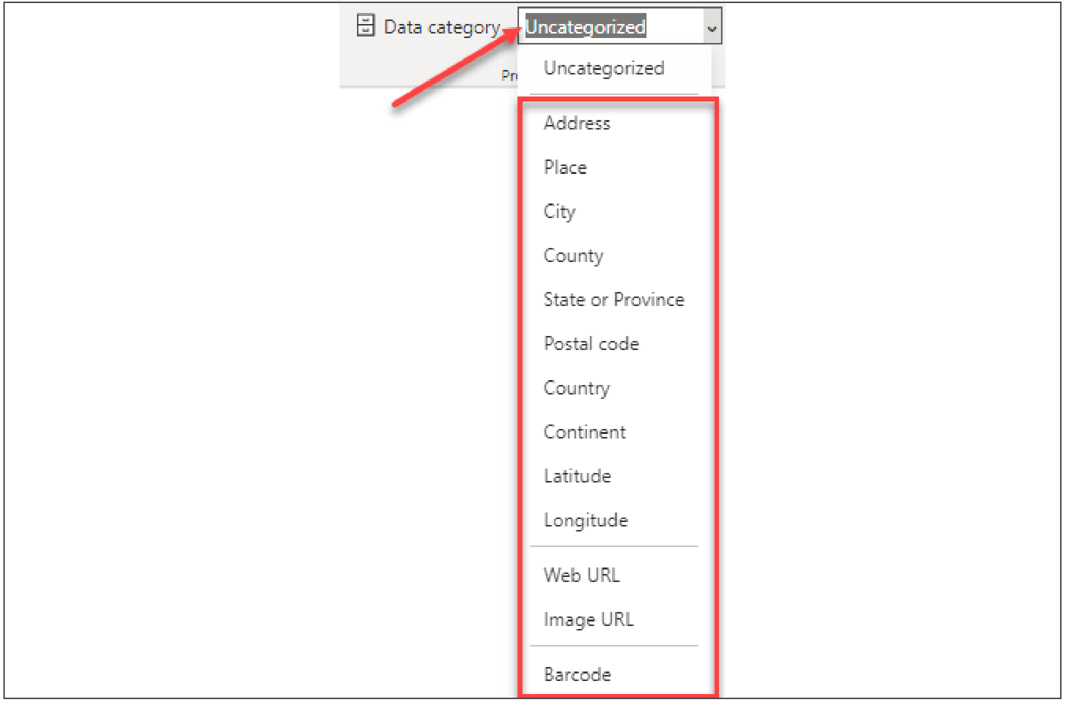


Figure 3.35: Options for data categorization

The most common use for data categorization is the classification of geographical data. When geographical data is added to a map, Bing maps may have to make some assumptions about how to map that data. This can sometimes cause inaccurate results. However, through data classification, you can reduce and possibly eliminate inaccurate results.

One method I have found extremely useful is combining multiple address columns (`City`, `State`) into a single column, and assigning the new column a data categorization of "**Place**". I have used this method with great success. See the following blog post for more tips on mapping geographical data: `https://tinyurl.com/pbiqs-categoryplace`.

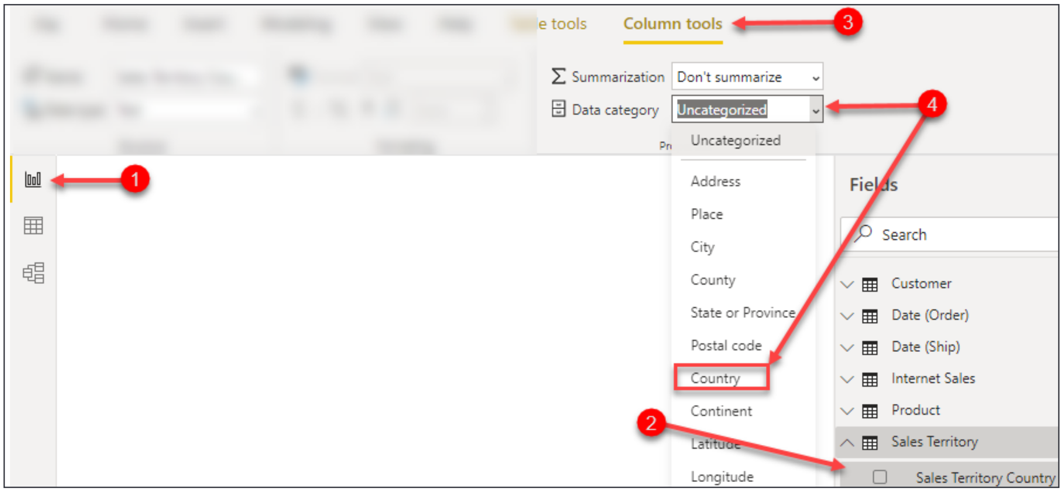


Figure 3.36: Modifying the data category

Follow the numbered steps to update a column's data category; see *Figure 3.36*:

1. Select the **Report** View from the left navigation bar.
2. Expand the **Sales Territory** table and select **Sales Territory Country**.
3. Select the **Column tools** ribbon.
4. Click the dropdown for **Data category** and select **Country.**

Explicitly classifying each of the geographical columns in your data model will help Bing Maps to properly map your data correctly. When geographical classifications are not used it is much more likely that data could be incorrectly mapped. The blog previously mentioned in this chapter shows data that was incorrectly mapped by Bing maps and how proper classification of data solved the mapping issue.

Creating hierarchies

Predefining hierarchies can provide several key benefits. Some of those benefits are listed here:

1. Hierarchies organize attributes and show relationships in the data.
2. Hierarchies allow easy drag and drop interactivity.
3. Hierarchies add significant analytical value to the visualization layer through drilling down and rolling up data, as necessary.

Hierarchies store information about relationships in the data that users may not have otherwise known. I remember when I was working for a client in the telecommunication industry and they had **Base Transceiver Stations** (**BTSes**) and sectors, and without looking at my notes, I could never remember the correct order. Did a BTS contain multiple sectors, or did a sector contain multiple BTSes? Once the hierarchy was added to the data model, I no longer had to worry about remembering the relationship because the relationship was stored in the hierarchy. Here is a list of common hierarchies:

1. Category | Subcategory | Product
2. Country | State | City
3. Year | Quarter | Month | Day

In order to create a new hierarchy, complete the numbered steps in *Figure 3.37*:

1. Expand the **Sales Territory** table.
2. Right-click on the **Sales Territory Country** column.
3. Select **New hierarchy** or **Create hierarchy**, depending on which view you're in:

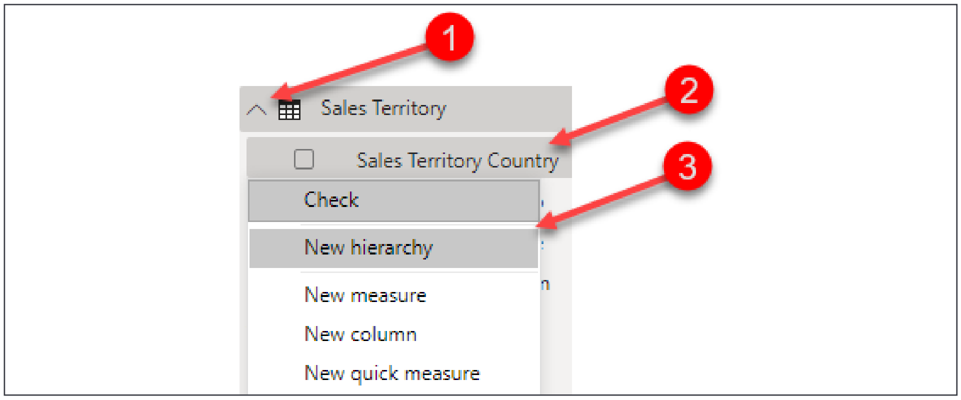


Figure 3.37: Create a new hierarchy

A new hierarchy has been created with a single column, and given a default name of `Sales Territory Country Hierarchy`. Right-click on the hierarchy created and rename it `Sales Territory Drilldown`. The next step is to add additional columns/attributes to the hierarchy. Complete the following steps as seen in *Figure 3.38*:

1. Within the **Sales Territory** table, right-click on **Sales Territory Region**.
2. Click on **Add to hierarchy**.

3. Select **Sales Territory Drilldown**.
4. Repeat *steps 1-3* for **Sales Territory Group**:

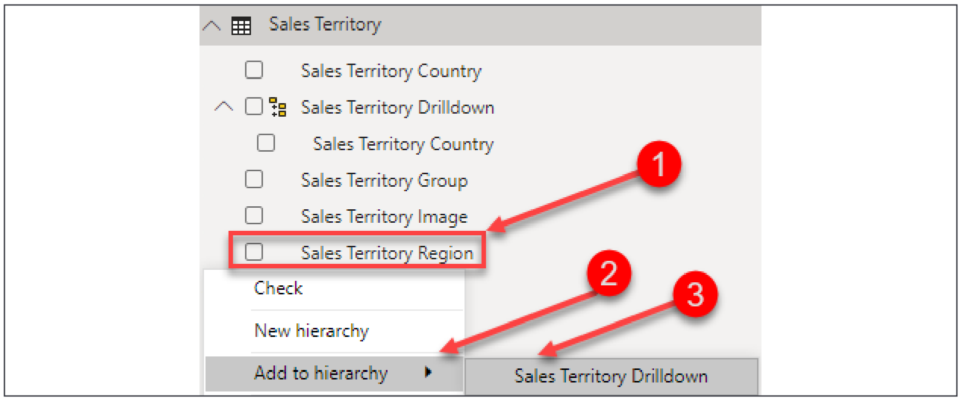


Figure 3.38: Adding columns/attributes to the hierarchy

The completed hierarchy can be seen in *Figure 3.39*. However, the order of the attributes is incorrect; the order should be **Sales Territory Group** | **Sales Territory Country** | **Sales Territory Region**:

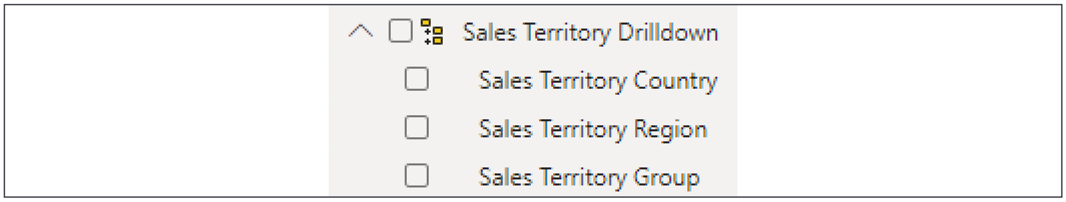


Figure 3.39: Completed hierarchy

To correct the order of the attributes:

1. Right-click on **Sales Territory Group**; see *Figure 3.40*.
2. Click **Move up**.
3. Repeat *steps 1* and *2*:

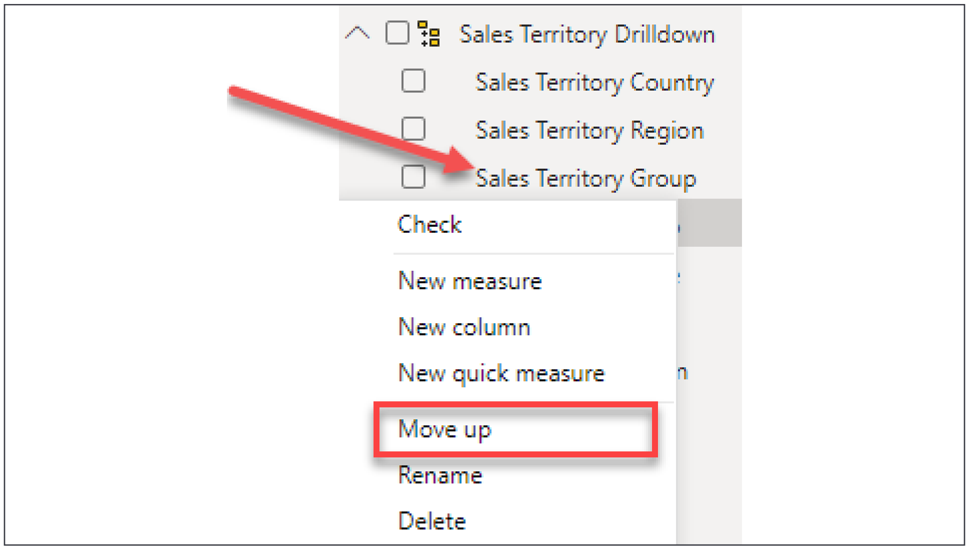


Figure 3.40: Reordering a hierarchy

In *Figure 3.41* you can see the correctly arranged hierarchy:

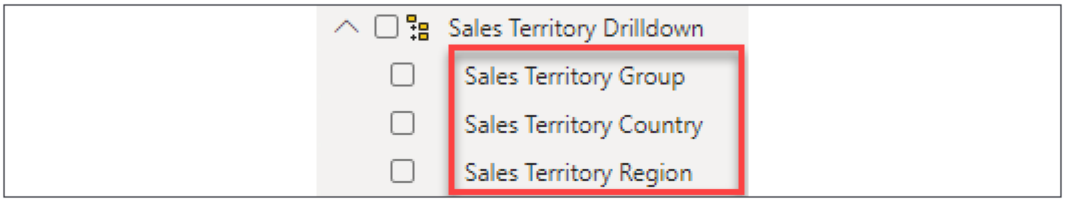


Figure 3.41: Completed Sales Territory hierarchy

In this section, you learned how many small but effective modifications can be leveraged to improve the readability and effectiveness of the data model. These necessary usability enhancements help to improve the user experience by making the model intelligent and easier to understand.

Now let's transition to discussing some considerations for data model performance.

Data model performance

Data model performance can be measured in two ways within Power BI, query performance and processing performance. Query performance is how quickly results are returned by visualizations and reports. Processing performance is a measure of how long it takes to perform a data refresh on the underlying dataset. Data model performance as a whole is very important and the Power BI developer should always be aware of how design decisions may affect performance today or in the future. A deep dive into performance is out of the scope of this book, but an overview is provided here.

Query performance

As you learned in *Chapter 1, Getting Started with Importing Data Options*, there are multiple ways that you can connect to data in Power BI. For example, you can import data, use DirectQuery, use live connection, or you can use a combination of import and direct queries with the composite model.

Importing data

Importing data is the most common method of connecting to data for Power BI models, storing the data in memory. This method is highly efficient for query performance due to the fact that all queries are answered from an in-memory cache, which provides unmatched analytical performance! Models that contain imported data historically require very little to no performance tuning, especially for smaller data models.

Data model design methodologies

Data models in Power BI are specifically designed for the purpose of extracting analytical value out of data to make informed business decisions. Therefore, the data should be modeled in such a way to effectively and efficiently report data. In Power BI, there are three types of data models that commonly appear and those are flat models, star schemas, and snowflake schemas.

A flat or completely denormalized model is where the entire data model is a single table with no supporting tables. Therefore, all your measurable items and all the descriptive attributes are in the same table. This model is very common and is a result of a lot of Excel users importing data directly into Power BI from their Excel worksheets. This method is highly inefficient and has several drawbacks:

- A flat model does not scale well; as the number of records in the table increases, the data model will consume significantly more resources due to the repetitiveness of data and the number of columns.
- A flat model is not flexible and does not hold up well to future changes.
- A flat model is not intelligent, simply meaning it's not easily understandable.
- Time series analysis calculations like Year to Date and Year over Year are much more difficult to author.

The next type of model is a star schema and this is the preferred way to model data in Power BI. The term star schema is derived from dimensional modeling. Dimensional modeling is the way enterprises and organizations have been designing their analytical data warehouses for over 30 years. A star schema has two types of tables, fact tables and dimension tables. The reason these data models are called star schemas is that the dimension tables surround the fact table and appear to represent a star. See *Figure 3.42*:

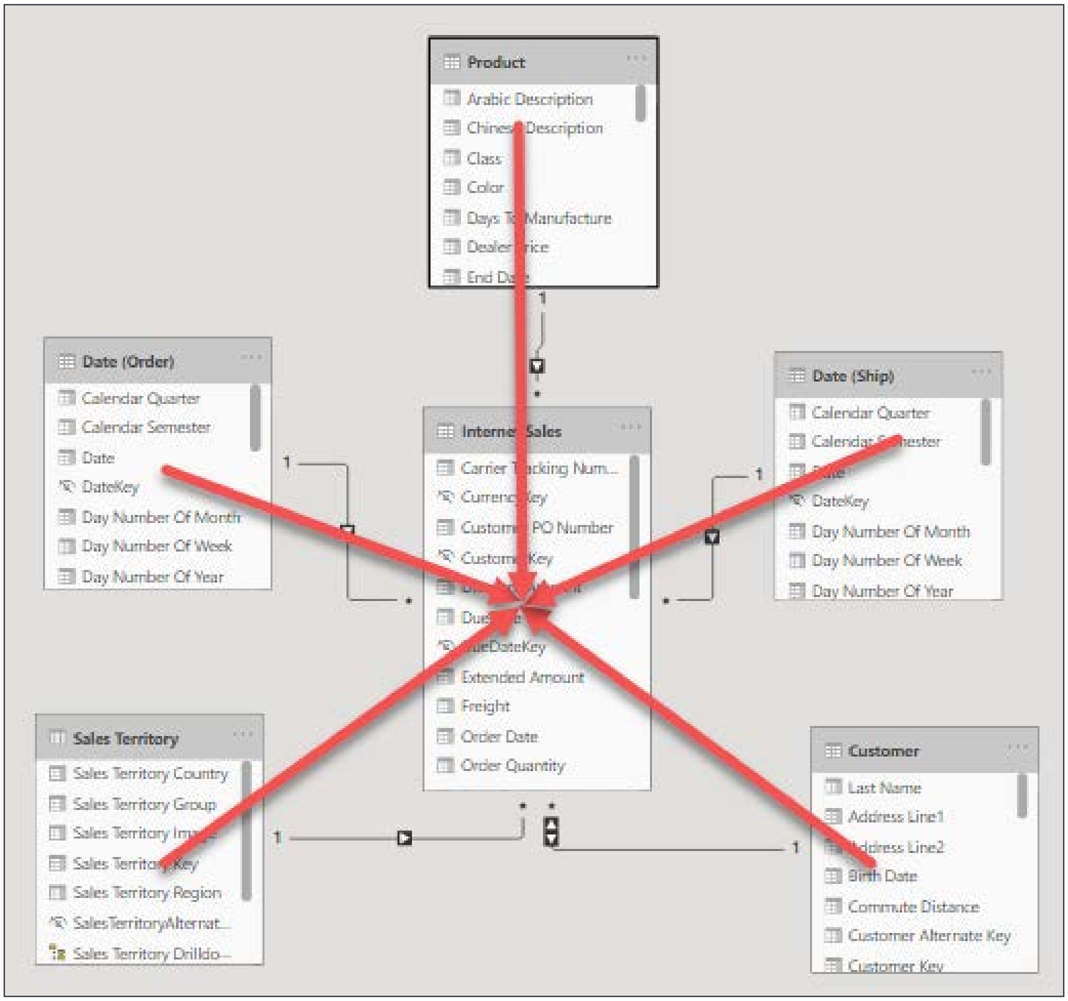


Figure 3.42: Star schema

Fact tables store metrics, the measurable items in your data model like sales, tax amount, duration of a phone call, and so on… A dimension table stores descriptive attributes that help you to explain your metrics. In a dimension table, related attributes are stored in their own separate and distinct table. For example, product name, color, size, weight, and other product-related columns would be stored in a product table.

Taking the time to build a star schema in Power BI Desktop has several advantages; please note that the following list is not a comprehensive list of all the advantages of a star schema:

- The data model is scalable, meaning it will be flexible to grow as more data is added.
- The data model is flexible and additional tables can more easily be integrated into the existing data model to support analytical requirements as they arise.
- Star schemas are intelligent and easily understandable.
- Star schemas make time intelligence calculations easy to implement.

The final type of data model I'd like to mention here is a snowflake schema; a visual depiction of this model more closely resembles a snowflake than a star. In dimensional modeling, most data models begin as star schemas but may evolve over time into snowflake schemas to support more advanced analytical requirements. A simple example of a snowflake schema would be if the product dimension were broken out into multiple tables like product category, product subcategory, and product.

DirectQuery

As discussed in *Chapter 1*, *Getting Started with Importing Data Options*, another method for connecting to data is DirectQuery. DirectQuery, unfortunately, has historically performed very poorly when it comes to query performance. DirectQuery is most commonly used when the dataset that needs to be analyzed is too large to import into Power BI.

Aggregations

Creating aggregations in Power BI provides a powerful mechanism for improving query performance. Aggregations can be used with imported or DirectQuery models, for massive performance gains!

Effectively implementing aggregations requires an understanding of the data and understanding how end users will generally query the data. With this knowledge, an aggregated table can be designed and used to answer a large number of user requests, rather than the original table storing many more rows of data.

Let's look at a hypothetical example: imagine a transaction table that has `100` million rows of data for the last year. If most visualizations will be performing counts and sums by date, then an aggregation can be built that returns total sales and total transactions grouped by date. In this scenario, the aggregate table would return `365` rows of data, `1` row for each day in the last year instead of the original 100-million-row transaction table. In most data models, it is unlikely that the date alone would suffice to answer most queries from end user requests. Therefore, additional attributes may need to be added to the aggregate table, for example, maybe adding the geography key is the missing ingredient. The aggregate table would now be total sales and total transactions grouped by date and geography. This would of course increase the size of the table significantly, depending on how many unique records exist in your geography table, but it would still be significantly smaller than your original transactional table and likely small enough to import the aggregated data into Power BI.

> The steps for effective implementation of aggregations would not fit within the scope of this book, however, to learn more on aggregations take a look at the following blog by Shabnam Watson: `https://shabnamwatson.wordpress.com/2019/11/21/aggregations-in-power-bi/`.

Now let's take a look at data modeling considerations for improving processing performance.

Processing performance

Imported datasets must go through a data refresh operation to load the most recent data into the data model. In today's "data-driven culture," organizations want more data and they want it faster than ever before. If a dataset takes hours to refresh, then you would be limited in how often you can refresh the dataset. On the other hand, if a dataset only takes minutes to refresh, you can refresh it more often throughout the day, providing richer insights and more time-sensitive access to the underlying data.

Query folding

As you learned previously in this book, query folding is the process of pushing work back to the underlying data source. Query folding is very important when the underlying data source is a relational database like Microsoft SQL Server and query folding can significantly improve the processing performance of a data model.

Incremental refresh

Historically, refreshing a data model in Power BI requires that all data be refreshed. Therefore, if a data model contains five years of data, then all five years of data and the associated rows would be refreshed each time a refresh occurs. As you can imagine, this can require a lot of overhead. What if a data refresh operation could take less than a minute, instead of hours?

I have seen the process of incremental refresh reduce data refresh operations from hours to only minutes. This is because incremental refresh does not reprocess all the data in the model. Instead, only the most recent data is loaded, while not touching the historical data. This would include new records or records that have been updated.

> Further reading: Implementation of incremental refresh is outside the scope of this book, however, you can learn more on incremental refresh by taking a look at the following blog: `https://docs.microsoft.com/en-us/power-bi/admin/service-premium-incremental-refresh`.

Best practices

There are a few recommended best practices that can help speed up data refresh operations. This is by no means a comprehensive list, but this list provides you with a starting point for building data models:

- Only import necessary columns for reporting; remove all other columns from your model.
- Likewise, only import necessary rows of data; filter out data that is not needed.
- Try to avoid highly unique columns; they have low compression and take up valuable resources.
- Disable `Auto date/time for new files`; see *Figure 3.11*.
- Create new columns in the Power Query Editor, rather than in DAX, when possible.

Summary

In this chapter, you learned that data models in Power BI Desktop should be understandable and designed for scalability and flexibility. You learned how to create new relationships and edit existing relationships. You also learned about how to handle and model complex relationships like many-to-many and role-playing tables. This chapter discussed the importance of usability enhancements like sorting columns, adjusting default summarization, data categorization, and hiding and renaming columns and tables. Finally, the chapter ended with a short discussion on performance considerations for querying and processing your data model. You are now prepared and ready to start building data models in Power BI Desktop!

These data relationships, combined with simple, yet critical usability enhancements, allow you to build a data model that is both coherent and intelligent. Historically, business intelligence projects have cost significant resources in terms of time and money. With Power BI Desktop and through a self-service approach to BI, you now have the tools necessary to build your own BI project within hours and immediately extract value from that model to make informed business decisions.

In the next chapter, you will learn about how to leverage data analysis expressions to further extend the analytical capabilities of your data model.

4
Leveraging DAX

Data Analysis Expressions (**DAX**) is a formula language that made its debut back in 2010 with the release of Power Pivot within Excel. Much of DAX is similar to Excel's functions, and therefore learning DAX is an easy transition for Excel users and Power users alike. In fact, DAX is so similar to Excel that I have seen new students become comfortable with the language and begin writing DAX within minutes.

The goal of this chapter is to introduce you to DAX and give you the confidence to start exploring this language on your own. Because of the brevity of this chapter, there will not be any discussions on in-depth DAX concepts and theory. There are, of course, many other books that are dedicated to just that.

Now, let's take a look at what is covered in this chapter:

- Building calculated columns
- Calculated measures – the basics
- Calculated measures – filter context
- Calculated measures – time intelligence
- Calculated measures – role-playing tables with DAX

Now, let's take a look at writing DAX by building calculated columns.

Building calculated columns

In this section, you will learn how to create calculated columns in Power BI using DAX. The building of calculated columns is a great way of extending the analytical capability of Power BI and by the end of this chapter, you will feel very comfortable with creating new columns through DAX. The writing of calculated columns logically occurs after the data model has been developed, therefore, in order to follow along with this section, you will need to open the `pbix` file `Chapter 4 - Leveraging DAX.pbix` from the `Microsoft-Power-BI-Start-Guide-Second-Edition-main\Starting Examples` directory.

Calculated columns are stored in the table in which they are assigned, and the values are static until the data is refreshed. You will learn more about refreshing data in a later chapter.

There are many use cases for calculated columns, but the two most common are as follows:

- Descriptive attributes
- Concatenated key columns

Now you are going to create your first calculated column. Before you get started, though, you need to first know that Power BI Desktop has IntelliSense. IntelliSense will help you out a lot when writing code, as you will discover very soon. This built-in functionality will autocomplete your code as you go and will also help you explore and discover new functions in the DAX language. In order to take advantage of IntelliSense, you simply need to start typing in the formula bar. Now you are ready to start writing DAX!

Click on **Data View** — this is located on the left navigation pane of the Power BI Desktop screen. Next, click on the `Customer` table from the **Fields** list. Once the `Customer` table has been selected, click **New column** — this is found on the **Table tools** ribbon, as shown in *Figure 4.1*:

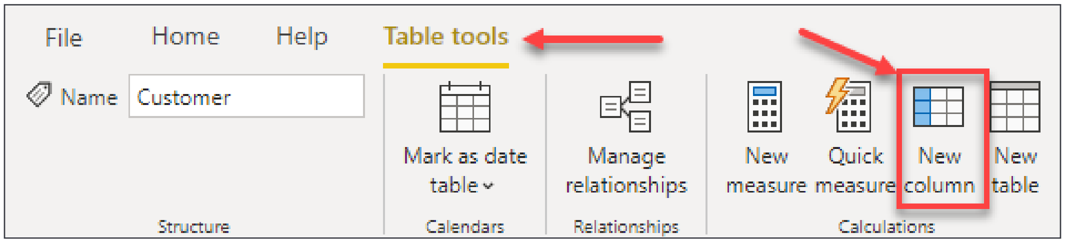
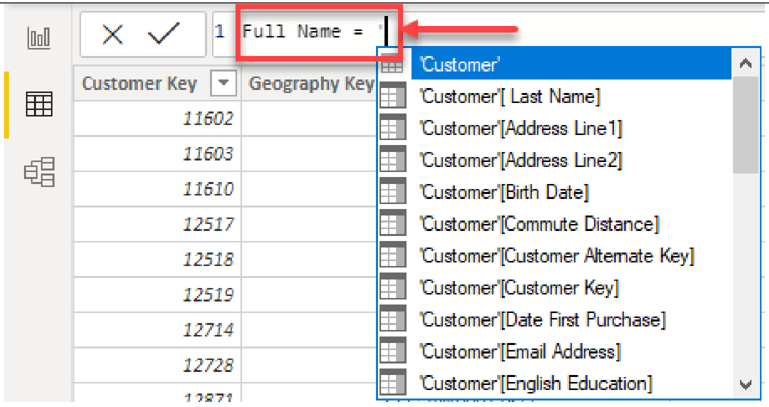


Figure 4.1: New calculated column

You will now see the text `Column =` in the formula bar. First, name the new column by replacing the default text of `Column` with `Full Name`. Then, move your cursor to after the equals sign and type a single quote character. Immediately after typing the single quote character, a list of autocomplete options will appear preceding the formula bar. This is IntelliSense at work. The first option in this list is the name of the table you currently have selected—`Customer`. Press the *Tab* key and the name of the table will automatically be added to the formula bar, as shown in *Figure 4.2*:



```
1 Full Name = '
```

Customer Key	Geography Key
11602	
11603	
11610	
12517	
12518	
12519	
12714	
12728	

'Customer'
'Customer'[Last Name]
'Customer'[Address Line1]
'Customer'[Address Line2]
'Customer'[Birth Date]
'Customer'[Commute Distance]
'Customer'[Customer Alternate Key]
'Customer'[Customer Key]
'Customer'[Date First Purchase]
'Customer'[Email Address]
'Customer'[English Education]

Figure 4.2: Using IntelliSense

At some point, you will inevitably discover that you can reference just the column name. As a best practice, we recommend always referencing both the table and column name anytime you use a column in your DAX code.

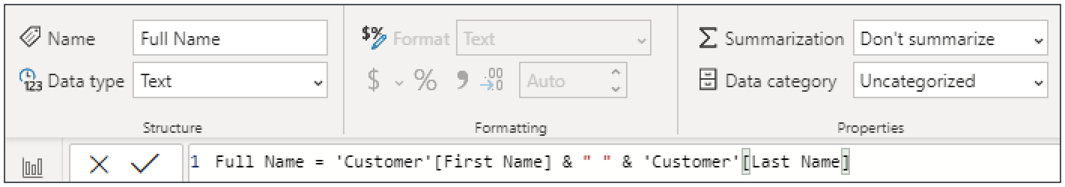
Next, type an opening square bracket into the formula bar followed by the capital letter `F`, making `[F`. Once again, you will immediately be presented with autocomplete options. The list of options has been limited to only columns that contain the letter *f*, and the first option available from the dropdown is `First Name`. Press the *Tab* key to autocomplete. The formula bar should now contain the following formula:

```
Full Name = 'Customer'[First Name]
```

The next step is to add a space, followed by the last name. There are two options in DAX for combining string values. The first option is the `concatenate` function. Unfortunately, `concatenate` only accepts two parameters; therefore, if you have more than two parameters, your code will require multiple `concatenate` function calls. On the other hand, you also have the option of using the ampersand sign (`&`) to combine strings.

The ampersand will first take both input parameters and convert them into strings. After this data conversion step, the two strings are then combined into one. Let's continue with the rest of the expression. Remember to use the built-in autocomplete functionality to help you write code.

Next, add a space and the last name column. To add a space—or any string literal value for that matter—into a DAX formula, you will use quotes on both sides of the string. For example, " " inserts a space between the first and last name columns. The completed DAX formula will look like *Figure 4.3*:

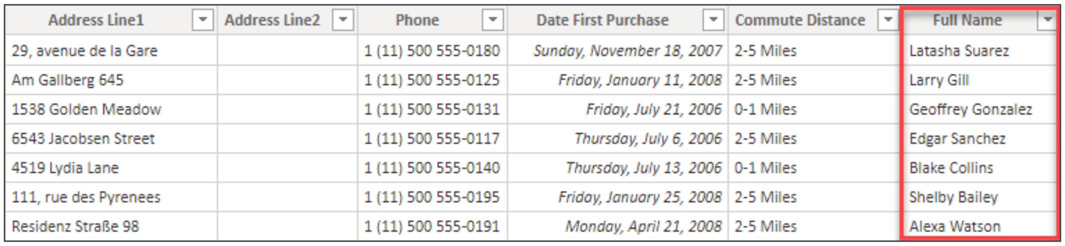


Name: Full Name
Data type: Text
Format: Text
Summarization: Don't summarize
Data category: Uncategorized

```
Full Name = 'Customer'[First Name] & " " & 'Customer'[Last Name]
```

Figure 4.3: Completed DAX example for Full Name

In *Figure 4.4*, you see the results of the completed expression in the `Customer` table:



Address Line1	Address Line2	Phone	Date First Purchase	Commute Distance	Full Name
29, avenue de la Gare		1 (11) 500 555-0180	Sunday, November 18, 2007	2-5 Miles	Latasha Suarez
Am Gallberg 645		1 (11) 500 555-0125	Friday, January 11, 2008	2-5 Miles	Larry Gill
1538 Golden Meadow		1 (11) 500 555-0131	Friday, July 21, 2006	0-1 Miles	Geoffrey Gonzalez
6543 Jacobsen Street		1 (11) 500 555-0117	Thursday, July 6, 2006	2-5 Miles	Edgar Sanchez
4519 Lydia Lane		1 (11) 500 555-0140	Thursday, July 13, 2006	0-1 Miles	Blake Collins
111, rue des Pyrenees		1 (11) 500 555-0195	Friday, January 25, 2008	2-5 Miles	Shelby Bailey
Residenz Straße 98		1 (11) 500 555-0191	Monday, April 21, 2008	2-5 Miles	Alexa Watson

Figure 4.4: Results of the Full Name calculated column in the Customer table

Now, let's take a look at an example of using string functions in DAX to create calculated columns.

String functions – Month Year

Now that you have completed your first calculated column, let's build a calculated column that stores the month-year value. The goal is to return a month-year column with the two-digit month and four-digit year separated by a dash, making "MM-YYYY". Let's build this calculation incrementally.

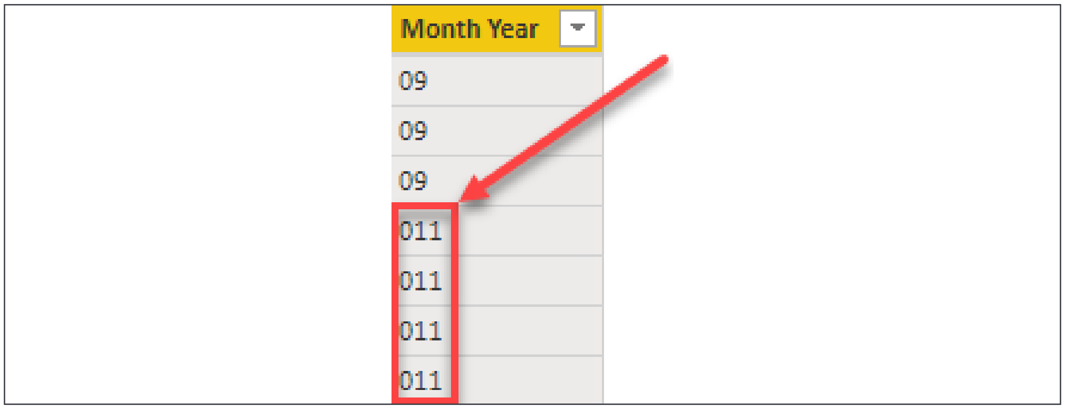
Select the **Date (Order)** table and then click **New Column** from the **Table tools** ribbon. Write the following code in the formula bar and then hit *Enter*:

```
Month Year = 'Date (Order)'[Month Number of Year]
```

As you begin validating the code, you will notice that this only returns the single-digit month with no leading zero. Your next attempt may look something like the following:

```
Month Year = "0" & 'Date (Order)'[Month Number of Year]
```

This will work for single-digit months; however, double-digit months will now return three digits. Take a look at *Figure 4.5*:



Month Year
09
09
09
011
011
011
011

Figure 4.5: Displaying Month Year

To improve upon this and only return the two-digit month, you can use the `RIGHT` function. The `RIGHT` function returns a specified number of characters from the right side of a string. Modify your existing DAX formula to look like the following:

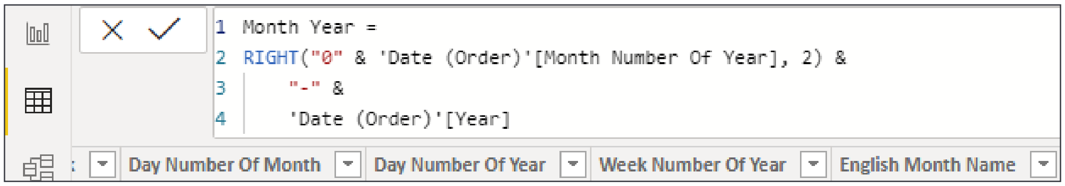
```
Month Year = RIGHT("0" & 'Date (Order)'[Month Number of Year], 2)
```

For a full list of text functions in DAX, please go to the following link: `https://tinyurl.com/pbiqs-text`

The rest of this formula can be completed quite easily. First, to add a dash, the following DAX code can be used:

```
Month Year = RIGHT("0" & 'Date (Order)'[Month Number of Year], 2) & "-"
```

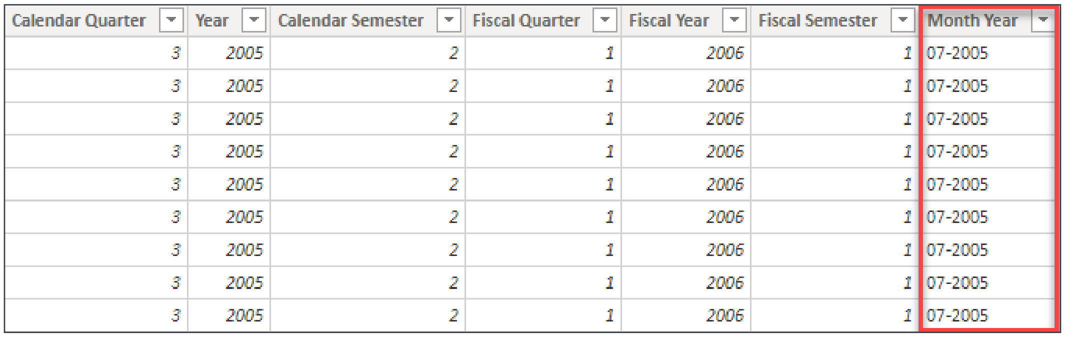
Complete the `Month Year` formula by combining the current string with the `Year` column. The completed example is seen in *Figure 4.6*:



```
Month Year =
RIGHT("0" & 'Date (Order)'[Month Number Of Year], 2) &
    "-" &
    'Date (Order)'[Year]
```

Figure 4.6: Displaying Month Year

In *Figure 4.7*, you see the results of the completed expression in the `Date` table:



Calendar Quarter	Year	Calendar Semester	Fiscal Quarter	Fiscal Year	Fiscal Semester	Month Year
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005
3	2005	2	1	2006	1	07-2005

Figure 4.7: Results of Month Year calculated column in the Date table

You may have noticed that the `Year` column has a data type of a whole number, and you may have expected that this numeric value would need to be converted to a `String` prior to the `combine` operation. However, remember that the ampersand operator will automatically convert both inputs into a `String` before performing the `combine` operation!

In this example, you learned how to create a `Month Year` column using a combination of the `Right` function with the ampersand operator. Next, you will learn an easier method for achieving the same goal with the `Format` function.

FORMAT function – Month Year

As with any other language, you will find that there are usually multiple ways to do something. Now you are going to learn how to perform the calculation that we saw in the previous section using the `FORMAT` function. The `FORMAT` function allows you to take a number or `Date` column and customize it in a number of ways. A side effect of the `FORMAT` function is that the resulting data type will be text. Let's perform the preceding calculation again, but this time using the `FORMAT` function.

Make sure you have the **Date (Order)** table selected, and then click on **Create a New Calculated Column** by selecting **New Column** from the **Table tools** ribbon. In the formula bar, write the following expression:

```
Month Year Format = FORMAT('Date (Order)'[Date], "MM-YYYY")
```

If you would like to take a full look at all the custom formatting options available using the `FORMAT` function, please take a look at `https://tinyurl.com/pbiqs-format`.

Now, let's take a look at the `DATEDIFF` function and how to implement conditional logic with the `IF` function in DAX.

Age calculation

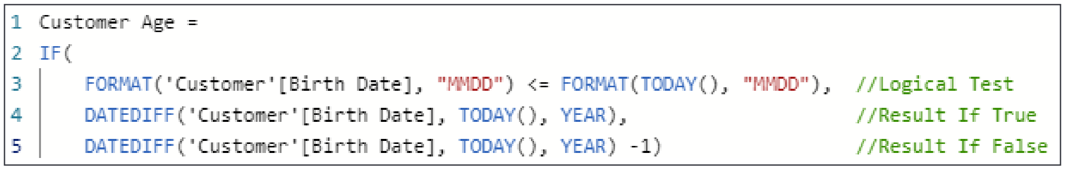
Next, you are going to determine each customer's age. The `Customer` table currently contains a column with the birth date for each customer. This column, along with the `TODAY` function and some DAX, will allow you to determine each customer's age. Your first attempt at this calculation may be to use the `DATEDIFF` function in a calculation that looks something like the following:

```
Customer Age = DATEDIFF('Customer'[Birth Date], TODAY(), YEAR)
```

The `TODAY` function returns the current date and time. The `DATEDIFF` function returns the count of the specified interval between two dates; however, it does not look at the day and month and therefore does not always return the correct age for each customer.

Let's rewrite the previous DAX formula in a different way. In this example, you are going to learn how to use conditional logic and the `FORMAT` function to return the proper Customer Age. Please keep in mind that there are many ways to perform this calculation.

Select the **Customer Age** column from the previous step and rewrite the formula to look like *Figure 4.8*:



```
Customer Age =
IF(
    FORMAT('Customer'[Birth Date], "MMDD") <= FORMAT(TODAY(), "MMDD"),   //Logical Test
    DATEDIFF('Customer'[Birth Date], TODAY(), YEAR),                     //Result If True
    DATEDIFF('Customer'[Birth Date], TODAY(), YEAR) -1)                  //Result If False
```

Figure 4.8: Customer Age calculation column

Formatting code is very important for readability and maintaining code. Power BI Desktop has built-in functionality to help out with code formatting. When you type *Shift* + *Enter* to navigate down to the next line in your formula bar, your code will be indented automatically where applicable.

When completed, the preceding code returns the correct age for each customer. The `FORMAT` function is used to return the two-digit month and two-digit day for each date (the Birth Date and `TODAY`'s date). Following the logical test portion of the `IF` statement are two expressions. The first expression is triggered if the logical test evaluates to `true`, and the second expression is triggered if the result of the test is `false`. Therefore, if the customer's month and day combo is less than or equal to today's month and day, then their birthday has already occurred this year, and the logical test will evaluate to `true`, which will trigger the first expression. If the customer's birthday has not yet occurred this year, then the second expression will execute.

In the preceding DAX formula, comments were added by using two forward slashes in the code. Comments are descriptive and are not executed with the rest of the DAX formula. Commenting code is always encouraged and will make your code more readable and easier to maintain.

In this example, you learned how to implement conditional logic with the `IF` function. Now let's look at the `SWITCH` function, which can be used as an alternative method to `IF`.

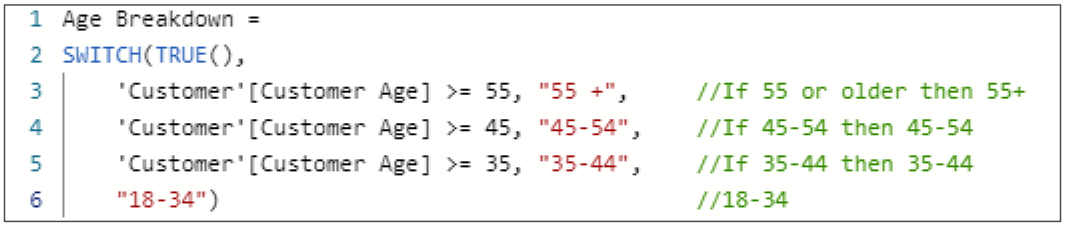
SWITCH() – age breakdown

Now that you have the customer's age, it's time to put each customer into an age bucket. For this example, there will be four separate age buckets:

- 18-34
- 35-44
- 45-54
- 55+

The `SWITCH` function is preferable to the `IF` function when performing multiple logical tests in a single DAX formula. This is because the `SWITCH` function is easier to read and makes debugging code much easier.

With the **Customer** table selected, click **New Column** from the **Modeling** ribbon. Type in the completed DAX formula as seen in *Figure 4.9*:



```
Age Breakdown =
SWITCH(TRUE(),
    'Customer'[Customer Age] >= 55, "55 +",     //If 55 or older then 55+
    'Customer'[Customer Age] >= 45, "45-54",    //If 45-54 then 45-54
    'Customer'[Customer Age] >= 35, "35-44",    //If 35-44 then 35-44
    "18-34")                                    //18-34
```

Figure 4.9: Conditional logic with SWITCH

The preceding formula is very readable and understandable. There are three logical tests, and if a customer age does not evaluate to `true` on any of those logical tests, then that customer is automatically put into the `18-34` age bucket.

The astute reader may have noticed that the second and third logical tests do not have an upper range assigned. For example, the second test simply checks whether the customer's age is `45` or greater. Naturally, you may assume that a customer whose age is `75` would be incorrectly assigned to the `45-54` age bucket. However, once a row evaluates to `true`, it is no longer available for subsequent logical tests. Someone who is `75` would have evaluated to `true` on the first logical test (`55+`) and would no longer be available for any further tests.

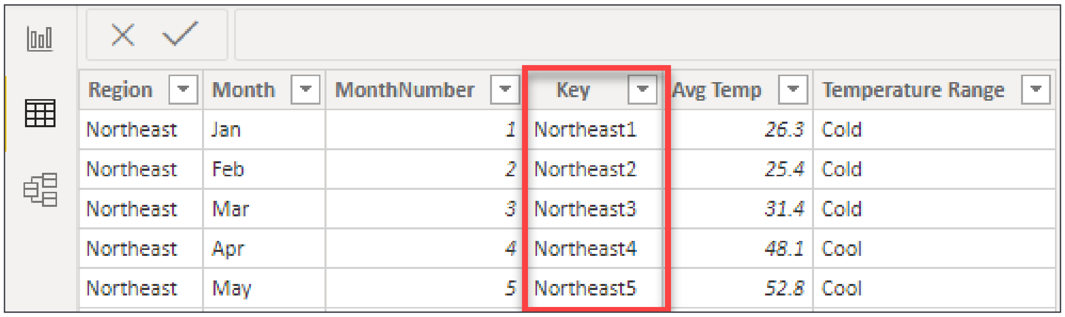
> If you would like a better understanding of using the `SWITCH` statement instead of nesting multiple `IF` statements, then you can check out a blog post by Rob Collie at `https://tinyurl.com/pbiqs-switch`.

Let's take a look at another important task in DAX: retrieving data from a column in another table. In Excel, you would just use the vlookup function, and in SQL, you would use a join. In DAX, you use navigation functions to retrieve this data.

Navigation functions – RELATED

It's finally time to create a relationship between the `Temperature` table and the `Internet Sales` table. The key on the `Temperature` table is a combination of the region name and the month number of the year.

This column combination makes a single row unique in this table, as shown here, in *Figure 4.10*:



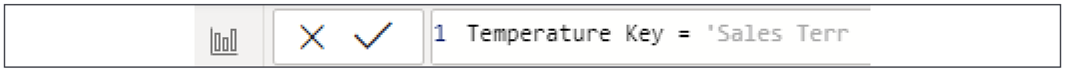
Region	Month	MonthNumber	Key	Avg Temp	Temperature Range
Northeast	Jan	1	Northeast1	26.3	Cold
Northeast	Feb	2	Northeast2	25.4	Cold
Northeast	Mar	3	Northeast3	31.4	Cold
Northeast	Apr	4	Northeast4	48.1	Cool
Northeast	May	5	Northeast5	52.8	Cool

Figure 4.10: Column combination that makes a single row unique

Unfortunately, neither of those two columns currently exists in the `Internet Sales` table. However, the `Internet Sales` table has a relationship with the `Sales Territory` table, and the `Sales Territory` table has the region. Therefore, you can determine the region for each sale by doing a simple `lookup` operation. Well, it should be that simple, but it's not quite that easy. Let's take a look at why.

Calculated columns do not automatically use the existing relationships in the data model. Calculated measures automatically see and interact with all relationships in the data model. Now let's take a look at why this is important.

In the following screenshot, I have created a new column in the `Internet Sales` table and I am trying to return the region name from the `Sales Territory` table. Take a look at *Figure 4.11*:

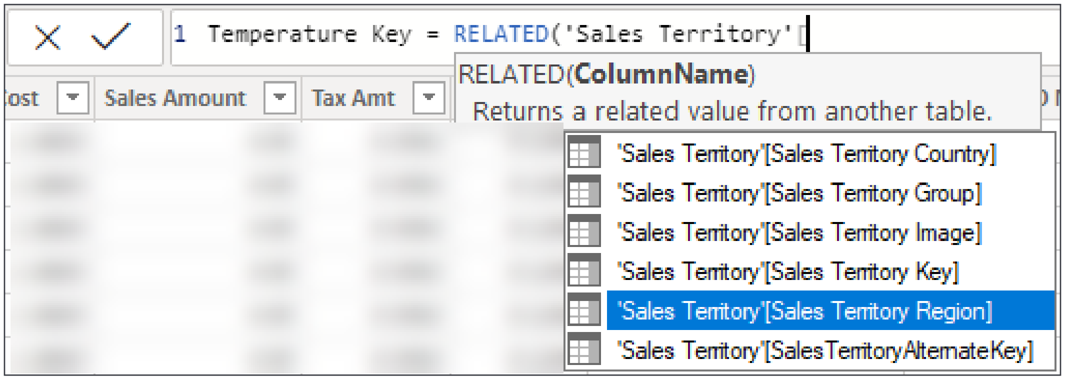


```
Temperature Key = 'Sales Terr
```

Figure 4.11: Sales Territory table

Note that there is no IntelliSense and that the autocomplete functionality is unavailable as I type in `Sales Territory`. The reason for this is the calculated column creates a row context and by default does not use the existing relationships in the data model. There is a much more complicated explanation behind all this, but for now, suffice to say that navigation functions (`RELATED` and `RELATEDTABLE`) allow calculated columns to interact with and use existing relationships.

If I rewrite the following DAX formula with the `RELATED` function, then you will notice that IntelliSense has returned, along with the autocomplete functionality that was previously discussed. The IntelliSense can be seen in *Figure 4.12*:



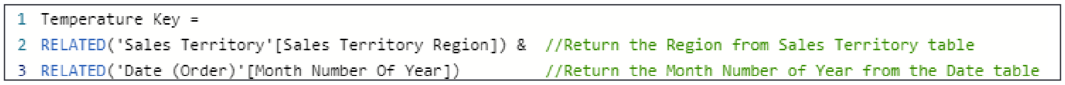
```
Temperature Key = RELATED('Sales Territory'[
```

RELATED(**ColumnName**)
Returns a related value from another table.

'Sales Territory'[Sales Territory Country]
'Sales Territory'[Sales Territory Group]
'Sales Territory'[Sales Territory Image]
'Sales Territory'[Sales Territory Key]
'Sales Territory'[Sales Territory Region]
'Sales Territory'[SalesTerritoryAlternateKey]

Figure 4.12: Temperature Key column

Now it's time to create a `Temperature Key` column on the `Internet Sales` table. Create a new column on the `Internet Sales` table and then type in the DAX formula seen in *Figure 4.13*:



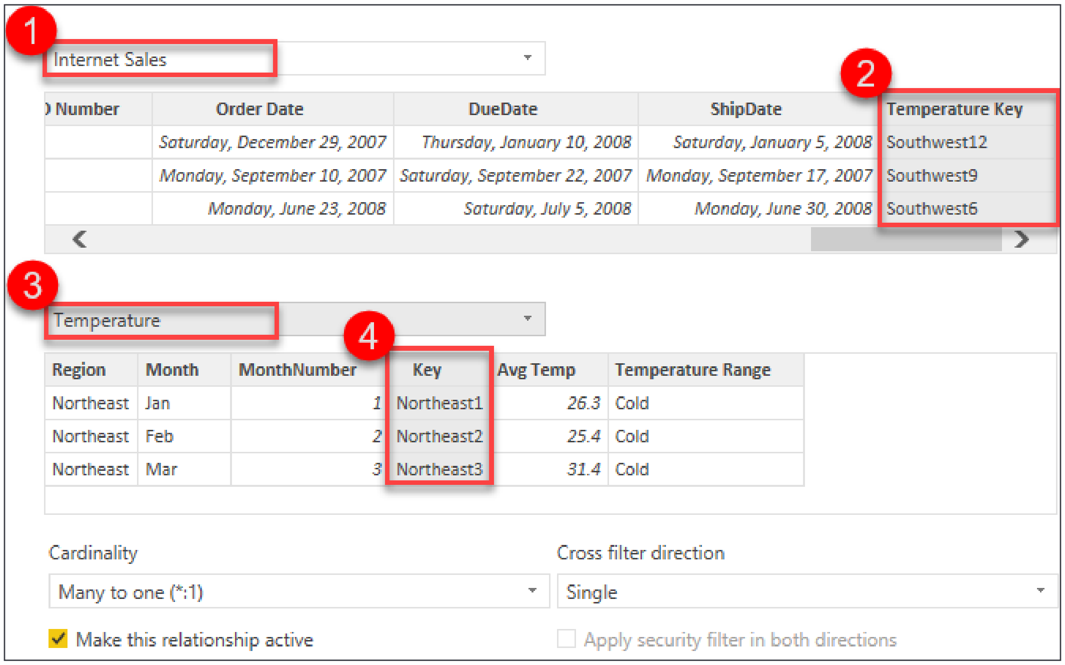
```
Temperature Key =
RELATED('Sales Territory'[Sales Territory Region]) &  //Return the Region from Sales Territory table
RELATED('Date (Order)'[Month Number Of Year])         //Return the Month Number of Year from the Date table
```

Figure 4.13: Temperature Key column of the Internet Sales table

Now that the `Temperature Key` column has been created in the `Internet Sales` table, let's create the relationship. Click **Manage Relationships** from the **Home** ribbon and then click **New...** to open the **Relationship editor** window. Then complete the following steps to create a new relationship. See the numbered items in *Figure 4.14*:

1. Select **Internet Sales** from the first drop-down selection list.
2. Select **Temperature Key** from the list of columns (scroll right).
3. Select **Temperature** from the second drop-down selection list.
4. Select **Key** from the list of columns.

5. Click **OK** to save your new relationship:



Internet Sales

) Number	Order Date	DueDate	ShipDate	Temperature Key
	Saturday, December 29, 2007	Thursday, January 10, 2008	Saturday, January 5, 2008	Southwest12
	Monday, September 10, 2007	Saturday, September 22, 2007	Monday, September 17, 2007	Southwest9
	Monday, June 23, 2008	Saturday, July 5, 2008	Monday, June 30, 2008	Southwest6

Temperature

Region	Month	MonthNumber	Key	Avg Temp	Temperature Range
Northeast	Jan	1	Northeast1	26.3	Cold
Northeast	Feb	2	Northeast2	25.4	Cold
Northeast	Mar	3	Northeast3	31.4	Cold

Cardinality: Many to one (*:1)

Cross filter direction: Single

✓ Make this relationship active

☐ Apply security filter in both directions

Figure 4.14: Creating a new relationship

So far in this chapter, you have learned how to create calculated columns on tables. These calculated columns increase the analytical capabilities of your data models by adding columns that can be leveraged to describe your metrics. You also learned how to create a concatenated key column in order to build a relationship between the `Temperature` and `Internet Sales` table. In the next section, you are going to learn how to use DAX to create calculated measures.

Calculated measures – the basics

Calculated measures are very different than calculated columns. Calculated measures are not static, and operate within the current filter context of a report; therefore, calculated measures are dynamic and ever-changing as the filter context changes. You were introduced to filter context in the previous chapter. The concept of the filter context will be slightly expanded on later in this chapter. Calculated measures are powerful analytical tools, and because of the automatic way that measures work with filter contexts, they are surprisingly simple to author.

Before you start learning about creating measures, let's first discuss the difference between implicit and explicit measures.

Implicit aggregations occur automatically on columns with numeric data types. You saw this in the previous chapter when the month number column was incorrectly aggregated after being added to a report. There are some advantages to this default behavior—for example, if you simply drag the `Sales Amount` column into a report, the value will be automatically aggregated and you won't have to spend time creating a measure. As discussed in the next section, it is generally considered a best practice to create explicit measures in lieu of implicit measures.

An explicit measure allows a user to create a calculated measure, and there are several benefits to using explicit measures:

- Measures can be built on each other.
- They encapsulate code, making logic changes less time-consuming.
- They centrally define number formatting, creating consistency.

Calculated measures can do the following:

- They can be assigned to any table and further assigned to folders within that table.
- They interact with all the relationships in the data model automatically, unlike calculated columns.
- They are not materialized in a column, and therefore cannot be validated in the **Data View**.

Now that you know what calculated measures are, let's take a look at how to create them.

Calculated measures – basic aggregations

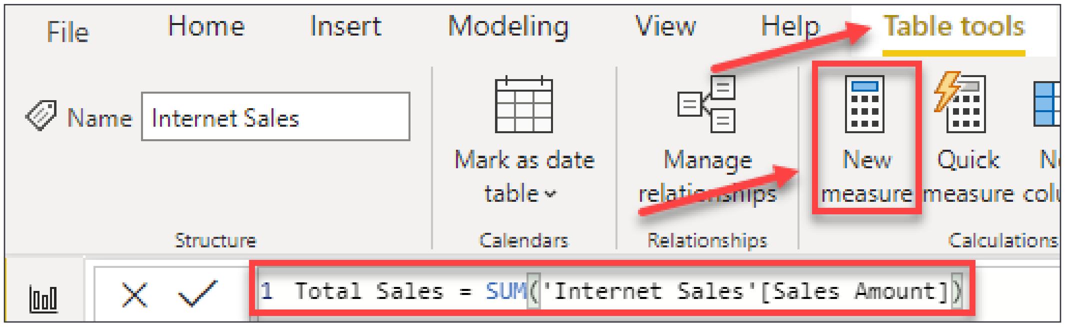
In this section, you are going to create four simple calculated measures. These calculated measures will create additional metrics that can be used in visualizations and reports to obtain deeper insights from your data:

- Total Sales
- Total Cost
- Profit
- Profit Margin

First, let's start by creating the `Total Sales` calculation.

Total Sales

To create your first measure, select the **Internet Sales** table and then click **New Measure...** from the **Table Tools** ribbon. See *Figure 4.15*:

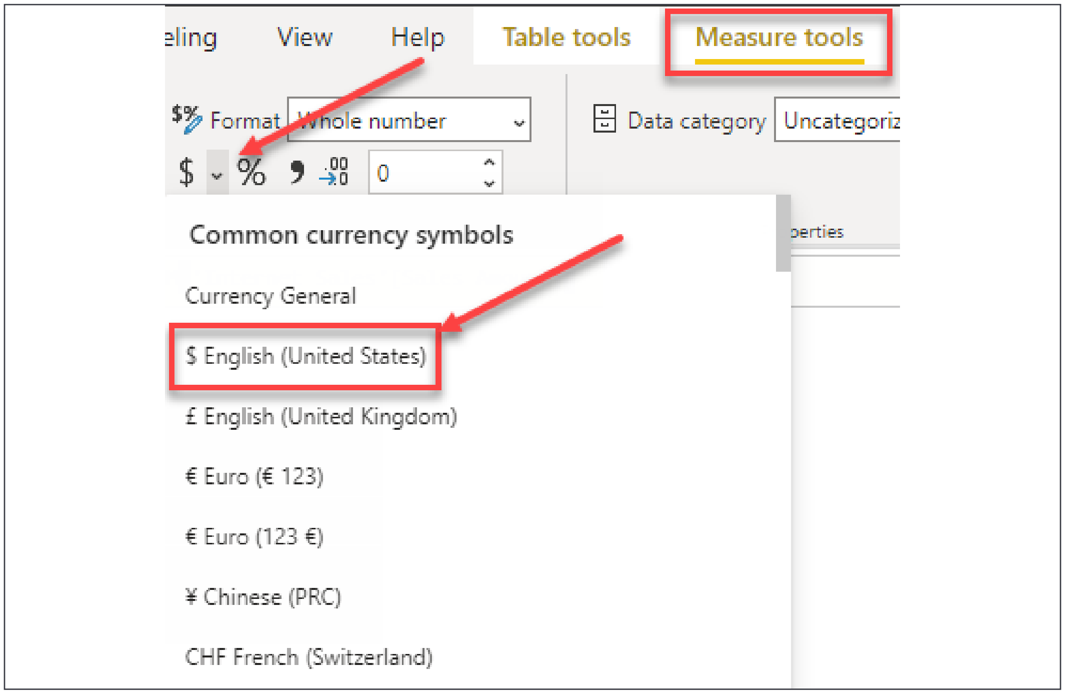


Name: Internet Sales

```
Total Sales = SUM('Internet Sales'[Sales Amount])
```

Figure 4.15: Create a Total Sales measure

One of the benefits of creating explicit measures is the ability to centralize formatting. Once the measure has been created, navigate to the **Measure tools** ribbon and change the formatting to **$ English (United States)**, as shown in *Figure 4.16*:



Format: Whole number

Figure 4.16: Change formatting to $ English (United States)

You just created your first calculated measure! It was simple, and, you will soon learn, extremely powerful. The total sales calculation is the sum of the sales amount, however, another way to read that calculation is the sum of the sales amount within the current filter context. You learned about filter context in the previous chapter and it will be further discussed later in this chapter, but for now, just know these seemingly simple calculations are very dynamic. Let's create some more calculated measures.

Total Cost

Now let's create the `Total Cost` measure. Once again, this is a simple `SUM` operation. Select the **Internet Sales** table, then click **New Measure...** from the **Measure tools** ribbon and type in the following DAX formula:

```
Total Cost = SUM('Internet Sales'[Total Product Cost])
```

Remember to apply formatting to this new measure; it is easy to miss this step when learning to create measures. The formatting should be **$English (United States)**.

Profit

`Profit` is the next measure you will create. You may attempt to write something such as the following:

```
Profit = SUM('Internet Sales'[Sales Amount]) - SUM('Internet
Sales'[Total Product Cost])
```

This calculation would be technically correct; however, it is not the most efficient way to write code. In fact, another benefit of building explicit measures is that they can be built on top of each other. Reusing existing calculated measures will make the code more readable, and make code changes easier and less time-consuming. Imagine for a moment that you discovered that the `Total Sales` calculation is not correct. If you encapsulated all this logic in a single measure and reused that measure in your other measures, then you need only change the original measure, and any updates will be pushed to all other measure references.

Now it is time to create the `Profit` measure. Select your **Internet Sales** table and then click on **New Measure...** from the **Measure tools** ribbon. Type the following into the formula bar—remember to apply formatting afterward:

```
Profit = [Total Sales] - [Total Cost]
```

This calculation returns the same results as the original attempt. The difference is that now you are reusing measures that were already created in the data model. You may have noticed that I referenced the name of the measure without the table name. When referencing explicit measures in your code, it is considered a best practice to exclude the table name.

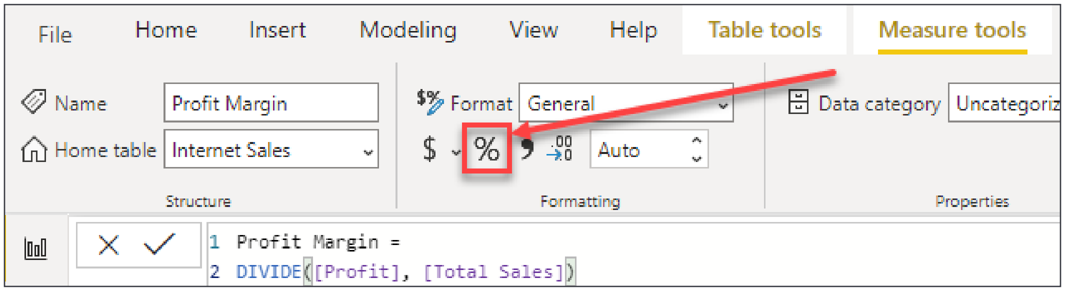
Profit Margin

Now it's time to create the `Profit Margin` calculation (the profit margin is simply (`profit/sales`). For this measure, you are going to use the `DIVIDE` function. The `DIVIDE` function is recommended over the divide operator (/) because the `DIVIDE` function automatically handles divide by zero occurrences. In the case of divide by zero occurrences, the `DIVIDE` function returns blank.

Create a new measure on the `Internet Sales` table using the following code:

```
Profit Margin = DIVIDE([Profit], [Total Sales])
```

Next, set the formatting as a percentage. From the **Modeling** ribbon, click on the % icon, as shown in *Figure 4.17*:



Name: Profit Margin
Home table: Internet Sales
Format: General
Auto
Data category: Uncategoriz

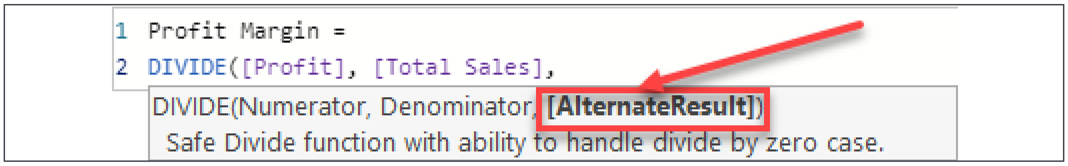
```
Profit Margin =
DIVIDE([Profit], [Total Sales])
```

Figure 4.17: Setting formatting as a percentage

Functions in DAX have required and optional parameters. So far, you have only learned about required parameters. Let's take a look at optional parameters.

Optional parameters

You may have noticed that the `DIVIDE` function accepted three parameters and you only provided two. The third parameter allows you to set an alternative result for divide by zero occurrences. This alternate result is optional. Optional parameters are denoted by square brackets on both sides of the parameter. These optional parameters are prevalent in many DAX functions. Take a look at *Figure 4.18*:



```
Profit Margin =
DIVIDE([Profit], [Total Sales],
```

DIVIDE(Numerator, Denominator, [AlternateResult])
Safe Divide function with ability to handle divide by zero case.

Figure 4.18: Optional parameters in DAX functions

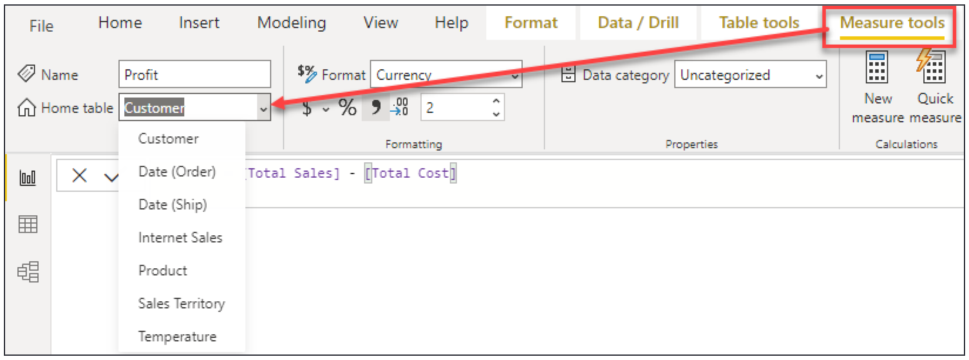
Optional parameters are very often overlooked by developers, but as you will learn, there is a lot of functionality and value that can be achieved by leveraging these parameters. Now, let's take a look at how and where to assign calculated measures.

Assignment of calculated measures

Unlike calculated columns, measures do not need to be assigned to a specific table to function properly. Because of this, it is very easy and common to forget to make sure the proper table is selected prior to creating a measure. This results in measures being assigned to random tables during development. Fortunately, you do not need to delete the measure and recreate it in the proper table, instead, you can simply move measures from one table to another by changing the **Home table**.

To move a calculated measure from one table to another, you will follow these steps, as you can see in *Figure 4.19*:

1. Select the measures.
2. Find the **Measure tools** ribbon.
3. Click the **Home table** dropdown and select the correct table:



Name: Profit
Home table: Customer
Format: Currency
Data category: Uncategorized
Decimal places: 2

Customer
Date (Order)
Date (Ship)
Internet Sales
Product
Sales Territory
Temperature

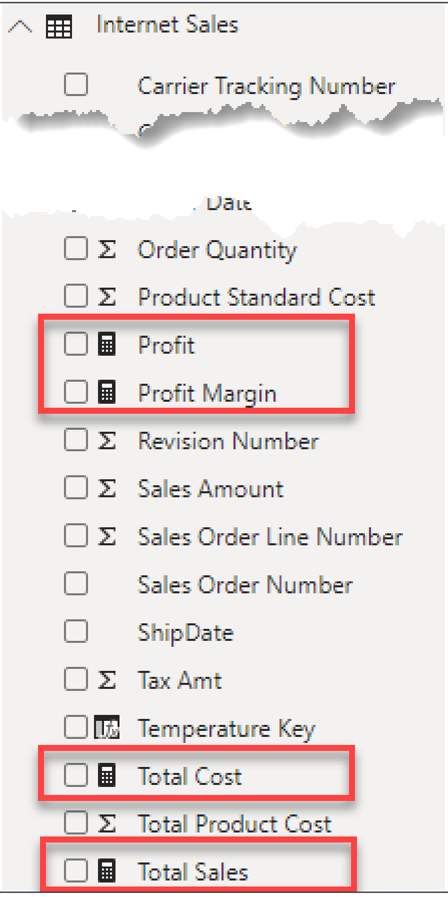
```
[Total Sales] - [Total Cost]
```

Figure 4.19: Moving a calculated measure to a new table

Calculated measures can be assigned to any table in your data model and will still function properly. However, measures should be assigned to the table where it logically makes the most sense. This way, the measure is easy to find and utilize in visualizations and reports. Let's take a look at how measures can be logically organized and grouped into folders.

Display folders

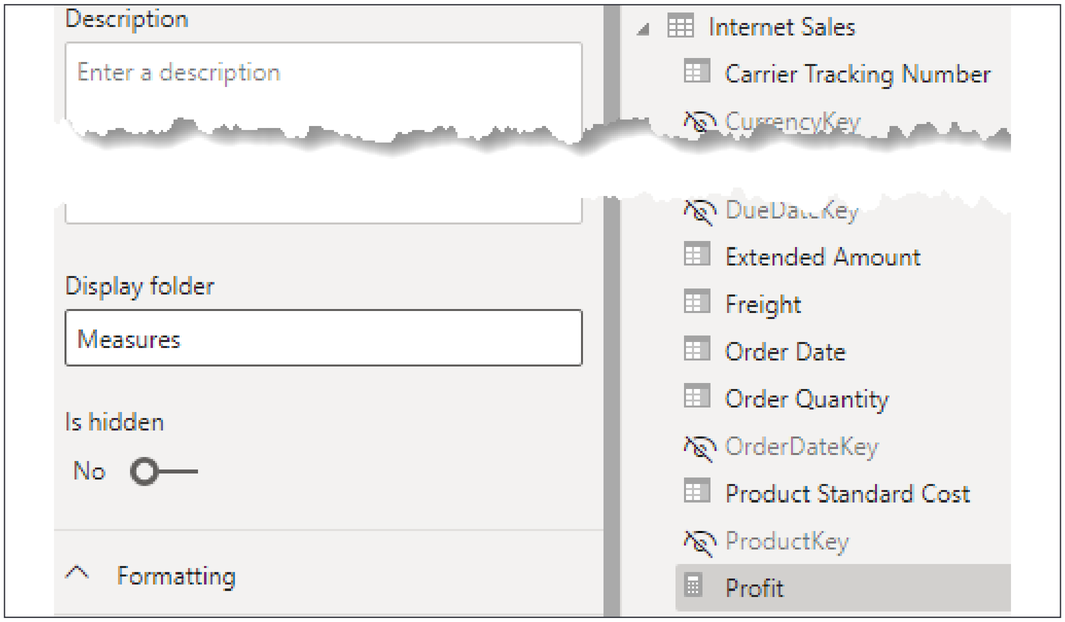
In Power BI, columns and measures can be assigned to folders. This is extremely useful for organizing related measures and improving the overall usability of the data model. By properly leveraging display folders, measures will be easier to find and similar measures, like time intelligence calculations, can be grouped in their own folder. As you can see in *Figure 4.20*, the newly created measures are mixed in with the existing columns:



Internet Sales
- Carrier Tracking Number
- Order Quantity
- Product Standard Cost
- Profit
- Profit Margin
- Revision Number
- Sales Amount
- Sales Order Line Number
- Sales Order Number
- ShipDate
- Tax Amt
- Temperature Key
- Total Cost
- Total Product Cost
- Total Sales

Figure 4.20: Calculated measures displayed in a table

At the time of writing, adding measures to display folders can only be accomplished from the **Model View**. Select **Model View** from the left navigation pane. Next, expand the **Internet Sales** table and select the **Profit** measure. Finally, in the **Properties** pane, find the **Display folder** property and type `Measures`. Take a look at *Figure 4.21*:



Description
Enter a description

Display folder
Measures

Is hidden
No

Formatting

Internet Sales
- Carrier Tracking Number
- CurrencyKey
- DueDateKey
- Extended Amount
- Freight
- Order Date
- Order Quantity
- OrderDateKey
- Product Standard Cost
- ProductKey
- Profit

Figure 4.21: Calculated measures displayed in a table

All of your measures can be moved to a display folder at one time. Simply multi-select the measures to be moved by holding down the *Ctrl* key while selecting each measure and then enter the folder name. See the completed example in *Figure 4.22*:

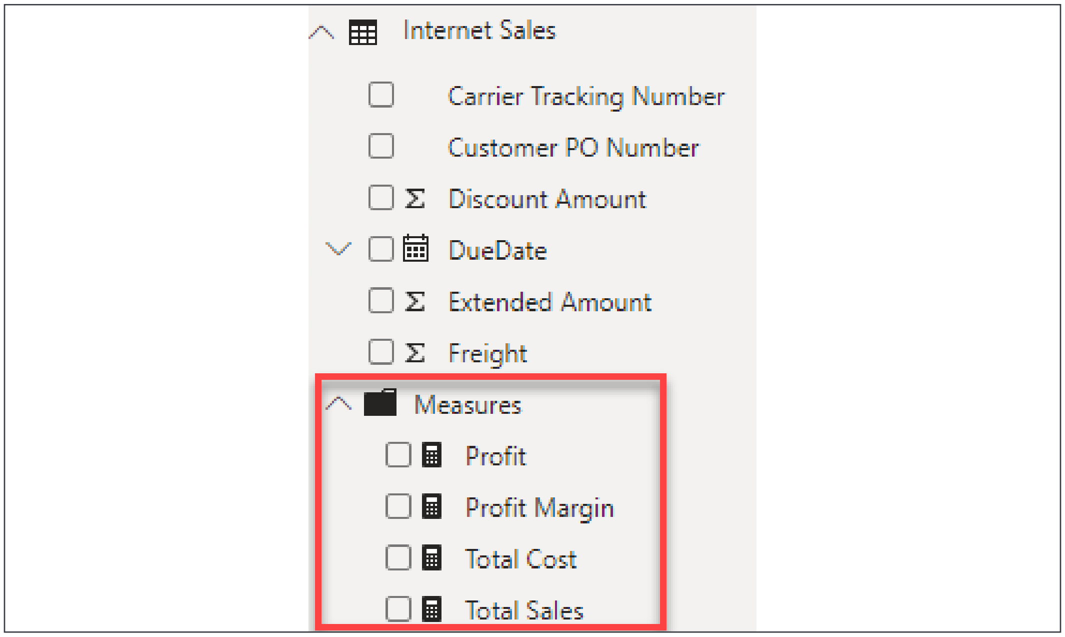


Figure 4.22: Calculated measures displayed in a table

Previously, we mentioned that these calculated measures are simple yet powerful. These measures are powerful because filtering in DAX occurs automatically. Let's take a deeper look at automatic filtering and filter context.

Filter context

The automatic filtering that occurs in Power BI is a really awesome feature and is one of the reasons that so many companies are gravitating to this tool. The active relationships that are defined in the data model, and that you learned how to create in the previous chapter, are automatically used by DAX to perform the automatic filtering of calculated measures. This is directly tied to the concept of the filter context. You were introduced to the filter context in the previous chapter. I want to briefly expand on the previous chapter here before discussing the `CALCULATE` function.

A simple definition of the filter context would be that it is simply anything in your report that is filtering a measure. There are quite a few items that make up the filter context. Let's take a look at a few of them:

- Any attributes on the rows; this includes the different axes in charts.
- Any attributes on the columns.

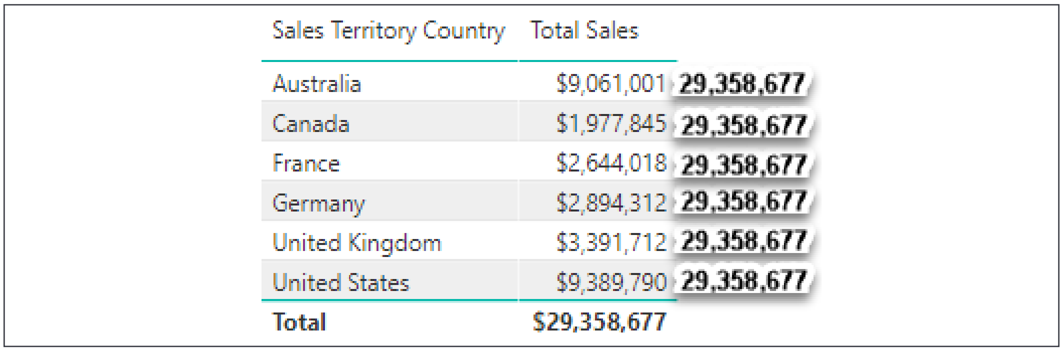
- Any filters applied by slicers (visual filters); slicers are discussed in the next chapter.
- Any filters applied explicitly through the **Filters** pane.
- Any filters explicitly added to a calculated measure

In short, the filter context makes the authoring of calculated measures a simple and intuitive process. A simple total sales calculation can be automatically filtered by all the tables in your data model without having to write any additional logic into your calculated measures. If you want to see total sales by customer, product name, product weight, country, or any other number of columns in your data model, simply add that column to your report and your measure is *auto-magically* filtered thanks to the active relationships!

Calculate

The `CALCULATE` function is an extremely powerful tool in the arsenal of any DAX author. In fact, the `CALCULATE` function is the single most important function in all of DAX. This is because the `CALCULATE` function can be used to ignore, overwrite, or change the existing filter context. You may be asking yourself why—why would anyone want to ignore the default behavior of Power BI? Let's take a look at an example.

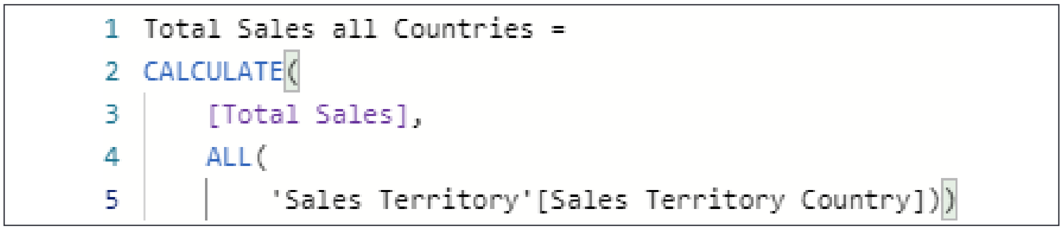
Let's assume you want to return the total sales of each country as a percentage of all countries. This is a very basic percentage of total calculation: `Total Sales` per country divided by `Total Sales` for all countries. However, how do you get the total sales of all the countries so that you can perform this calculation? This is where the `CALCULATE` function comes into the picture. Take a look at *Figure 4.23*:



Sales Territory Country	Total Sales	
Australia	$9,061,001	29,358,677
Canada	$1,977,845	29,358,677
France	$2,644,018	29,358,677
Germany	$2,894,312	29,358,677
United Kingdom	$3,391,712	29,358,677
United States	$9,389,790	29,358,677
Total	**$29,358,677**	

Figure 4.23: Calculating the total sales of all the countries

To do the percentage of total calculation, you first need the `Total Sales all Countries` on the same row as `Total Sales`. Therefore, you need to create a new calculated measure that ignores any filters that come from the `Country` attribute. Create a new calculated measure on your `Internet Sales` table using the following DAX formula:



```
Total Sales all Countries =
CALCULATE(
    [Total Sales],
    ALL(
        'Sales Territory'[Sales Territory Country]))
```

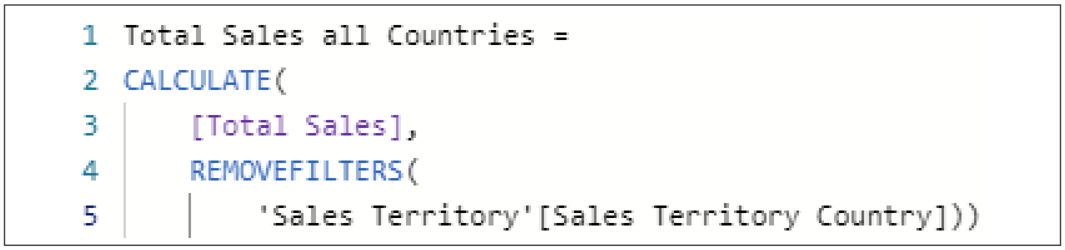
Figure 4.24: Use CALCULATE to ignore filters from Country

The calculation in *Figure 4.24* will return all sales for all countries, explicitly ignoring any filters that come from the `Country` column. Let's briefly discuss how and why this works.

The first parameter of the `CALCULATE` function is an expression, and you can think of this as an aggregation of some kind. In this example, the aggregation is simply `Total Sales`. The second parameter is a filter that allows the current filter context to be modified in some way. In the preceding example, the filter context is modified by *ignoring any filters* that come from the `Country` attribute. Let's take a look at the definition for the `ALL` function used in the second parameter of the `CALCULATE` function:

`ALL`: Returns all the rows in a table, or all the values in a column, *ignoring any filters* that may have been applied.

Alternatively, the `REMOVEFILTERS` function can be used instead of `ALL` to achieve the same results. For this example, these functions can be used interchangeably. I find that most developers new to DAX find `REMOVEFILTERS` a bit easier to understand. Modify the measure created in the last step, `Total Sales all Countries`, to use `REMOVEFILTERS` instead of the `ALL` function, as you can see in *Figure 4.25*:



```
Total Sales all Countries =
CALCULATE(
    [Total Sales],
    REMOVEFILTERS(
        'Sales Territory'[Sales Territory Country]))
```

Figure 4.25: Replace the ALL function with REMOVEFILTERS

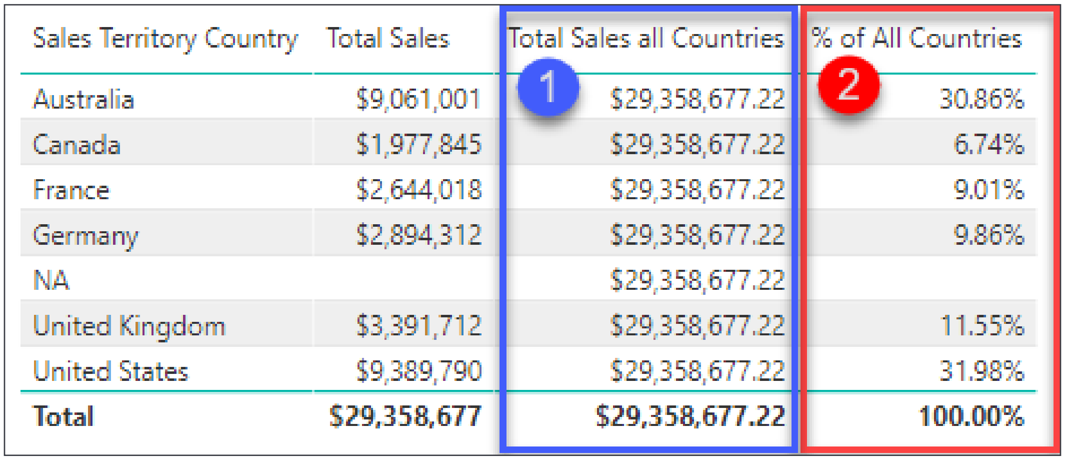
The most difficult challenge to creating our percentage of total calculation in DAX is creating the total sales for all countries. With this calculated measure completed, let's complete the percentage of total calculation.

The percentage of total calculation

Now, create another calculated measure on the `Internet Sales` table using the following code. Make sure that you format the measure as a percentage:

```
% of All Countries = DIVIDE([Total Sales], [Total Sales all Countries])
```

In *Figure 4.26*, you can see the completed example with both of the new measures created in this section. Without a basic understanding of the `CALCULATE` function, this type of percentage of total calculation would be nearly impossible:



Sales Territory Country	Total Sales	Total Sales all Countries	% of All Countries
Australia	$9,061,001	$29,358,677.22	30.86%
Canada	$1,977,845	$29,358,677.22	6.74%
France	$2,644,018	$29,358,677.22	9.01%
Germany	$2,894,312	$29,358,677.22	9.86%
NA		$29,358,677.22	
United Kingdom	$3,391,712	$29,358,677.22	11.55%
United States	$9,389,790	$29,358,677.22	31.98%
Total	**$29,358,677**	**$29,358,677.22**	**100.00%**

Figure 4.26: Completed example with new measures

Time intelligence

Another advantage of Power BI is how easily time intelligence can be added to your data model. DAX has a comprehensive list of built-in time intelligence functions that can be easily leveraged and add significant analytical value to your data model. In this section, you are going to learn how to use these built-in functions to create the following measures:

- Year to Date Sales
- Year to Date Sales (Fiscal Calendar)
- Prior Year Sales

Take a look at the alternative methods for calculating time intelligence in the DAX cheat sheet at `https://tinyurl.com/pbiqs-daxcheatsheet`.

In order to leverage time intelligence functions in DAX, you must have a date table in your data model and that date table must have all available dates with no gaps. These are very important conditions that must be met. Oftentimes, developers try to use the date column from their transaction table (fact table). This can result in calculations that do not work and return incorrect results. In the previous chapter, you learned how to properly build a relationship from your date table to your fact table and multiple methods for marking your date table as a date table. Now that we have added some clarity here, let's create a year to date sales calculation.

YTD Sales

Create a new calculated measure on your `Internet Sales` table using the following DAX formula. Remember to format the measure as `$English (United States)`:

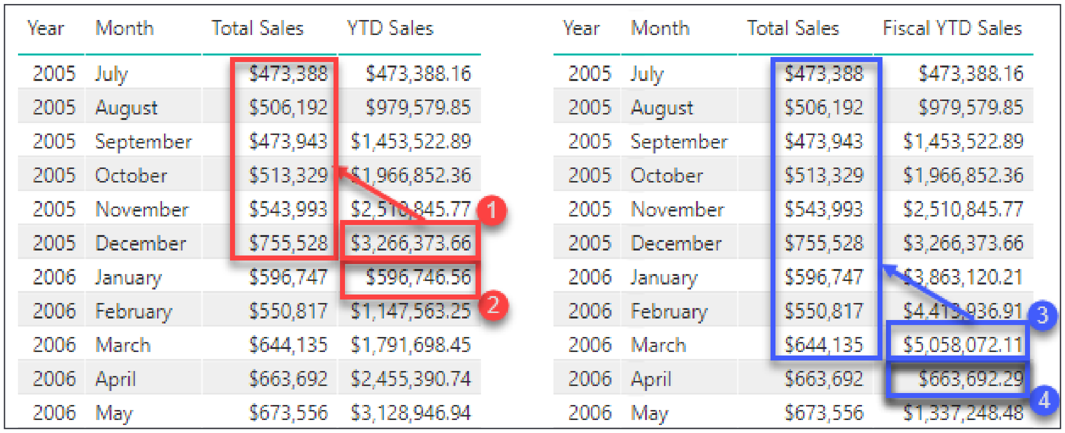
```
YTD Sales = TOTALYTD([Total Sales], 'Date (Order)'[Date])
```

YTD Sales (fiscal calendar)

Maybe your requirement is slightly more complex, and you need to see the year to date sales based on your fiscal year end rather than the calendar year-end date. The `TOTALYTD` function has an optional parameter that allows you to change the default year-end date from `12/31` to a different date. Create a new calculated measure on your `Internet Sales` table using the following DAX formula:

```
Fiscal YTD Sales = TOTALYTD([Total Sales], 'Date (Order)'[Date],
"03/31")
```

Now, let's take a look at both of these new measures in a table in Power BI:



Year	Month	Total Sales	YTD Sales
2005	July	$473,388	$473,388.16
2005	August	$506,192	$979,579.85
2005	September	$473,943	$1,453,522.89
2005	October	$513,329	$1,966,852.36
2005	November	$543,993	$2,510,845.77
2005	December	$755,528	$3,266,373.66
2006	January	$596,747	$596,746.56
2006	February	$550,817	$1,147,563.25
2006	March	$644,135	$1,791,698.45
2006	April	$663,692	$2,455,390.74
2006	May	$673,556	$3,128,946.94

Year	Month	Total Sales	Fiscal YTD Sales
2005	July	$473,388	$473,388.16
2005	August	$506,192	$979,579.85
2005	September	$473,943	$1,453,522.89
2005	October	$513,329	$1,966,852.36
2005	November	$543,993	$2,510,845.77
2005	December	$755,528	$3,266,373.66
2006	January	$596,747	$3,863,120.21
2006	February	$550,817	$4,413,936.91
2006	March	$644,135	$5,058,072.11
2006	April	$663,692	$663,692.29
2006	May	$673,556	$1,337,248.48

Figure 4.27: Comparing YTD Sales with Fiscal YTD Sales

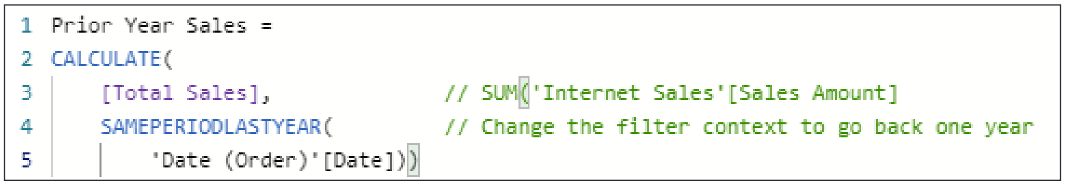
The newly created measures `YTD Sales` and `Fiscal YTD Sales` have both been added to the preceding table. Let's take a closer look at how these two measures are different; the relevant sections in the table are annotated with the numbers one to four, corresponding to the following notes:

1. The amount displayed for `December 2005` is `$3,266,374`. This is the cumulative total of all sales from `January 1, 2005` to `December 31, 2005`.
2. As expected, the cumulative total starts over as the year switches from `2005` to `2006`; therefore, the `YTD Sales` amount for `January 2006` is `$596,747`.
3. In the `Fiscal YTD Sales` column, the cumulative total works slightly differently. The displayed amount of `$5,058,072` is the cumulative total of all sales from `April 1, 2005` to `March 31, 2006`.
4. Unlike the `YTD Sales` measure, the `Fiscal YTD Sales` measure does not start over until `April 1`. The amount displayed for `April 2006` of `$663,692` is the cumulative total for `April`. This number will grow each month until `May 31`, at which point the number will reset again.

Prior Year Sales

A lot of time series analysis consists of comparing current metrics to the previous month or the previous year. There are many functions in DAX that work in conjunction with the `CALCULATE` function to make these types of calculations possible. In this section, you are going to create a new measure to return the total sales for the prior year.

Using *Figure 4.28* as a reference, create a new calculated measure on your `Internet Sales` table for `Prior Year Sales`:



```
Prior Year Sales =
CALCULATE(
    [Total Sales],              // SUM('Internet Sales'[Sales Amount]
    SAMEPERIODLASTYEAR(         // Change the filter context to go back one year
        'Date (Order)'[Date]))
```

Figure 4.28: Create a Prior Year Sales calculation

`CALCULATE` allows you to ignore or even change the current filter context. In the preceding formula, `CALCULATE` is used to take the current filter context and modify it to one year prior. This calculated measure also works at the day, month, quarter, and year level of the hierarchy. For example, if you were looking at sales for `June 15, 2020`, then the `Prior Year Sales` measure would return sales for `June 15, 2019`. However, if you were simply analyzing your sales aggregated at the month level for `June 2020`, then the measure would return the sales for `June 2019`.

For a comprehensive list of all the built-in time intelligence functions, please take a look at `https://tinyurl.com/pbiqs-timeintelligence`.

In this section, you learned how to add time series analysis to your data model, adding significant analytical value and allowing you to extract valuable insights from your data across time. In other programming languages, it would take significant amounts of code and an in-depth validation process to perform the same calculations that can be achieved in DAX with minimal effort.

Role-playing tables with DAX

In *Chapter 3*, *Building the Data Model*, you learned how to develop your data model to deal with role-playing tables, by importing a table multiple times. We mentioned then that there was an alternative method using DAX. In this section, we will explore this alternative method and the pros and cons of using DAX versus the method you have previously learned.

Since leveraging DAX does not require importing a table multiple times, you will immediately gain savings on storage and, unlike the other method, with DAX you will not need to manage multiple tables in Power BI Desktop.

The DAX method requires that inactive relationships be created in order to work correctly. Inactive relationships are not often used in DAX because they are not used automatically like active relationships. Unlike active relationships, you can have more than one inactive relationship between two tables.

Let's create a new relationship between the `Internet Sales` table and the `Date (Order)` table. First, open the relationship editor by referring to *Figure 4.29* and the steps following:

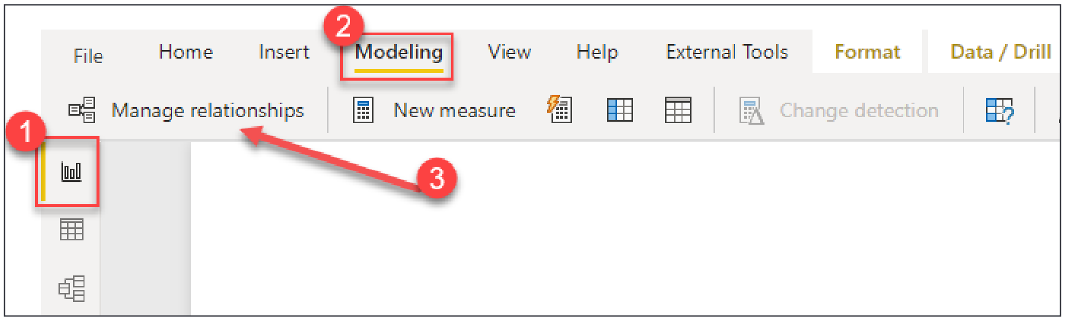
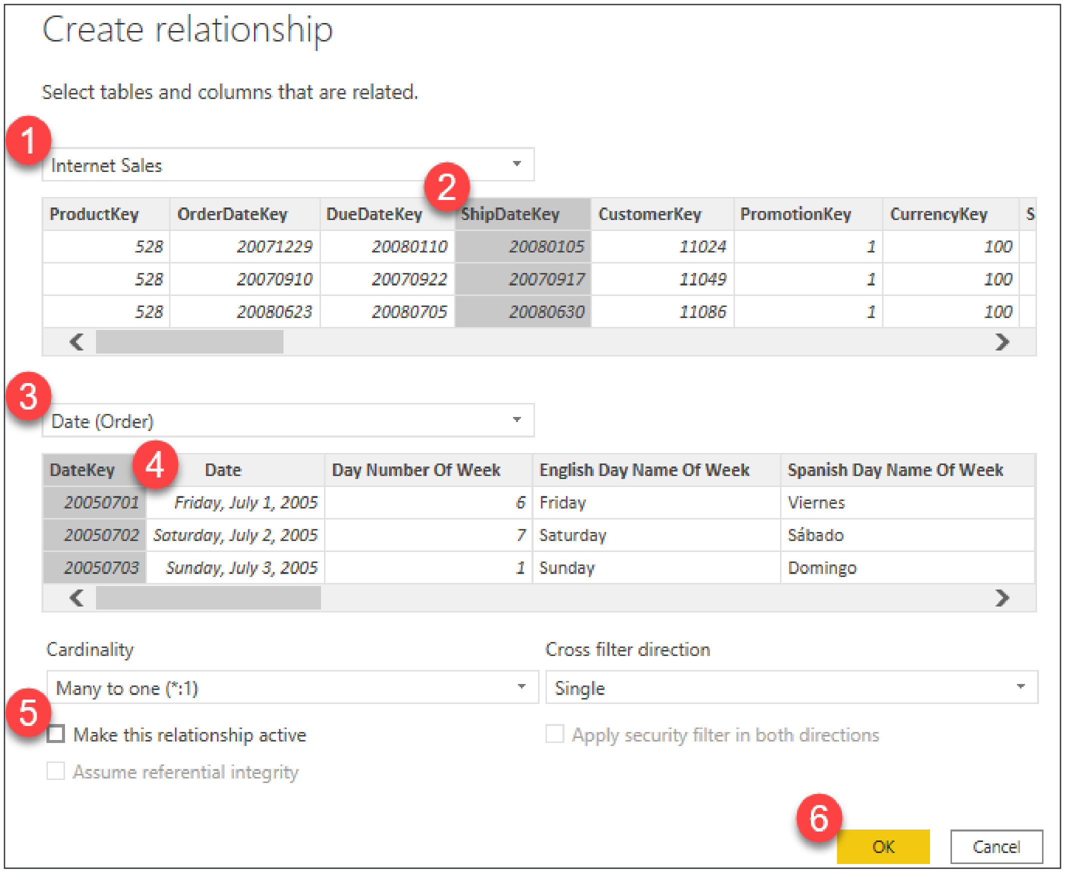


Figure 4.29: Launch the Manage relationships dialog box

1. Navigate to the **Report View**.
2. Select the **Modeling** ribbon across the top of Power BI Desktop.
3. Click **Manage relationships**.

Once the **Manage relationships** box appears, click on **New…** to create a new relationship. Continue creating the relationship with the steps by referring to *Figure 4.30* and the steps following:



Create relationship

Select tables and columns that are related.

Internet Sales

ProductKey	OrderDateKey	DueDateKey	ShipDateKey	CustomerKey	PromotionKey	CurrencyKey	S
528	20071229	20080110	20080105	11024	1	100	
528	20070910	20070922	20070917	11049	1	100	
528	20080623	20080705	20080630	11086	1	100	

Date (Order)

DateKey	Date	Day Number Of Week	English Day Name Of Week	Spanish Day Name Of Week
20050701	Friday, July 1, 2005	6	Friday	Viernes
20050702	Saturday, July 2, 2005	7	Saturday	Sábado
20050703	Sunday, July 3, 2005	1	Sunday	Domingo

Cardinality: Many to one (*:1)

Cross filter direction: Single

☐ Make this relationship active

☐ Apply security filter in both directions

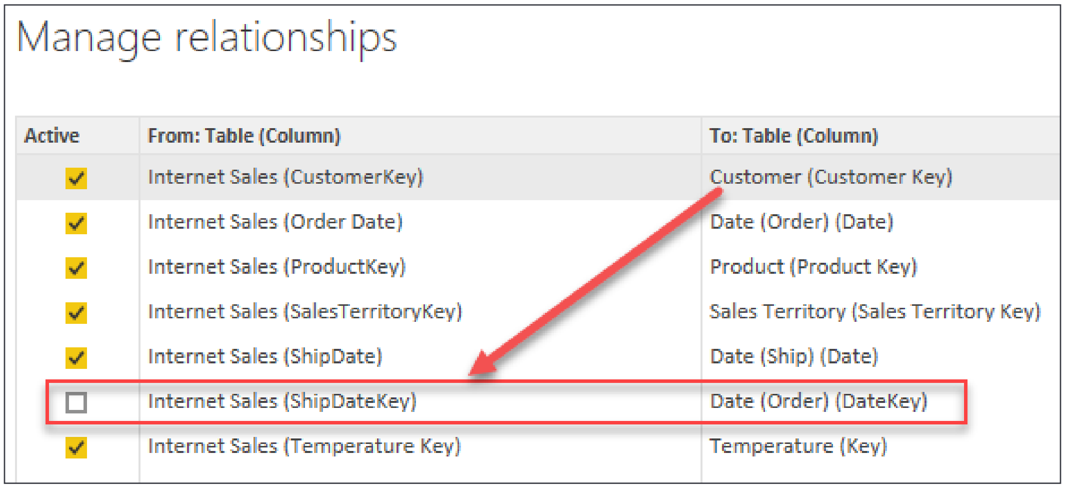
☐ Assume referential integrity

OK Cancel

Figure 4.30: Create the inactive relationship between Internet Sales and Date (Order)

1. Select **Internet Sales** from the drop-down menu.
2. Select the **ShipDateKey** column from the list of columns.
3. Select **Date (Order)** from the drop-down menu.
4. Select the **DateKey** column from the list of columns.
5. Do not select **Make this relationship active**.
6. Click **OK**.

The new relationship can be observed in *Figure 4.31*, which is a screenshot of the **Manage relationships** dialog box:

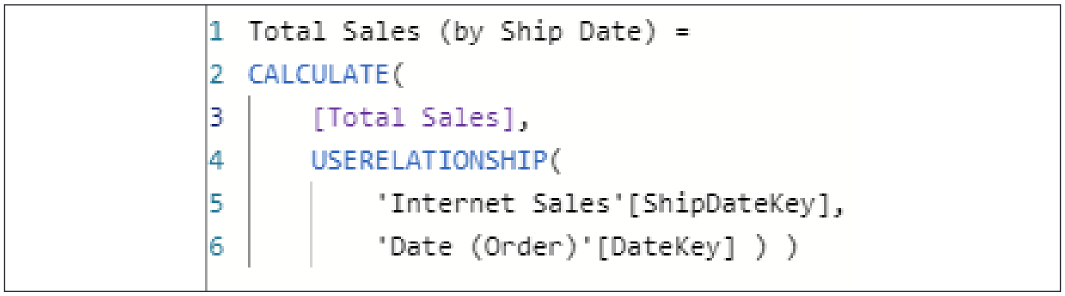


Manage relationships

Active	From: Table (Column)	To: Table (Column)
✓	Internet Sales (CustomerKey)	Customer (Customer Key)
✓	Internet Sales (Order Date)	Date (Order) (Date)
✓	Internet Sales (ProductKey)	Product (Product Key)
✓	Internet Sales (SalesTerritoryKey)	Sales Territory (Sales Territory Key)
✓	Internet Sales (ShipDate)	Date (Ship) (Date)
☐	Internet Sales (ShipDateKey)	Date (Order) (DateKey)
✓	Internet Sales (Temperature Key)	Temperature (Key)

Figure 4.31: New relationship between Internet Sales and Date (Order)

Now that the inactive relationship has been created, we can create the calculated measure to return `Total Sales` by `Ship Date`. The completed calculated measure can be seen in *Figure 4.32*:

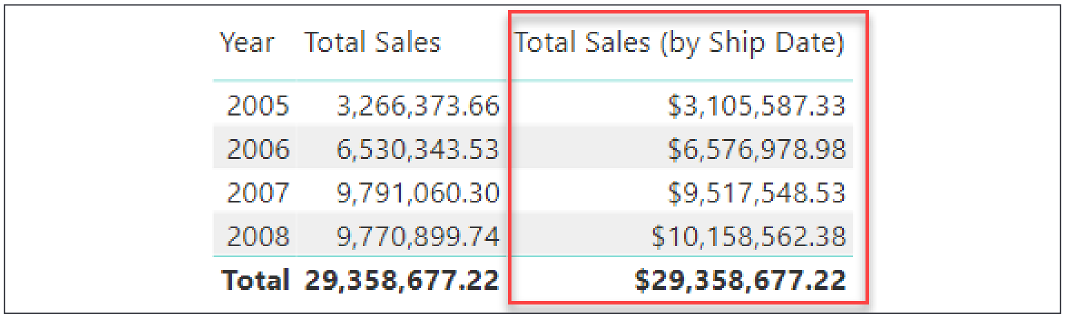


```
Total Sales (by Ship Date) =
CALCULATE(
    [Total Sales],
    USERELATIONSHIP(
        'Internet Sales'[ShipDateKey],
        'Date (Order)'[DateKey] ) )
```

Figure 4.32: New calculated measure

This measure will make use of two functions in DAX. First, the `CALCULATE` function is used here because the filter context is going to be modified to use the inactive relationship rather than the active relationship. Second, the `USERELATIONSHIP` function specifies that the `Internet Sales` table should be filtered by `ShipDateKey` rather than the active relationship on `OrderDateKey`.

The completed measure can be seen in *Figure 4.33* along with the original `Total Sales` calculation:



Year	Total Sales	Total Sales (by Ship Date)
2005	3,266,373.66	$3,105,587.33
2006	6,530,343.53	$6,576,978.98
2007	9,791,060.30	$9,517,548.53
2008	9,770,899.74	$10,158,562.38
Total	**29,358,677.22**	**$29,358,677.22**

Figure 4.33: Validating the new calculated measure

In *Figure 4.33*, the `Total Sales` measure is returning the total sales based on the active relationship in the data model, which is on `OrderDateKey`, therefore `$3,266,373` is returned for the year `2005`. Alternatively, the `Total Sales (by Ship Date)` measure is returning `$3,105,587` in sales.

This approach does not require importing additional tables and therefore is superior to the method you learned in *Chapter 3*, *Building the Data Model*, for optimizing space in your data model. However, with the DAX method, you would be required to create a new measure for every measure in your data model that you wanted to see by the `Ship Date`. Therefore if you had 50 measures in your table, you would create a new version of each of those measures and would specify that the new measure should use the inactive relationship on `ShipDateKey` rather than the current active relationship. Because of this reason alone, the method you learned in *Chapter 3*, *Building the Data Model*, is the most common approach to handling role-playing tables.

> With the addition of external tools and calculation groups, you can now create one measure to support role-playing tables! This makes the DAX method significantly easier to implement than ever before. Want to learn more? Check out the following YouTube video on this implementation: `https://tinyurl.com/RolePlayingTables`.

In this section, you learned an alternative method to provide support for role-playing tables in Power BI Desktop. This method has historically required significantly more development effort and therefore has not been as popular as the method you learned previously. However, by leveraging calculation groups, you can create a single measure that will support almost all your role-playing needs!

As we bring this chapter to a close, I feel it's necessary to mention that there are several developer-friendly tools that can help the DAX developer gain better insights into their data models. These tools are outside the scope of this book but as you continue your journey with DAX, you will want to learn more about DAX Studio and the Tabular Editor.

Summary

In this chapter, you learned that DAX allows you to significantly enhance your data model by improving the analytical capabilities with a relatively small amount of code. You also learned how to create calculated columns and measures and how to use DAX to perform useful time series analysis on your data.

This chapter merely scratched the surface of what is possible with DAX. As you further explore the DAX language on your own, you will quickly become a proficient author of DAX formulas. As with everyone who learns DAX, you will inevitably learn that there is a layer of complexity to DAX that will require further education to really master. When you get to this point, it would be advantageous to look for classes or books that will help you to take your skills to the next level and truly master DAX!

5 Visualizing Data

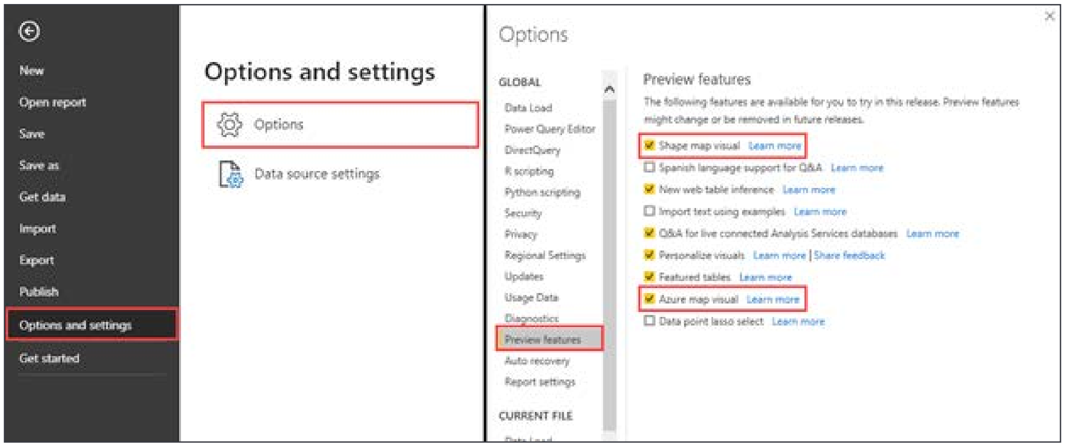
Power BI is best known for its impressive visualization capabilities. Up to this point, the focus has been on importing data and modeling it to your specifications. The goal of this chapter is to bring that data to life through impactful visuals. The number of visuals is vast, and the aim is to provide an overview of most of the included visuals. It is impossible to do an in-depth tour of all the options; instead the focus will be on getting familiar with the basic configuration, appropriate use for each of the built-in visuals, and how to acquire custom visuals not included in Power BI by default. The topics detailed in this chapter include the following:

- Report view basics
- Creating new visuals
- Filtering visualizations and data
- Visualizing tabular data
- Visualizing categorical data
- Visualizing trend data
- Visualizing KPI data
- Visualizing data using cards
- Visualizing geographical data
- Natural language
- Visuals from analytics
- Power BI custom visuals
- Data visualization tips and tricks

At the time of this book's publication, there are 36 readily available visuals in Power BI Desktop including the **Shape map** and **Azure map** visuals that are in preview and must first manually be enabled to use. Let's get started with bringing the model you have worked on up to this point to life!

With Power BI's rapid update cycle, there will be many visuals added to the application over time. If you would like to leverage these as soon as they are available, you can find them in the **Preview features** section of Power BI Desktop's options. *Figure 5.1* shows how to access the **Preview features** setting. Once you have enabled something in this area, it usually requires you to restart Power BI Desktop, so make sure to save your work!

To turn on **Preview features**, click **File** | **Options and settings** | **Options** | **Preview features** and check the box next to **Shape map visual** and **Azure map visual**.



Preview features

The following features are available for you to try in this release. Preview features might change or be removed in future releases.

- ☑ Shape map visual Learn more
- ☐ Spanish language support for Q&A Learn more
- ☑ New web table inference Learn more
- ☐ Import text using examples Learn more
- ☑ Q&A for live connected Analysis Services databases Learn more
- ☑ Personalize visuals Learn more | Share feedback
- ☑ Featured tables Learn more
- ☑ Azure map visual Learn more
- ☐ Data point lasso select Learn more

Figure 5.1: Enable Power BI preview features on the Options menu

As features are moved from preview to generally available, they will automatically fall off the preview features list and be automatically available upon loading Power BI Desktop. Other preview features are available but because they are not related to visualizations they will not be explored in this chapter.

Report view basics

As soon as you launch Power BI Desktop and close the initial splash screen, you will find yourself in the **Report** view, which is where you will stay for the duration of this chapter. In the previous chapter, you explored the **Model** view as well as the **Data** view, but these areas are not necessary for the visualization work discussed in this chapter. There are many items of interest in this initial **Report** view area that need to be discussed so that you can work efficiently. Let's open the completed Power BI file from *Chapter 4*, *Leveraging DAX*, which includes all of the calculated columns and calculated measures that will be used in the upcoming visuals.

For this chapter, you can build on top of the completed `pbix` file from *Chapter 4*, *Leveraging DAX*. If you would like to keep your work from each chapter separate, please follow the noted steps here. Open the completed `pbix` file called `Chapter 5 - Visualizing Data.pbix`. Then, under the **File** option, choose **Save As** and give this file a new name for the work you will be doing in *Chapter 5*, *Visualizing Data*.

Let's review the key areas of Power BI Desktop:

1. **Report view**: Displays the report canvas, page navigation, and panes for customizing visualizations within the report. This is the default view open when Power BI Desktop is launched.
2. **Report canvas**: The main design area holding all report visuals.
3. **More visuals**: A menu with options to access custom visuals from AppSource or local files. After importing, these will appear in the **Visualizations** pane.
4. **Filters pane**: Apply filters to various scopes:
    - **Filters on this page** applies to every visual on the selected page.
    - **Filters on all pages** applies to every visual on every page in the report.
    - **Filters on this visual** only appears when a visual is selected, and only affects the selected visual.
5. **Visualizations pane**: Consists of four sections working together to customize the data and formatting of visualizations:
    - **The Visuals section** displays all available visualizations including enabled preview and imported custom visuals.

- **The Fields section** displays buckets used to populate the different areas on the visual and varies based on the visual chosen. For instance, a table will have a single **Values** bucket, while a pie chart will have **Legend**, **Details**, **Values**, and **Tooltips** buckets.
- **The Format section** controls the look and feel of the visual. The formatting options will vary based on the visual selected but generally include title, font size and color, and data label settings.
- **The Analytics section** allows for the addition of reference lines like minimum or maximum thresholds, the median line, and an average line. The options will vary based on the visual selected and often allow for both static and data-driven lines.

6. **Fields pane**: Displays all available fields to be added to visuals and filters. If a table or column is hidden in the data view it will not appear in the **Fields** pane.
7. **Page navigation**: Select which report page to display on the canvas. Each page has a limited work area where visuals are displayed, so it is common to have more than one page in a Power BI report. Pages can be added by clicking the plus button at the end of the page list.

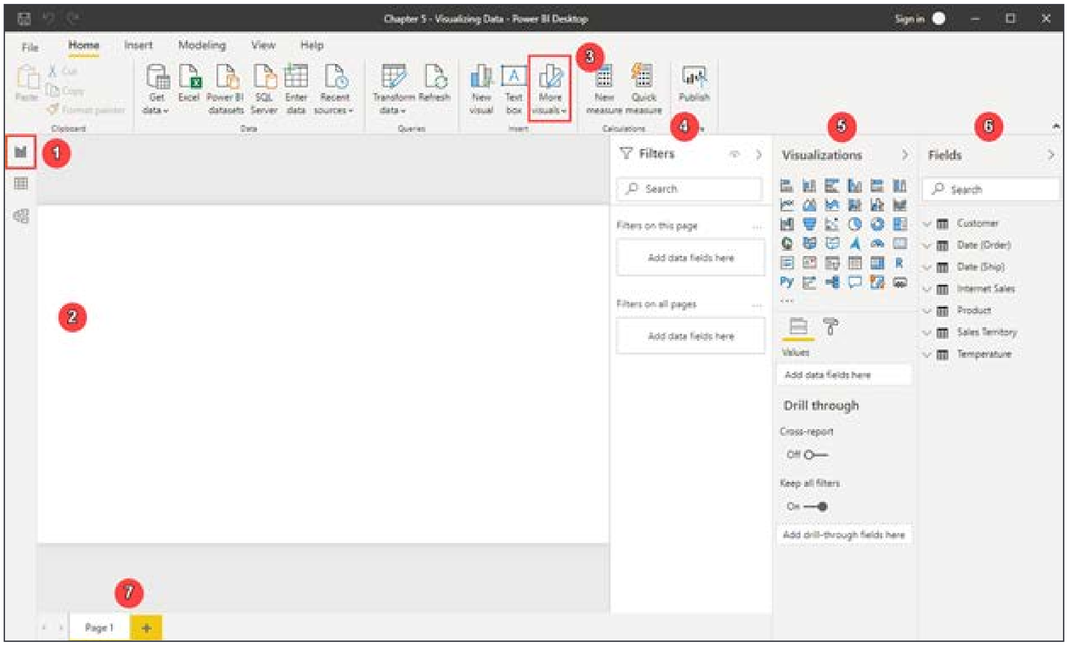


Figure 5.2: First view of Power BI Desktop

It is important to note that when working with visual filters, a visual must be selected. A visual is selected when you see the anchor points around the visual in question after clicking on it. Now that you are familiar with the **Report** view features and layout, it is time to start visualizing!

Creating new visuals

Before exploring the various visualizations available in Power BI let's look at the three ways to add visuals to the report canvas. All these methods will result in the same final product. However, depending on the type of visualization needed it may cut a few clicks off your workflow to use one method over another.

The first, and least common, method for adding a visual is using the **New visual** button on the ribbon. This will add a blank stacked column chart to the **Report** canvas at which point you can start to drag and drop fields or check the box next to a field to add it to the visual. If a stacked bar chart is not the desired visual, it can be changed by selecting a different visual from the **Visualizations** pane:

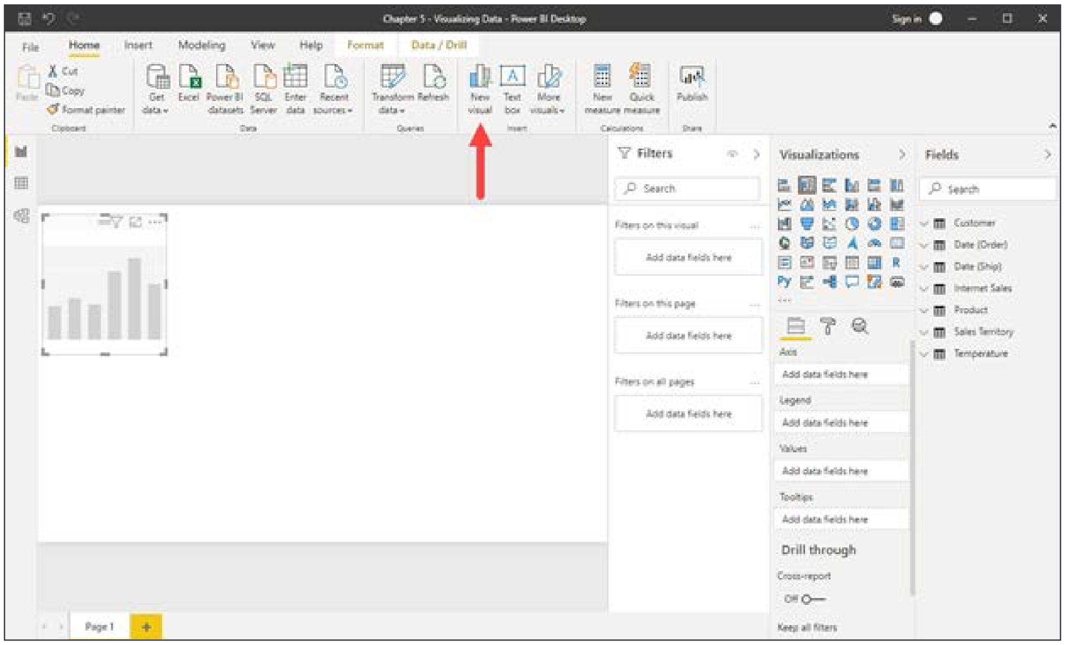


Figure 5.3: New visual button on the Home ribbon to add a blank visual

The second method for creating a new visual is starting from the **Fields** pane. To get started simply check the box next to a field or drag a field and drop it on the **Values** bucket in the **Visualizations** pane. A new visual will be created based on the data type of the field selected. The result is generally a clustered column chart for numeric fields and a table for non-numeric fields. You can then change to the desired visual if the correct type was not generated automatically.

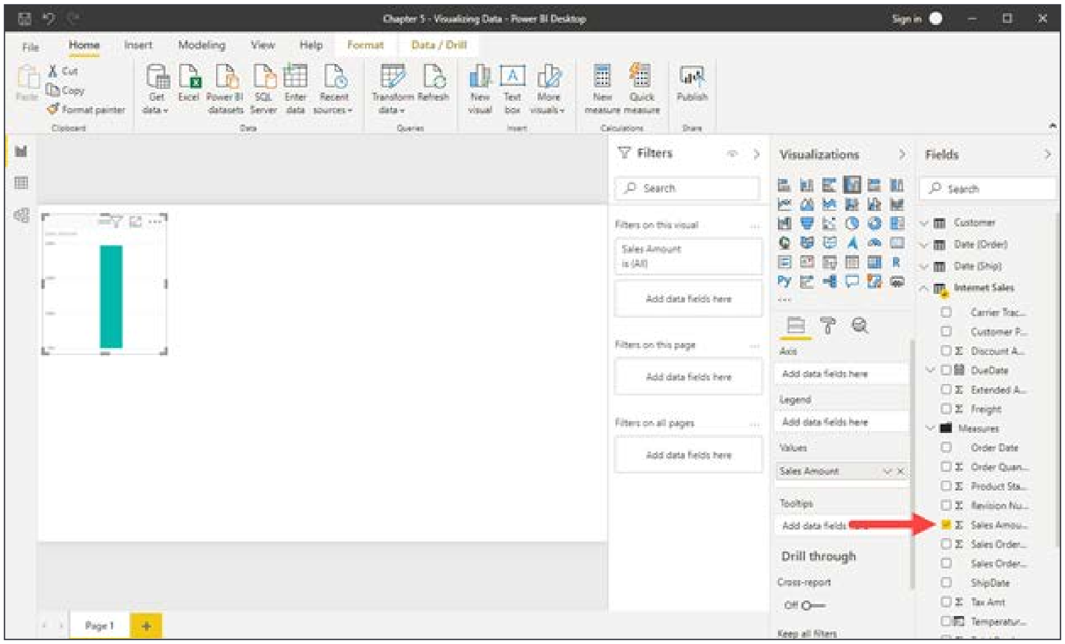


Figure 5.4: Create a new visual by checking the box next to any item in the field list

The final method is to start from the **Visualizations** pane, which allows for a more customized visualization creation experience. Using this method, you will first determine the type of visual needed and select it from the list. The result will be a blank visual that can then be populated with the desired fields being checked off or dragged from the **Fields** pane to the field buckets in the **Visualizations** pane.

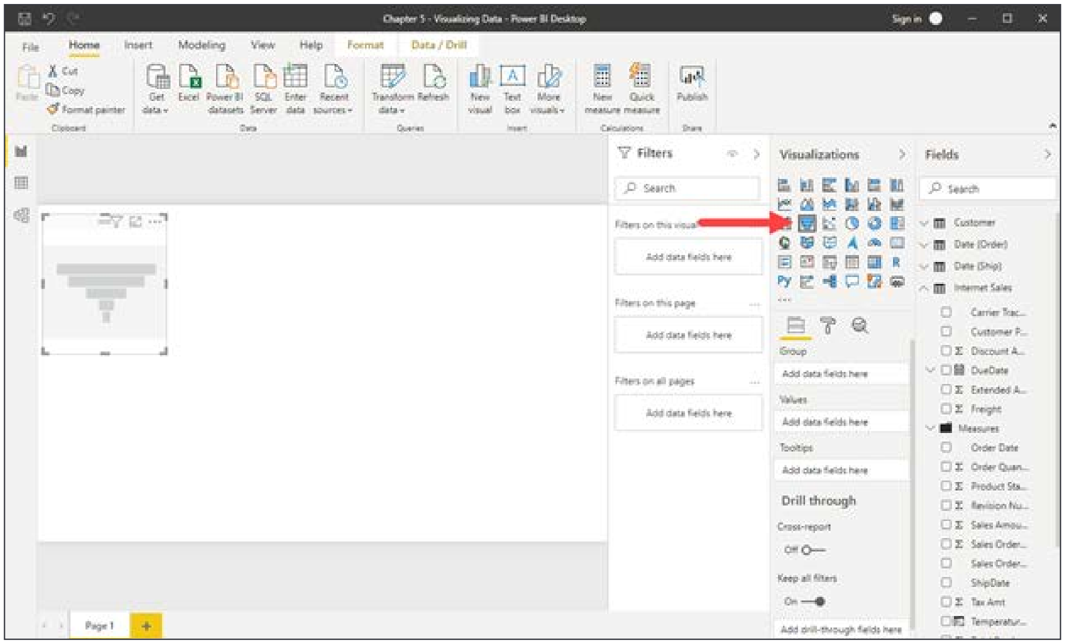


Figure 5.5: Create a blank visual of your choice by clicking on any item in the Visualizations pane

Now that you have a good understanding of the various methods for creating new visualizations on the **Report** canvas, let's get to work building some high-impact visuals.

Filtering visualizations and data

Filtering the data that users will see within a Power BI report is the most effective way to answer very specific questions about that data, and there are many ways to accomplish this. One of Power BI's most useful features is its ability to allow users to interact with a visual, which will then apply the selection as a filter to the rest of the visuals on that page. This is known as cross-filtering. This behavior really puts the power into the user's hands, and they can decide how they want to filter the visuals. This makes a report much more robust because it can answer many more questions about the data without the need to create and maintain additional pages or visuals.

Along with this functionality, report developers can add more visible and explicit forms of filtering using the slicer visual that is available in the **Visualizations** pane. This provides the option to choose a very specific field from the data that you know end users will want to use to filter some or all of the visualizations on the page.

The default interaction between two visuals is called cross-highlighting. Consider a report with a bar chart showing sales by country and a pie chart showing profit by age. Under the **default behavior**, selecting the **United States** in the bar chat would cause the pie chart to continue showing sales for all countries while highlighting the slicer that corresponds to the **United States**. This is very useful for seeing how a subset of one visual is represented inside another. The interaction can be modified to cross-filter rather than highlight. With the cross-filter behavior, selecting the **United States** in the bar chart would filter out all data except the **United States** from the pie chart, reducing the overall cumulative profit value. This interaction is useful when looking to explore specific subsets of report data across all visualizations.

Now, let's dive in and get a better understanding of these two filtering options, as they will most definitely be elements in the finished reports.

Cross-filtering and cross-highlighting

Almost every single visual that is readily available within Power BI has some sort of element that users can interact with. At the same time, every visual can be impacted by these very same elements. This provides a lot of flexibility when it comes to deciding which visuals to include on a report page. Cross-highlighting will be covered again later in this chapter, but it is important to understand how this feature works so it can be leveraged throughout the examples to come. Let's create two very simple visuals based off the current data model so you can see exactly how cross-highlighting works. For right now, let's not worry about the details of these visuals as they will be fully described in later sections of this chapter.

Let's look at setting up the example:

1. From the **Visualizations** pane, select the **Stacked column chart**. Make sure the anchor points discussed earlier are visible. If necessary, click on the blank chart placeholder on the **Report** canvas so the anchor points will appear.
2. From the **Fields** pane, check the box next to **Total Sales** from the **Internet Sales** table. Notice that the field shows up under the **Values** bucket of the **Fields** section.
3. From the **Fields** pane, drag **Sales Territory Country** from the **Sales Territory** table to the **Axis** bucket in the **Fields** section. Resize the visual to make it easier to read the labels. Reference *Figure 5.6* to validate that everything is set correctly.

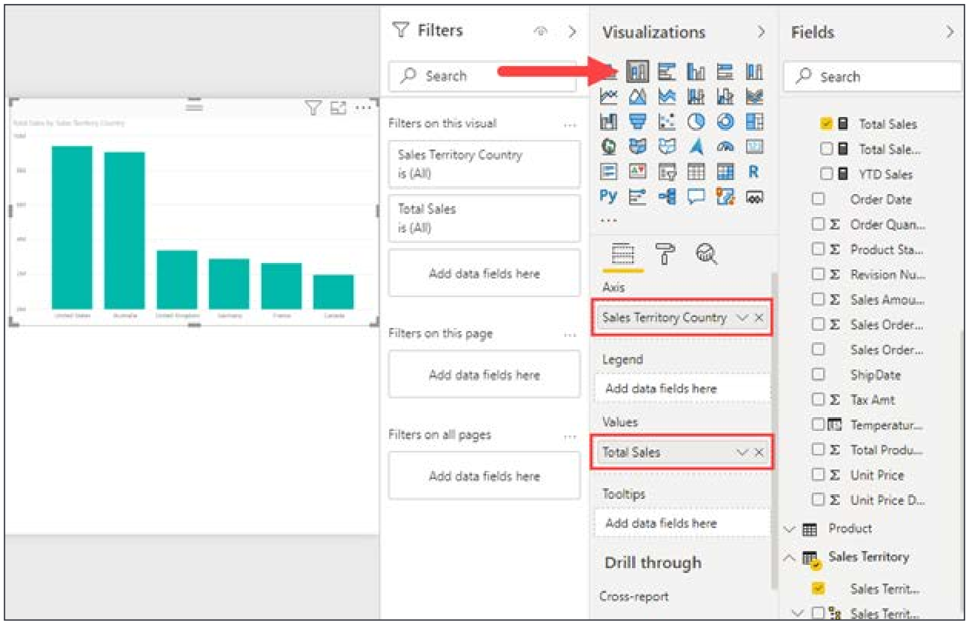


Figure 5.6: Stacked column chart showing sales by country

You may notice that some of the visual elements do not meet your standards. For example, the size of the text for various items in this visual is far too small to read. These are the types of changes that would be made in the **Format** area but we will not be doing so in this specific example. Common formatting options for each of the visuals will be discussed within their respective sections in this chapter.

4. You can already start to interact with any of the columns in the chart, but since this is the only visual, it really isn't that exciting. Add another visual to the **Report** canvas; make sure you left-click somewhere in the empty space so that no visual is currently selected.
5. Next, from the **Visualizations** pane, select the **Pie chart**, which will be added to the **Report** canvas. You may have to move the visual to a location more to your liking.
6. In the **Fields** pane, check the box next to **Age Breakdown** in the **Customer** table. If it does not go to the **Legend** bucket, drag it there.

7. Using either of the two methods described so far, add **Profit** from the **Internet Sales** table to the **Values** bucket. See *Figure 5.7* to verify the setup:

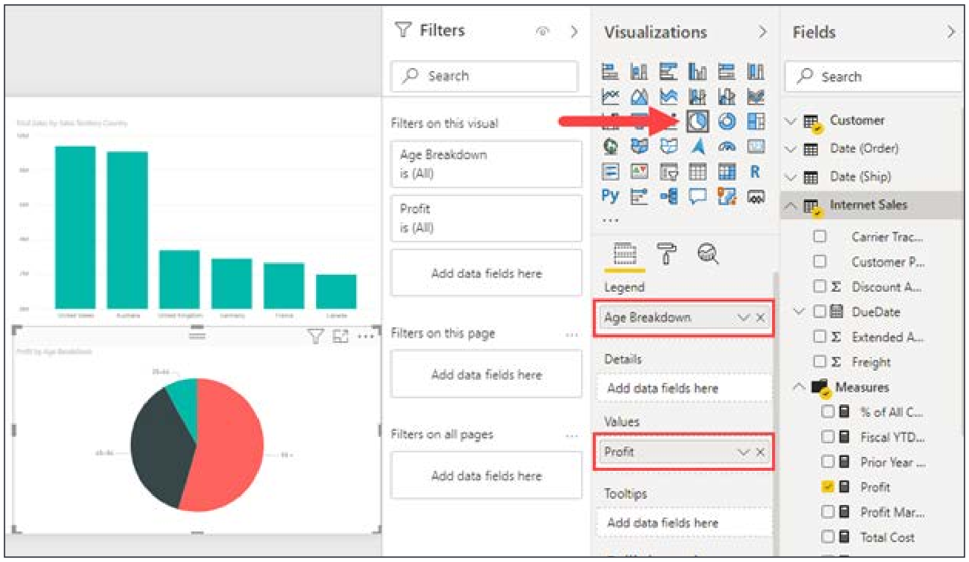


Figure 5.7: Pie chart showing profit by age breakdown

Now that the example is all set and there are two visuals in the **Report** canvas, you can really see how cross-highlighting works. Select (left-mouse-click) the column labeled **United States** in the stacked column chart. You will immediately see that the pie chart changes to having a much smaller highlighted area. By hovering over the **35-44** section of the pie chart, you can now see that the `United States` makes up `$246,952.81` of the `$977,695.57` total for that category. This same type of highlighting can be done by selecting a slice of the pie chart, which will then highlight a subset of the stacked column chart. Just with this simple example, you can see how effective cross-highlighting is in answering questions about the data. Keep this in mind as you move forward with the other examples so you can keep seeing the impact highlighting has.

Edit interactions

Throughout all the examples to come, you will have the capability of using cross-highlighting and cross-filtering. Almost everything seen inside a visual can be selected, and it will affect all the other visuals within that same report page. This behavior can be altered though, and there will be situations where you do not want a specific visual to be filtered by any others.

The way to control this is through an option called **Edit interactions**, which can be found on the **Format** ribbon when a visual is selected. When you select the **Edit interactions** button, you will see new icons next to all the other visuals on the current page, as seen in *Figure 5.8*. In this example, the **pie chart** is selected and you can now decide if any of the other visuals will be affected by cross-highlighting or cross-filtering from the **pie chart**. The two primary icons are a column chart with a funnel in the lower-right corner, which lets us know that the visual will be cross-filtered, and a circle with a line through it designating that the visual will not be affected at all; no filtering or highlighting will occur when interacting with the paired visual. Based on the visual type, there will be an icon that looks like a column chart but no funnel in the lower-right corner, which you can see on the stacked column chart. This means that the visual will be cross-highlighted rather than filtered, as shown in *Figure 5.8*. This option is something that you will have to do for each individual visual.

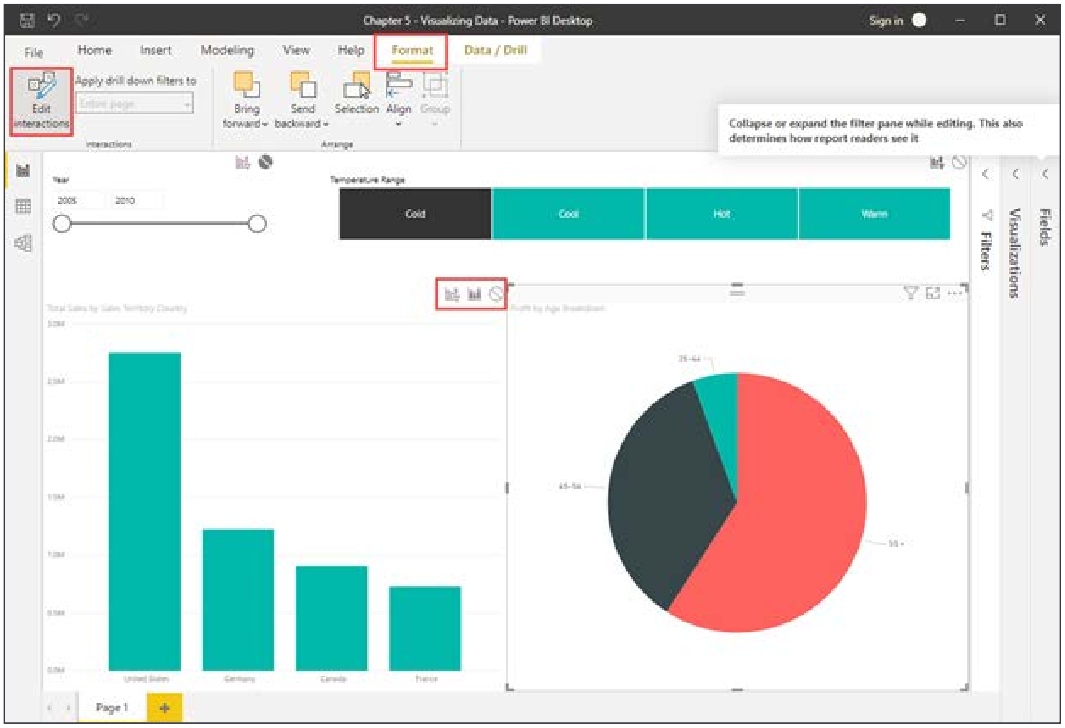


Figure 5.8: Change default cross-filtering and cross-highlighting behavior with Edit interactions

In general, all visuals allow the options for no interaction and filtering. Only a subset of visuals, like the bar, column, and pie charts, allow highlighting. The default interaction behavior is highlighting. If highlighting is not available for the visual pair, then the default behavior is filtering.

Slicer

Now that you know cross-filtering will always be an option for users, what do you do when end users want to filter by something that isn't used inside any of the visuals? This is where the **Slicer** visual comes into play. The **Slicer** visual only allows one field to be displayed but, depending on the data type of that field, different presentation options will be available.

The slicer has a different set of options based on the following types of data being displayed:

- String/text
- Numeric
- Date

Let's explore these different options with the visuals that have already been built.

String/text

Let's start by setting up a slicer with string or text values:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. In the **Visualizations** pane, select the **Slicer**. Move it to some place convenient within the **Report** canvas. You can use the anchor points to resize the visual as you see fit.

3. In the **Fields** pane, check the box next to **Temperature Range** from the **Temperature** table to add it to the selected slicer **Fields** bucket.

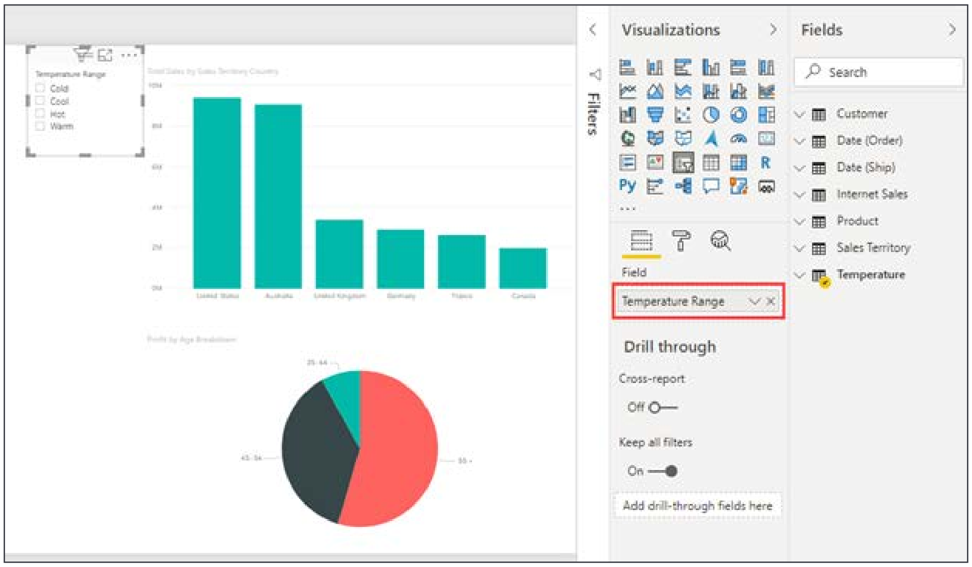


Figure 5.9: Slicer showing the Temperature Range field

The slicer will default to the **List** view. This allows users to see a distinct list of all the options they can now filter on from the specific field. You should see four temperature options in the list each with a blank box to their left. Clicking in a box will single-select a member from the list resulting in other visuals being filtered.

If you were to select the **Cold** option, the stacked column chart would be showing the **Total Sales by Sales Territory Country** when the weather was cold.

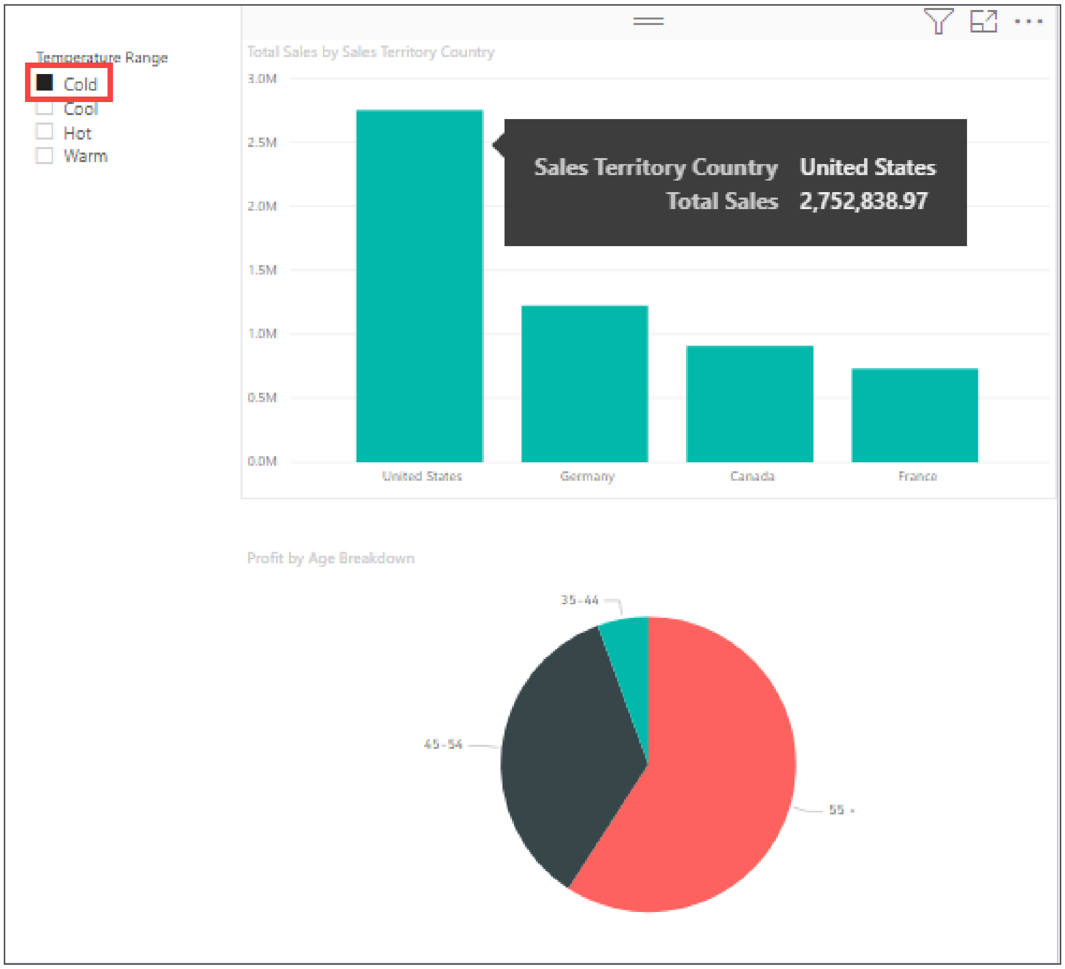


Figure 5.10: Stacked column chart filtered to the Cold Temperature Range

To multi-select, you have two options. The first is to hold down the *Ctrl* key on your keyboard while making your selections. The second option lies within the **Format** area under the **Selection Controls** expandable menu. Here, you will find an option called **Single Select**, which is set to **On** by default, and by turning this off you no longer need to hold the *Ctrl* key to multi-select.

There is an exception to the rule that a slicer accepts only one field, and that is in relation to hierarchies. If hierarchical data is used as a filter, multiple fields may be added to the slicer's **Field** bucket. When this happens, the slicer will display a stair-stepped list or drop-down set of values. The slicer behaves the same as described in this section but allows for a much more user-friendly display of data. By using hierarchies, it is possible to create much larger lists of values while keeping it easy for users to find the members by which to filter. The hierarchies used in a slicer can be explicitly defined in the data model, or they can instead be created automatically by dragging multiple fields from the same table into the slicer, or even multiple fields from different tables if a relationship exists between the tables.

Let's set up a slicer with a hierarchy:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. In the **Visualizations** pane, select the **Slicer**. Move it to some place convenient within the **Report** canvas.
3. In the **Fields** pane, check the box next to **Sales Territory Drilldown** from the **Sales Territory** table to add it to the selected slicer **Field** bucket.

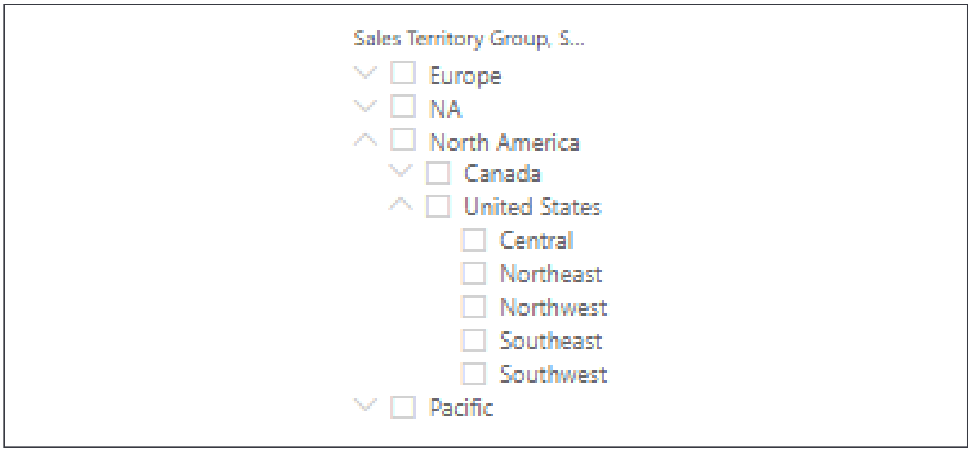


Figure 5.11: Slicer with the Sales Territory Drilldown hierarchy

Unique to slicers using string/text values is the ability to add search functionality. Clicking the ellipses **(...)** in the top-right corner of the slicer header will reveal a menu of options, the first of which is **Search**.

Adding a search option greatly improves the user experience when working with large lists.

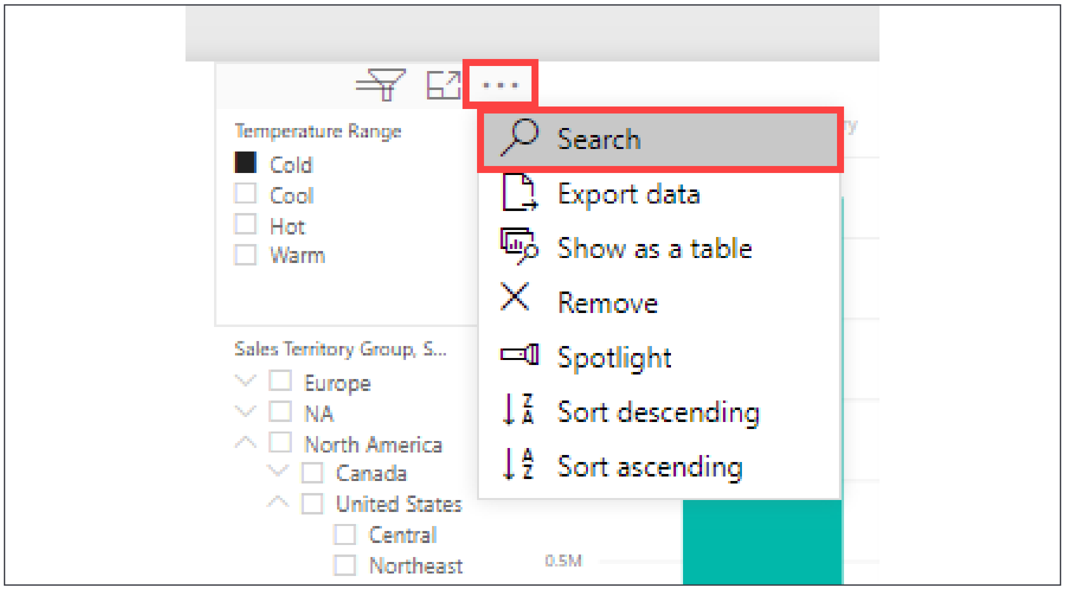


Figure 5.12: Enable search on slicers using a string/text field

Using hierarchies in slicers is an easy way to reduce the number of slicers on a report page, which in turn will free up valuable canvas real estate for storytelling through visuals.

Numeric

Now, add another slicer to the current report page, which uses a numeric field, to explore the numeric range slicer:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Slicer**. Move and resize it as you see fit.
3. From the **Fields** pane, check the box next to **Year** from the **Date (Order)** table.

Immediately, you will see a very different presentation for the filter. A numeric field will result in a sliding bar that can be moved from either side to give a range of values, which will be used to filter the other visuals on the page. By moving the left end of the slider one value to the right, the year `2005` will be removed from the selected range and the data in the visuals has changed. See *Figure 5.13*.

The slicer can also be set to use the **List** format that was seen in the temperature slicer example above. To change the display format, click the down arrow located in the upper-right corner of the slicer. If the down arrow and eraser are not visible simply hover the mouse over the slicer.

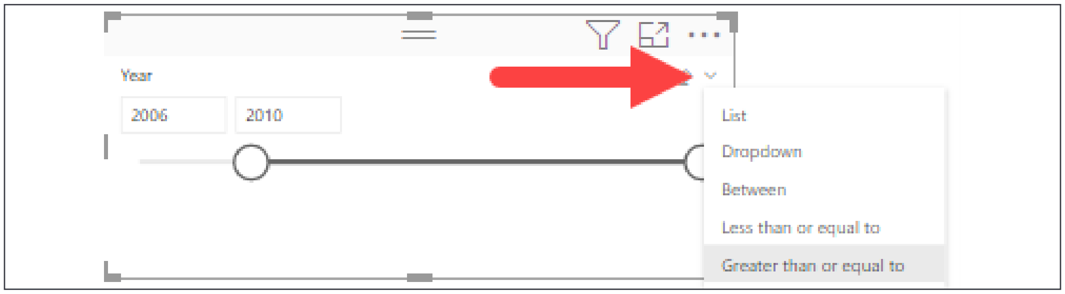


Figure 5.13: Display options for slicers using a numeric field

The format options from *Figure 5.13* are as follows:

- **List**: A distinct list of values from the selected field. Best used when there are a small number of options to choose from.
- **Dropdown**: Drop-down menu containing a distinct list of values from the selected field. Like the **List** option in functionality, but choices are hidden until a user expands the dropdown. Also best used for a smaller set of values so users don't have to scroll through hundreds of choices.
- **Between**: This choice will only present itself for fields that are of the numeric and date data types. It allows users to specify a boundary-inclusive range of values. This means a range between `100` and `500` will include data points `100` and `500` rather than being filtered out.
- **Less than or equal to**: Similar to the **Between** option, but the sliding scale can only be adjusted from the right side, the upper boundary, which is included in the filter values.
- **Greater than or equal to**: This is the same as the previous option, except you can only adjust the sliding scale from the left side, the lower boundary, which is included in the filter values.

When using the **List** option for a smaller set of filter choices, try changing the orientation from vertical to horizontal. If you add a background color to this setup, it gives the feeling of having buttons to filter with. To set this up, just go to the **Format** area of the slicer. Expand the **General** area and switch the value within the **Orientation** section to **Horizontal**. Then, expand the **Items** area and select a font color and background color of your choice, and you will see the design feels like a set of buttons.

Be sure to consider the context in which a numeric filter will be used and decide the appropriate format. A dropdown or a list may be more suitable when filtering tire sizes as the user will likely be looking for a single or small range of values. However, when filtering based on price, one of the range options, such as **Between**, may be more applicable due to the vast variations in prices based on manufacturer, size, mileage rating, and so on, and this would make searching through a list very time-consuming.

Date

Add a fourth slicer to the current **Report** page, which uses a **Date** field:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Slicer**. Move and resize it as you see fit. From the **Fields** pane, check the box next to **Date** from the **Date (Order)** table.

At first glance it appears Power BI has just generated another numeric range slicer. However, the lower and upper boundaries are dates. Clicking on either boundary will display in a calendar to aid in selecting a date.

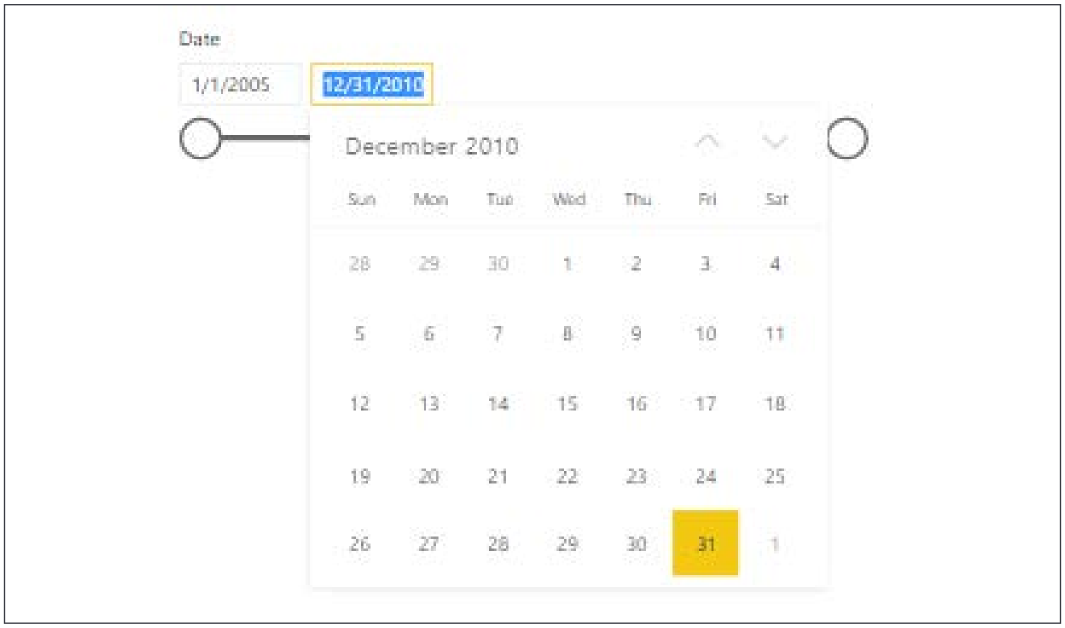


Figure 5.14: Calendar displayed when selecting a date on a slicer using a date field

In addition to the options available to the text and numeric slicers, the date slicer adds relative date and time formats. The relative filter, shown below, allows ranges to be set relative to the current date or time. It can be configured to look at the last, current, or next *N* number of units. The relative units can be days, weeks, months, or years for a relative date. The relative units can be minutes or hours for a relative time.

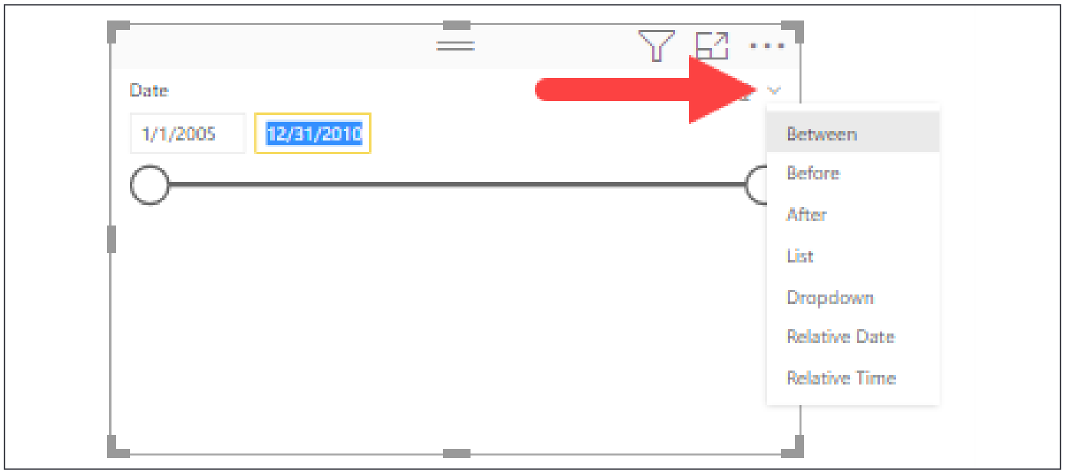


Figure 5.15: Display options for slicers using a date field

You have now seen a couple of different ways to allow users to filter the visuals that have been created for them. Cross-filtering will always be there for users, but you can take a more traditional route with the **Slicer** visual and present them specific options they would find meaningful to filter the data.

The last step is to rename this report page from **Page 1** to **Slicers** by right-clicking the page name and selecting **Rename Page**.

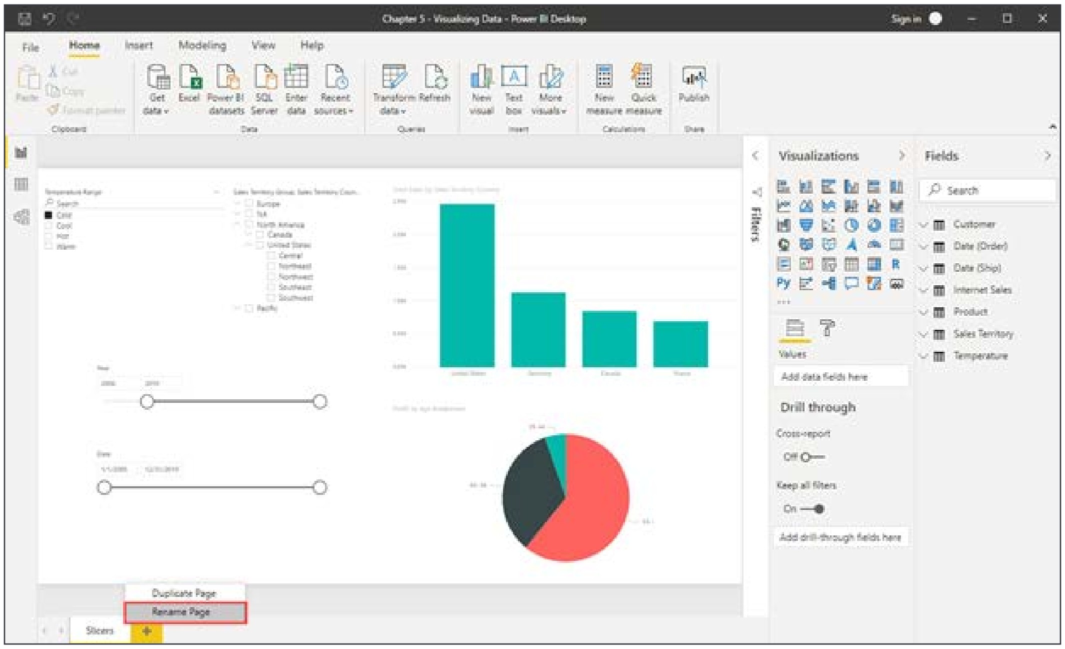


Figure 5.16: Options menu to duplicate or rename report pages

With the slicers created, let's dive into the various ways to visualize data starting with the most foundational of all visualizations: tables and matrices.

Visualizing tabular data

There are many options within Power BI to visually represent data, but sometimes users may want to see and compare detail-level data and exact values. In these scenarios, using the **Table** or **Matrix** visual is the most effective option. When leveraging either of these two visuals, it is important to take advantage of the **Format** section of the **Visualizations** pane to ensure that users can easily interpret the data that is being presented. One of the best ways to bring attention to values of importance with these visuals is by using **Conditional formatting**. This section will also take advantage of the hierarchies created in *Chapter 3*, *Building the Data Model*, to allow for drilldowns within the visuals.

Table

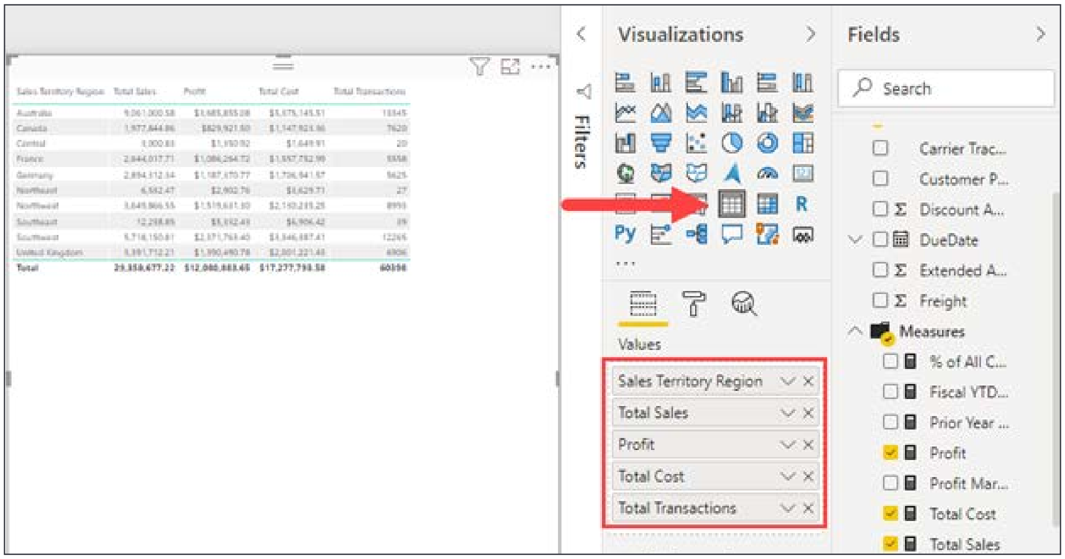
The table visual is perfect for looking at many values (measures) for a category. To really make the table shine, you will also want to take advantage of the **Conditional formatting** options. In this example, you will be using the **Sales Territory Region** as the category and looking at four different values to analyze each region's performance.

Let's look at setting up a table:

1. Add a new page to the report by clicking the plus icon at the far right of the page list below the **Report** canvas.
2. Rename the new blank page from `Page 1` to `Tabular Data`.
3. From the **Visualizations** pane select the **Table** visual. Resize it to take up a little less than half the **Report** canvas. Notice, like the slicer, that there is only one bucket in which to populate fields, called **Values**.
4. Add the following fields by locating them in the **Fields** pane and clicking the checkbox next to each:

    - **Sales Territory Region** from the **Sales Territory** table
    - **Total Sales** from the **Internet Sales** table
    - **Profit** from the **Internet Sales** table
    - **Total Cost** from the **Internet Sales** table
    - **Total Transactions** from the **Internet Sales** table

See *Figure 5.17* for reference:



Sales Territory Region	Total Sales	Profit	Total Cost	Total Transactions
Australia	9,061,000.58	$1,685,855.08	$5,375,145.51	13345
Canada	1,977,844.86	$829,921.50	$1,147,923.36	7620
Central	3,000.83	$1,350.92	$1,649.91	20
France	2,644,017.71	$1,086,264.72	$1,557,752.99	5558
Germany	2,894,312.34	$1,187,370.77	$1,706,941.57	5625
Northeast	6,532.47	$2,902.76	$3,629.71	27
Northwest	3,649,866.55	$1,519,631.30	$2,130,235.25	8993
Southeast	12,238.85	$5,332.43	$6,906.42	39
Southwest	5,718,150.81	$2,371,763.40	$3,346,387.41	12265
United Kingdom	3,391,712.21	$1,390,490.78	$2,001,221.43	6906
Total	29,358,677.22	$12,080,883.65	$17,277,793.58	60398

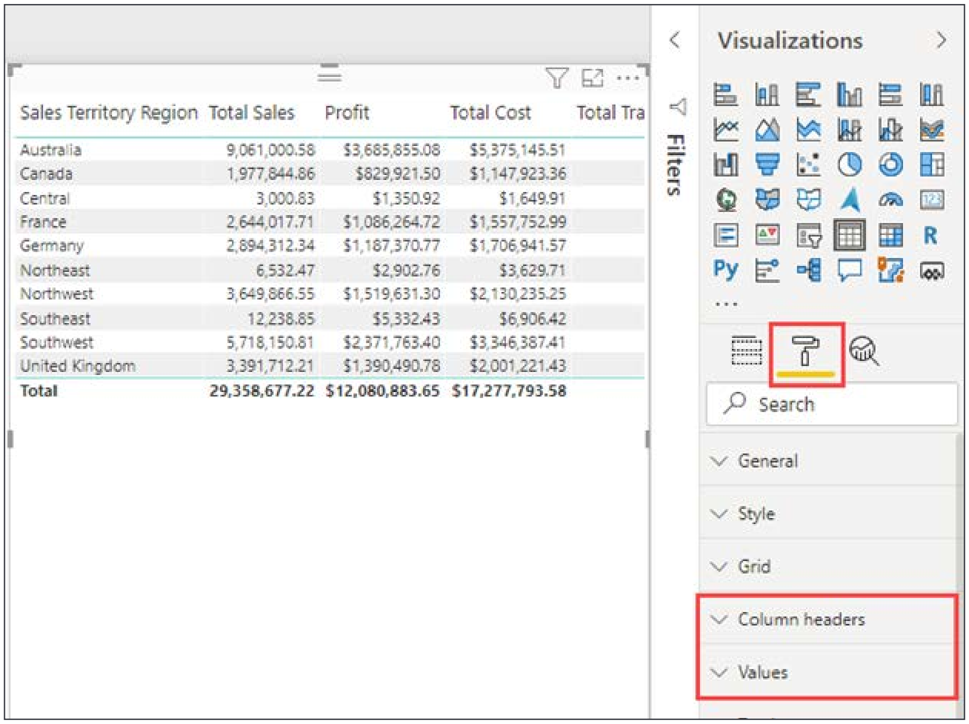
Figure 5.17: A table visual with Sales Territory Region and several measures

Already, you can see how this table provides great insights about the selected category, **Sales Territory Region**. While the default formatting effectively displays the data there are many formatting options that can be adjusted to enhance the table's appearance. First, change the size of the text for the data, as well as the headers:

1. With the **Table** visual selected, go into the **Format** section (paint roller icon) of the **Visualizations** pane and expand the **Column headers** section.

   There are many options that can be adjusted, but for now let's simply adjust the **Text Size** option to something larger, making it easier to read the headers.

2. Next, expand the **Values** area and make the same change here for the **Text Size** option.



Sales Territory Region	Total Sales	Profit	Total Cost	Total Tra
Australia	9,061,000.58	$3,685,855.08	$5,375,145.51	
Canada	1,977,844.86	$829,921.50	$1,147,923.36	
Central	3,000.83	$1,350.92	$1,649.91	
France	2,644,017.71	$1,086,264.72	$1,557,752.99	
Germany	2,894,312.34	$1,187,370.77	$1,706,941.57	
Northeast	6,532.47	$2,902.76	$3,629.71	
Northwest	3,649,866.55	$1,519,631.30	$2,130,235.25	
Southeast	12,238.85	$5,332.43	$6,906.42	
Southwest	5,718,150.81	$2,371,763.40	$3,346,387.41	
United Kingdom	3,391,712.21	$1,390,490.78	$2,001,221.43	
Total	**29,358,677.22**	**$12,080,883.65**	**$17,277,793.58**	

Figure 5.18: The Format section of the Visualizations pane offers many options to customize visualizations

Now that the table is easier to read, let's explore the **Conditional formatting** options, which will provide customized text or background colors based off data values:

1. Return to the **Visualizations** pane's **Fields** section where the five fields previously added can be seen under the **Values** bucket. Note the small drop-down arrow next to each field.
2. Select the arrow next to **Total Sales** and locate the option for **Conditional formatting**, as shown in *Figure 5.19*. With the mouse over the **Conditional formatting** option, you will be presented with several choices that are similar in functionality and setup. Select the **Background color** option.

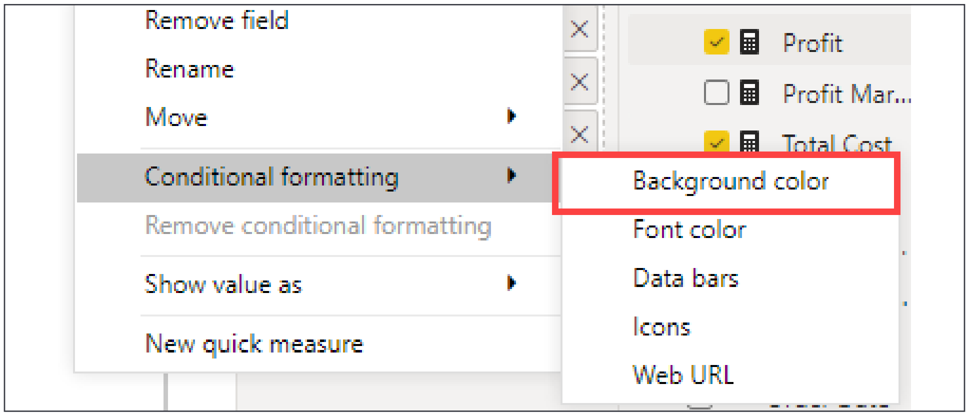
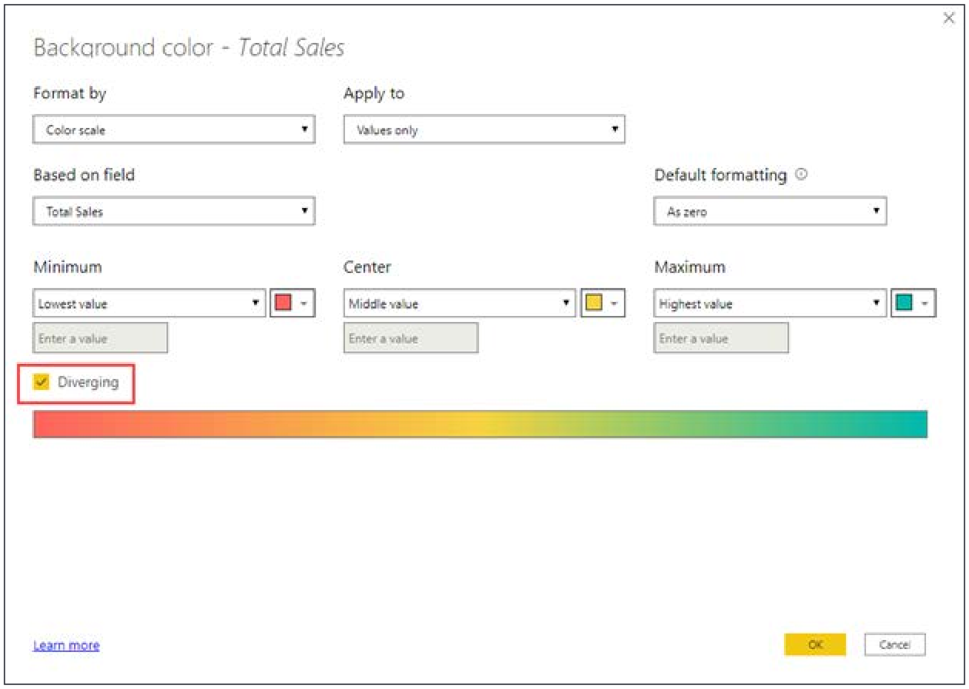


Figure 5.19: Conditional formatting options available from a field in the Visualizations pane

3. In the resulting menu, place a checkmark in the box that is in the bottom left labeled **Diverging**.


Background color - *Total Sales*

Format by: Color scale

Apply to: Values only

Based on field: Total Sales

Default formatting: As zero

Minimum: Lowest value

Center: Middle value

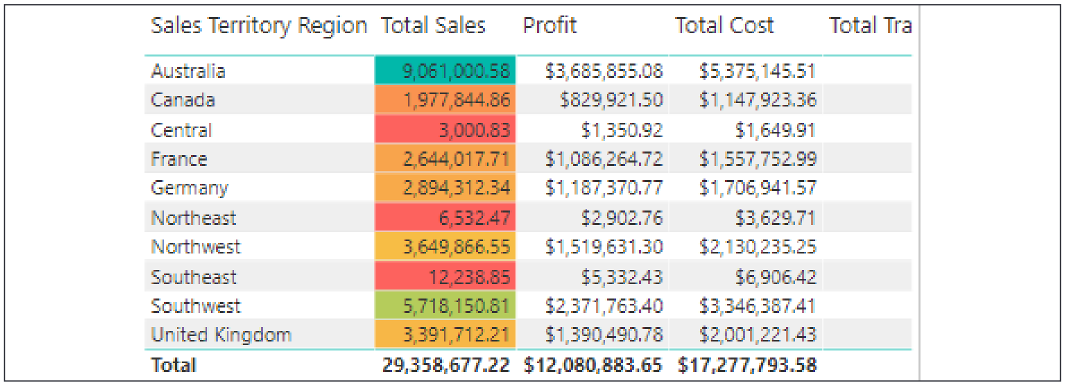
Maximum: Highest value

✓ Diverging

Figure 5.20: Background conditional formatting configuration screen

4. Click **OK**.

Notice that the **Total Sales** column is color-coded to easily identify the regions that are good (green) and bad (red) performers. This is something that can be applied to any columns you feel would be enhanced by conditional formatting. With the use of this table visual, you can gain a very quick and detailed understanding of performance for the **Sales Territory Region** category.



Sales Territory Region	Total Sales	Profit	Total Cost	Total Tra
Australia	9,061,000.58	$3,685,855.08	$5,375,145.51	
Canada	1,977,844.86	$829,921.50	$1,147,923.36	
Central	3,000.83	$1,350.92	$1,649.91	
France	2,644,017.71	$1,086,264.72	$1,557,752.99	
Germany	2,894,312.34	$1,187,370.77	$1,706,941.57	
Northeast	6,532.47	$2,902.76	$3,629.71	
Northwest	3,649,866.55	$1,519,631.30	$2,130,235.25	
Southeast	12,238.85	$5,332.43	$6,906.42	
Southwest	5,718,150.81	$2,371,763.40	$3,346,387.41	
United Kingdom	3,391,712.21	$1,390,490.78	$2,001,221.43	
Total	**29,358,677.22**	**$12,080,883.65**	**$17,277,793.58**	

Figure 5.21: Background conditional formatting applied to the Total Sales field in the table visual

It is important to remember cross-highlighting and cross-filtering with the table visual. Any of the rows that are present within the table can be selected and will apply a filter to all other visuals on the same page.

Often, the report consumers will need to see how data from multiple categories intersect. To do this, you will explore the matrix, which builds on the foundation created by the table visualization.

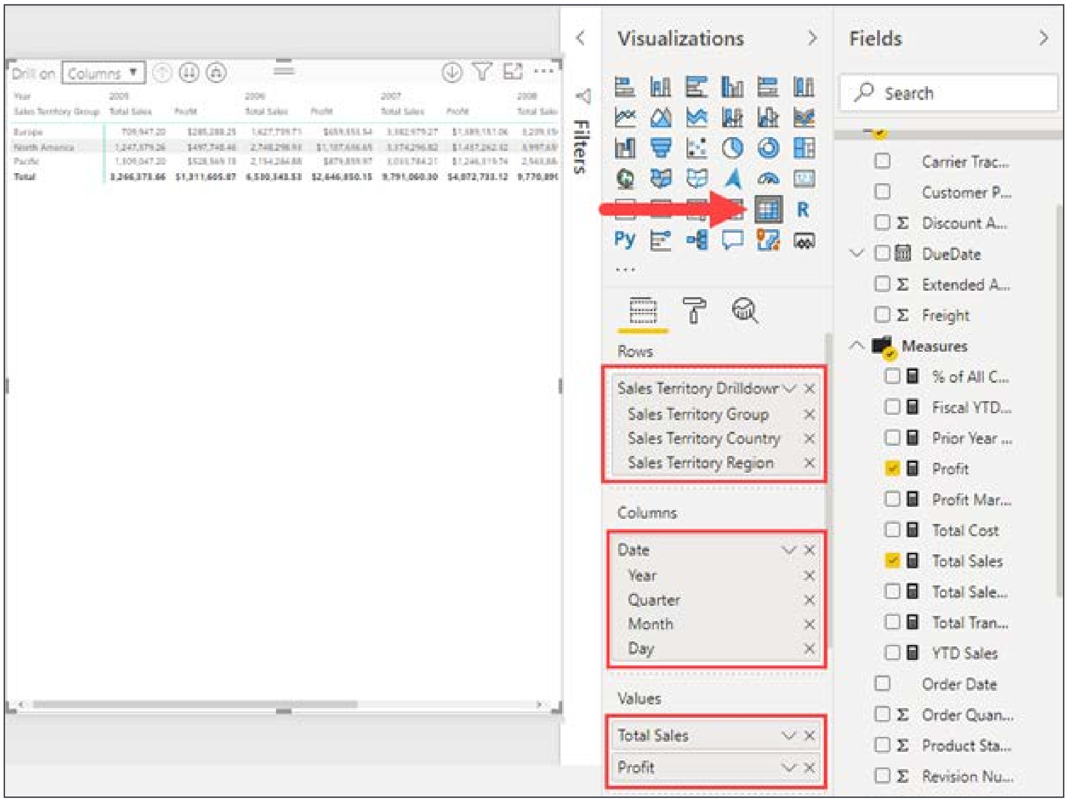
Matrix

Where a table does a great job of allowing users to consume tons of detailed data about a single category, the **Matrix** visual can accomplish this for more than one category. The **Matrix** visual allows users to select a category for the rows and columns allowing them to see detailed data at a cross-section of two categories. Where a table will display duplicate values, a matrix will aggregate the data. **Conditional formatting** is also available for use within the **Matrix** visual and is incorporated in the same fashion as accomplished in the previous example. Other than **Conditional formatting**, the matrix visual can take advantage of established hierarchies to give users the capability of drilling down into more granular data. Many of the other visuals can also take advantage of hierarchies, but for tabular data the **Matrix** visual does a great job with this.

Let's look at setting up a **Matrix**:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Matrix**.
3. From the **Fields** pane, drag **Sales Territory Drilldown** from the **Sales Territory** table to the **Rows** bucket.
4. From the **Fields** pane, drag **Date** (a natural hierarchy in Power BI) from the **Date (Order)** table to the **Columns** bucket. This will bring in the **Year**, **Quarter**, **Month**, and **Day** fields.
5. Finally, from the **Fields** pane, drag **Total Sales** and **Profit** from the **Internet Sales** table to the **Values** bucket.

See *Figure 5.22* for reference. Move and resize the matrix as you see fit.



Year	2005		2006		2007		2008
Sales Territory Group	Total Sales	Profit	Total Sales	Profit	Total Sales	Profit	Total Sales
Europe	709,947.20	$285,288.25	1,427,759.71	$659,553.54	3,082,979.27	$1,389,151.06	3,229,15
North America	1,247,879.26	$497,748.46	2,748,298.91	$1,107,646.65	3,374,296.82	$1,457,262.02	3,997,65
Pacific	1,309,047.20	$528,569.18	2,154,284.88	$879,859.97	3,033,784.21	$1,246,319.74	2,543,88
Total	3,266,373.66	$1,311,605.87	6,530,343.53	$2,646,850.15	9,791,060.30	$4,072,733.12	9,770,89

Rows
- Sales Territory Drilldown
  - Sales Territory Group
  - Sales Territory Country
  - Sales Territory Region

Columns
- Date
  - Year
  - Quarter
  - Month
  - Day

Values
- Total Sales
- Profit

Fields
- ☐ Carrier Trac...
- ☐ Customer P...
- ☐ Σ Discount A...
- ☐ DueDate
- ☐ Σ Extended A...
- ☐ Σ Freight
- Measures
  - ☐ % of All C...
  - ☐ Fiscal YTD...
  - ☐ Prior Year ...
  - ✓ Profit
  - ☐ Profit Mar...
  - ☐ Total Cost
  - ✓ Total Sales
  - ☐ Total Sale...
  - ☐ Total Tran...
  - ☐ YTD Sales
- ☐ Order Date
- ☐ Σ Order Quan...
- ☐ Σ Product Sta...
- ☐ Σ Revision Nu...

Figure 5.22: Field selection for the matrix visual

Now, you can see that the amount of insight available to report consumers is even greater than that of the **Table** visual. You should apply the same format changes to the header and value **Text size** as were applied to the **Table** at this point. The **Matrix** allows users to see detailed information about the different geographic regions, as well as a breakdown per year. Also, you will see that there are some new icons in the upper left of the visual that relate to the drilldown feature referenced earlier in this chapter. Because hierarchies are present on both the rows and columns, you must decide which you would like to expand for further details from the **Drill on** drop-down menu. Focus solely on the rows option and expand the geographical category. The first upward-pointing arrow, which should be currently grayed out, allows users to move up a level in the hierarchy. The button is unavailable because the highest level of the hierarchy is currently display. The option just to the right of this, which is depicted by two disconnected downward arrows, will change the category to the next level of the hierarchy, which is the **Sales Territory Country** in this example. Select this option two times so the **Sales Territory Region** level of the hierarchy is displayed. Notice that the higher levels of the hierarchy are not displayed in the report. The third option, which is depicted by two connected downward arrows, will also go down one level at a time through the hierarchy, but results in the previous (higher) level continuing to be visible on the matrix. By having the **Matrix** and **Table** next to each other, you can see the difference in detail that can be achieved by each of them. Both, though, can benefit greatly from **Conditional formatting**.

Visualizing categorical data

Where the **Table** and **Matrix** visuals allow for a detailed look at multiple measures, the visuals in this section are best for displaying a data value across multiple categories. In the upcoming visuals, you will be displaying bars, columns, and other visual elements, which will be proportional to the data value. These visuals have a far less detailed view of the data, but it is very easy and quick to distinguish the differences of the values within the chosen categories. All of the visuals allow for cross-highlighting, cross-filtering, and the use of drilldowns, which will not be a focus since it was covered in the previous examples. This section will focus on how to understand and configure the following visuals:

- Bar and column charts
- Pie and donut charts
- Treemaps
- Scatter charts

Continue using the same Power BI report from the previous examples. Start by creating a new report page called `Categorical Data`.

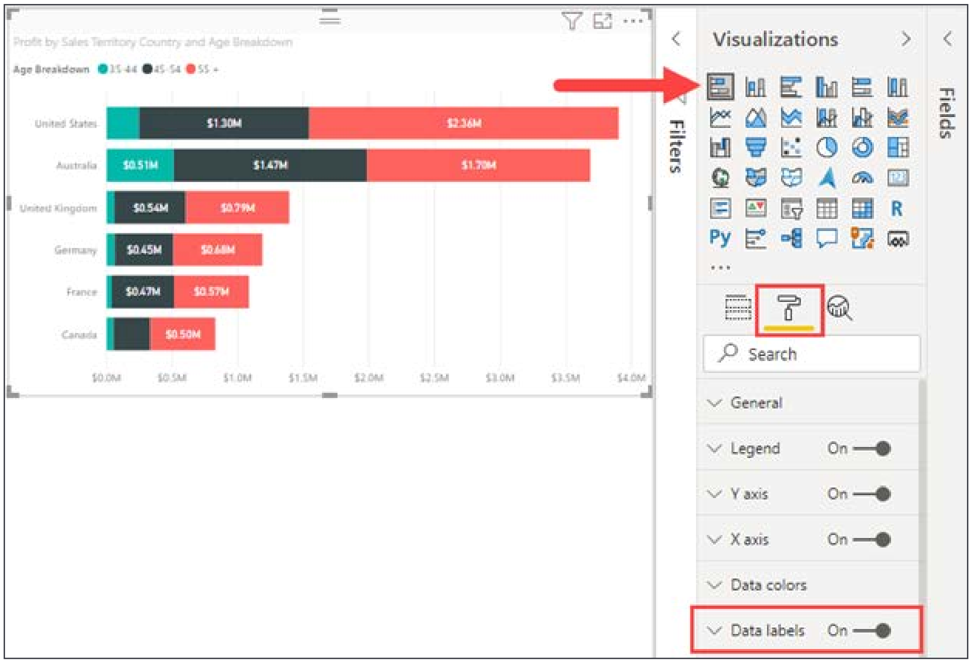
Bar and column charts

Both the **Bar** and **Column** charts are very similar in setup and how they visualize data. The only difference here will be the orientation: the **Bar chart** uses rectangular bars horizontally where the length of the bar is proportional to the amount of data, while the **Column chart** displays the bars vertically, but both are used to compare two or more values. Both visualizations have three different formats: **Stacked**, **Clustered**, and **100% stacked**. For this example, you will focus on the **Bar chart**, but users can easily switch over to the **Column chart** with the click of a button.

> There are some situations where the **Bar chart** will better display data, and the same thing can be said of the **Column chart**. The biggest limitation for the **Column chart** would be the limited space on the **X axis** where the category would go. So, if you have a lot of data labels or if they are very long, you may find that the **Bar chart** is the better option. An example where you might choose the **Column chart** over the **Bar chart** is if your dataset contains negative values. In a **Bar chart**, the negative values will show on the left side while in a **Column chart** they will display on the bottom. Users generally associate negative values with a downward direction.

Let's look at setting up a bar chart:

1. From the **Visualizations** pane, select the **Stacked bar chart**. Move and resize the visual to take up a quarter of the **Report** canvas.
2. From the **Fields** pane, drag **Sales Territory Country** from the **Sales Territory** table to the **Axis** bucket.
3. Next, from the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Values** bucket. This forms the base of the visual and visualizes which countries make the most profit.
4. Extend this visual to break down each country's profit by age groups. From the **Fields** pane, drag **Age Breakdown** from the **Customer** table to the **Legend** bucket.
5. Optionally, in the **Visualizations** pane switch to the **Format** section and toggle the **Data Labels** to **On**.



General
Legend On
Y axis On
X axis On
Data colors
Data labels On

Figure 5.23: Data labels can be turned on from the Format section of the Visualizations pane

In regard to the other two options, **Clustered** and **100% stacked**, you can simply select those visuals to experience the different presentations. You will notice the **data labels** remain and add great value regardless of the visual selection.

Pie and donut charts

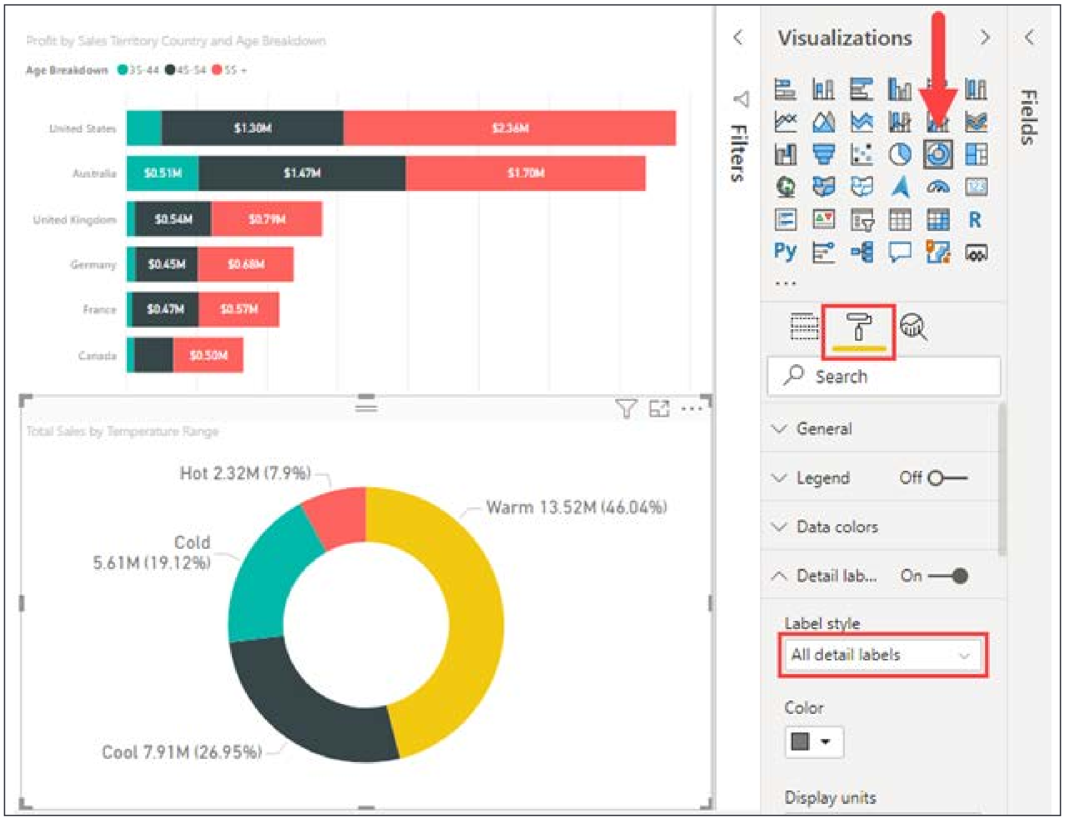
Both the **Pie chart** and **Donut chart** are meant to visualize a particular section compared to the whole, rather than comparing individual values to each other. The only difference between the two is that the **Donut chart** has a hole in the middle, which could allow for some sort of label. Both of these visuals can be very effective in allowing cross-highlighting, but if there are too many categories it can become difficult to read and interpret.

Let's look at setting up a **Donut chart**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Donut chart**. Move and resize it to take up a quarter of the **Report** canvas, preferably above or below the **Bar chart**.

3. From the **Fields** pane, drag **Temperature Range** from the **Temperature** table to the **Legend** bucket.
4. From the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **Values** bucket.

Because there are only four values within the **Temperature Range** category, this chart looks very clean and easy to understand. There is something, though, that can be added that will make it even easier to read: detail labels. This option is very similar to **category labels** in that you can display the data of each of the quadrants without having to use the tooltips. One thing that is different though is that it is already on, and all you need to do is decide how much detail to have displayed. More values being present can cause even more clutter though. To access these options, go to the **Format** section of the **Visualizations** pane, expand the **Detail labels** option, and manipulate the **Label style** dropdown. For this example, choose the **All detail labels** option and increase the font size if desired. As you can see in *Figure 5.24*, you now have a very nice and easy way to understand the presented data, as well as use it for cross-filtering and cross-highlighting:



Label style: All detail labels

Figure 5.24: Label style settings for the donut chart

When creating pie and donut charts consider how filtering the data may affect the readability of the chart. In addition to having too many slices that clutter the chart, having slices that are too narrow to easily identify, or slices that are very similar in size, can be detrimental to a consumer's ability to draw accurate conclusions from the chart.

Treemap

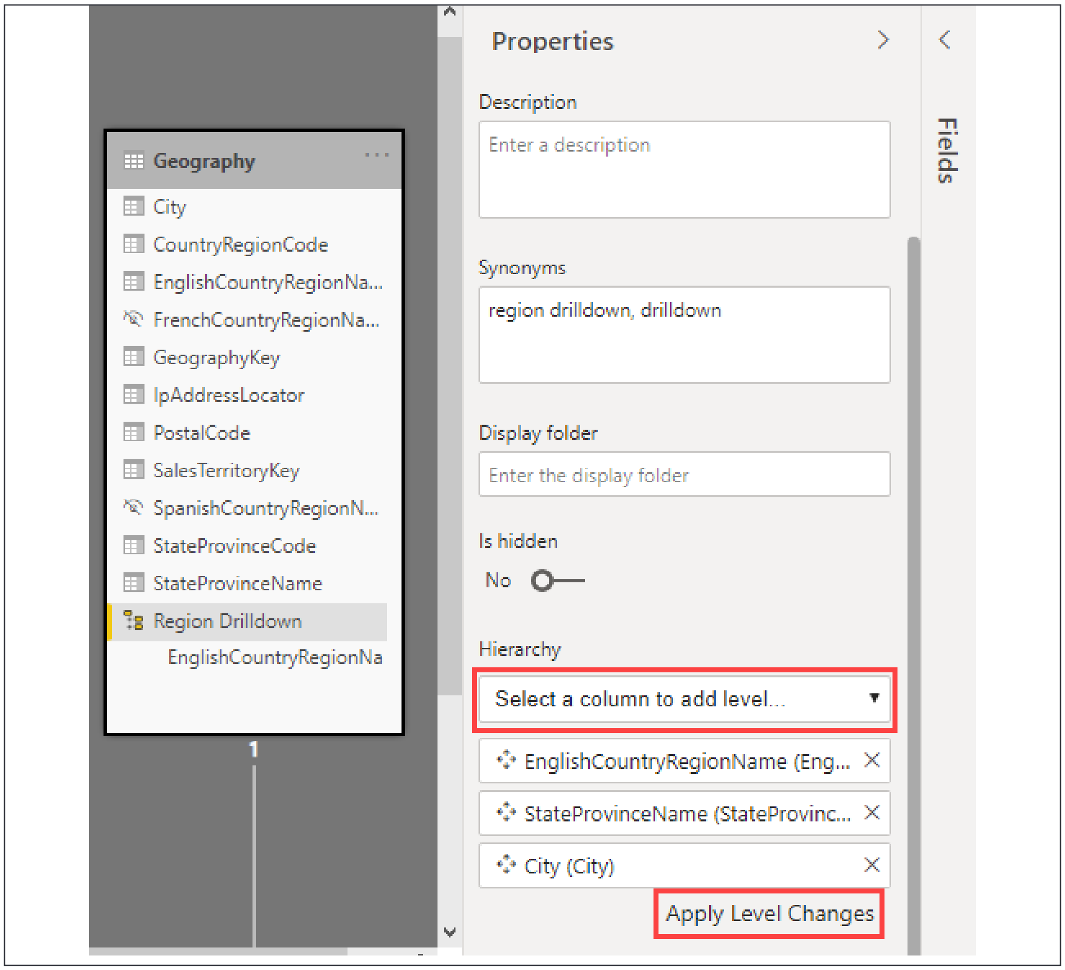
A fantastic visual for displaying hierarchies is the **Treemap** visual. It accomplishes this by nesting the data in rectangles, which are represented by color, and this is commonly known as a "branch." If you add a category into the **Details** bucket of the visual you will note smaller rectangles within the "branches" and these are known as "leaves," hence the name **Treemap**. In order to maximize this visual, you will need to do a little extra setup and bring in a new table, and create a new hierarchy. Let's go through this process now:

Let's look at setting up a treemap:

You need to bring in the **DimGeography** table from the `AdventureWorksDW` Excel workbook. Since you accomplished this during *Chapter 3*, *Building the Data Model*, you should be able to see this source under the **Recent Sources** option on the **Home** ribbon. If not, you can connect to this source by pointing to this location: `Microsoft-Power-BI-Start-Guide-Second-Edition-main\Data Sources\AdventureWorksDW.xlsx`:

1. Once the **Navigator** appears, place a checkmark next to the **DimGeography** table and click **Load**.
2. You will need to do a couple of quick fixes to this new table before you can leverage it. Navigate to the **Model** view and delete the inactive relationship between **Sales Territory** and **DimGeography**.
3. Next, rename the table to **Geography** and hide the **FrenchCountryRegionName** and **SpanishCountryRegionName** fields.
4. Create a new hierarchy. Right-click on the **EnglishCountryRegionName** column and select **Create hierarchy** from the dropdown. Rename the new hierarchy `Region Drilldown`.
5. With the hierarchy selected, add **StateProvinceName** to the hierarchy by changing the **Select a column to add level...** option in the **Properties** pane to the **StateProvinceName** field.

6. Repeat the previous step to add the **City** field to the hierarchy. Click **Apply Level Changes**.



Description: Enter a description

Synonyms: region drilldown, drilldown

Display folder: Enter the display folder

Is hidden: No

Hierarchy: Select a column to add level...

EnglishCountryRegionName (Eng...

StateProvinceName (StateProvinc...

City (City)

Figure 5.25: Apply fields and order to the Region Drilldown hierarchy

Now that you have a new geographical hierarchy that goes all the way down to the city level, you can see how this will display with the **Treemap** visual.

Let's look at setting up a **Treemap**:

1. Navigate back to the **Report** view. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Treemap**. Move and resize this visual so that it takes up a quarter of the remaining report canvas.

3. From the **Fields** pane, drag **Region Drilldown** from the **Geography** table to the **Group** bucket.
4. Next, from the **Fields** pane, drag **Total Sales** from **Internet Sales** to the **Values** bucket.
5. Last, from the **Fields** pane, drag **Year** from the **Date (Order)** table to the **Details** bucket.

The size of each of the rectangles is determined by the value being measured, which in this case is **Total Sales**. The "leaves" in this visual are portrayed by the **Year** category while the **Region Drilldown** creates the "branches." Because you are using a hierarchy, you have full access to the **Drilldown** capabilities shown earlier. You should also now be able to tell that the **Treemap** visual arranges the rectangles by size from top left (largest) to bottom right (smallest).

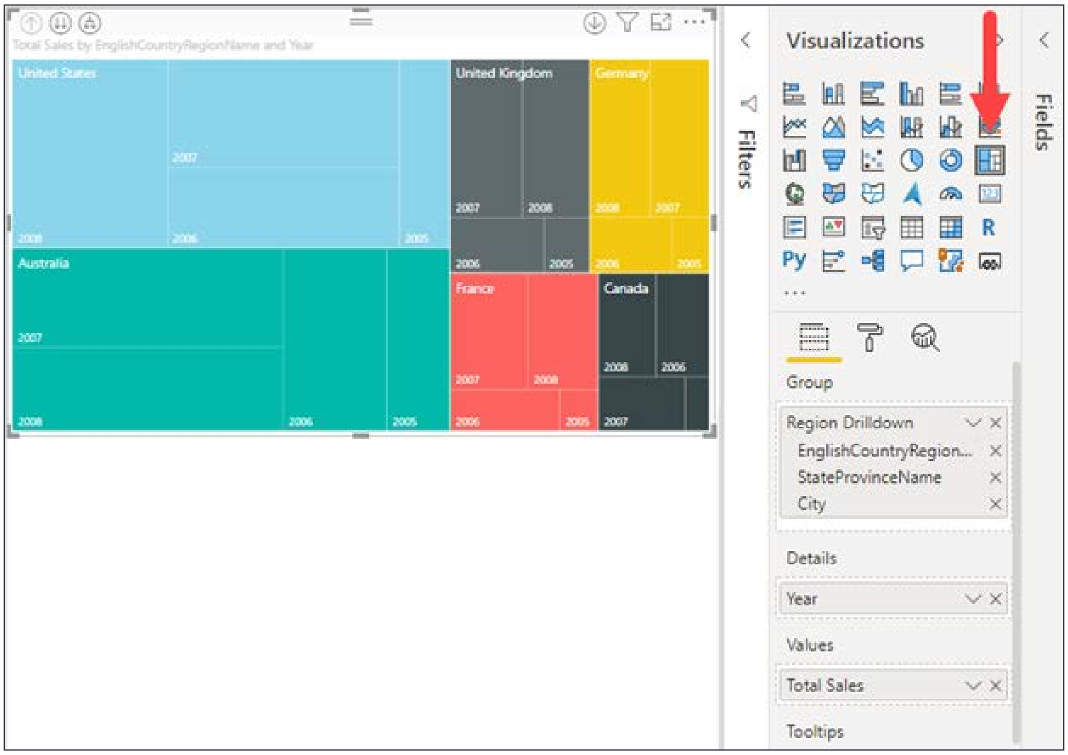


Figure 5.26: The treemap visual with group and detail levels displayed

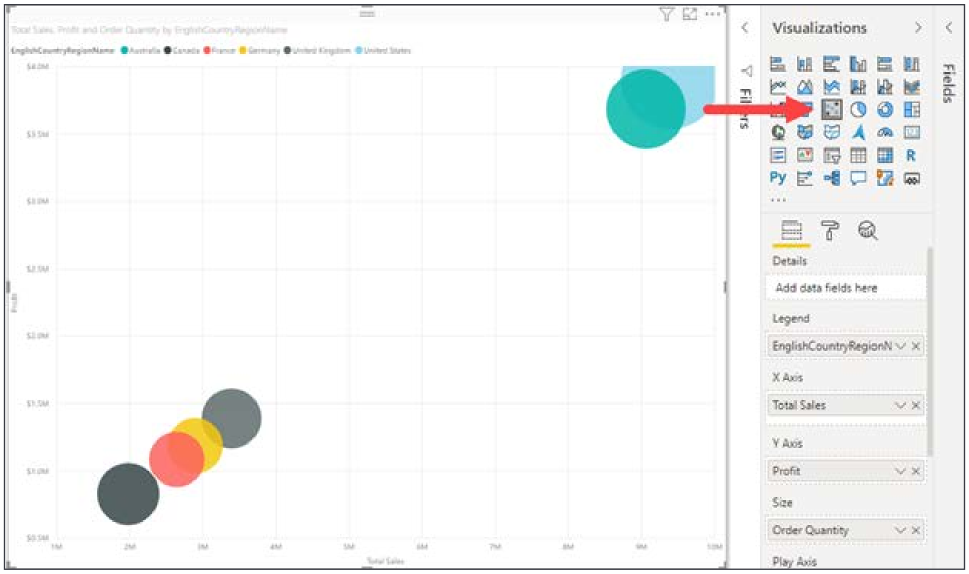
Look to treemaps as an alternative when bar and column charts become too cluttered by the number of categories because it still allows the consumer to compare the size of one category to another.

Scatter chart

The last visual used for categorical data is the **Scatter chart**, sometimes referred to as the **Bubble chart**. This visual allows you to show the relationships between two or three numerical values. You are given the opportunity to place values on the X and Y axes, but what is different about this visual is the ability to add a third value for the size, and this is where the name **Bubble chart** comes from. There is also a very unique option available within the **Fields** section to really bring this data to life, and it is called the **Play Axis**. Let's create the **Scatter chart** first, and then discuss the **Play Axis**.

Let's look at setting up a **Scatter chart**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. In the **Visualizations** pane, select the Scatter chart. Move and resize it to take up the remainder of the **Report** canvas.
3. From the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **X Axis** bucket.
4. From the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Y Axis**.
5. From the **Fields** pane, drag **Order Quantity** from the **Internet Sales** table to the **Size** bucket.
6. Finally, from the **Fields** pane, drag **EnglishCountryRegionName** from the **Geography** table to the **Legend** bucket. The visual should look similar to *Figure 5.27*.


Total Sales, Profit and Order Quantity by EnglishCountryRegionName
EnglishCountryRegionName ● Australia ● Canada ● France ● Germany ● United Kingdom ● United States
Profit
Total Sales
Visualizations
Filters
Fields

Details: Add data fields here
Legend: EnglishCountryRegionN
X Axis: Total Sales
Y Axis: Profit
Size: Order Quantity
Play Axis

Figure 5.27: Scatter plot configured to show sales, profit, and order quantity by EnglishCountryRegionName

Now, the last part that you will configure on this visual will be the **Play Axis**, which is unique to the **Scatter chart**. By adding a component of time, you can bring a little animation to this visual. For our example, add the **English Month Name** field from the **Date (Orders)** table to the **Play Axis** bucket, and you will see a **play** button appear along with the 12 months. By pressing the play button, you will now be able to watch the bubbles move to display their values at specific moments in time.

The **Scatter chart** uses a sampling algorithm when plotting larger sets of data to improve performance. The standard method used plots every 10th data point. In general, that sampling method is adequate. However, as datasets grow larger, high-density clusters of data can be oversampled leaving some sparse data points to be completely omitted from the chart. To solve this issue a setting is available in the **Format** section under the **General** options to enable a **High Density Sampling** algorithm that takes proximity to nearby data points into account, thereby ensuring the data points outside the high-density cluster are represented on the chart rather than being missed simply because they were not the 1 in 10 selected for display. This setting prioritizes an accurate distribution over accurate density on the **Scatter chart**. When showing items with no data, adding a ratio line, or using the **Play Axis**, the high-density setting will be ignored and the scatter chart will revert back to the standard sampling described at the beginning of this section.

Visualizing trend data

The term **trend data** refers to displaying and comparing the change in value over time. Power BI provides many options in this category, each with its own focus. The idea for each of the visuals is to draw attention to the total value across a length of time. Create a new report page called `Trend Data`, and dive right in to see what the differences are between the following options:

- Line and Area charts
- Combo charts
- Ribbon charts
- Waterfall charts
- Funnel charts

To begin, let's explore the line and area charts. These are the most commonly used charts for visualizing trend data, and the ones that the visualizations report consumers are likely most familiar with already.

Line and Area charts

The **Line chart** is the most basic of the options when it comes to analyzing data over time. The **Area chart** and **Stacked area chart** are based on the **Line chart**; the difference is that the area between the axes and the line is filled in with colors to show volume. Because of this, the focus will be on the line chart for the next example.

Let's look at setting up a **Line chart**:

1. From the **Visualizations** pane, select the **Line chart**. Move it to take up a quarter of the **Report** canvas.
2. From the **Fields** pane, drag the **Date** field from the **Date (Order)** table to the **Axis** bucket.
3. Add two measures to compare over time. From the **Fields** pane, drag **Total Sales** and **Prior Year Sales** from the **Internet Sales** table to the **Values** bucket.
4. Finally, click **Expand all down one level in the hierarchy** two times to display the quarter and month as seen in *Figure 5.28*.

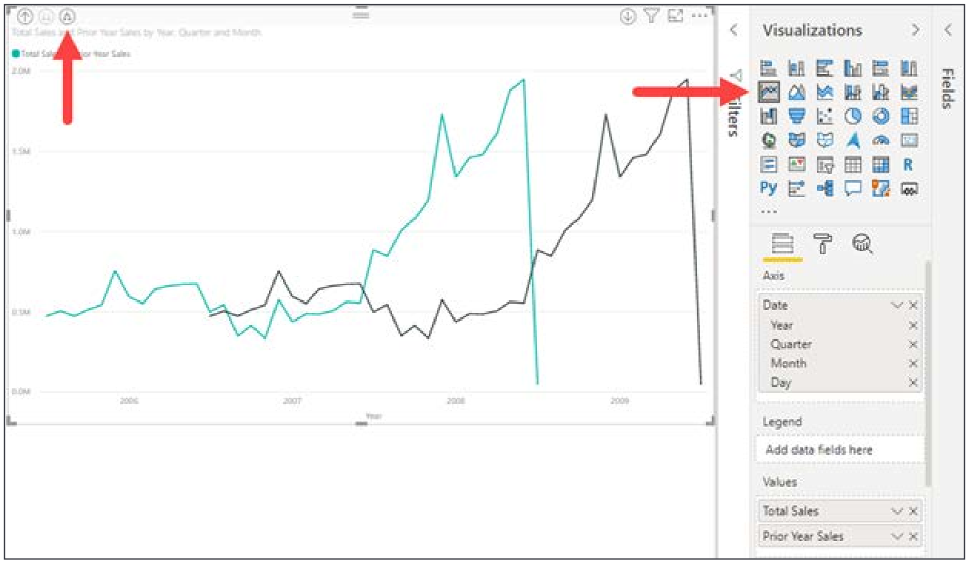


Figure 5.28: Sales and Prior Year Sales line chart with an indicator on how to drill down to quarter, month, and day levels

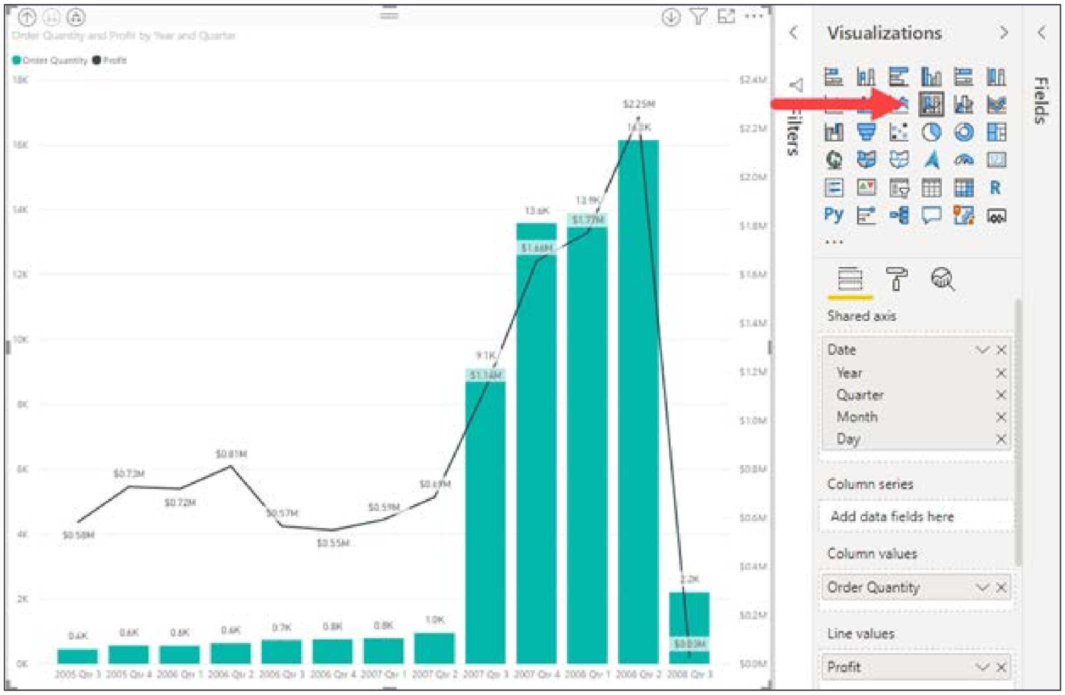
With this **Line chart**, you can clearly see there was a large growth in sales between **2007** and **2008**. Visuals that focus on trend data can very easily illustrate any outliers, which can allow users to further investigate the cause for the seen trend. This visual can also benefit from some of the formatting options such as data labels.

Combo charts

As the name states, **Combo chart** combine the **Line chart** and **Column chart** together in one visual. Users can choose to have either the **Stacked column** format or the **Clustered column** format. By combining these two visuals together, you can make a very quick comparison of the data. The main benefit of this type of chart is that you can have one or two Y axes. Two measures can either share the same Y axis, like **Total Sales** and **Profit**, which are both numeric values, or, they could be based on completely different values, like **Order Quantity** and **Profit**, which are numeric and percentage, respectively. Let's use two different axes for this example:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Line and stacked column chart** visual. Resize it to take up a quarter of the **Report** canvas.
3. From the **Fields** pane, drag **Date** from the **Date (Order)** table to the **Shared Axis** bucket.
4. From the **Fields** pane, drag **Order Quantity** from the **Internet Sales** table to the **Column Values** bucket.
5. Finally, from the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Line Values** bucket.

In this example, you can see that there are two Y axes; the left one relates to the **Order Quantity** while the right one corresponds with the **Profit**. Expand the hierarchy one level; this will give more data points to see the trending between the two measures, as seen in *Figure 5.29*:



Visualizations

Shared axis

Date
Year
Quarter
Month
Day

Column series

Add data fields here

Column values

Order Quantity

Line values

Profit

Figure 5.29: Combo chart with columns representing order quantity and a line representing profit

From this visual, it's fairly easy to validate that when more items are sold more profit is made. This, like many other visuals, can also benefit from data labels.

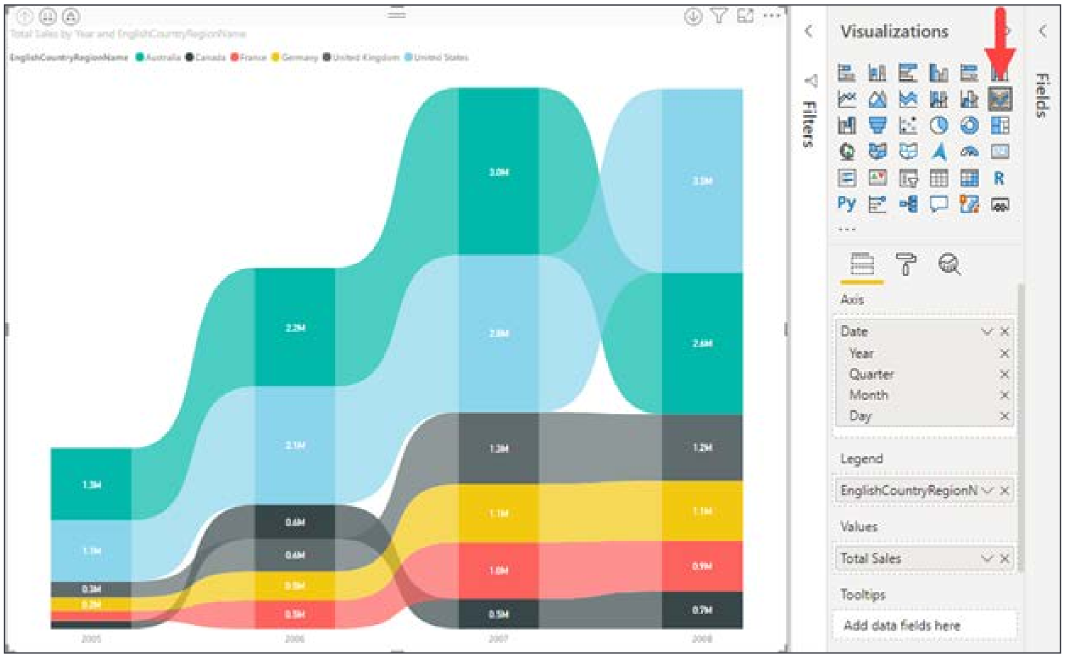
Ribbon chart

The **Ribbon chart** is no different than the other visuals explored in this section; it is good at viewing data over time. What makes ribbon charts effective though is their ability at showing rank change; the highest range or value is always displayed on the top for each of the time periods. The chart also does have a unique visual flowing appeal to it that is different than the other visuals.

Let's look at setting up a **Ribbon chart**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Ribbon chart** visual. Resize it to take up a quarter of the **Report** canvas.
3. From the **Fields** pane, drag **Date** from the **Date (Order)** table to the **Axis** bucket.
4. Next, from the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **Values** bucket. At this point, you will see that it looks like a **Column chart**.
5. Upon adding a category to the **Legend** bucket, the visual will display a flowing ribbon. For this exercise, drag **EnglishCountryRegionName** from the **Geography** table to the **Legend** bucket.

The first thing you may notice is the lighter areas between time periods; this is really one of the best parts of the **Ribbon chart**. This area shows the value for the category for the previous period and the upcoming one. Also, the tooltip gives each value a rank and shows any increases and decreases. This, like many other visuals, also gets a nice visibility improvement by adding data labels, as seen in *Figure 5.30*.


Total Sales by Year and EnglishCountryRegionName

EnglishCountryRegionName ● Australia ● Canada ● France ● Germany ● United Kingdom ● United States

Axis: Date (Year, Quarter, Month, Day)
Legend: EnglishCountryRegionName
Values: Total Sales
Tooltips: Add data fields here

Figure 5.30: Ribbon chart showing total sales by country and year

The dynamic ranking feature of the ribbon visualization makes it unique but does come at the cost of making it more difficult to discern size in relation to prior periods or size in relation to other categories within the same period.

Waterfall chart

This next visual, the **Waterfall chart**, is very helpful in understanding the changes that occur from an initial value. It displays a running total in relation to values being added or subtracted. By populating a field in the **Breakdown** option of the visual, you can see if it has had a positive or negative impact from value to value.

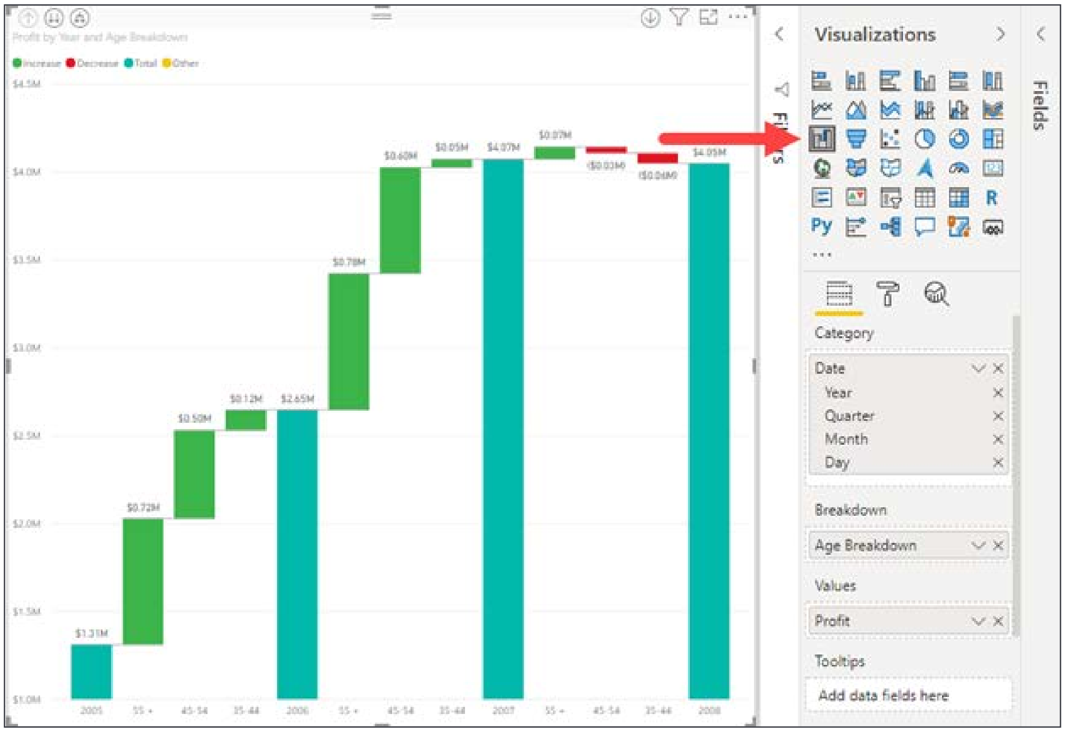
Let's look at setting up a **Waterfall chart**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Waterfall chart**. The current report page should have a quarter of the area still available. Use half of this for the **Waterfall chart**.
3. From the **Fields** pane, drag **Date** from the **Date (Order)** table to the **Category** bucket.
4. Next, from the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Values** bucket. This will show how much each year has contributed to the total profit.

Finally, from the **Fields** pane, drag **Age Breakdown** from the **Customer** table to the **Breakdown** bucket.

Now, you can see the strength of the **Waterfall chart**, and you can see how much contribution each age group provided between years. By default, the visual uses the green color to indicate positive changes and red to indicate negative changes, but this can be changed from the **Format** section if you are so inclined.

Depending on how many values are within your breakdown category, enabling data labels can be useful in this visual, as seen in *Figure 5.31*:



Category

Date
Year
Quarter
Month
Day

Breakdown

Age Breakdown

Values

Profit

Tooltips

Add data fields here

Figure 5.31: Waterfall chart showing profit by age breakdown and year

The **Waterfall chart** is particularly useful when searching for how much a particular category (represented by the breakdown field) contributes to the overall gain/loss between two periods.

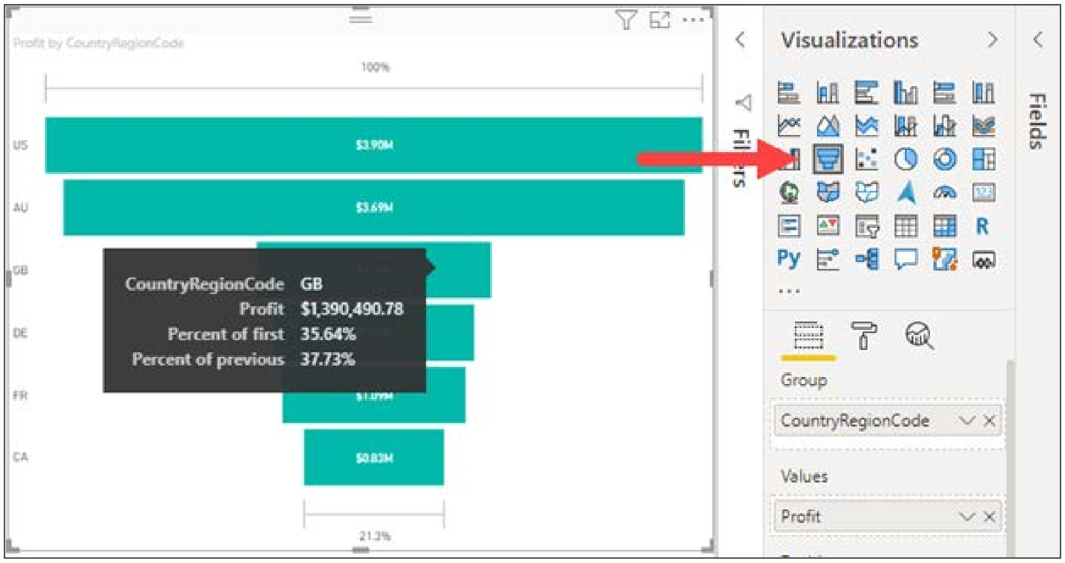
Funnel chart

The **Funnel chart** allows users to see the percentage difference between values. Normally, the highest value is at the top and the lowest is at the bottom, which gives the look of a funnel. Each stage of the funnel will tell the percentage difference between itself and the previous stage, as well as compared to the highest stage. With this type of design, it makes sense that the **Funnel chart** is very effective when visualizing a linear process with at least three or four stages. The sample dataset does not have a process with multiple stages, but there is data that will still create something that gives value.

Let's look at setting up a **Funnel chart**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Funnel chart**. It should fill in the final remaining space on the **Report** canvas.
3. From the **Fields** pane, drag **CountryRegionCode** from the **Geography** table to the **Group** bucket.
4. Finally, from the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Values** bucket.

The way this visual is set up allows you to very easily identify which countries make the most profit and which make the least, but this is something that can be achieved with many other visuals. What gives the **Funnel chart** an edge is when you hover over one of the sections within the funnel and note the items that appear within the tooltip. You will see, when hovering over the section for **FR**, that the tooltip lets you know how it compares to the section directly above it, as well as how it compares to the highest section, which is represented by the **US**.



CountryRegionCode GB
Profit $1,390,490.78
Percent of first 35.64%
Percent of previous 37.73%

Figure 5.32: Funnel chart showing profit by country and as a percent of the largest profit winner

There is no shortage of ways to visualize trend data in Power BI. Next, let's look at calling out important data points using KPIs.

Visualizing KPI data

KPIs, or **Key Performance Indicators**, are measurable values that demonstrate how well a company is achieving a certain objective. Power BI has several options to measure the progress being made towards a goal for operational processes. The strength of a KPI visual lies in its simplicity. It displays a single value and its progress toward a specific goal.

Create a new report page called `KPI Data` and take a closer look at the gauge and KPI visuals.

Gauge

The **Gauge** visual displays a single value within a circular arc and its progress toward a specified goal or target value. The **Target value** is represented by a line within the arc. With the current dataset there is not a measure that can be used to illustrate an accurate business goal, so one will have to be created. Before setting up this visual, a new calculated measure will need to be created.

The gauge will be using the **Total Sales** field as the **Value** field. The target will be 10% more than the previous year's total sales, so a DAX calculation is needed to create this measure:

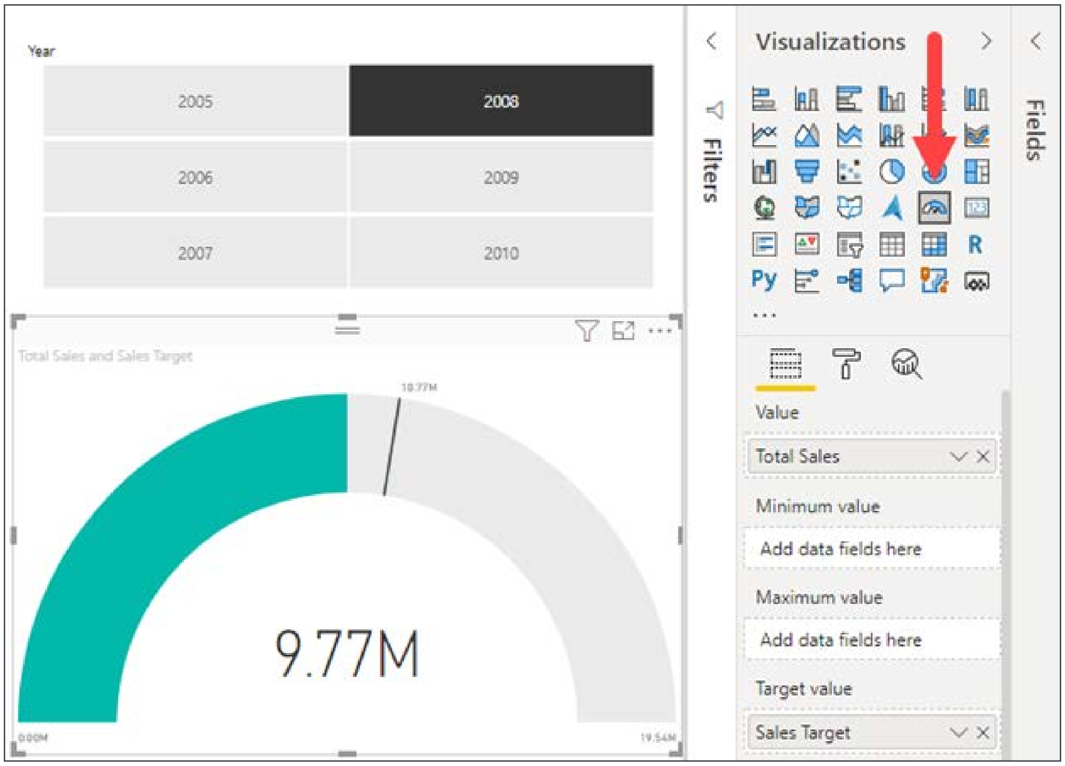
1. In the **Fields** pane, right-click the **Internet Sales** table and select the **New Measure** option. This brings the focus to the formula bar.
2. Name the measure **Sales Target**, and use the following DAX formula to get our target:

    ```
    Sales Target = [Prior Year Sales] * 1.1
    ```

Now that all the necessary measures have been created, let's set up the **Gauge** visual and create the first KPI:

1. From the **Visualizations** pane, select the **Gauge**. Move and resize it as you see fit.
2. From the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **Values** bucket.
3. From the **Fields** pane, drag **Sales Target** from the **Internet Sales** table to the **Target Values** bucket.

Using a **slicer** visual alongside this KPI will be helpful with this dataset. Add the **slicer** visual using the **Year** field from the **Date (Order)** table for the **Value**. If you choose the year **2008**, you will see that the value changes along with the target, as seen in *Figure 5.33*. With this dataset, the year `2008` has the most recent transactions, and because of this visual, you can see that the goal has still not been met. If you look at any of the other previous years, you can validate that the total sales surpass the target every year.



Value
Total Sales
Minimum value
Add data fields here
Maximum value
Add data fields here
Target value
Sales Target

Figure 5.33: Gauge showing sales vs. target sales for the year 2008

The **Gauge** does not require a target, maximum, or minimum field but they each help create a more user-friendly visual. The minimum and maximum values can be set manually on the gauge axis formatting options for the visual if a dynamic range is not required.

KPI

Where the **Gauge** visual uses the circular arc to show the current progress, the **KPI** visual takes a more explicit approach and just shows the value in plain text, along with the goal. The only real visual elements that are in play with this visual occur when the indicator value is lower than the goal and the text is shown in red, and when it has surpassed the goal and the text is in green. This is one of the more direct visuals and perfectly exemplifies what users look for in a **KPI**.

Let's look at setting up a **KPI**:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **KPI**. Move and resize it as you see fit.
3. From the **Fields** pane, drag **Total Sales** from **Internet Sales** to the **Indicator** bucket.
4. Next, from the **Fields** pane, drag **Prior Year Sales** from the **Internet Sales** table to the **Target Goals** bucket.
5. Finally, from the **Fields** pane, drag **Year** from the **Date (Order)** table to the **Trend Axis**.

If, after following the preceding steps, the visual displays a value of Blank for the indicator, do not worry. This is because it is trying to show the `Total Sales` for the year `2010`, the most recent value in the dataset. Unfortunately, there are no sales for **2009** or **2010**, so to have this visual display correctly simply choose any other year from the slicer that was added in the previous section. Once you have accomplished this, you will now be able to view the **KPI** visual, and it should look like *Figure 5.34*.

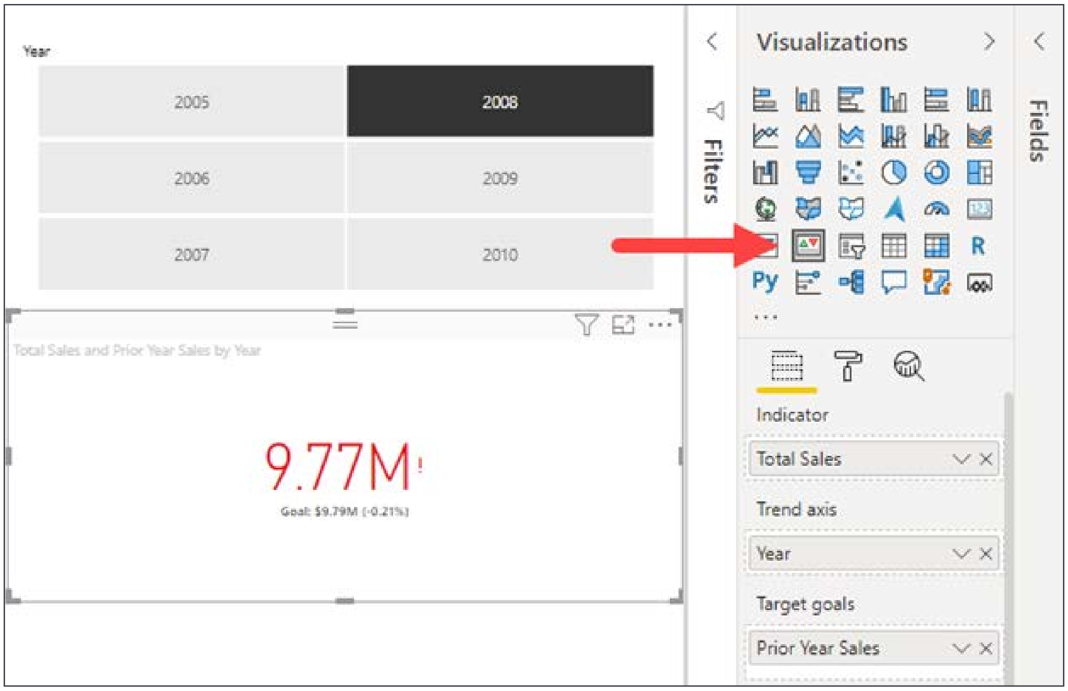


Figure 5.34: KPI showing sales vs. the prior year sales for 2008

Be sure to look at the formatting options for the **KPI** visual to set the appropriate color coding for the indicator. The default settings have higher values as "good" but this is not always the case. Imagine a scenario where the **KPI** is visualizing shipping delays, in that case a lower number would be better and the **KPI** can be configured as such.

Visualizing data using cards

The ways for Power BI to get detailed data into the hands of a user are vast. Tables, matrices, bar chats, and combo charts all provide large quantities of data to users in a single visual. Sometimes, like a **KPI**, users just need to see a number. When the trend or target components of a **KPI** are not required, turn to the **Card** visualization. The **Card** is the most basic of visuals displaying only a single value. If slightly more detail is necessary, but required at a group level, look to the **Multi-row card**.

Before moving on, create a new report page called `Card Data`.

Card

The **Card** is useful for highlighting a series of related metrics in a dashboard, displaying the most recent or oldest date in a dataset, and calling out important numbers for a detailed report. Some formatting options are available to change the font size or color, but at its core, the card visual just displays a single value.

Let's look at setting up a **Card**:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Card**. Move and resize it as you see fit.
3. From the **Fields** pane, drag **Sales Amount** from the **Internet Sales** table to the **Fields** bucket.
4. Explore the **Format** section to change the category text, title text, or switch the display units from millions to thousands.

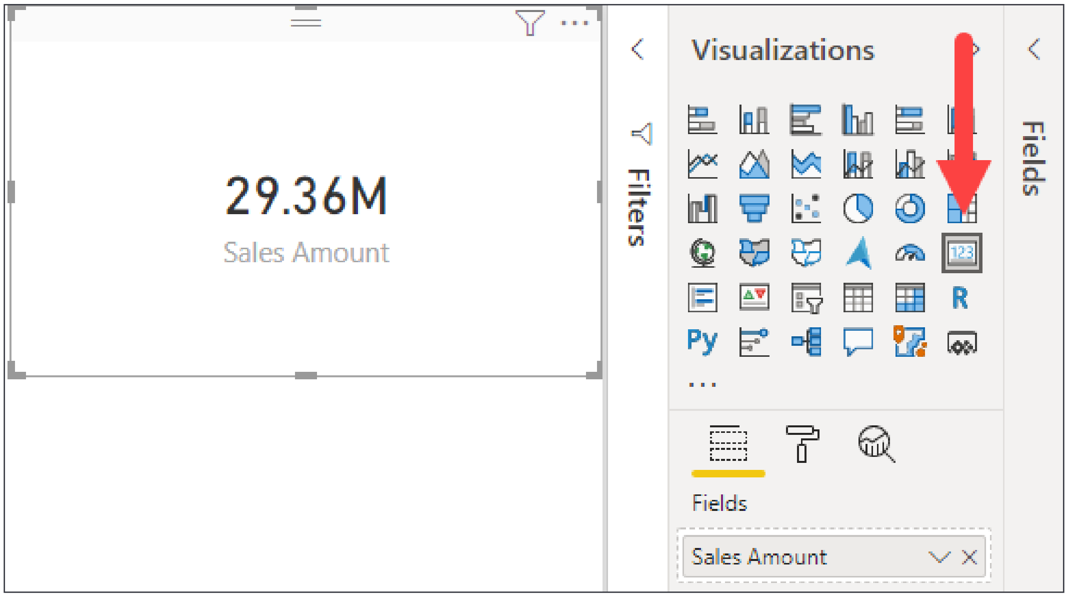


Figure 5.35: Card showing the aggregate total sales amount

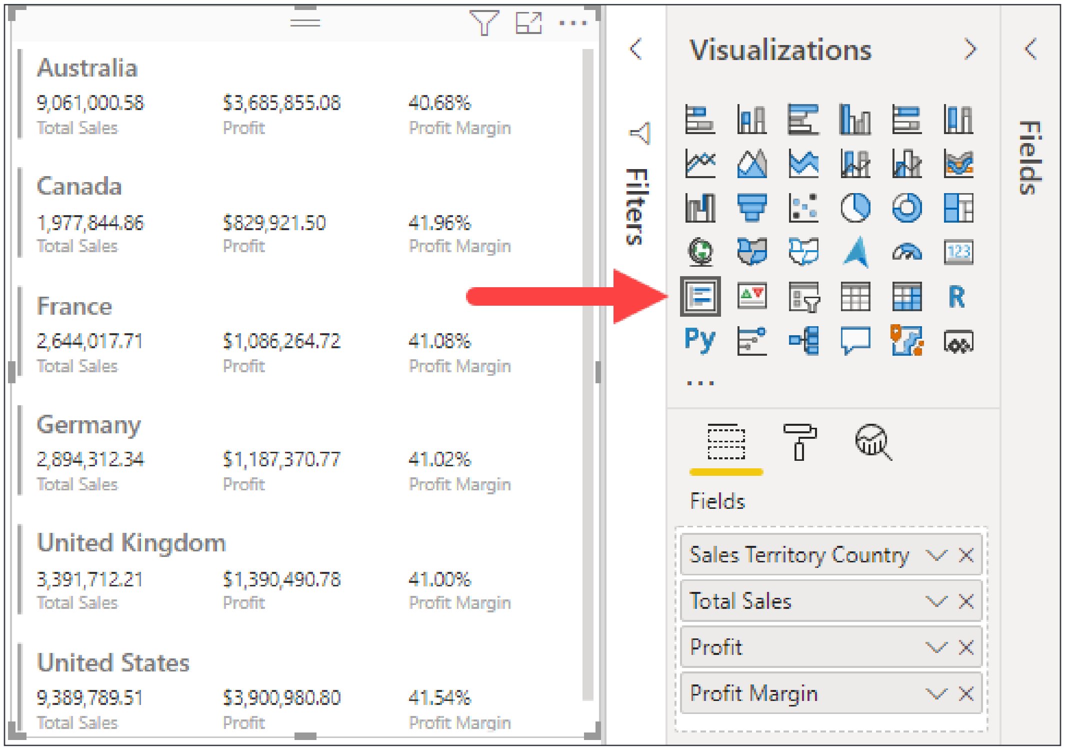
It is important to ensure the report provides context for what is being displayed on the **Card** because it lacks categories. Consider using slicers on report pages with cards rather than report- or page-level filters to ensure users are fully aware of the filters being applied to the card.

Multi-row card

The **Multi-row card** allows for slightly more data to be displayed than the card. It accepts multiple fields and automatically groups all non-summarized fields. For instance, adding the **Sales Territory Country** and **Total Sales** would result in one row per country. Adding the **Color** field from the **Product** table would automatically group the **Total Sales** by both **Sales Territory Country** and **Color**. This behavior sounds similar to a **Table** or **Matrix**, but the **Multi-row card** does not display data in a tabular format, instead it creates separate sections in the visual for each group.

Let's look at setting up a **Multi-row card**:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Multi-row card**. Move and resize it as you see fit.
3. From the **Fields** pane, add the following fields to the **Fields** bucket:
    - **Sales Territory Country** from the **Sales Territory table**
    - **Total Sales** from the **Internet Sales** table
    - **Profit** from the **Internet Sales** table
    - **Profit Margin** from the **Internet Sales** table



Australia
9,061,000.58 Total Sales | $3,685,855.08 Profit | 40.68% Profit Margin

Canada
1,977,844.86 Total Sales | $829,921.50 Profit | 41.96% Profit Margin

France
2,644,017.71 Total Sales | $1,086,264.72 Profit | 41.08% Profit Margin

Germany
2,894,312.34 Total Sales | $1,187,370.77 Profit | 41.02% Profit Margin

United Kingdom
3,391,712.21 Total Sales | $1,390,490.78 Profit | 41.00% Profit Margin

United States
9,389,789.51 Total Sales | $3,900,980.80 Profit | 41.54% Profit Margin

Fields
- Sales Territory Country
- Total Sales
- Profit
- Profit Margin

Figure 5.36: Multi-row card showing sales and profit measures by country

While the **Multi-row card** can display more fields compared to the card, it comes at the cost of customization. There is little to no control over how the data is displayed outside some basic font size and color options.

Visualizing geographical data

One of the most exciting ways to visualize data in Power BI is through the various maps. All the maps serve the same purpose, to illustrate data in relation to locations around the world, but there are some small differences between each of them. All of the maps, except the **Shape map**, have the option to visualize latitude and longitude coordinates, which will be the best way to ensure the appropriate location is being displayed. The reason for this is because the information provided to the visual will be sent to **Bing Maps** to verify the positioning on the map. If you do not provide enough detail, then **Bing** may not return the desired results. For example, if you were to provide the map visual with a field that contains only the city name, that could result in some confusion because there may be multiple cities in the United States with that name. In these scenarios, you will either want to supply some sort of geo-hierarchy to give a better definition, or create new columns with more detailed information. Power BI also has a built-in feature when dealing with geographic data that allows users to help identify the type of data that is being provided: this is called the data category. Let's go ahead and take advantage of this for our dataset to make the map visuals more accurate:

1. From the **Fields** pane, expand the **Geography** table. Select the **City** field by clicking the name of the field rather than the checkbox to its left.
2. On the **Column Tools** ribbon change the **Data category** to **City**. Once here, you will see the **Data category** option.

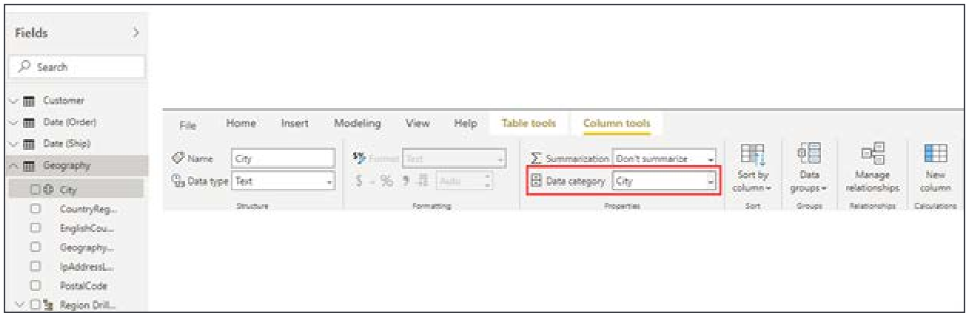


Figure 5.37: Change the data category for a field on the Column tools tab of the ribbon while on the Report view

3. Repeat the steps above for the **StateProvinceName** field, selecting the **State or Province** data category.
4. Repeat the steps above for the **EnglishCountryRegionName**, selecting the **Country** data category.

Now that you have defined the geographical data for Power BI, you can proceed with using the various map visuals. One thing of note is that using any of these visuals does require internet access because data will be sent to **Bing Maps** or **ESRI** depending on the visual chosen.

Before you begin, create a new report page called `Geographical Data`.

Map

The first visual to illustrate geographical data is simply called the **map** visual. This visual is also referred to as the **bubble map** because it plots the points of data with circles that can be set to change in size based off a supplied measure. With this visual, if you have the latitude and longitude coordinates in your dataset, then nothing needs to be sent to **Bing Maps**. Such detailed data is unavailable, so you will need to supply the necessary information through the **Location** bucket, which will be sent to **Bing Maps**.

Let's look at setting up a map:

1. From the **Visualizations** pane, select the **Map** visual. Move and resize it to take up a quarter of the **Report** canvas.
2. To ensure there is no confusion about the locations to be mapped, use the geo-hierarchy, which has been created within the **Geography** able. From the **Fields** pane, drag the **Region Drilldown** from the **Geography** table to the **Location** bucket. Six countries will be represented by a bubble.
3. Next, from the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **Size** bucket. This value will dictate the size of the bubbles displayed for each city on the map. Larger bubbles indicate countries with higher sales amounts.
4. Finally, from the **Fields** pane, drag **Age Breakdown** from the **Customer** table to the **Legend** bucket. With this, the bubbles start to look like little pie charts, as seen in *Figure 5.38*.

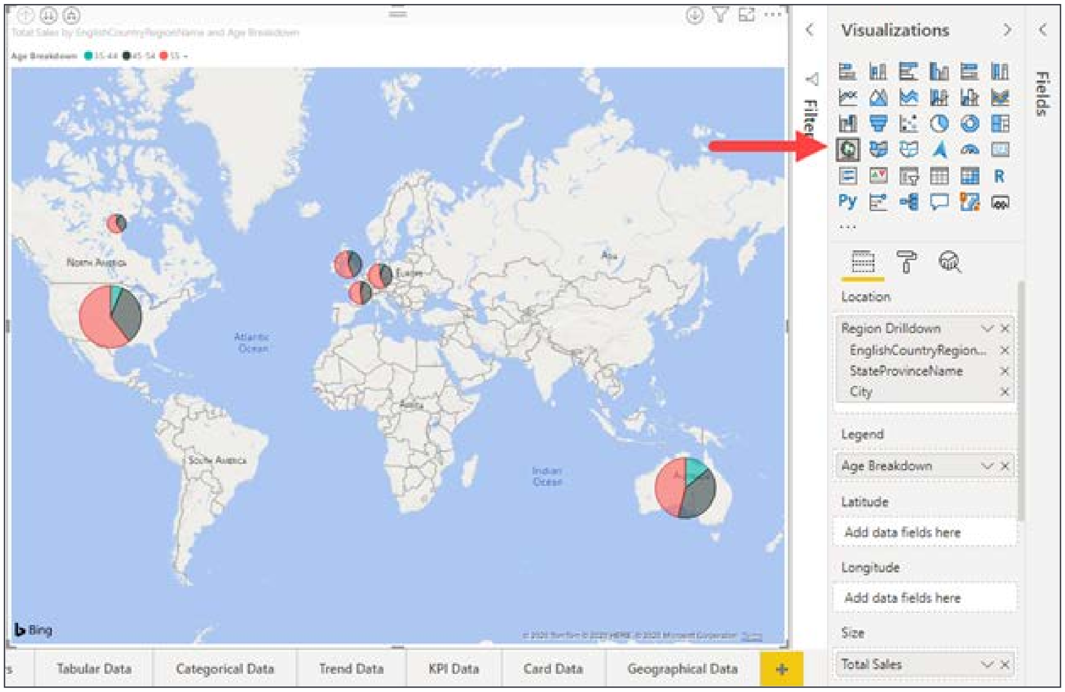


Figure 5.38: A map showing sales by country by age breakdown

When using a geo-hierarchy with a map, enabling the **Drill** mode, which is signified by the down arrow in the upper right, can make this visual even more enjoyable. Remember this for any visual where you have a hierarchy selected; you should explore the different views it gives you.

Filled map

Unlike the traditional map visual, which uses a bubble to indicate locations, the **Filled map** visual uses shading to display the geographic data. So, the lighter an area looks, the lower the representative value. For this visual, it is recommended to visit the **Format** section and dictate the range of colors for the shading so it will appear more apparent.

Let's look at setting up a **Filled map**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Filled map**. Move and resize it to take up a quarter of the **Report** canvas.
3. From the **Fields** pane, drag **Region Drilldown** from the **Geography** table to the **Location** bucket.
4. From the **Visualizations** pane, switch to the **Format** section. Expand the **Data colors** options. Click the conditional formatting button next to the color selector.

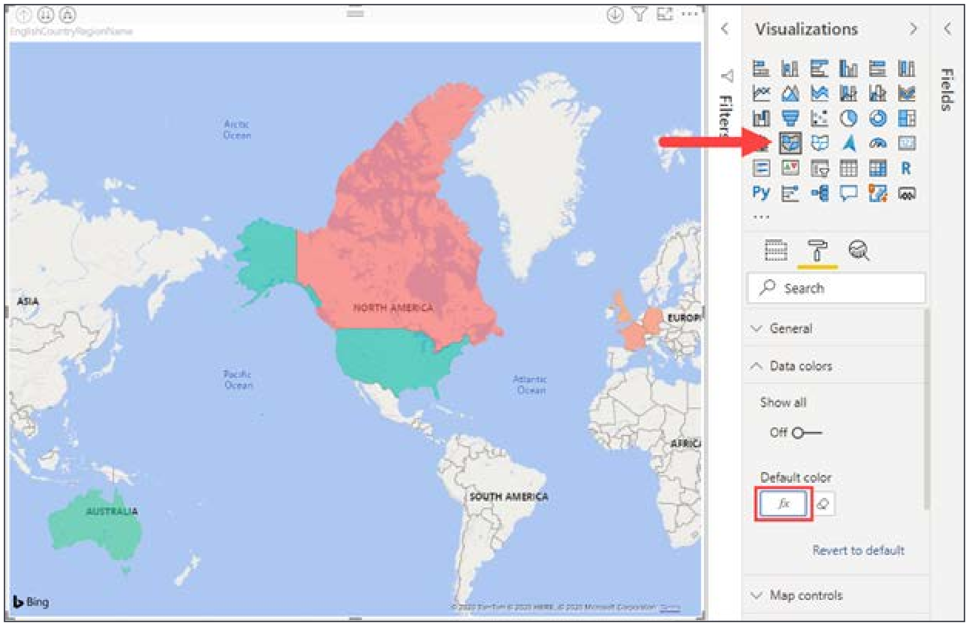
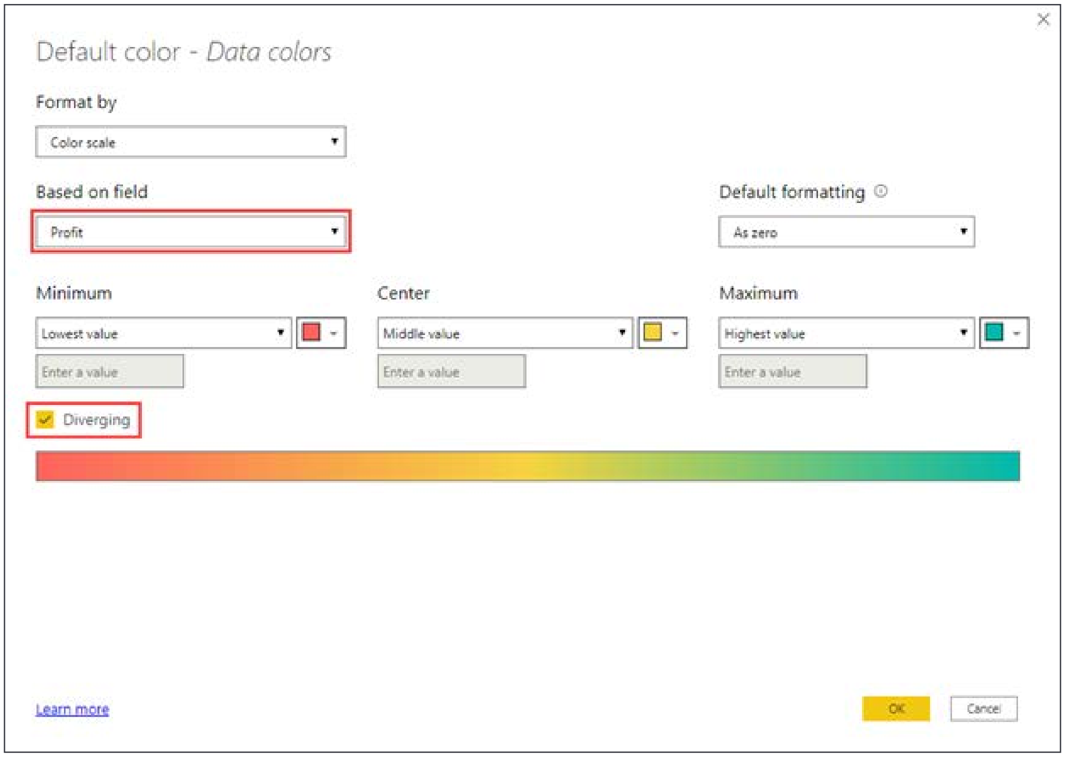


Figure 5.39: Filled map highlighting each country in the Region Drilldown hierarchy

5. Change the **Based on field** setting to the **Profit** field from the **Internet Sales** table.
6. Check the box next to the **Diverging** option. Click **OK**.


Default color - *Data colors*

Format by: Color scale

Based on field: Profit

Default formatting: As zero

Minimum: Lowest value

Center: Middle value

Maximum: Highest value

Enter a value

✓ Diverging

Figure 5.40: Configuration to set colors on the filled map based on profit

The base layer on the filled map can be changed to a variety of themes including road, dark, light, and aerial, which shows satellite imagery.

Shape map

Similar to the **Filled map**, the **Shape map** visual uses shading/saturation to show the geographic data. One thing that does make the **Shape map** unique is that it allows users to upload their own maps to be illustrated. In order to accomplish this, you must have a JSON file that contains all the necessary information required by Power BI. By default, the visual does offer some standard maps but currently does not have an option to show the entire world.

Let's look at setting up a **Shape map**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **Shape map**. Move and resize it to take up a quarter of the **Report** canvas.
3. From the **Fields** pane, drag **StateProvinceName** from the **Geography** table to the **Location** bucket. Do not be alarmed if nothing appears initially, you still need to tell Power BI which map to use.
4. From the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Color saturation** bucket.
5. From the **Format** section of the **Visualizations** pane, expand the **Shape** section where there will be a drop-down selection for the **Map** category. For this example, select **USA: states**.
6. This is another example where taking control of what colors will be used for the shading can be helpful. Apply the same **Diverging** setting from the **Filled map** under the **Data colors** options.

In addition to simple geographical mapping, the **Shape map** provides the ultimate flexibility allowing you to bring more detailed mapping, such as census tracts, to Power BI.

ArcGIS Map

The **ArcGIS Map** visual is very different in that there is an option to pay for additional features. Also, the location where you can make visual changes to the map is different as well. Normally, you would access the **Format** section of the **Visualizations** pane but for this map, you must hit the ellipsis in the upper-right corner of the visual and choose the **Edit** option. You will be focused on a couple of key areas, but there are a lot of options that are worth exploring.

Let's look at setting up an **ArcGIS Map**:

1. Ensure no visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select the **ArcGIS Map**. Move and resize it to take up the final quarter of the report canvas.

3. From the **Fields** pane, drag **StateProvinceName** from the **Geography** table to the **Location** bucket.
4. From the **Fields** pane, drag **Total Sales** from the **Internet Sales** table to the **Color** bucket.

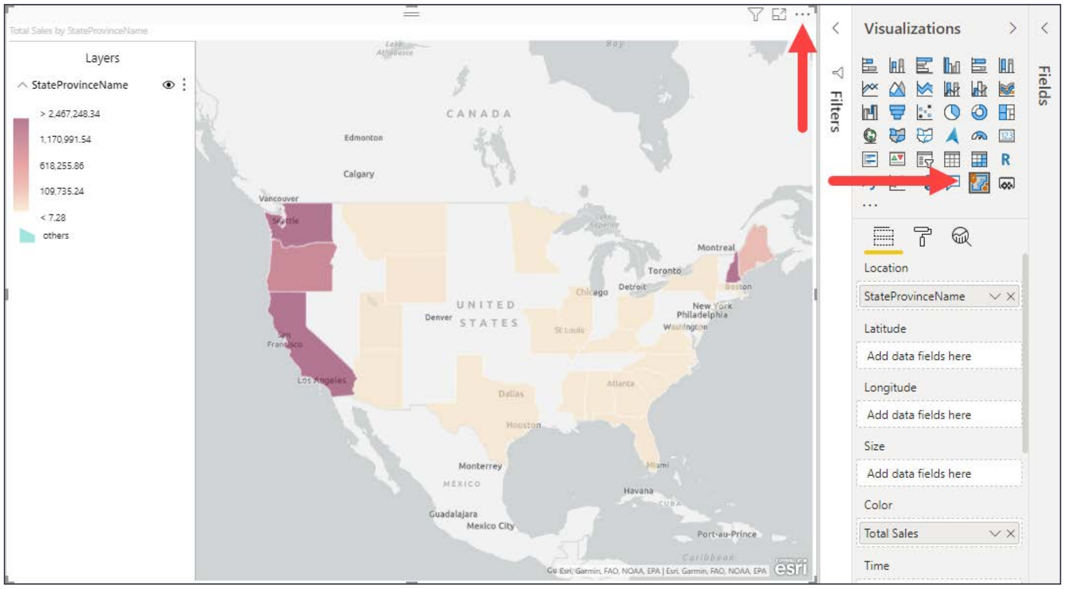


Figure 5.41: ArcGIS map showing total sales by state

This visual is ready to go with the current configuration, but if you want to change how things look you must take a new route that is unique to this visual. In the upper right-hand corner, you will see an ellipsis; left-click this and choose the **Edit** option highlighted in *Figure 5.41*. This brings up a display that looks very similar to **Focus Mode**, but you will notice there are quite a few options at the top of the map highlighted in *Figure 5.42*. The first area to visit to make a slight change will be the **Symbol style** option. Here, you can control the level of transparency as well as the color palette being used.

Select the drop-down menu for the **Color ramp** option and choose whatever selection you find enjoyable.

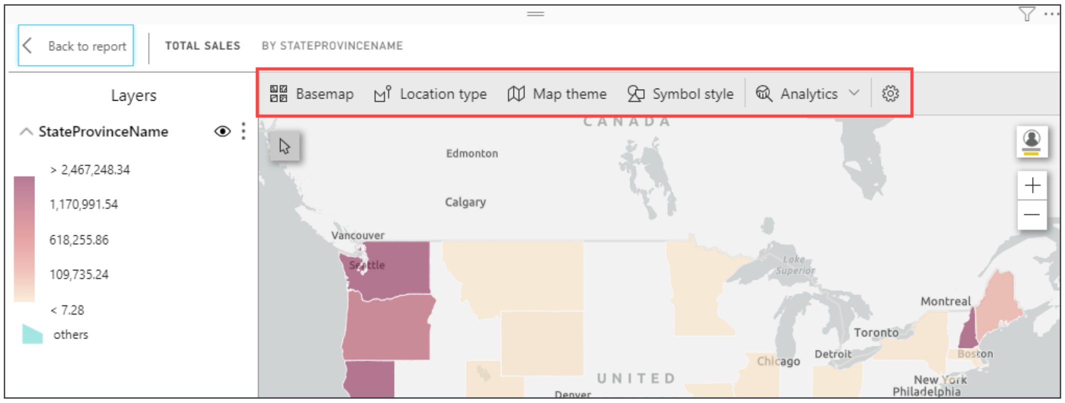


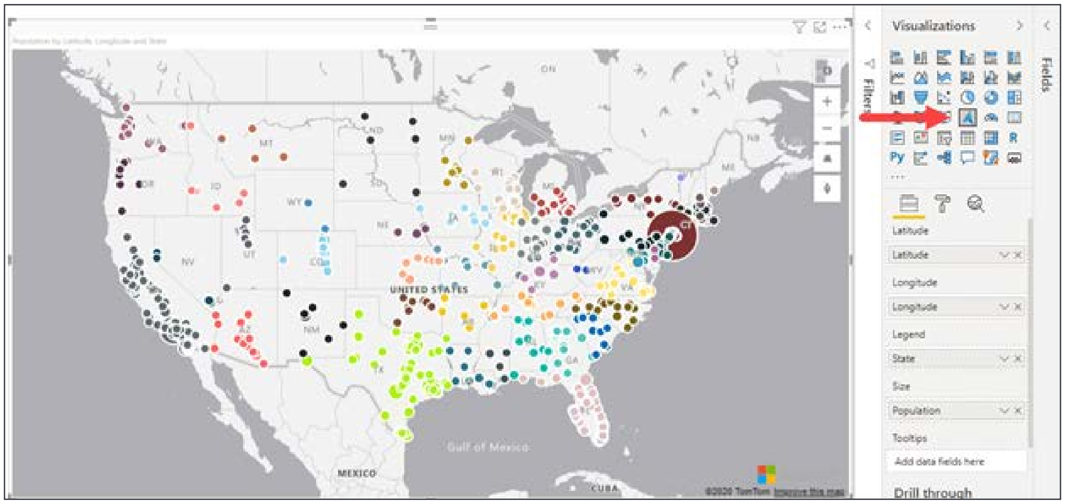
Figure 5.42: Options menu in the ArcGIS map that provides vast customizations

This is the only change you will be making for this example, but you should take the time and examine all the other options available to you. Remember, there are even more options to choose from if you decided to subscribe and pay for this visual.

Azure maps

The newest member of the Power BI mapping family is the **Azure maps** visual. Unlike some of the other options, this map requires latitude and longitude. It does not accept generic locations like city or state, or even more specific locations like ZIP code. The map style can be changed between several options including satellite, hybrid, grayscale, and terrain. A powerful feature of this map is the ability to add reference layers that can be uploaded in GeoJSON form. Other notable functionality includes overlaying a bar chart on the map and displaying real-time traffic.

Due to the latitude and longitude data point requirement, there is no sample data available in the lab, but a screenshot has been included for reference. In *Figure 5.43* you will notice buckets for **Latitude**, **Longitude**, **Legend** (used for color coding groups), **Size**, and **Tooltips**.



Latitude
Latitude
Longitude
Longitude
Legend
State
Size
Population
Tooltips
Add data fields here

Figure 5.43: Azure map showing population by location

All the maps described in this chapter are very similar, but each has a specific functionality that does not exist in the others. The traditional map and **Filled map** visuals are the most used, but you will need to decide when one might illustrate your dataset better than the other.

Natural language

Not all data is as straight forward as showing the sales amount by month. Often, when a report is being developed you may not know all the different visualizations a user would like to see. While Power BI has great flexibility thanks to built-in cross-filtering, drilldown, and the ability to see data behind a visual, it will never be able to cover all possible reporting scenarios. One of the most powerful ways to enable self-service functionality in Power BI is using the **Q&A** visual. The **Q&A** feature is often described as a search engine for your data.

The **Q&A** visual allows users to simply ask a question in plain English and receive an answer in the form of a pre-built visual. This is great for data exploration as well thanks to search suggestions and autocomplete functionality. The suggestions are only as good as the data model you have built. Without specific domain knowledge, Power BI makes suggestions for additional terms people may search for. In the case of the model in the examples, Power BI has suggested a few additional terms that could be used in place of customer, which are client, consumer, user, or buyer. Adding these as synonyms in the data model will provide added flexibility to users searching for answers.

This visual is unique in that it does not have a **Field** section in the **Visualizations** pane. All the setup is done in the visual itself on the **Report** canvas.

Let's look at setting up a **Q&A** visual:

1. Create a new report page called `Q&A`.
2. From the **Visualizations** pane, select **Q&A**. Move and resize it to take up the left half of the canvas.
3. In the **Ask a question about your data box**, type the following query: `total sales`. Notice the visual creates a card showing total sales of **29.36 M**.
4. Continue typing the following in the **Ask a question about your data box**: `total sales by sales territory`. Choose the suggested result, **total sales by sales territory sales territory country**. The visual has now switched to a **Bar chart** showing sales by country.
5. Continue typing the following in the **Ask a question about your data box**: `total sales by sales territory sales territory country and age breakdown`. The visual now shows a **Clustured bar chart**.
6. Complete the query as `total sales by sales territory sales territory country and age breakdown as stacked bar chart`.
7. Finally, click the **Turn this Q&A result into a standard visual** button to the right of the query box as indicated in *Figure 5.44*.

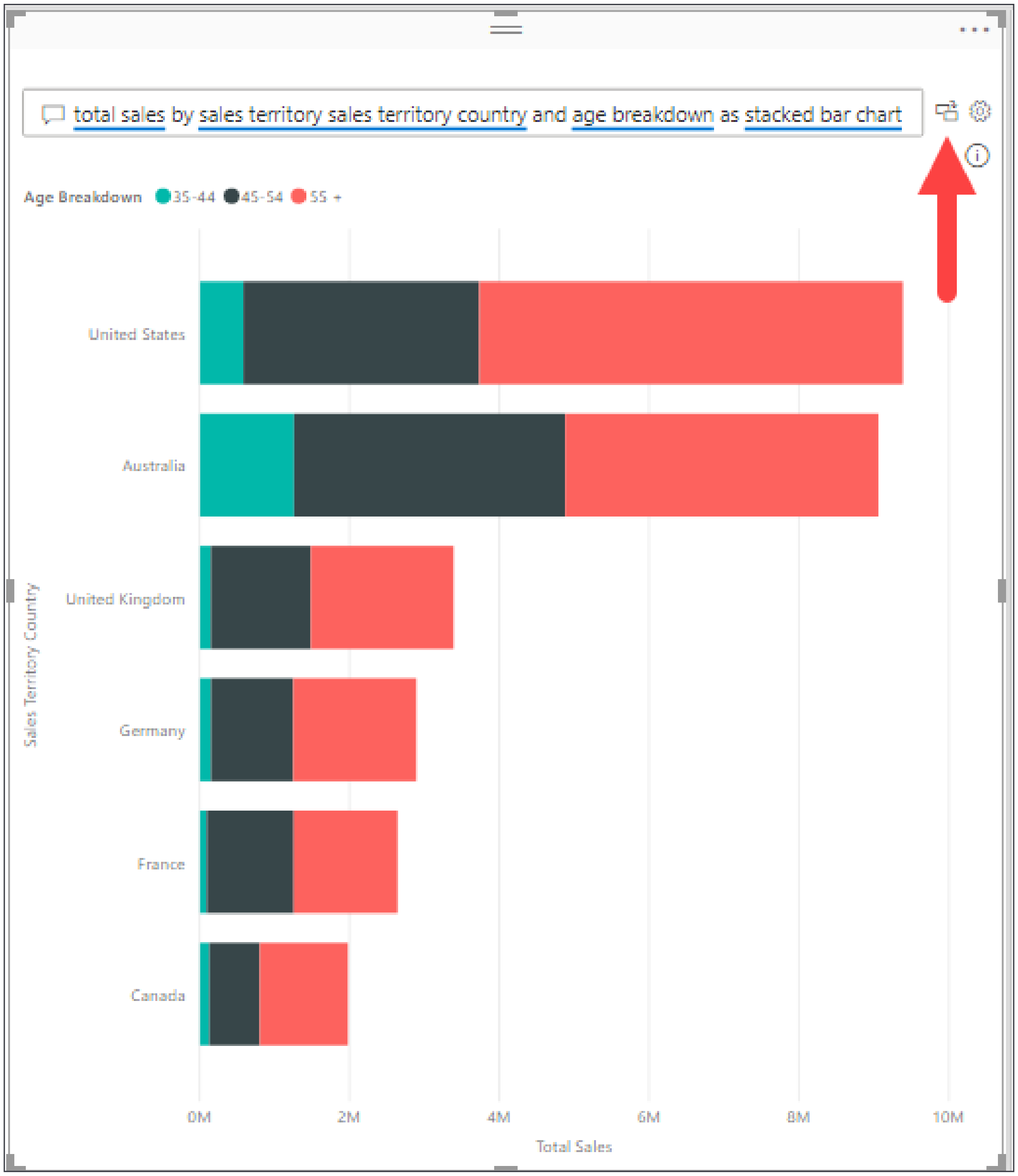

total sales by sales territory sales territory country and age breakdown as stacked bar chart

Figure 5.44: Use the Turn this Q&A result into a standard visual button to keep the visual built by the Q&A result

Let's create one additional **Q&A** visual to see how visual interactions work:

1. Ensure no other visuals are selected by clicking any blank area on the **Report** canvas.
2. From the **Visualizations** pane, select **Q&A**. Move and resize it to take up the right half of the canvas.
3. In the **Ask a question about your data box**, type the following query: `profit by date (order) month as column chart`.
4. In the column chart, click the **February** column. Notice the change in the **Stacked bar chart**.
5. In the **Column chart**, click the **February** column again to reset the selection.
6. In the **Stacked bar chart**, click **United States Age 45-54**. Notice the change in the column chart inside the **Q&A** visual.

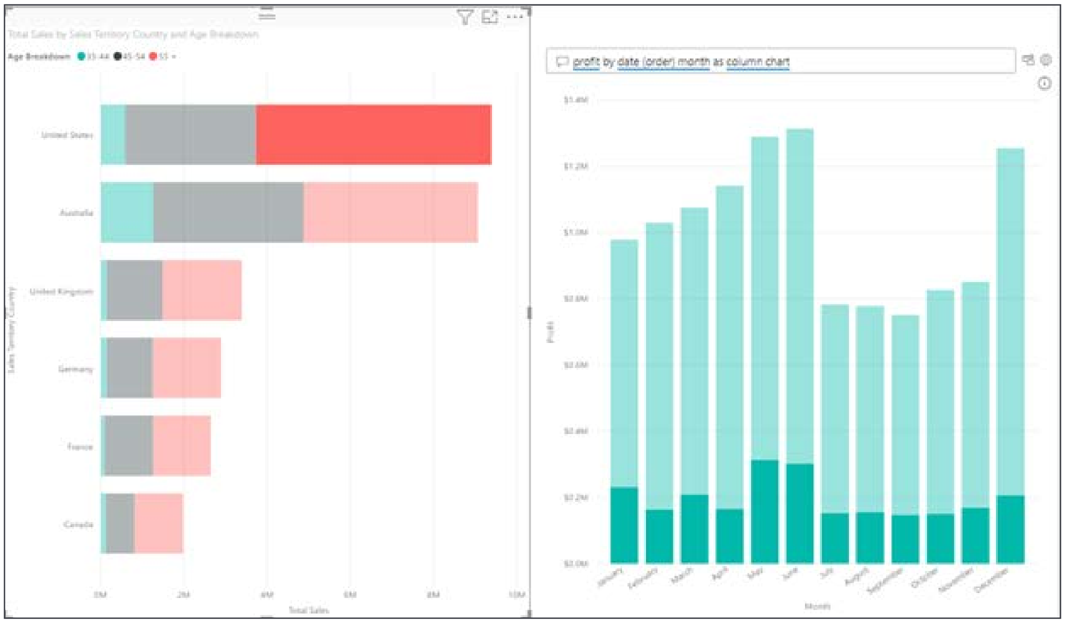


Figure 5.45: Q&A visual being filtered by a standard visual

As you have seen, the **Q&A** visual is not only capable of aiding in the creation of new visuals, it is also a powerful tool for users to explore the data, create their own custom visuals, and interact with other visuals. The ability to interact with other visuals provides a great amount of flexibility to any report.

Visuals from analytics

Up to this point all the visuals have been focused on visualizing the data in the data model. There are a couple of visuals that go one step further and provide information about the data that are not easily gained by a human looking at a report. These visuals leverage machine learning to provide actionable insight and allow the use of additional programming languages in Power BI.

Two of the most common programming languages in use today are `R` and `Python`. Power BI offers a built-in visual for each of these languages with an easy interface for bridging the gap between the Power BI data model and the programming language surface. Each of these requires a local installation for Power BI to use for processing. Simply add the fields you would like to use in your code to the **Fields** bucket for the visual and reference them by name in your code. A few lines of sample code are generated to show the proper way to reference the fields as well. Adding the `R` or `Python` visual unlocks dozens of additional visualization possibilities including boxplots, stem plots, 3D scatterplots, and contour plots.

The final visualization is the key influencers visual. If you have ever wanted to understand what impact different fields have on one another this visual will help. Define the field to be analyzed and then simply add all the fields you wish to analyze as influencers. The result will show how each field influenced the metric being analyzed, a rank showing which had the largest influence, and to what extent the field was influenced. For instance, you can determine what influence, if any, the month of the year, the latitude, the elevation, and the number of days of sun had on the temperature in a particular city ranked and quantified. Visual interactions are maintained as well, meaning you could filter the key influencers visualization with data from a slicer or bar chart and as the user changes the slicer to selects bars in the chart, the key influencers would reevaluate based on the new filtered dataset.

These visuals provide a great deal of additional value to a Power BI report if the built-in visualizations do not provide the insights required. The key influencers visual will also provide valuable insight into the impact relationships between data points are having.

Power BI custom visuals

Throughout this chapter, you have seen many different visuals and how they work with specific types of data. Although there are many options readily available with Power BI, you have access to 100+ more visuals from Microsoft AppSource right at your fingertips. Users can either navigate to AppSource via any web browser, or while inside of Power BI Desktop you can select the **From AppSource** option in the **Home** ribbon's **More Visuals** menu.

Once you select this option, a menu will appear where you can simply search the entire collection of custom visuals available. Once you have found a visual that you would like to use, just click the **Add** button shown in yellow. Users can also download the visualization file, which can be imported into Power BI by using the **From my files** option, which is also in the **Home** ribbon's **More Visuals** menu. It is important to understand that when you select a custom visual, it saves as part of the Power BI report file and doesn't remain inside of the application. So, if you just downloaded a custom visual and then closed down Power BI, when you restart the application you will not see that custom visual unless you open the report you saved the custom visual to. This is a fantastic feature, and it only continues to grow so it is worthwhile to check out AppSource.

Data visualization tips and tricks

You have created six different report pages filled with different visuals and investigated different configuration options for each of them. That being said, you have barely scratched the surface of all the features that are available to you, and with the very quick update cycle Power BI has, that list of features will keep growing. This final section will explore a couple of features that are not exclusive to just one visual, but can really help out when designing a report. It is highly recommended to watch the monthly videos that the Power BI team produces alongside the actual product update. This way, you can know exactly what is new and how to use it.

Changing visuals

Throughout this chapter the workflow has been the same: add a blank visual then add fields. Often this will work in a real-world development environment as well. However, there are times when you will not know what the best visual is for your data. It is not uncommon to create a bar chart only to realize you need to use a date that would be better served as a column chart. Maybe the requirements change, and the table needs to have an additional category added to the row groups causing the visual to switch to a matrix. It is entirely possible to rebuild the visual, however, the more useful option is to simply change an existing visual. To change between visuals simply select an existing visual on the **Report** canvas and select the desired visual from the **Visualizations** pane.

Be sure to note that when changing between visualizations the field buckets are often different, which may cause some fields to be dropped from the visual. For instance, switching from a **Column chart** to a **Treemap** generally works well. The axis on the **Column chart** becomes the group on the treemap.

However, switching to a gauge will cause Power BI to pick a single field for the value and all other fields will be dropped. Power BI does maintain the metadata from your visual choices and as long as no other major changes have been made you can often switch between visuals and your prior settings will be restored. The prior visual metadata is cleared when Power BI Desktop is closed.

Formatting visuals

Many references have been made in this chapter to conditional formatting and visual formatting. These options can help enhance the look of a report and help users gain an understanding of the data more quickly by drawing their eye to specific elements or making certain key information stand out. It is highly recommended to explore the **Format** section of the **Visualizations** pane for each of the visuals created in this chapter to see the options that are available. Some options, like the title text, background, and visual header toggle, are nearly universal. In general, visuals from the same family will share the same or very similar options. For instance, a table and matrix will both have options for formatting the headers, values, and grid lines, while the trend charts will have options for axis scales, data labels, and plot surface. It is often useful to work on formatting a single visual to the desired look then use the **Format painter** to apply the same settings to other visuals.

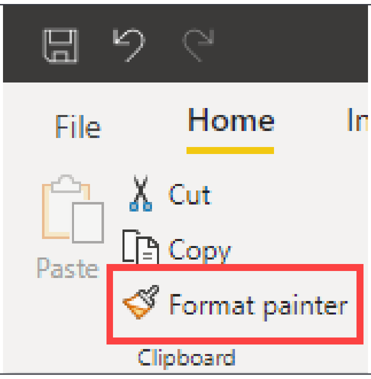
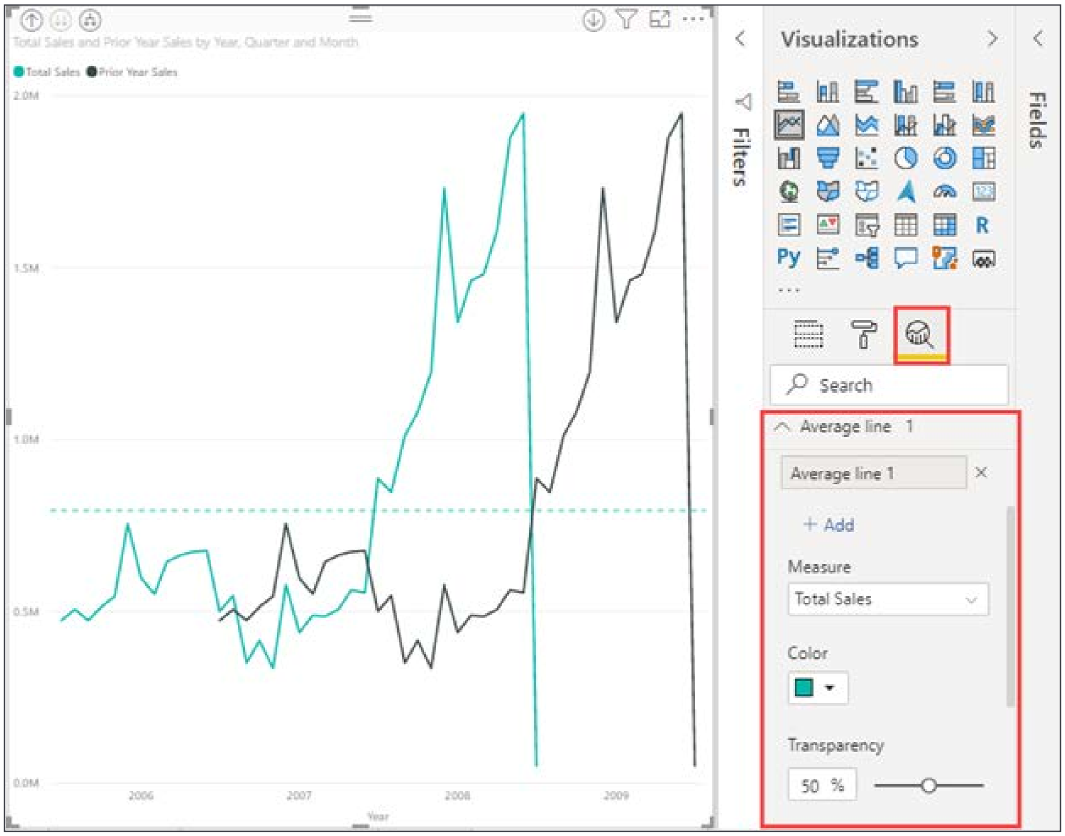


Figure 5.46: Format painter is found on the Home tab of the ribbon

Not all options will transfer (for instance, no grid lines on a pie chart) but the overlap will transfer even to visuals of a completely visualization different type.

The Analytics section

For every visual, you worked with the **Fields** section and the **Format** section of the **Visualizations** pane, but there is an option you may have noticed that is called the **Analytics** section. This option is available for most visuals, but some of the options will not appear; for our example look at the **line chart** example created earlier in this chapter. Once you have that visual selected, you can navigate to the **Analytics** section and see that you are presented with up to seven different lines that can be added to the visual. All you must do is decide which one to be displayed and turn it on. For this visual, add an **Average Line** by expanding that section and selecting the **Add** option. Once the line has been added, you can change the color, name, transparency, style, and position from this same area, as seen in *Figure 5.47*. Users can add as many of these lines as they so choose, but remember, more is not necessarily better.


Total Sales and Prior Year Sales by Year, Quarter and Month
● Total Sales ● Prior Year Sales
2.0M
1.5M
1.0M
0.5M
0.0M
2006
2007
2008
2009
Year
Filters
Visualizations
Fields
Py
R
Search

Average line 1

Average line 1 ×

+ Add

Measure: Total Sales

Color: 🟩

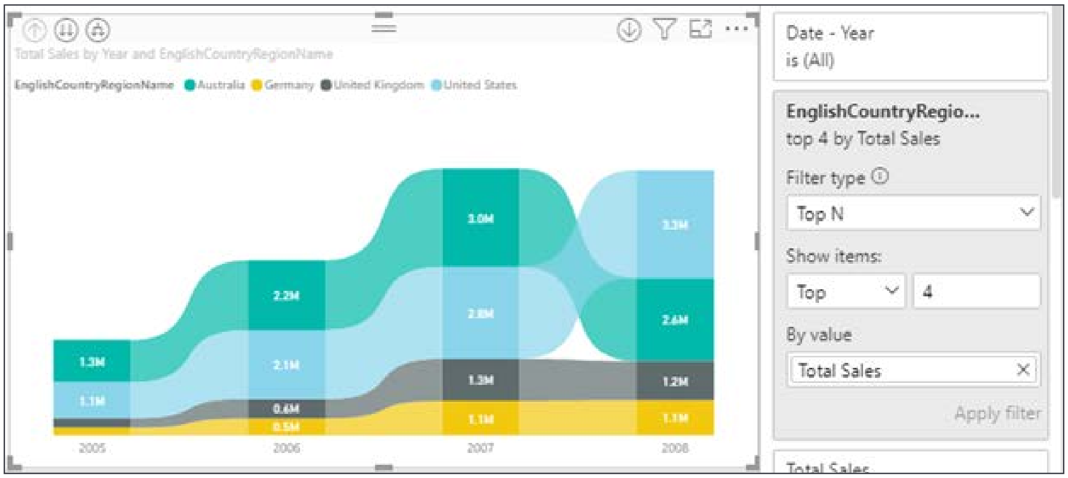
Transparency: 50 %

Figure 5.47: Reference lines being added from the Analytics section of the Visualizations pane

Additionally, if the visualization is based on a time data source, a forecast option will appear in the Analytics section. Specify the necessary input information such as forecast length and confidence interval and a forecast line will be added to the visual.

The Top N filter

At the very beginning of this chapter, there was a brief explanation about the **Filters** pane and how filters can be applied to different scopes. There are a couple of choices available to users for the filter fields, but the focus here will be on the **Top N** option. Even though it is called the **Top N** filter, this option allows a filter that will show either the top or bottom number of values. For example, if you look at the **Ribbon chart** created earlier in this chapter, you can see that there are six countries that appear in the visual. With this filter, you can set it so that it only displays the top four countries based off a chosen measure. So, in this situation, you could have that measure be **Total Sales**, which is what the visual is showing, or really anything you want. Let's go ahead and click the dropdown next to the **EnglishCountryRegion** field in **Visual level filters**. If **Top N** isn't showing by default in the **Filter type** section, select it from the dropdown. For the **Show items** section, leave the value of **Top** and manually input the number **4**, as shown in *Figure 5.48*. The last thing that needs to be done is to decide what measure will be used to determine the top four countries; keep things simple and drag in the **Total Sales** measure, and click **Apply filter**. The most important thing to remember is that you can use any measure you want for this filter.


Total Sales by Year and EnglishCountryRegionName
EnglishCountryRegionName ● Australia ● Germany ● United Kingdom ● United States
1.3M
1.1M
2.2M
2.1M
0.6M
0.5M
3.0M
2.8M
1.3M
1.1M
3.3M
2.6M
1.2M
1.1M
2005
2006
2007
2008

Date - Year
is (All)

EnglishCountryRegio...
top 4 by Total Sales

Filter type
Top N

Show items:
Top 4

By value
Total Sales

Apply filter

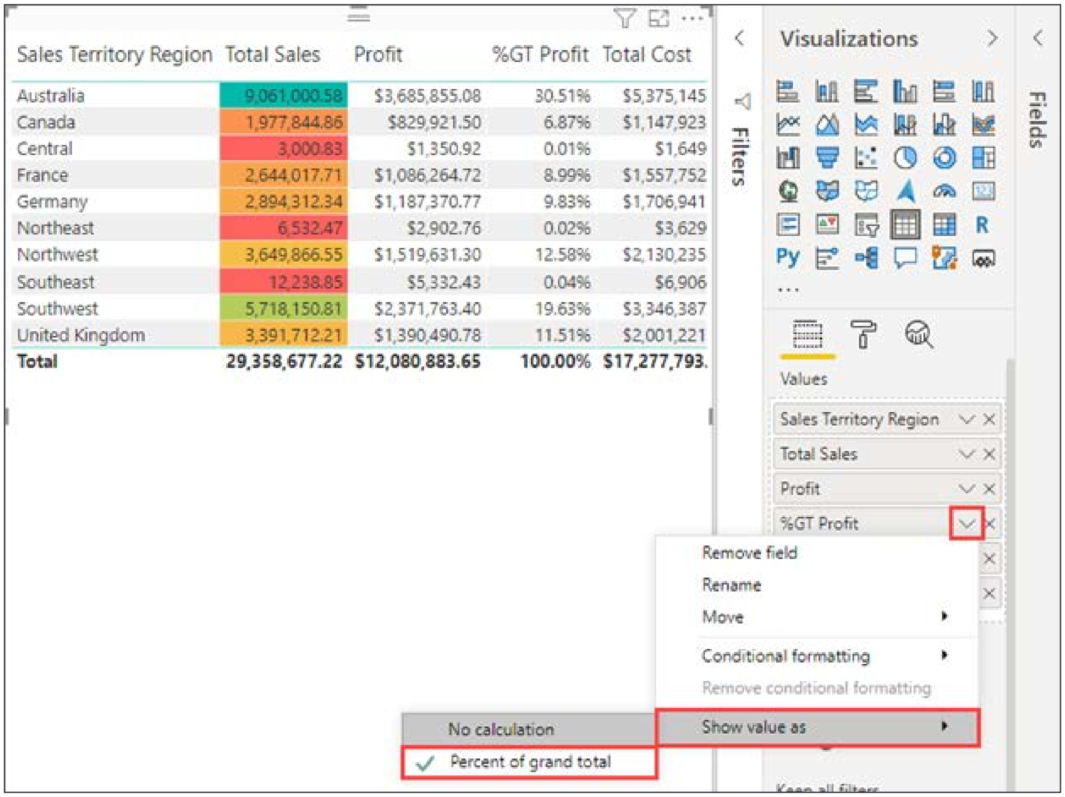
Total Sales

Figure 5.48: Ribbon chart filtered to the top 4 countries by total sales

The **Top N** option can also be changed to advanced filtering, which allows for string search, blank, include/exclude, and range filtering.

Show value as

Earlier in this chapter, you went through an example to take advantage of conditional formatting. This option can be found by clicking the downward arrow next to a field that is being used in a visual. Within this area is where you will find another option that is labeled **Show value as**. This option will only be available for numeric data types and allows values to be displayed as a percentage of the grand total. The best way to take advantage of this is to place an identical column side by side and then use this option to display one of them as a percentage. For our example, revisit the **matrix** visual you created for the **Tabular data** section. Locate the **Profit** measure in the **Fields** pane and drag it into the **Values** bucket for the visual, placing it directly after the **Profit** measure that is already in place, referencing *Figure 5.49*. The visual looks a little odd since there is a duplicated column, but now change the new field to show a percentage. Within the dropdown for the second representation of **Profit**, choose the **Show value as** option and select **Percent of grand total**.



Sales Territory Region	Total Sales	Profit	%GT Profit	Total Cost
Australia	9,061,000.58	$3,685,855.08	30.51%	$5,375,145
Canada	1,977,844.86	$829,921.50	6.87%	$1,147,923
Central	3,000.83	$1,350.92	0.01%	$1,649
France	2,644,017.71	$1,086,264.72	8.99%	$1,557,752
Germany	2,894,312.34	$1,187,370.77	9.83%	$1,706,941
Northeast	6,532.47	$2,902.76	0.02%	$3,629
Northwest	3,649,866.55	$1,519,631.30	12.58%	$2,130,235
Southeast	12,238.85	$5,332.43	0.04%	$6,906
Southwest	5,718,150.81	$2,371,763.40	19.63%	$3,346,387
United Kingdom	3,391,712.21	$1,390,490.78	11.51%	$2,001,221
Total	**29,358,677.22**	**$12,080,883.65**	**100.00%**	**$17,277,793.**

Figure 5.49: Change the value displayed from dollars to a percent of grand total

The matrix was already a great visual to quickly see a lot of metric information about the sales territory regions, but now you have a firm understanding of what percentage each country is contributing to the grand total.

Summary

In this chapter, the focus was on how to configure visuals and what data they best illustrate. You also saw a couple of the most common formatting options that are used with these visuals. In the next chapter, you will look into the concept of digital storytelling. Power BI has a strong set of options that can be leveraged to allow users to experience and navigate through the data in an adventurous and exploratory manner.

6 Digital Storytelling with Power BI

In the previous chapter, you learned how to explore many of the readily available visuals within Power BI and saw how they can showcase your data. With the assistance of cross-highlighting and cross-filtering, you can also make the visuals work with each other. But there is so much more than just simple drag-and-drop reporting within Power BI. Power BI has several useful storytelling features. Alongside all of the different visuals, Power BI has a set of features that can tie together not only individual charts and graphs, but that can also allow users to navigate through multiple pages to discover exactly the level of detail they want from the data. Using these features, you can weave together the data in a way that allows interactivity far beyond what has already been seen. This allows users to take control of how they will view your Power BI report. If they just want to take a quick glance at a summary view of the data, they can; but if they wish to dive deeper, you can offer multiple paths to take. This chapter will investigate the following digital storytelling features:

- Configuring drill through
- Capturing report views with bookmarks
- Combining object visibility with bookmarks
- Report pages as tooltips

When using these features, there are many different approaches that can be taken. You will be looking at them in their most basic forms, but they can flourish when you use your imagination. At the time of this book's publication, the idea of digital storytelling has become extremely popular, which will more than likely foster even more features for the future of Power BI, so keep an eye out!

For this chapter, you will be using the completed Power BI file from *Chapter 5*, *Visualizing Data*. If you have not completed this on your own, you can open a completed version, located at `Microsoft-Power-BI-Start-Guide-Second-Edition-main\Completed Examples\Chapter 5 - Visualizing Data.pbix`. It is recommended that, upon opening this file, you immediately use the **Save As** option and name the report `Chapter 6 - Digital Storytelling with Power BI`. By doing this, you can preserve your work from chapter to chapter.

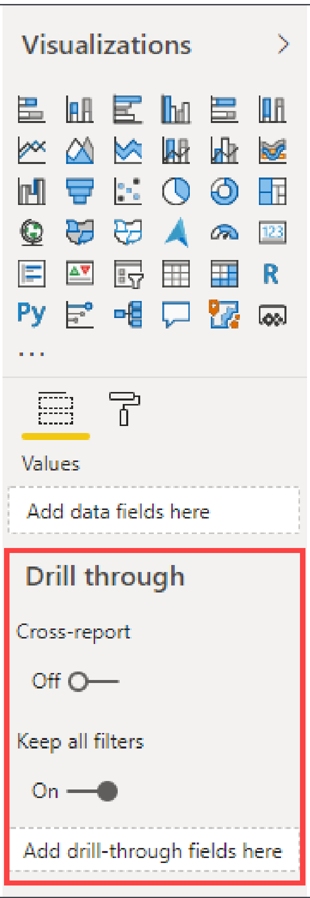
Possibly the most fundamental method for empowering digital storytelling is providing report consumers with the ability to tie multiple report pages to the same context; in Power BI, this is accomplished by using drill through.

Configuring drill through

In *Chapter 5*, *Visualizing Data*, you saw the power of filtering to allow a single visual to provide many different views of the data. For instance, a **Bar chart** showing all sales could also show sales by year if cross-filtered by a date **Slicer**. You also saw how the filter pane could be applied to visuals on a single page or across the entire report. Up to this point, those were the only two options available. The **Drill through** feature allows users to navigate from one report visual to another report page while maintaining the filter context of the visual. A common example of the use of **Drill through** is going from a summary to a detail page. A summary page may contain several visualizations for sales data all aggregated at the country level. One of those could be a **Pie chart** showing total sales broken down by country. While this can be useful, many users will want access to more detailed information, such as all the sales that happened in a particular country. A **Drill through** filter will allow users to right-click on a slice of the **Pie chart**, possibly representing the `United States`, and drill through to a detail report showing a table of sales that are now filtered to the `United States`. This allows users to quickly move from summary to detail and back to summary without ever needing to open the **Filters** pane. With the right configuration, **Drill through** is a powerful data exploration tool.

Drill through filters are applied at the page level only and are configured in the **Fields** section of the **Visualizations** pane; they cannot be applied at the visualization or report level. The **Drill through** section has three options to configure:

- **Cross-report**: Drill through to another report in the same Power BI workspace or app when deployed to the Power BI service.
- **Keep all filters**: When enabled, all filter context from the source visual in addition to the fields listed in the field bucket will be applied. When disabled, only fields listed in the **Drill through** field bucket will be applied as filters.
- **Add drill-through fields here**: Fields added to this bucket will automatically be enabled for drill through any time they are present in a visualization on any other page within the same report.



Drill through

Cross-report

Off

Keep all filters

On

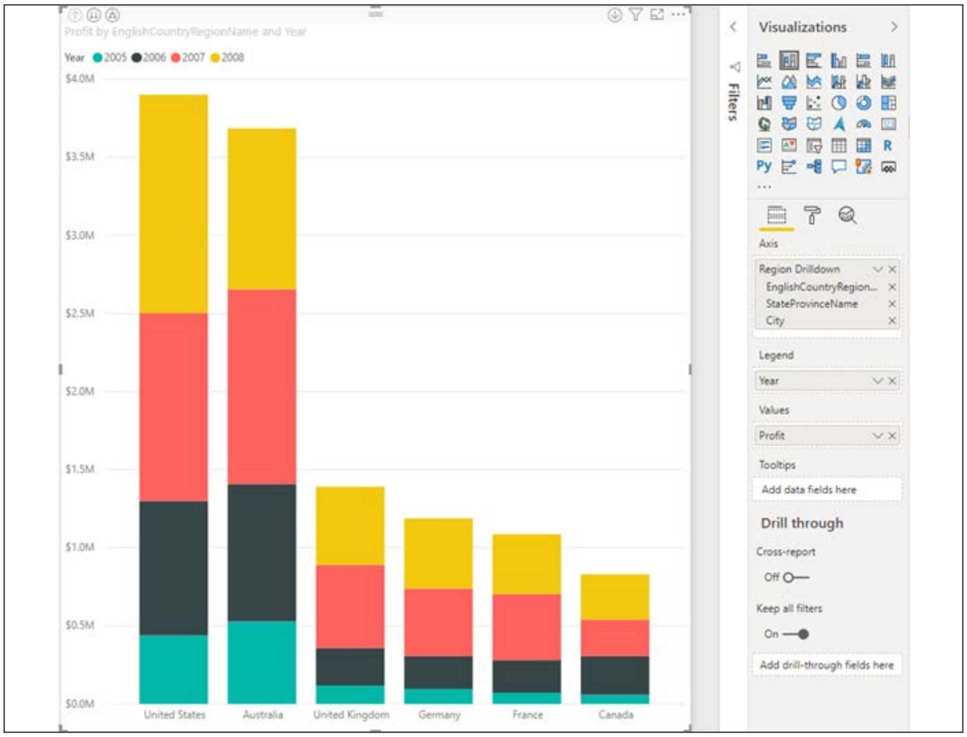
Add drill-through fields here

Figure 6.1: Drill through settings on the Visualizations pane

Let's explore an example by copying some of the visuals created previously, in *Chapter 5*, *Visualizing Data*, and moving them into new pages, leveraging the **Drill through** filter option.

Let's look at setting up the example. Note that the **Cross-report** and **Keep all filters** options should be set to **Off** and **On** respectively, as shown in *Figure 6.1*, then take the following steps:

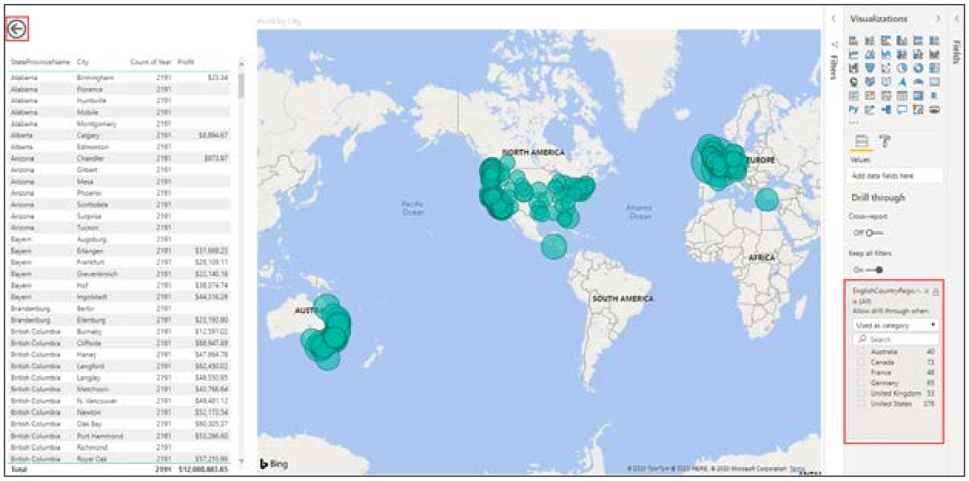
1. Create two new report pages: the first one should be called **Summary** and the second **Drill Through**.
2. Navigate to the **Summary** report page and add a **Stacked column chart** visual. Move and resize the visual to take up the right half of the **Report** canvas.
3. From the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Values** bucket.
4. From the **Fields** pane, drag **Region Drilldown** from the **Geography** table to the **Axis** bucket.
5. From the **Fields** pane, drag **Year** from the **Date (Order)** table to the **Legend** bucket:



Axis: Region Drilldown (EnglishCountryRegion..., StateProvinceName, City)
Legend: Year
Values: Profit
Tooltips: Add data fields here
Drill through
Cross-report: Off
Keep all filters: On
Add drill-through fields here

Figure 6.2: Bar chart displaying profit by country and year

6. Next, navigate to the **Drill Through** page. Add a **Table** visual. Move and resize the visual to take up the left third of the **Report** page, but leave a small amount of space above the visual, approximately 1/16 the height of the report page.
7. From the **Fields** pane, drag the following fields to the **Values** bucket:
    - **StateProvinceName** from the **Geography** table
    - **City** from the **Geography** table
    - **Year** from the **Date (Order)** table
    - **Profit** from the **Internet Sales** table
8. Next, add a **Map** visual to take up the right two-thirds of the **Report** page.
9. From the **Fields** pane, drag **City** from the **Geography** table to the **Location** bucket.
10. From the **Fields** pane, drag **Profit** from the **Internet Sales** table to the **Size** bucket.
11. Finally, populate the **Drill through** fields by dragging **EnglishCountryRegionName** from the **Geography** table to the **Drill through** fields bucket:



StateProvinceName	City	Count of Year	Profit
Alabama	Birmingham	2191	$23.34
Alabama	Florence	2191	
Alabama	Huntsville	2191	
Alabama	Mobile	2191	
Alabama	Montgomery	2191	
Alberta	Calgary	2191	$8,894.87
Alberta	Edmonton	2191	
Arizona	Chandler	2191	$873.97
Arizona	Gilbert	2191	
Arizona	Mesa	2191	
Arizona	Phoenix	2191	
Arizona	Scottsdale	2191	
Arizona	Surprise	2191	
Arizona	Tucson	2191	
Bayern	Augsburg	2191	
Bayern	Erlangen	2191	$31,988.23
Bayern	Frankfurt	2191	$26,109.11
Bayern	Grevenbroich	2191	$22,140.18
Bayern	Hof	2191	$38,374.74
Bayern	Ingolstadt	2191	$44,316.28
Brandenburg	Berlin	2191	
Brandenburg	Eilenburg	2191	$23,190.90
British Columbia	Burnaby	2191	$12,391.02
British Columbia	Cliffside	2191	$58,947.89
British Columbia	Haney	2191	$47,864.78
British Columbia	Langford	2191	$62,450.02
British Columbia	Langley	2191	$46,530.95
British Columbia	Metchosin	2191	$40,768.64
British Columbia	N. Vancouver	2191	$48,481.12
British Columbia	Newton	2191	$52,173.54
British Columbia	Oak Bay	2191	$90,305.37
British Columbia	Port Hammond	2191	$53,266.60
British Columbia	Richmond	2191	
British Columbia	Royal Oak	2191	$57,255.98
Total		2191	$12,080,883.65

Drill through

Cross-report: Off

Keep all filters: On

EnglishCountryRegio... is (All)

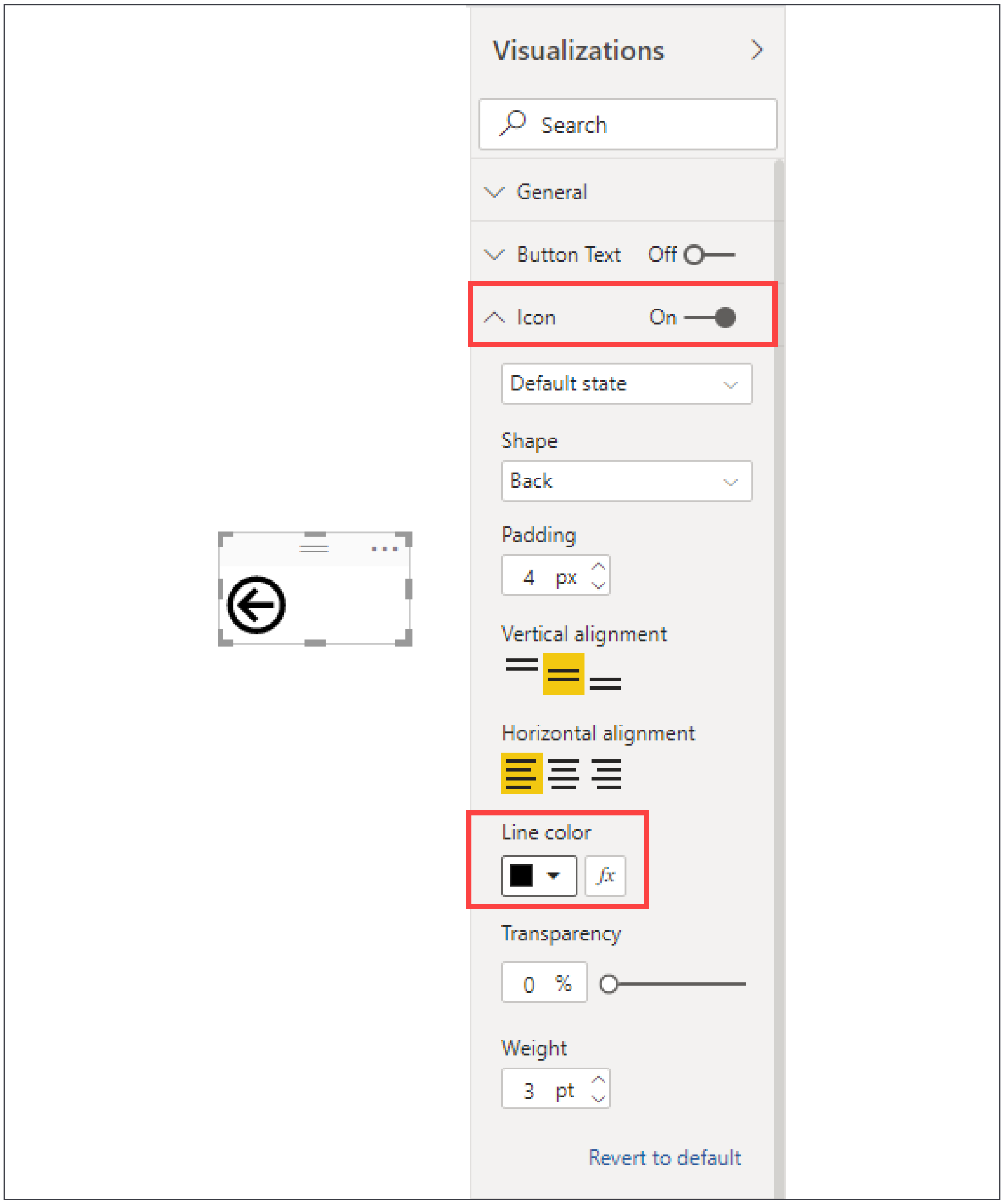
Allow drill through when: Used as category

Australia	40
Canada	73
France	48
Germany	65
United Kingdom	51
United States	378

Figure 6.3: Map with country on the drill through fields enabling the back button

When placing a field into the **Drill through** bucket, you will notice that a backward arrow image is automatically added to the page in the upper left-hand corner. This is simply an image that has been set with an action to go back to the previous page. By selecting the image, you will find that there are quite a few familiar format settings available in the **Format** section.

One of the more common settings to change is the **Line color** option under **Icon**, which will allow the selection of a color to make the back arrow more visible:



Visualizations

Search

General

Button Text Off

Icon On

Default state

Shape: Back

Padding: 4 px

Vertical alignment

Horizontal alignment

Line color

Transparency: 0 %

Weight: 3 pt

Revert to default

Figure 6.4: Back arrow with line color set to black

Everything is set for this example to demonstrate how **Drill through** works. Proceed by taking the following steps:

1. Navigate to the **Summary** page. Right-click the **2008** section for **United States**. There is now an option called **Drill through**. Hovering the mouse over this new option will present a list of available drill through reports. In this scenario, only one option exists. It is important to note that you can have as many drill through reports as you desire. Click the **Drill Through** option:

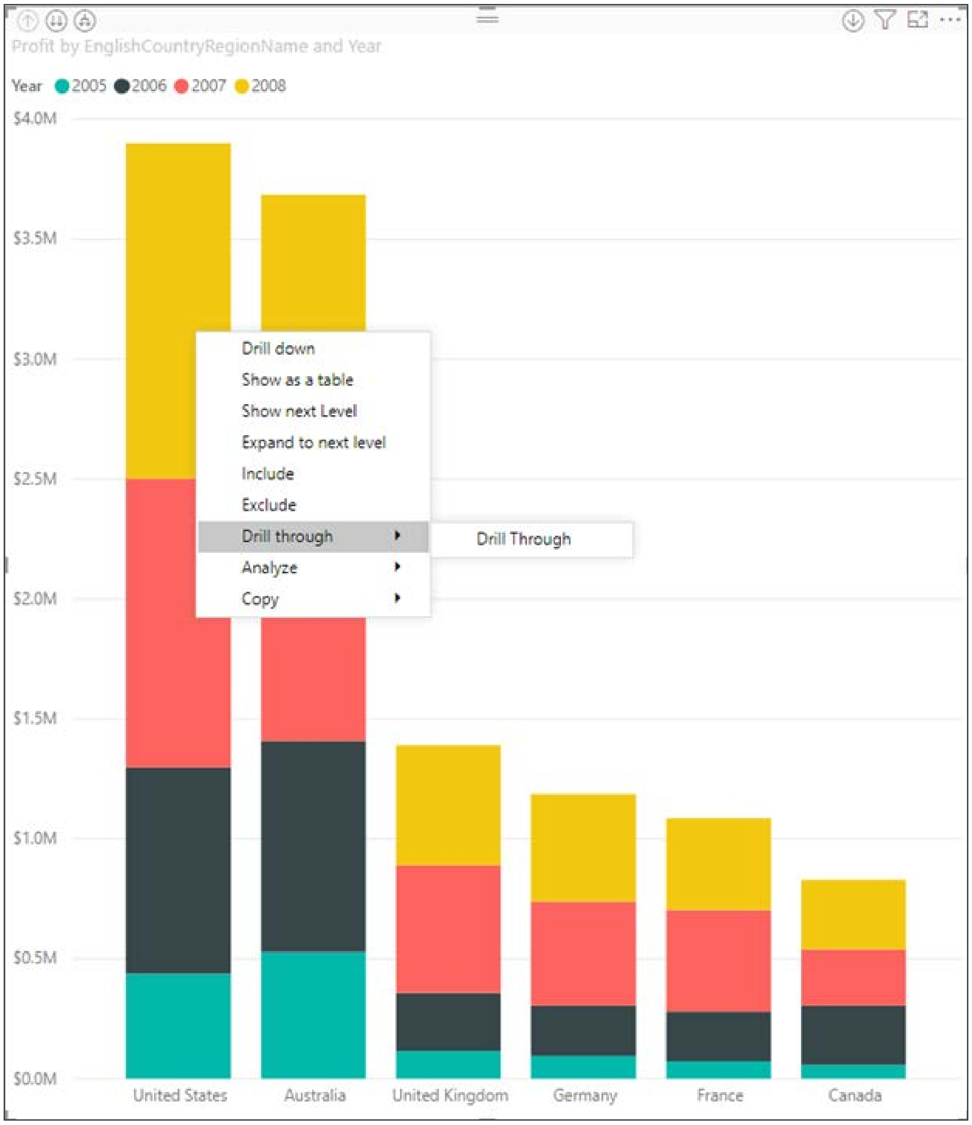
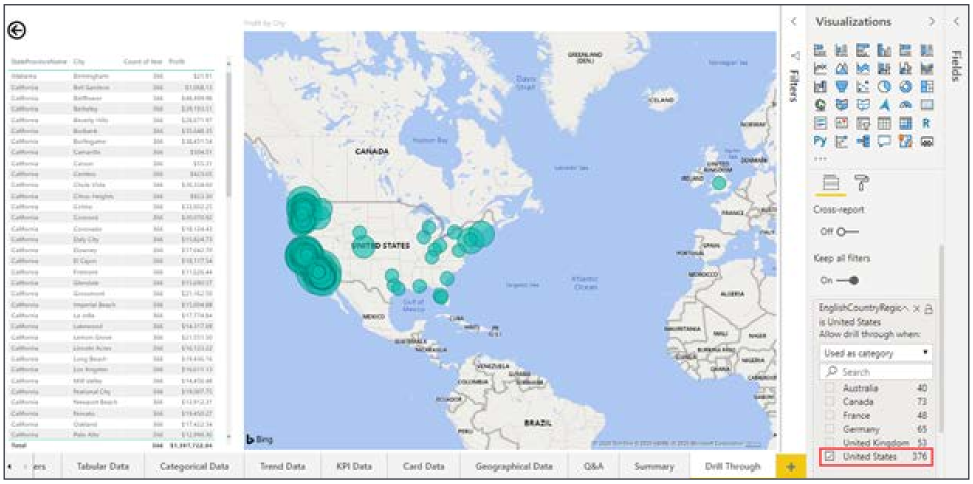


Figure 6.5: Right-click menu showing the reports available for drill through

2. Upon left-clicking the **Drill Through** option, you will be taken to that page. Notice both visuals have been filtered by the value of **United States**, and because the **Keep all filters** option is turned **on**, they are also filtered to the context of only **2008**. Had the **Keep all filters** option been turned off, the visuals would be displaying only the **United States**, but all years:



Cross-report
Off

Keep all filters
On

EnglishCountryRegio...
is United States
Allow drill through when:
Used as category

☐	Australia	40
☐	Canada	73
☐	France	48
☐	Germany	65
☐	United Kingdom	53
☑	United States	376

Figure 6.6: United States filter applied after performing drill through from the bar chart on the Summary page

As you can see, using drill through in this scenario allows you to dive deeper into sales records for a specific country, in a specific year. If you were to navigate back to the **Summary** page (using the page navigation or the back button in the top-left corner of the canvas) and make a different selection, those new filters would take effect on these two visuals. Thus, you can see that now you have two report pages that interact with each other. As more and more pages are added to the report, users will always have the option to drill through to this report with whatever filters they have chosen provided the visual uses the **EnglishCountryRegionName** field.

Drill through provides users with an ad hoc path to data exploration allowing them to choose when and where to go deeper. There will be times when a more curated storytelling experience is required, and that is accomplished using bookmarks.

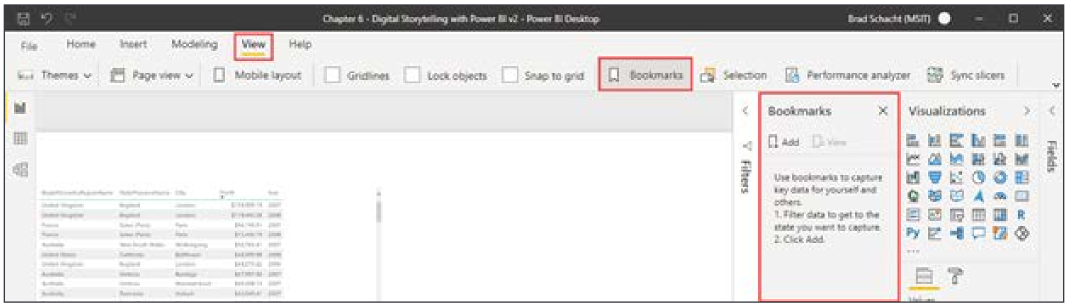
Capturing report views with bookmarks

Cross-filtering, cross-highlighting, and Drill through filters make a big impact on how users consume the data in Power BI reports. Sometimes, though, you may want to ensure that users see the data in a very specific way that will truly show its impact, satisfy report requirements, or simply provide alternate views of the data.

You can guide report consumers in a very interactive way using **Bookmarks** and showing or hiding visualizations in the **Selection** pane. Using these options, you can make better use of the available canvas on each report page and still make it feel as if users have many choices as to how they will view the data.

The **Bookmarks** feature allows report creators to capture the view of a **Report** page. **Bookmarks** will save the current state of all filters, slicers, in-focus items, sorting, and spotlight visuals (more on that feature later in this section) on a page at the time when the bookmark is created. This allows users to return to the captured state by simply selecting the bookmark in question.

To begin working with **bookmarks**, navigate to the **View** ribbon and select **Bookmarks** from the **Show Panes** section. You will see a new pane present itself to the left of the **Visualizations** pane:



Use bookmarks to capture key data for yourself and others.
1. Filter data to get to the state you want to capture.
2. Click Add.

Figure 6.7: Showing the Bookmarks pane

Because you have not created any bookmarks, the only option available is **Add**. First, let's bring in a couple more visuals to the **Summary** page:

1. First, copy an existing visual to the **Summary** page. Navigate to the **Trend Data** report page. Select the **Line chart**, which shows **Total Sales** and **Prior Year Sales**. Press *Ctrl* + *C* on the keyboard or click the **Copy** button from the **Home** ribbon.
2. Navigate to the **Summary** page. Press *Ctrl* + *V* on the keyboard or click the **Paste** button from the **Home** ribbon. Move and resize the visual as you see fit, leaving a small amount of space to add a filter.

3. Next, add a **Slicer** to the **Summary** page using the **Age Breakdown** field from the `Customer` table. Optionally, display the slicer as a series of buttons by navigating to the **Format** Area for the slicer and changing the **Orientation** property to **Horizontal** within the **General** properties section:

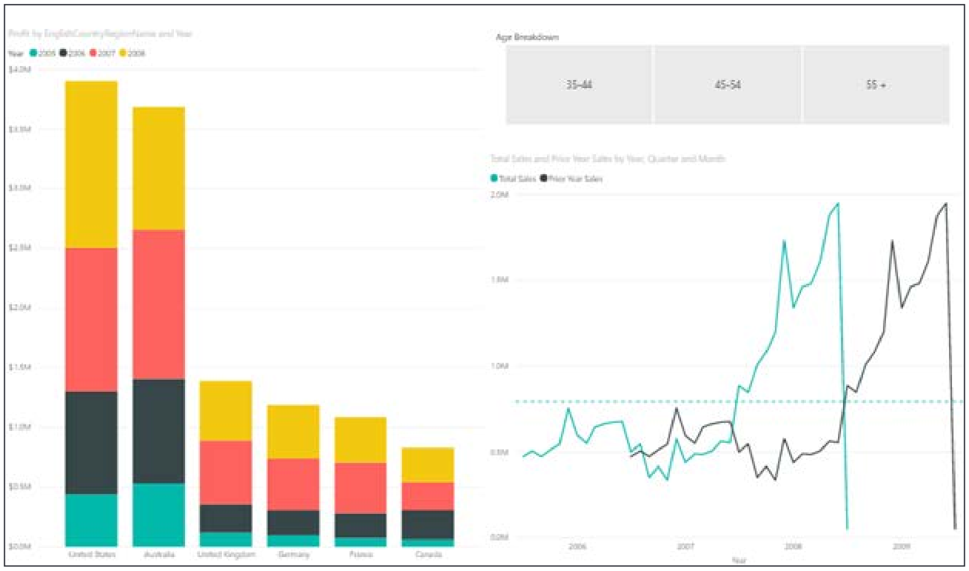


Figure 6.8: Summary page with line chart and slicer added

The slicer will filter both the **Bar** and **Line chart** without any additional work by leveraging Power BI's cross-filtering functionality. While it's not required, setting the filter to a series of buttons allows a consumer to more easily identify what filter context has been applied to this page of the report.

With the visuals in place, you can start to create bookmarks. There are a couple of different approaches that can be adopted. The first option you will look at is simply filtering the data to a specific state and then selecting the **Add** option inside the **Bookmarks** pane. Select the option of **35-44** from the slicer to filter the **Summary** page. Creating a bookmark for this really isn't impactful because this is something that users can do by themselves with a visual slicer, but you can use some of the other features in combination with this to create a specialized view of the data—for instance, the **Spotlight** option. Select the ellipsis in the upper right-hand corner of the **Stacked column chart** visual and choose the **Spotlight** option, which will fade all other visuals on the page. **Spotlight** is useful for drawing attention and focus to a single visual while keeping the remainder of the report page visible so users can gather context for the data.

Now select the **Add** option inside of the **Bookmarks** pane and rename the bookmark as **Spotlight Column 35-44**. To rename the bookmark, select the ellipsis to the right of the newly created bookmark. You will see the **Rename** option, along with many others, as shown in *Figure 6.9*:

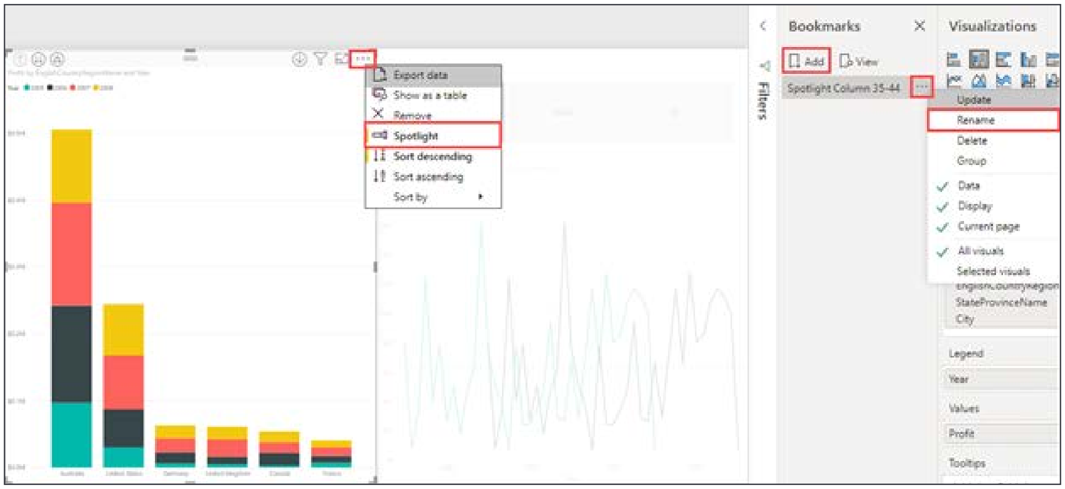


Figure 6.9: Spotlight option on the bar chart visual in addition to the Add and Rename bookmark options

Below is a short description of how each of the options on the options menu affects the bookmark:

- **Update**: Overwrite the bookmark settings with the current state of the page. To update a bookmark, do not click the name of the bookmark as Power BI will switch to that bookmark, resetting the state of the report. Set the report to the desired state and only then click the ellipsis next to the desired bookmark and select **Update**.
- **Rename**: Change the name of the bookmark.
- **Delete**: Remove a bookmark.
- **Data**: When enabled, the bookmark retains the current state of the **Filters** pane and the selection of any visuals (slicer selection, visual highlighting, the selection of a section on a bar chart, and so on).
- **Display**: When enabled, the bookmark retains visual properties, such as the **Spotlight** feature and the visibility.

- **Current page**: When enabled, selecting a bookmark automatically takes the user to the page where the bookmark was created and applies the data and display settings according to the bookmark. When disabled, a bookmark will only function when the user is already on the page from which the bookmark was created. This option effectively disables a bookmark unless you are on the page the bookmark references.
- **All visuals**: When selected, all visuals on the page, both visible and hidden, are part of the bookmark.
- **Selected visuals**: When selected, only the visuals that are selected, whether visible or hidden, when the bookmark is created or updated will be stored.

As you can see from these options, there are many different behaviors that can be controlled with bookmarks.

Now let's look at how bookmarks can be used. Click any area in the **Report** canvas or surrounding area where there are no visuals. This will deselect all visuals and the bookmark. Switch the **Slicer** visual to **45-54** and once again use the **Spotlight** feature on the **Stacked column chart** and create another bookmark called **Spotlight Column 45-54**. Add a third bookmark following the same steps but pointing to the **55+** option within the **Slicer**. This one should be called **Spotlight Column 55+**. Users can now open the **Bookmark** pane and choose to view whichever bookmark they would like very easily.

An additional way to view bookmarks is in a slide show style. Just to the right of the **Add** button is an option labeled **View** that will bring up some new icons at the bottom of the **Report** page. A forward and back arrow allows you to move through all the available bookmarks and tell a tailored story about the data. Also, while in this mode, all of the visuals are still completely available to be interacted with. To exit, simply choose the **X** icon next to the arrows at the bottom or the **Exit** option within the **Bookmarks** pane. The order of bookmarks can be very important when using the slide show view. The order can be changed by simply dragging and dropping the bookmarks into the desired order:

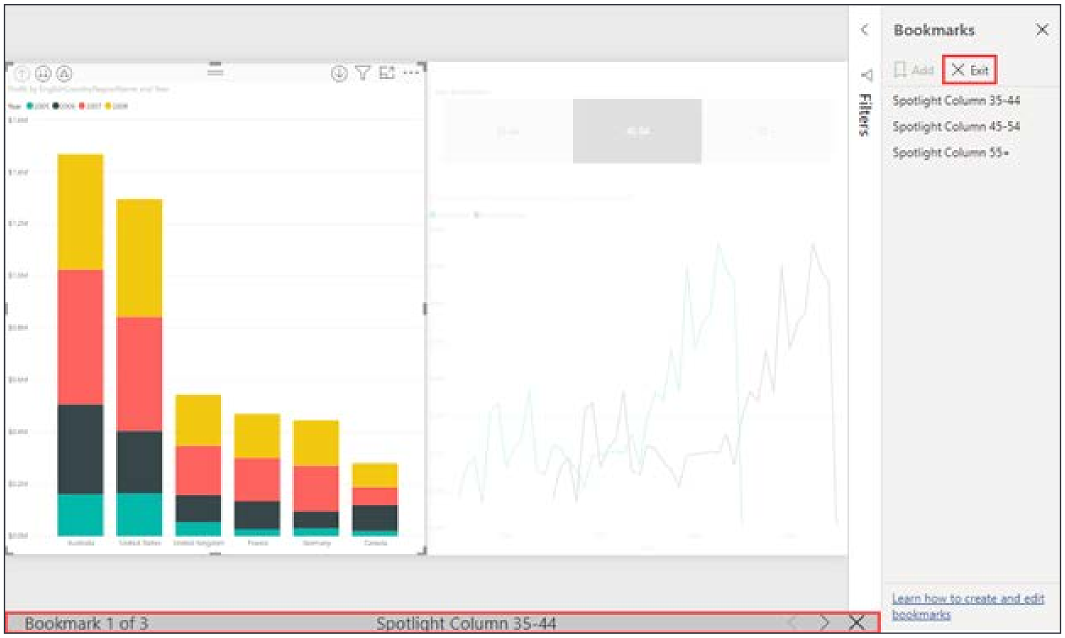


Figure 6.10: Options for exiting the bookmarks view

You can see many ways to use **Bookmarks**, but there are still more. Another fantastic way to guide your audience to these tailored views of the data is by using images to link to bookmarks. To get a better understanding of how to accomplish this, let's look at the **Selection** pane.

Combining object visibility with bookmarks

The **Selection** pane provides a list of all objects on the current page and allows you to show or hide visuals. This is useful if a slicer or visual is needed for cross-filtering but is not needed for analysis. It is also useful to reuse the same **Report** page for the same data but using different visuals when you are pressed for space. The following section will demonstrate how to maximize your use of space when visualizing data in different ways.

Bookmarking alternate views of the same data

Some users may want to see sales by country as a **Bar chart**, and others may want to see it as a **Table**. If there is not enough room for both visuals, the default answer may be to create a new page. However, it can be cumbersome to recreate and maintain the same exact filters on multiple pages. An alternate solution would be to put both visuals on the same page and dynamically show or hide them based on a user selection of "chart" or "table." Let's look at how this scenario could be implemented:

1. On the **View** ribbon, click the **Selection** option in the **Show Panes** section. The **Selection** pane appears adjacent to the **Bookmarks** pane.
2. Navigate to the **Summary** page and create a duplicate of the **Stacked column chart**. This can be done by selecting the chart and pressing *Ctrl* + *C* then *Ctrl* + *V* or using the **Copy** and **Paste** buttons on the **Home** ribbon.
3. With the duplicate visual selected, change it to a **Table** visual. Move it so that it lies directly on top of the **Column chart**. Initially, it will look a little chaotic. You will see that this new visual is showing up in the **Selection** pane. In my example, it is called **Table**:

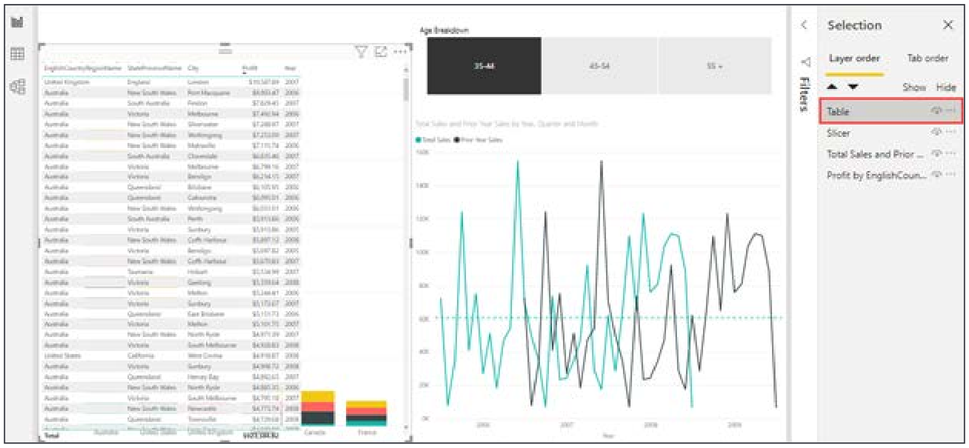


Figure 6.11: Table and bar chart displayed on top of each other

4. Just to the right of this object, inside of the **Selection** pane, you will see an eye icon.

5. Click the eye icon. You will see that the table visual disappears from the canvas—it is still part of the **Report** page but has been hidden.
6. Add a new bookmark and rename it **Chart View**. Also, for this new **Chart View** bookmark, ensure that the **Data** option is not selected. The goal is to bookmark only the visual selection, not the data selection:

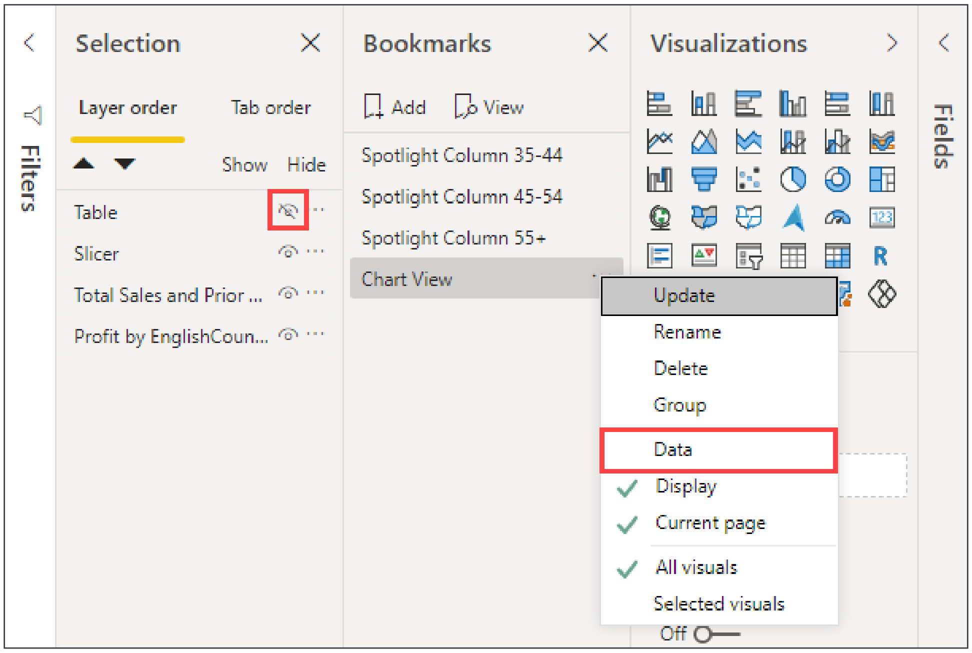


Figure 6.12: Chart View bookmark with data selection settings removed from the bookmark

Using the knowledge from the example you just completed, create one final bookmark that shows the table but hides the **Stacked column chart**. Call this bookmark **Table View** and be sure to remove the data selection from the bookmark options:

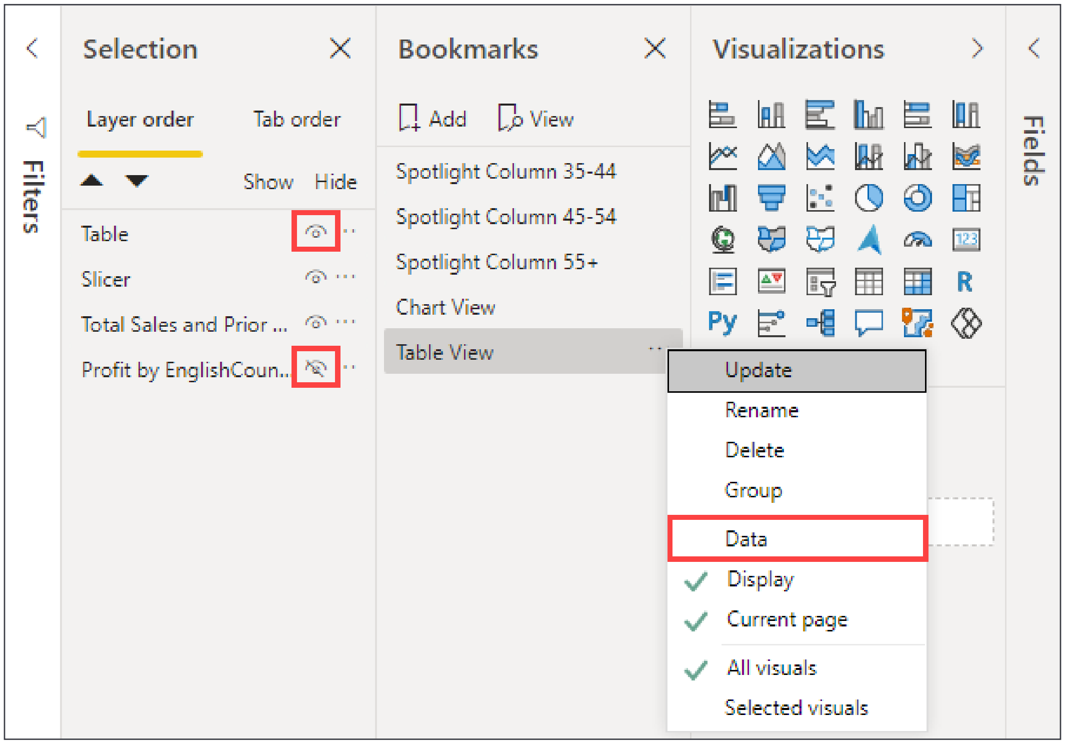


Figure 6.13: Table View bookmark settings

You can now see two different ways of displaying the same data within the same **Report** page, making efficient use of the available space. With the current report configuration, users need to open the **Bookmarks** pane to move between the **Table View** and **Chart View** bookmarks. While this is functional, it is not user friendly. Adding a button to the report that automatically selects the appropriate bookmark is a great way to make the bookmark experience more approachable.

Using buttons to select bookmarks

Buttons can provide users with an even easier method for switching between the table and column bookmarks. To add buttons to your report, take the following steps:

1. While on the **Summary** page of the report, navigate to the **Insert** ribbon and click the **Image** button in the **Elements** section. This will launch a file browser to select an image file.
2. Navigate to the directory `Power-BI-Start-Guide-Second-Edition-main\Data Sources` and select the `Chart.png` image to add it to the canvas. In the **Format** section of the **Visualizations** pane, turn the **Title** property **On**, name the image **Chart Button**, then turn the **Title** property **Off**. This will help distinguish between the buttons in the **Selection** pane but not display the title on the image in the report:

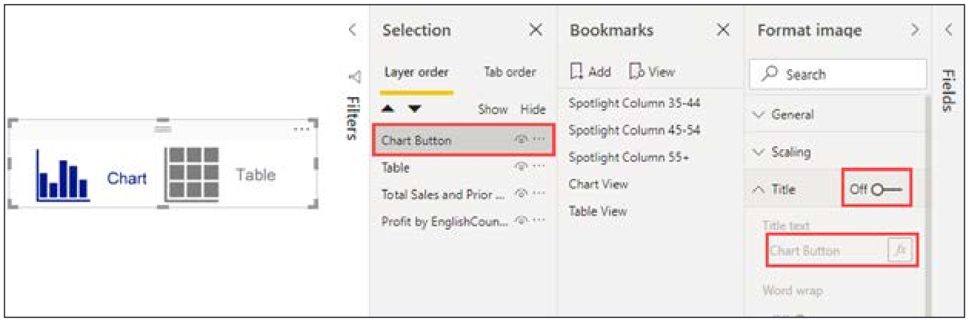


Figure 6.14: Title disabled on the Chart Button

3. Repeat this process to add `Table.png` and change the title to **Table Button**.

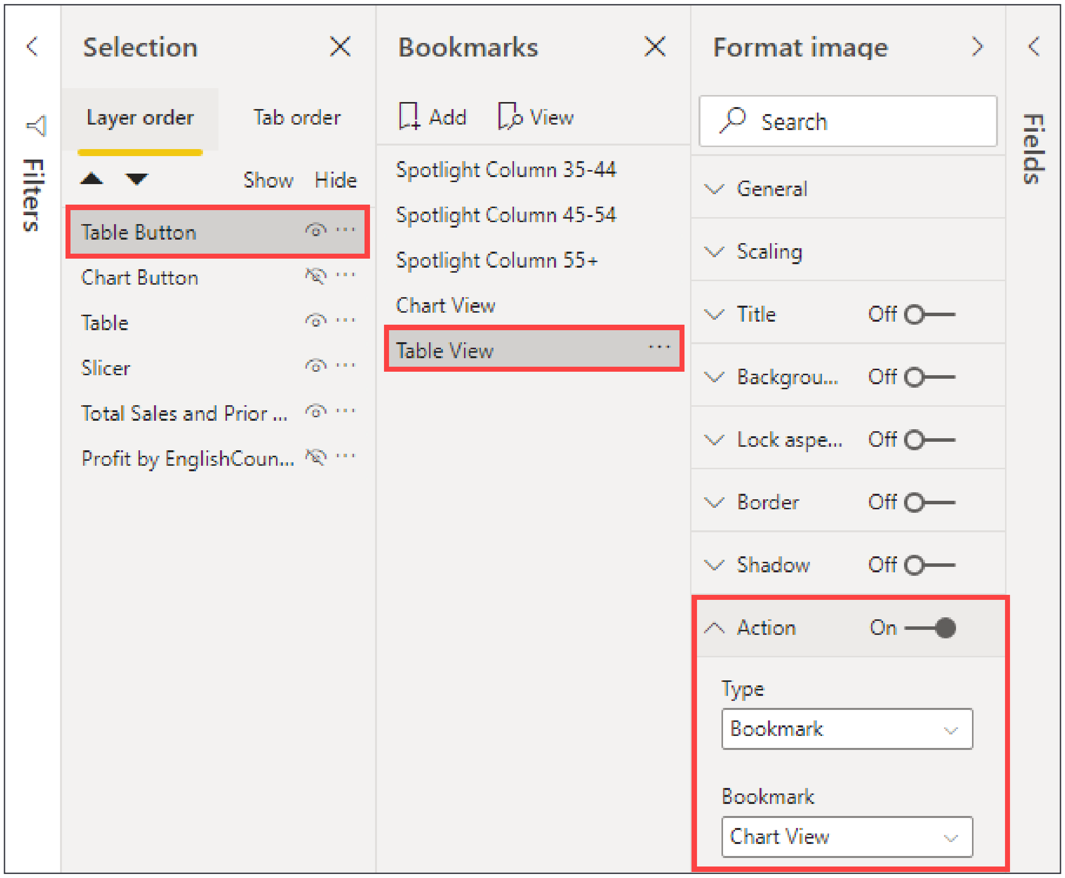
To the best of your ability, stack the images on top of each other. You may need to reduce the size of other visualizations to allow space for the images.

Now it's time to turn these images into buttons the user can press to toggle between the **Chart View** and **Table View** bookmarks. This requires a couple of quick updates to the **Chart View** and **Table View** bookmarks.

Begin by selecting the **Chart View** bookmark and then hiding the **Table Button** image in the **Selection** pane. Select the ellipsis for the **Chart View** bookmark and choose the **Update** option. Now make the same change on the **Table View** bookmark, selecting the **Table View** bookmark, hiding the **Chart Button** image, and choosing the **Update** option from the bookmark's ellipsis.

The last piece that will tie all this together is to assign an action to the appropriate image within the bookmarks. An action will allow users to click on the **Chart Button** image, visible on the **Chart View** bookmark, and taken to the **Table View** bookmark, giving the appearance of a toggle switch. Similarly, the **Table Button** image, visible on the **Table View** bookmark, will take the user to the **Chart View** bookmark again, giving the appearance of toggling to the other view.

While the **Table View** bookmark is selected, highlight the **Table Button** image in the **Selection** pane. The **Visualizations** pane will change to **Format Image**. Locate and expand the **Action** properties. Change the toggle to **On**, select **Bookmark** from the **Type** dropdown, and select **Chart View** from the **Bookmark** dropdown, as shown in *Figure 6.15*:



Action On

Type: Bookmark

Bookmark: Chart View

Figure 6.15: Turning an image into a button by creating an action that navigates to the Chart View bookmark

Now, when a user clicks on the **Table Button** image they will be taken to the **Chart View** bookmark, making a static image feel like an interactive button. In order to experience this behavior while developing the report, just hold the *Ctrl* key on the keyboard and left-click the image, and you will be taken to the **Chart View** bookmark. When the report is deployed to the Power BI service, users will not need to hold *Ctrl* while clicking the button to interact with it. They will simply left-click the image.

To finish this example, make the same changes to the **Chart View** bookmark and set the **Chart Button** image to have an **Action** that will navigate back to the **Table View** bookmark. Hopefully, with these examples you can start to see the depth of what can be achieved by using the **Selection** and **Bookmarks** panes for digital storytelling.

Guiding report consumers through visualizations is helpful, but sometimes switching to a different report page with a completely different view of the data removes the user from their workflow. In cases where more detail is required, but you would like to keep users in their workflow, you can enhance the built-in tooltips by displaying a report page as a tooltip.

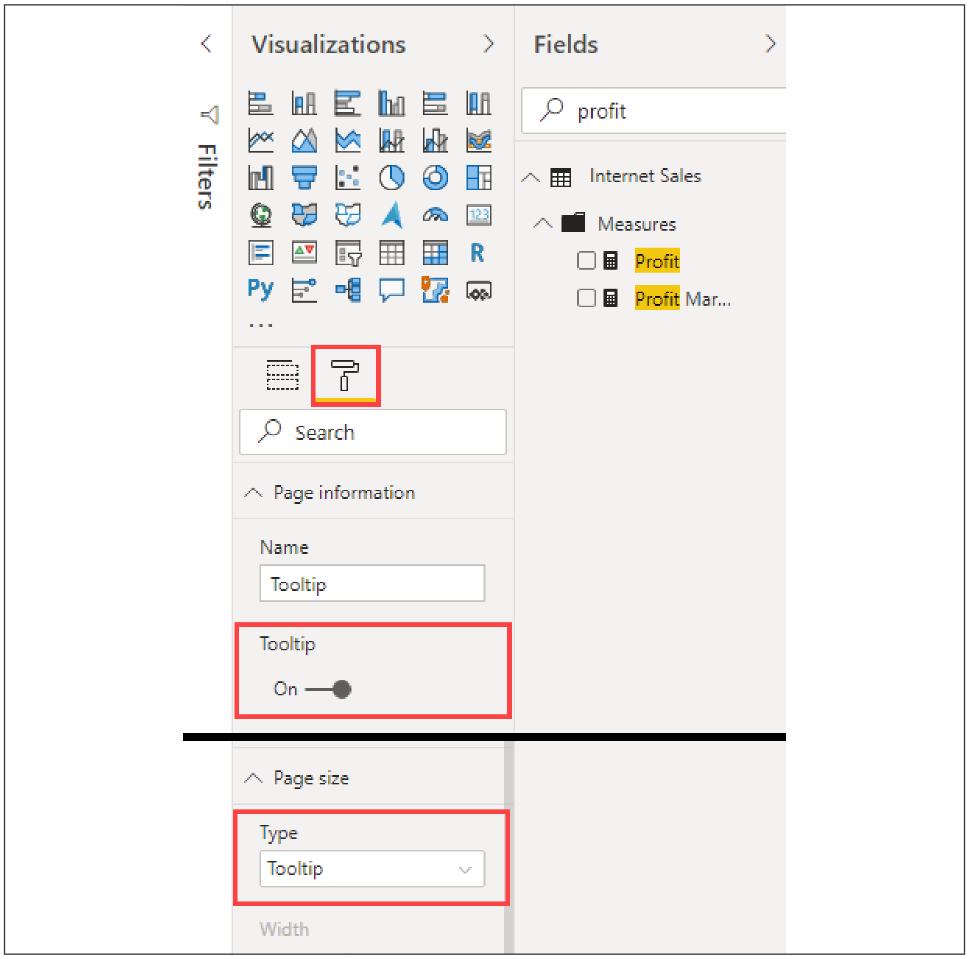
Report pages as tooltips

Tooltips are an incredibly useful feature that allows a user to see precise information about a piece of a visual while moving the mouse around the **Report** canvas. While the formatting options discussed in the previous chapter can display value labels on a visual, sometimes that can cause a report to become too cluttered or a visual may just be too small to display a label. Tooltips solve this problem by allowing a user to see the label information for only the slide of data they care about. But what if those tooltips could display even more information and provide even greater insight? Thankfully, Power BI comes through on this front by allowing you to specify a report page as a tooltip for a visual.

Power BI includes a few different important options for tooltip visuals. First, to use a visual for a tooltip, you must create a report page and set the property for **Tooltip** to **On**, which is found in the **Format** section, then **Page Information** settings. Next, any page can be a tooltip, but report pages are large and are often too big to be an effective tooltip. Instead, consider changing the **Page size | Type** property (also in the **Format** section) to **Tooltip**. This will make the canvas a small, more manageable tooltip. Next, locate and select the visual on which you would like to use the visual tooltip. In the **Format** section, there is a section for **Tooltip** settings, including a **Type**, which can be set to **Report Page** for custom tooltip visuals. You can then set the **Page** to display as the tooltip or allow Power BI to intelligently choose the appropriate page (if multiple pages are defined as tooltips) by leaving the setting on **Auto**. Finally, don't forget about the filter context for the tooltip by leveraging the tooltip filters, which will replace the drill through filters on the **Visualizations** pane when a page's **Tooltip** setting is changed to **On**.

Let's continue using the **Summary** page and build a visual tooltip to see how this functionality works:

1. Add a new page to the report and name the page **Tooltip**. Right-click on the page name and select **Hide page** since users will not be navigating to this page directly.
2. From the **Visualizations** pane, change to the **Format** section. Expand the **Page information** properties and change the **Tooltip** toggle setting to **On**. Expand the **Page size** properties and change the **Type** to **Tooltip**:



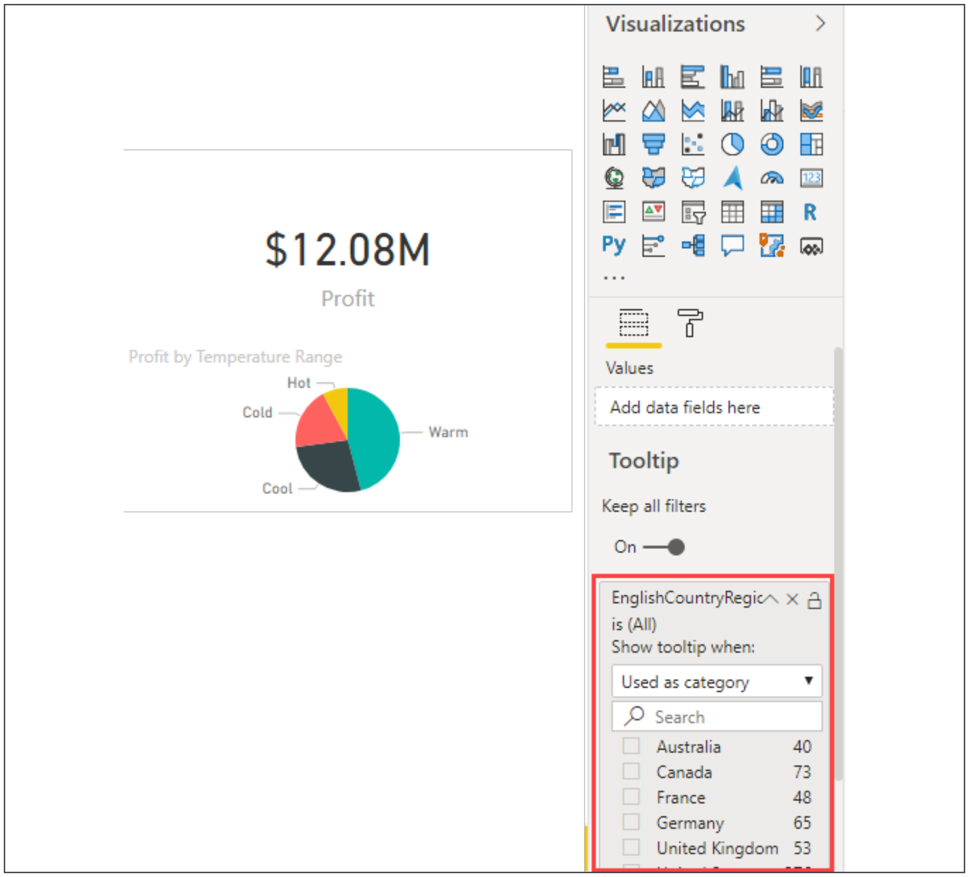
Name: Tooltip

Tooltip: On

Type: Tooltip

Figure 6.16: Format options to turn the report page into a tooltip and change the size to tooltip dimensions

3. By default, Power BI will scale the canvas to fit the screen. When we change the **Page size** to **Tooltip** it may not look like the canvas is much smaller because of the scaling. To see the actual, reduced size of the canvas, navigate to the **View** ribbon, then locate the **Page view** option in the **Scale to fit** section and change to **Actual size**.
4. On the top half of the canvas, create a **Card** visual using `Profit` from the `Internet Sales` table.
5. On the bottom half of the canvas, create a **Pie chart** visual using `Temperature Range` from the `Temperature` table as the **Legend** and `Profit` from the `Internet Sales` table as the **Values**.
6. To make the visual filter based on location, click anywhere on the blank canvas to deselect any visuals, and add **EnglishCountryRegionName** to the tooltip fields bucket on the **Visualizations** pane:



EnglishCountryRegic
is (All)
Show tooltip when:
Used as category

Australia	40
Canada	73
France	48
Germany	65
United Kingdom	53

Figure 6.17: Enabling the tooltip page as an option any time the EnglishCountryRegionName field is used in a visualization

7. Next, return to the **Summary** page of the report. Select the **Stacked column chart**. In the **Visualizations** pane, navigate to the **Format** section. Locate the **Tooltip** properties and select **Report page** for the **Type** property and **Tooltip** for the **Page** property. Now, when hovering the mouse over a column in the chart, the visual tooltip we just created should appear and the country will be passed in as a filter to the tooltip:

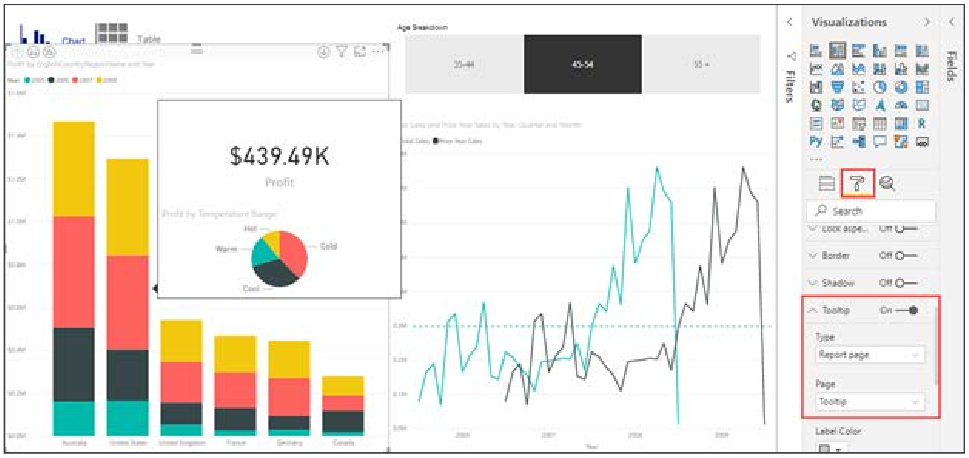


Figure 6.18: Setting the tooltip on a visualization to a report page

Many of the settings on a tooltip can be changed to provide more relevant information to users, but visual tooltips offer a powerful way to extend the tooltip functionality. By creating small pages of visuals and leveraging filters, you can provide a vast amount of additional data and insight that just cannot be matched by the default tooltips.

Summary

Being able to use the features discussed in this chapter effectively will turn interactive reports into dynamic digital storytelling tools. Report developers have a wide variety of tools at their disposal to tell exciting stories from using space more efficiently by creating toggles, empowering users to drill through to gain detail level insights, adding value by enhancing the built-in tooltips, or calling out important views with bookmarks. In the next chapter, you will see how to take this completed Power BI report and share it with others.

7
Using a Cloud Deployment with the Power BI Service

You've spent the course of this book creating amazing reports using the Power BI Desktop client. Now, it's time to share those reports with your team, company, or customers. In this chapter, you're going to learn about the Power BI service and how to use it for the following:

- Deploying reports to the Power BI service
- Creating and interacting with dashboards
- Sharing your dashboards
- Setting up row-level security
- Scheduling data refreshes

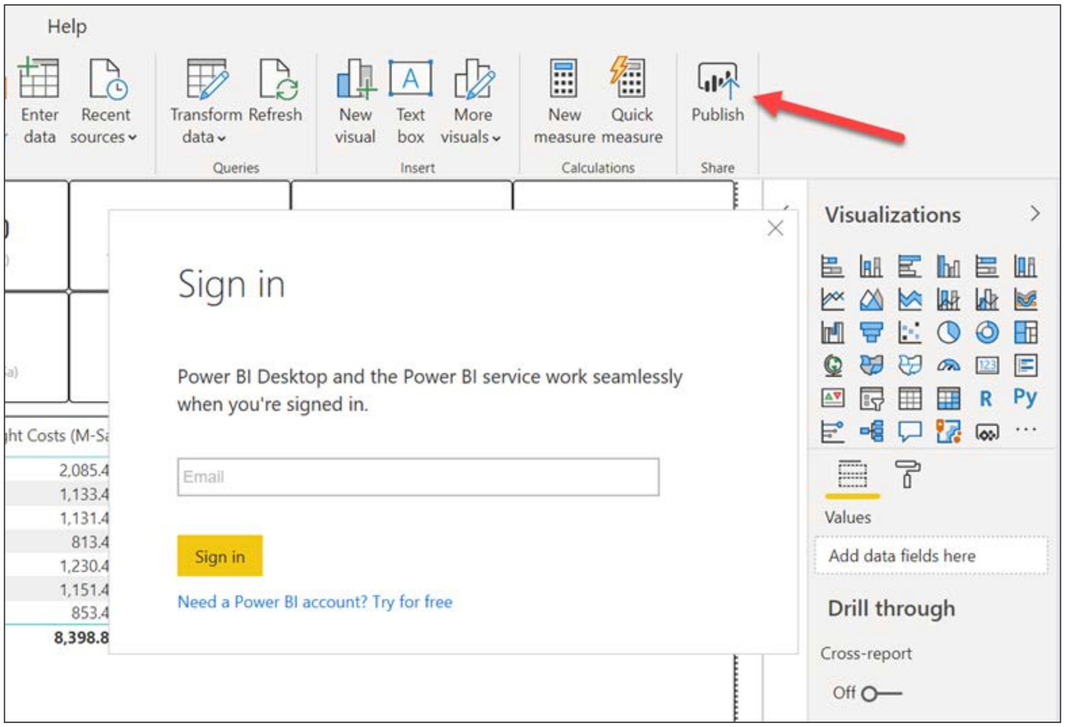
The Power BI service operates a freemium model. You can get most of the features in the free model, but when you want to share data with others and use team development, it will need to be upgraded to the Pro edition. Other features requiring the Pro edition are the ability to store larger datasets and refreshing more frequently, to name a couple.

Before you begin this chapter, make sure you sign up for a free account at Power BI (`https://powerbi.microsoft.com/en-us/get-started/`). Some sections of this book will require a Pro license, such as the section dealing with workspaces.

Now, let's get started and begin exploring how to deploy reports to the Power BI service.

Deploying reports to the Power BI service

There are numerous ways to publish a report to the `PowerBI.com` service, but the easiest way is by using Power BI Desktop. To do this, you'll need to simply open the report you want to deploy to the Power BI service, then click the **Publish** button in the desktop application, as shown in the following screenshot. If you have not previously signed in with your free `PowerBI.com` account, you will be prompted to create one or sign in with an existing account:



Sign in

Power BI Desktop and the Power BI service work seamlessly when you're signed in.

Email

Sign in

Need a Power BI account? Try for free

Figure 7.1: Power BI Sign in window

You'll then be asked which workspace you want to deploy to. A workspace is an area in the Power BI service much like a folder, where you can bundle your reports, datasets, and dashboards. You can also assign security to the workspace and not have to worry about securing each item individually.

Most importantly, it allows for team development of a Power BI solution, where you can have multiple authors on a solution. We'll cover much more about workspaces in the *Sharing your dashboards* section of this chapter.

At this point, select the **My Workspace** item, which will send the report and its data to your personal workspace. The report will then deploy to the Power BI service. The amount of time this takes will depend on how large your dataset is. You'll then be presented with two options: **Open** the Report or **Get Quick Insights**.

Quick Insights is an amazing feature in Power BI that will try to find additional interesting insights about your data that you may not have noticed initially. For example, in the following screenshot of the sample report, the feature found that **Contoso** dominated all other manufacturers in the **Adventure Works** dataset. You'll notice that it not only provides a graphic of the data, but also a narrative to the right of the graphic. If you find any of the insights especially interesting, you can click the pushpin at the top right of the graphic to save it into a dashboard. We'll cover dashboards in the next section of this chapter:

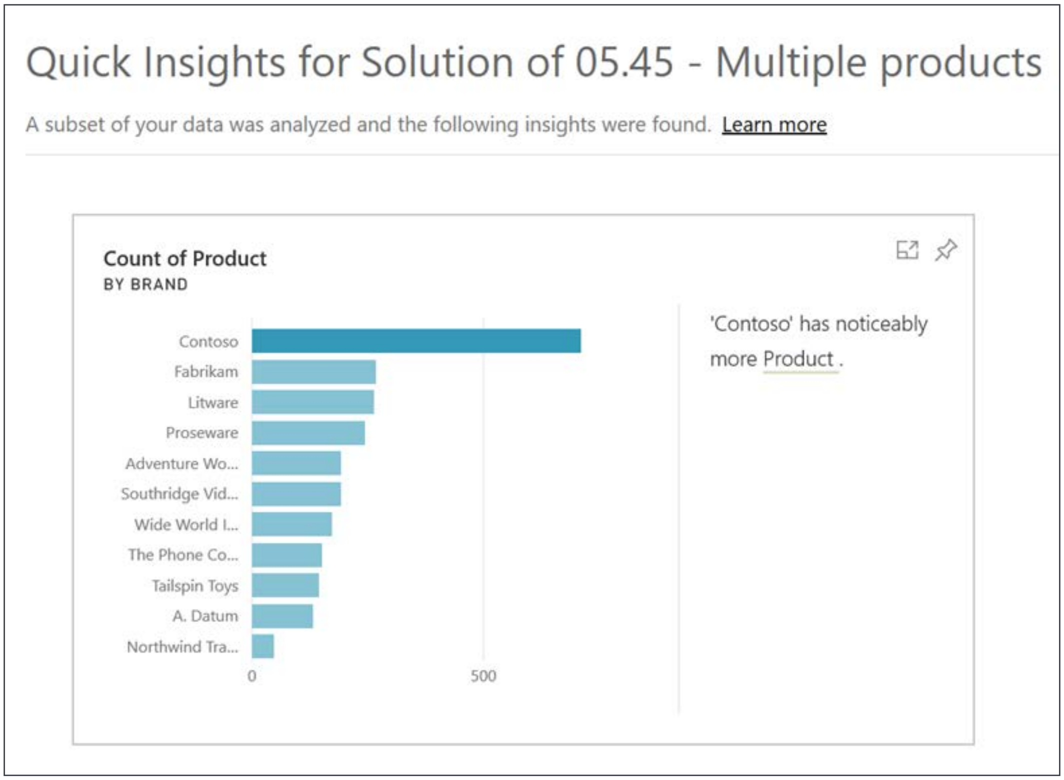
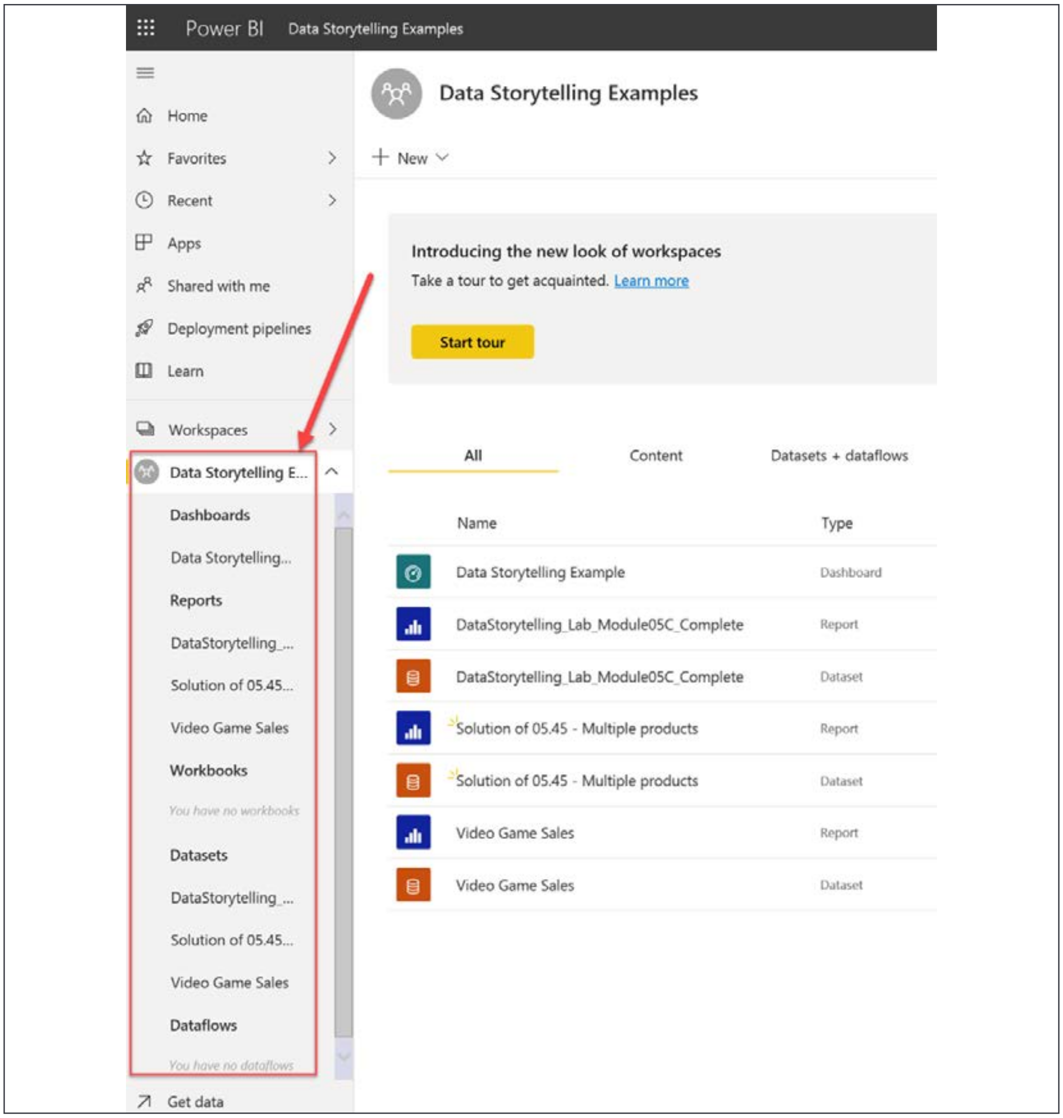

Quick Insights for Solution of 05.45 - Multiple products
A subset of your data was analyzed and the following insights were found. Learn more
Count of Product
BY BRAND
Contoso
Fabrikam
Litware
Proseware
Adventure Wo...
Southridge Vid...
Wide World I...
The Phone Co...
Tailspin Toys
A. Datum
Northwind Tra...
0
500
'Contoso' has noticeably more Product .

Figure 7.2: Quick Insights results in the Power BI service

If you open the report, `PowerBI.com` will launch in any web browser and show you the same report that you were viewing on the desktop. You'll also be able to immediately see the report in the Power BI mobile app from your Android or iPhone. `PowerBI.com` has five key areas that you can interact with:

- **Dashboards**: You can pin the best elements from multiple reports into a unified set of dashboards. These dashboards are the first thing most of your casual users will interact with.
- **Reports**: This area refers to the projects that you have built in Power BI Desktop or in the service. These reports can be explored, modified, or downloaded in this section.
- **Workbooks**: You can upload Excel workbooks into this area. These Excel workbooks can be used as datasets or can form pieces of the workbook that can be pinned to a dashboard.
- **Datasets**: This is the raw data that you have built in Power BI Desktop. When you click a given dataset, you can build new reports from it. You can also build a new dataset by clicking **Get data** in the bottom-left corner of your browser.
- **Dataflows**: This new feature in Power BI offers online self-service **Extract, Transform, Load** (**ETL**) and data preparation. This allows organizations to unify data from various sources, prepare the data for consumption, and ultimately publish it as a shared, central data source for users to view in Power BI.



Introducing the new look of workspaces

Take a tour to get acquainted. Learn more

Name	Type
Data Storytelling Example	Dashboard
DataStorytelling_Lab_Module05C_Complete	Report
DataStorytelling_Lab_Module05C_Complete	Dataset
Solution of 05.45 - Multiple products	Report
Solution of 05.45 - Multiple products	Dataset
Video Game Sales	Report
Video Game Sales	Dataset

Figure 7.3: Exploring a workspace in the Power BI service

Now, let's explore the underlying features of the reports in the Power BI service, as well as the other main features.

Datasets

The **Datasets** area of Power BI holds the raw data that makes up your reports. When you left-click on one of your datasets, the designer opens to build reports from the dataset. The designer can be used to perform the following actions:

- Create more quick insights
- Create new reports
- Refresh or schedule refreshes
- Manage permissions
- Download as a Power BI Desktop file (`.pbix`)

When you start with a dataset, users can create new reports from your data if they have the right permissions, even when accessing it through the web. The entire user interface will feel nearly identical to Power BI Desktop, but you will be lacking the ability to modify the model, query, and relationships, as well as lacking the ability to create measures or calculated columns. The best part of building reports using the online Power BI framework is that you have a central dataset that your organization's central IT team can own, modify, and make human-readable for use by the entire organization.

Workbooks

The **Workbooks** section gives you the ability to upload Excel workbooks, which can be used as datasets for a report or to pin selected parts of that workbook to a dashboard. Workbooks can be updated by either reuploading the workbook, using the database management gateway, or using OneDrive. OneDrive is Microsoft's cloud-hosted hard drive system. With OneDrive, you can simply share or save your Excel workbooks, and if you're using a workbook in a Power BI report, it can also refresh manually or on a schedule.

Now we're explored some of the fundamental elements of Power BI's online service, let's use it to create and interact with our own projects.

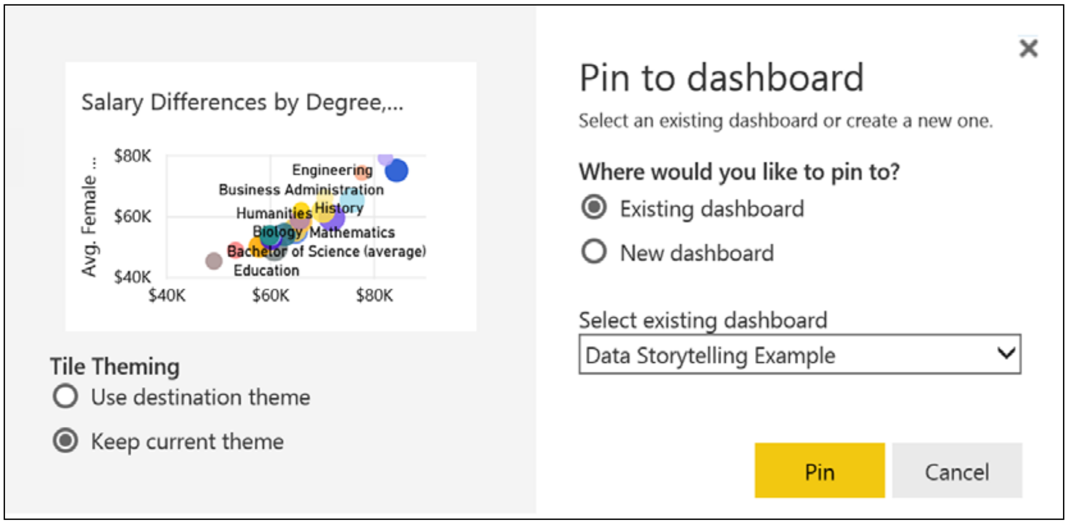
Creating and interacting with dashboards

Once you have deployed your datasets and are using them in reports, you're ready to bring together the many elements into a single dashboard. Often, your management team is going to want a unified executive dashboard that combines elements such as sales numbers, bank balances, customer satisfaction scores, and more into a single dashboard. The amazing thing about dashboards in Power BI is that data can be actionable and reacted to quickly. You can strategically display the most important information your viewers need to see from multiple reports and pages. For a deeper dive, you can click on any dashboard element and be immediately taken to the report that is the source for that information. You can also subscribe to the dashboard and create mobile alerts when certain numbers on the dashboard reach a milestone.

Now, let's jump in and apply this knowledge.

Creating your first dashboard

To create your first dashboard, start by opening a report that has some interesting data. On each of the charts, tiles, and other elements, you'll see a pin icon in the top right of that object. After you click on the pin, it will ask you which dashboard you wish to pin that report element to. You can, at that point, create a **New dashboard** or choose an **Existing dashboard** to add the element to, as shown in the following screenshot. This is what makes Power BI so magical—you're able to append data from your accounting department next to data from your sales and customer service teams, giving your executives one place to look:


Salary Differences by Degree,...
Avg. Female ...
$80K
$60K
$40K
$40K
$60K
$80K
Engineering
Business Administration
Humanities
History
Biology
Mathematics
Bachelor of Science (average)
Education
Pin to dashboard
Select an existing dashboard or create a new one.
Where would you like to pin to?
Select existing dashboard
Pin
Cancel
Tile Theming

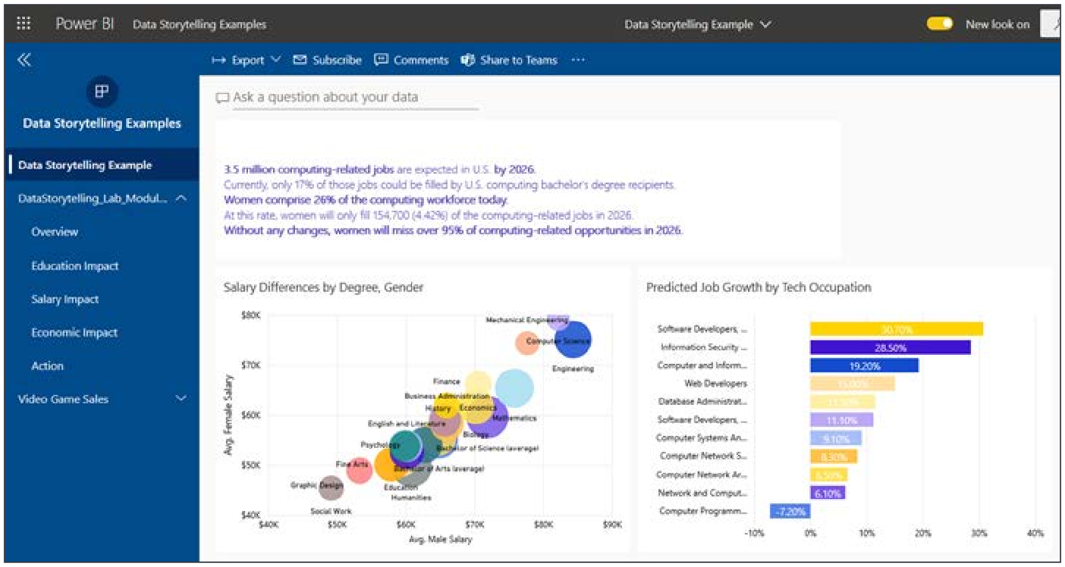
Existing dashboard [✓]
New dashboard

Select existing dashboard: Data Storytelling Example

Tile Theming
Use destination theme
Keep current theme [✓]

Figure 7.4: Pin a visual to a dashboard

If you have an existing dashboard, then select **Existing dashboard** and choose which one you want to use. If you don't have a dashboard yet, select **New dashboard**, give it a name, and then click **Pin**. Once you pin the first item to the dashboard, you'll be prompted with a link to the dashboard. The newly created dashboard will allow you to resize elements and add additional tiles of information. You can click **Add tile** in the upper-right corner to add additional interesting data, such as web content, images (such as logos), text data, and videos to the dashboard. Many people use this in the line-manager dashboard to insert a company logo and a short video from the executive team talking about the initiative of the quarter that relates to the dashboard.



3.5 million computing-related jobs are expected in U.S. by 2026.
Currently, only 17% of those jobs could be filled by U.S. computing bachelor's degree recipients.
Women comprise 26% of the computing workforce today.
At this rate, women will only fill 154,700 (4.42%) of the computing-related jobs in 2026.
Without any changes, women will miss over 95% of computing-related opportunities in 2026.

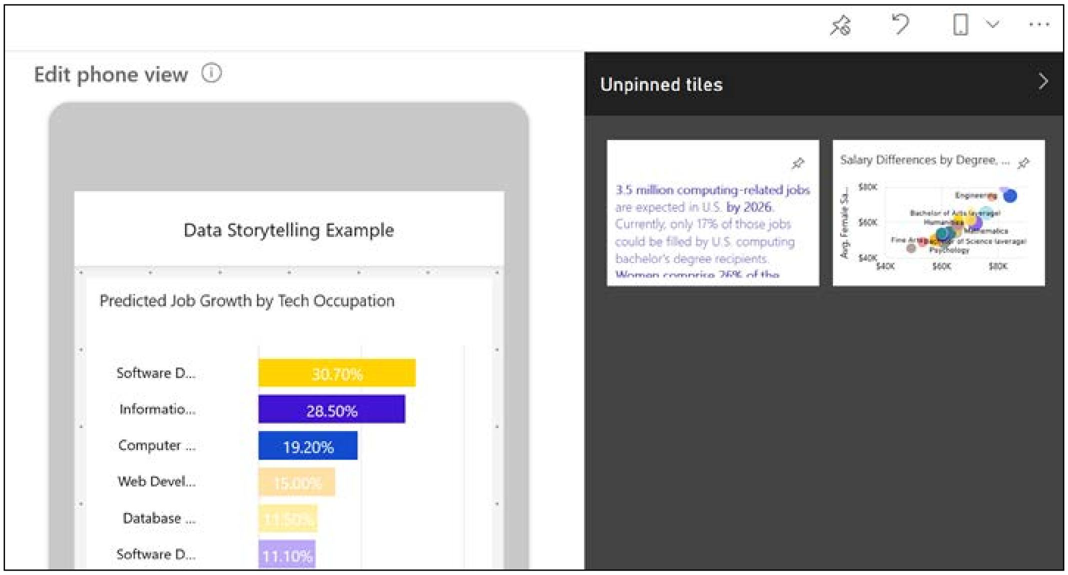
Figure 7.5: Dashboard with several visuals in the Power BI service

You can also pin real-time data as a tile, using custom streaming data. Simply click on the ellipsis on the top ribbon and choose **Add** tile. Once you click **Custom Streaming Dataset**, you have the option to add a new dataset from **Azure Stream Analytics** or **PubNub**, or a developer can use an API to push data directly into the dashboard. **Azure Stream Analytics** is the most common of these live data streams. In this mechanism, devices could stream data through Azure Event Hub, for example, and then get aggregated with **Azure Stream Analytics**. Imagine the power of a smart power grid sending thousands of records in a second to the cloud, and then **Azure Stream Analytics** aggregating this to a single record every five seconds, the status shown by a moving needle on a gauge or line graph in Power BI.

A good way to view Power BI is from a phone, either in web view or in the native Power BI client, which is downloadable from the App Store for Android or iPhone.

There are going to be some dashboard elements that you will likely want to exclude from a phone device because the surface area is too small. By the very nature of the device, most people sign into Power BI on their phone to get a quick look at the numbers. For those consumers, you can create a specialized phone view of the dashboard.

Simply click on the ellipsis in the top ribbon of the dashboard and select **Mobile View**. The default phone view will contain every element from the **Web View**. To remove items, hover over each report element and click the pushpin to move it to the **Unpinned Tiles** section, as shown in the following screenshot. Once you're done, you can click the phone icon (or **Mobile View** name, based on your resolution) and flip it back to **Web View** again:



3.5 million computing-related jobs are expected in U.S. by 2026. Currently, only 17% of those jobs could be filled by U.S. computing bachelor's degree recipients. Women comprise 26% of the

Figure 7.6: Power BI Mobile view

There are some really neat dashboard features we can explore, too. Let's return to the dashboard and explore.

Asking your dashboard a question

Once the dashboard is complete, you're able to ask questions about your data. Right above the dashboard data, you'll see the area where you can **Ask a question about your data**. For example, you enter a request to "*Show me the total stores by state*," and Power BI will typically produce a geographical response.

If you'd prefer to see your answer as a bar chart instead of a map, you can explicitly ask for it as a graph element—for example, "*Show me the total stores by state in a bar chart*."

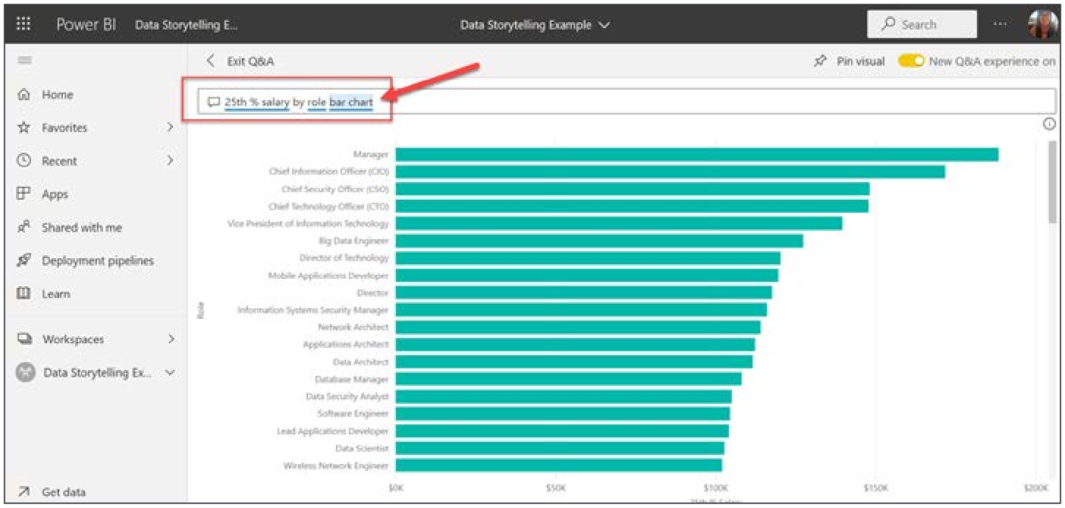
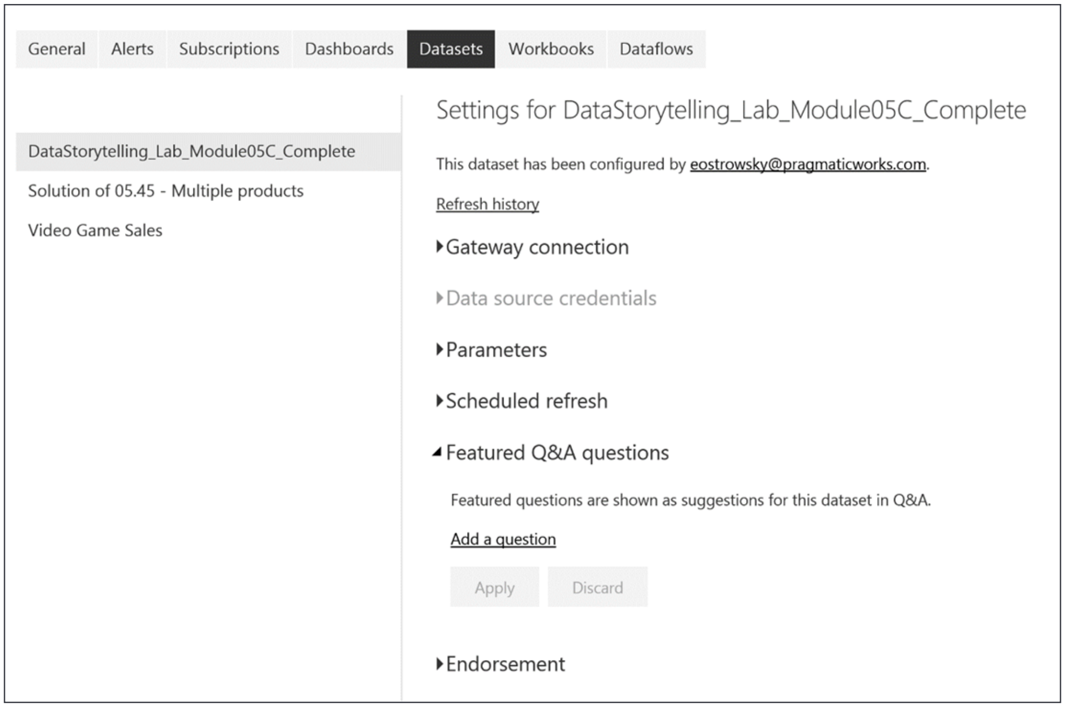


Figure 7.7: Q&A feature in the Power BI service

If you like the answer that comes back, you can click **Pin visual** in the top-right corner to pin the report item to a dashboard. You can also expand the **Filters** and **Visualizations** on the right to be very precise with your report item. For example, you may only want to see stores with sales above a certain level. While Power BI is great at answering questions with filters, it sometimes needs fine-tuning. If you're curious as to where Power BI pulled this data from, below your newly created report, you'll see the source of the data from which the report was derived.

A great way to encourage your users to utilize this feature is to seed Power BI with some sample questions. To do this, select the settings gearbox in the upper-right corner of your screen. Once there, click the dataset that you wish to create sample questions for in the **Datasets** tab, as shown in the following screenshot. Expand the **Featured Q&A questions** section, click **Add a question**, and add several questions that might interest your user:



DataStorytelling_Lab_Module05C_Complete
Solution of 05.45 - Multiple products
Video Game Sales

Settings for DataStorytelling_Lab_Module05C_Complete

This dataset has been configured by eostrowsky@pragmaticworks.com.

Refresh history

▸Gateway connection
▸Data source credentials
▸Parameters
▸Scheduled refresh
◂Featured Q&A questions

Featured questions are shown as suggestions for this dataset in Q&A.

Add a question

▸Endorsement

Figure 7.8: Q&A setting in the Power BI service

Creating featured questions will help your users to start to use the vocabulary of the report. For example, your sales team may be used to calling someone a "client," but your marketing team uses the term "customer." Featured questions will encourage all users to refer to customers as clients. If you want to have your cake and eat it too, you can create synonyms inside Power BI Desktop. You can do this in the **Modeling** tab in Power BI Desktop when looking at your relationships. You can also create more advanced linguistic models in Power BI Desktop by importing linguistic models if you've developed them. This can help with questions that you think users might ask, such as "*Who is my best customer in New York*" or "*Show me the worst employees by office*." The linguistic model would translate what "*best*" and "*worst*" means to the company.

One of the amazing features you can use inside of Power BI is to ask questions through Cortana, Windows's voice-operated assistant. With Cortana integration enabled in the **Settings** tab, your users will be able to ask questions in Windows without logging into Power BI and can get quick answers right from the **Start** menu. To do this, the user must have their company account (typically Office 365) associated with Windows by going to **Settings** | **Account** in Windows. You must also connect Office 365 to Cortana as a connected service.

We've covered developer options in the Power BI service, now let's learn optimal ways to share with report consumers.

Subscribing to reports and dashboards

To discourage users from printing reports and dashboards, you can have them subscribe to the reports and dashboards instead. This will email the report or dashboard to the user when the data changes on the report, typically daily or weekly. This can be done by selecting **Subscribe** in the upper ribbon. Power BI will read the account you're signed in with and subscribe you using that email address. When subscribing to reports, you must select the report page that you wish to be emailed to you. With dashboards, the entire dashboard will be emailed.

You can also set up alerts from your mobile device to alert you when a critical number changes on a report. While looking at a dashboard, you can click the alert icon (it looks like a bell) to create an alert. This will monitor the data on the report, and upon that number hitting a certain specified threshold based on the rule that you set, it will send you a phone alert and, optionally, an additional email. Alerts are great mechanisms to let you know if a given critical number, such as a profit margin, has fallen.

Subscriptions and alerts can be managed in the Power BI settings area under the **Subscription** option. You can turn off alerts and subscriptions here, as well as editing subscriptions. By default, the frequency of subscriptions will be whenever the data is updated, but this happens typically no more than once per day (although this can be altered).

Alerts are only one way to notify consumers. Let's explore other ways.

Sharing your dashboards

Sharing in Power BI is quite simple, but you'll want to consider what your goal is first. If your goal is simply to share a view-only version of a report or dashboard that users could engage with, the basic sharing mechanism can do that. Conversely, if your goal is to allow users to also edit the report, you will want to use a workspace and assign roles to users in the workspace settings. Lastly, if you want to logically package reports and dashboards together, and have the ability to have fine control over which reports can be seen by default, consider using Power BI apps.

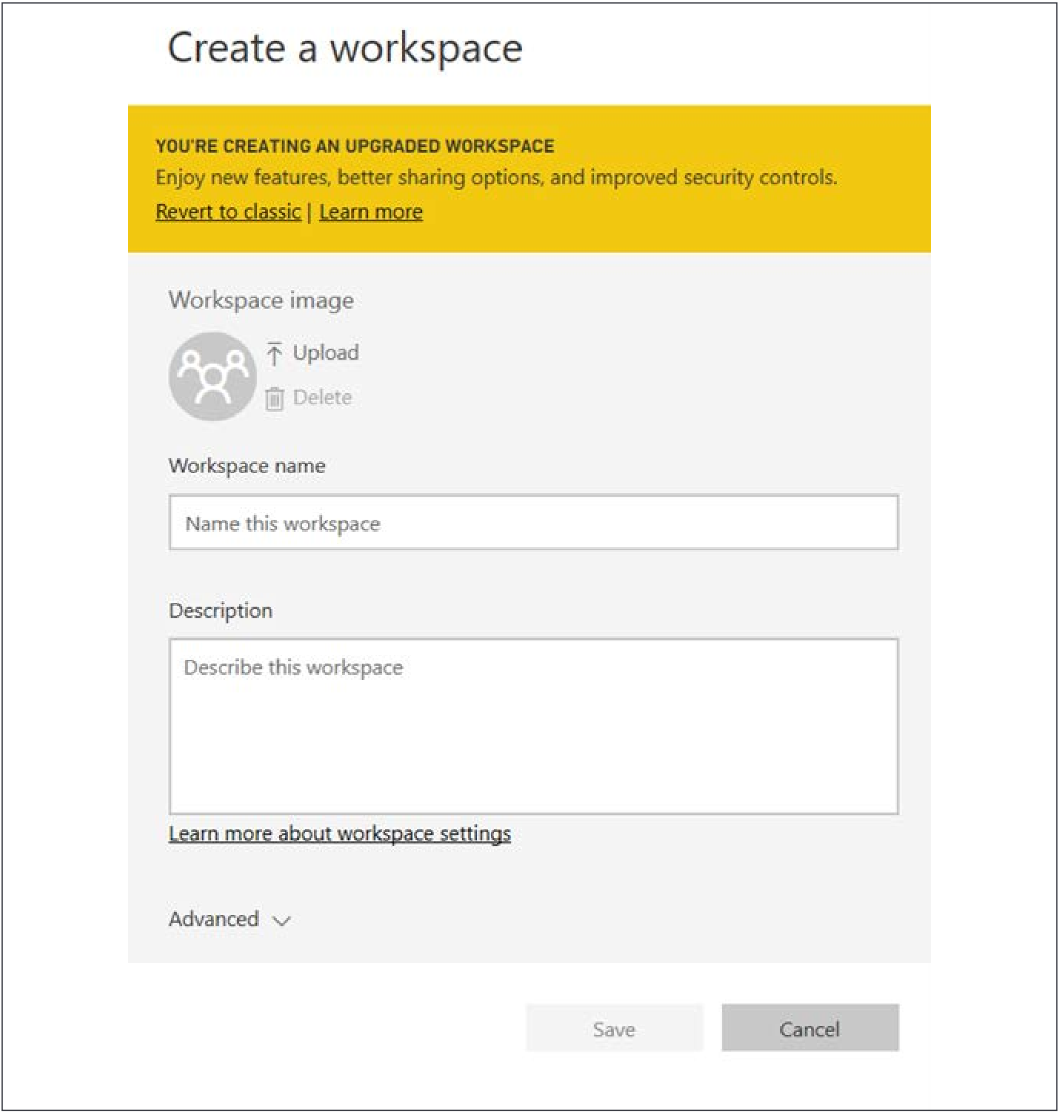
The easiest way to share a dashboard or report is to simply click **Share** on the ribbon of any report or dashboard. Simply type the email address of the user that you want to share with and what type of access you want to give them. While you can't allow them to edit the report or dashboard, they will be able to view and reshare the report themselves. At any time, you can also see what assets are shared with you by clicking **Shared with Me** from the left menu of the **Service** page. Then, you will see a list of users that have shared items with you. You can click on this list to filter the report lists that are shared with you.

Workspaces

Workspaces are areas where groups of users can collaborate on datasets, reports, and dashboards. You can create a workspace if you have a Pro license of the Power BI service. This is the main way that your BI developers will be able to co-develop the same sets of data and reports. Typically, you'll create a workspace for each department in your company for the teams to store their items and data.

To create one, simply expand the **Workspaces** section in the left navigation menu and click **Create a workspace**. Name the workspace that you wish to create and define whether members can edit the content or just view the content, as shown in the following screenshot, *Figure 7.9*. You can also define whether users will be able to see the content of what's inside the workspace without being a member. This doesn't mean they'll be able to see the reports, but they will be able to see the metadata.
If you're running the Power BI Premium edition, you can also assign **Dedicated capacity** to a given workspace to increase the amount of data storage.

This is handy for those executive reports that must always return their visuals in a few seconds:



Create a workspace

YOU'RE CREATING AN UPGRADED WORKSPACE
Enjoy new features, better sharing options, and improved security controls.
Revert to classic | Learn more

Workspace image
Upload
Delete

Workspace name
Name this workspace

Description
Describe this workspace

Learn more about workspace settings

Advanced

Save
Cancel

Figure 7.9: Creating a workspace in the Power BI service

At any time, you can change the permissions or add users by editing the workspace if you have permission to do so. To do this, select the ellipsis button next to the workspace name on the main **Workspace** menu and click **Edit this Workspace**.

Setting up a workspace, its roles, and permissions covers the most basic access and security issues by defining who can access the report and other objects. Now let's dive into further access and security options.

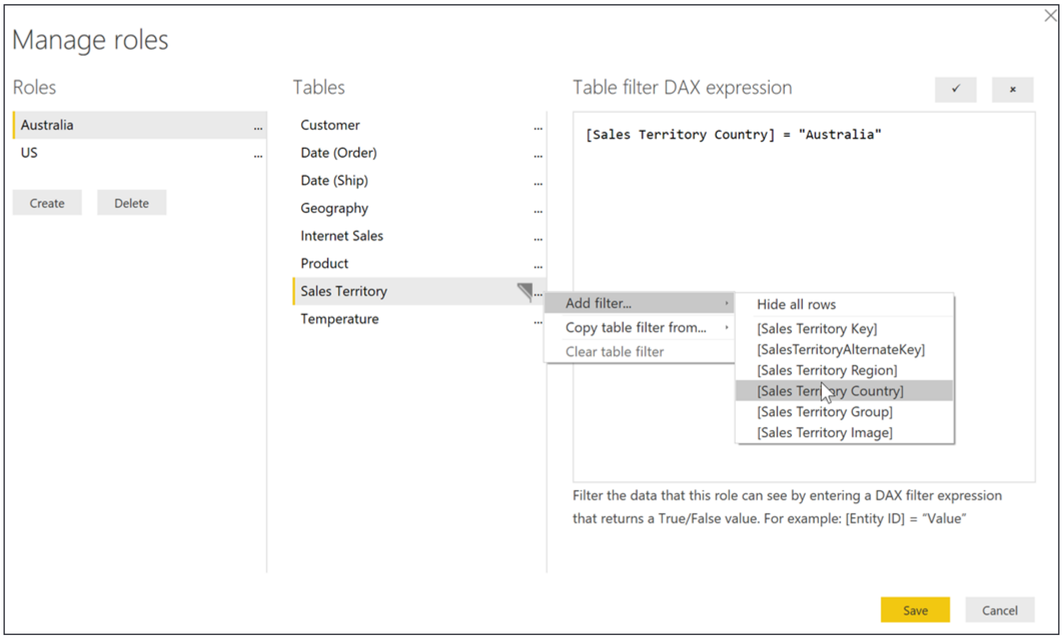
Setting up row-level security

In most organizations, security is not just a report-level decision. Organizations want more granular decisions, such as whether a sales executive can only see his or her own data. Another example is the ability for a teacher to see their own students, the school's principal to see all the teachers at their school, and the school board members to see all of the school's data. This level of granularity is quite possible in Power BI, but will require some thought ahead of time on how to lay out the data.

To show an example of this, we'll need to go back to the Power BI Desktop and open `Chapter 5 - Visualizing Data.pbix` from a previous chapter's example; this file can be downloaded from this book's GitHub repository at `https://github.com/PacktPublishing/Microsoft-Power-BI-Start-Guide-Second-Edition/blob/main/Completed%20Examples/Chapter%205%20-%20Visualizing%20Data.pbix`. The goal of this example is to ensure that United States sales managers can only see US sales, and likewise for Australian sales managers and Australian sales. We'll only use two countries in our example, but the same example can apply to the entire world, and can be expanded to be made more dynamic.

To create this type of automated filter based on your user credentials, you'll need to use DAX language snippets. Open the Power BI Desktop and click **Manage roles** from the **Modeling** ribbon in the report. Then, click **Create** to make a new role called **US**. Then, select **Sales Territory** as your table to filter on and click **Add filter...** | [**Sales Territory Country**], as shown in the following screenshot, *Figure 7.10*. This will create a stub of code in the **Table filter DAX expression** box that shows `[Sales Territory Country] = Value`. Simply replace `Value` with **Australia**, and your first role is created when you **Save**.

Do the same for **US** to complete the example:



```
[Sales Territory Country] = "Australia"
```

Filter the data that this role can see by entering a DAX filter expression that returns a True/False value. For example: [Entity ID] = "Value"

Figure 7.10: Setting up row-level security

Now that we've created the two rules, let's test them out. The Power BI desktop will not automatically filter the data for you, since you have access to the underlying data anyway, but it can be used to test it. Click **View as** roles from the **Modeling** tab and select the role you wish to test. You'll notice after you click on **Australia**, for example, that every report element on each report page filters at that point to only show **Australian** data. Power BI Desktop also warns you that you're filtering the data, and that you can click **Stop viewing** to stop viewing as the role. Once you're ready to see what you've done on the Power BI service, publish the report to your Power BI account and open the report there.

Navigate to the dataset matching your report and select **Security**. You can then select each role and type the email address of each member of that role. Click **Add** and then **Save** to start using the role, as shown in the following screenshot, *Figure 7.11*. You can also add **Azure Active Directory Security Groups** (such as your **Australian Employee group**) to this role if you have one created already in **Azure Active Directory**. After clicking **Save**, members of that role will only see their own data in dashboards, reports, and any new reports that they build from the dataset:

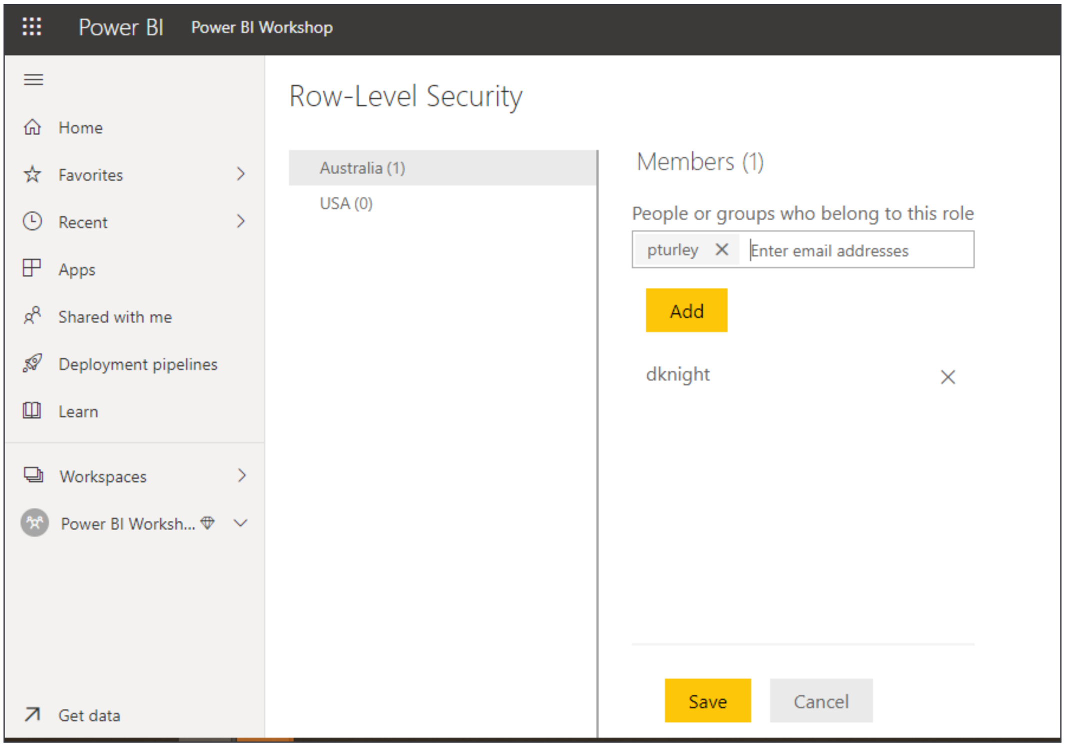


Figure 7.11: Assigning row-level security in the Power BI Service

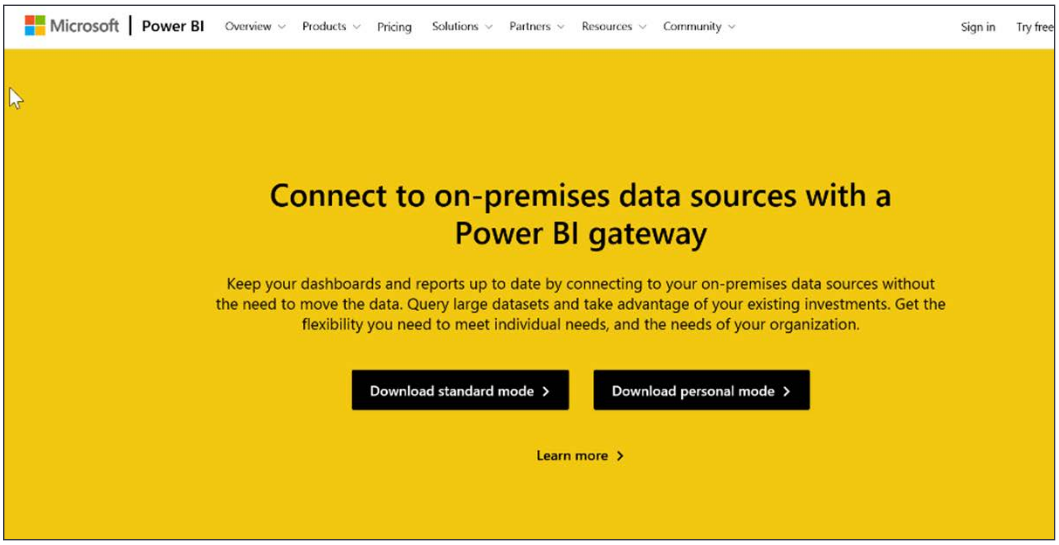
If your user has edit rights to the workspace or dataset, then these roles will not work since they already have the ability to see the underlying data. However, roles do work if the user is connecting to Power BI Desktop to see the data through Excel. Make sure the members of the workspace only have view rights selected if this feature is important to you. Additionally, as of the time of writing, when row-level security is turned on, Q&A will no longer work. Now, let's learn about another important facet of reporting: scheduling refreshes.

Scheduling data refreshes

Once you have a report that everyone depends on, you're not going to want to refresh it manually each day. The Power BI service has the ability to refresh your datasets up to every half an hour – at the top and bottom of each hour – up to eight times a day for the Power BI Pro edition when you're not doing real-time analysis. If all of your data lives in the cloud, refreshing is very simple. However, if you have some data or files on-premises, you must install the on-premises gateway.

Don't forget that if you want to see data in real time, you have the option to perform a direct query, where clicks run queries against your source system. Doing this will slow your reports down by large factors. You can also do real-time analysis of your data by using Azure services, such as Stream Analytics, where elements in your dashboards refresh every second.

The on-premises gateways can be used across multiple cloud services, such as Power BI, PowerApps, Logic Apps, and Power Automate. You can download the free gateway from the top-right download icon on `PowerBI.com` once you're signed in. The first question that will be asked during the installation is whether you want to install the data gateway in personal mode or on-premises standard mode:



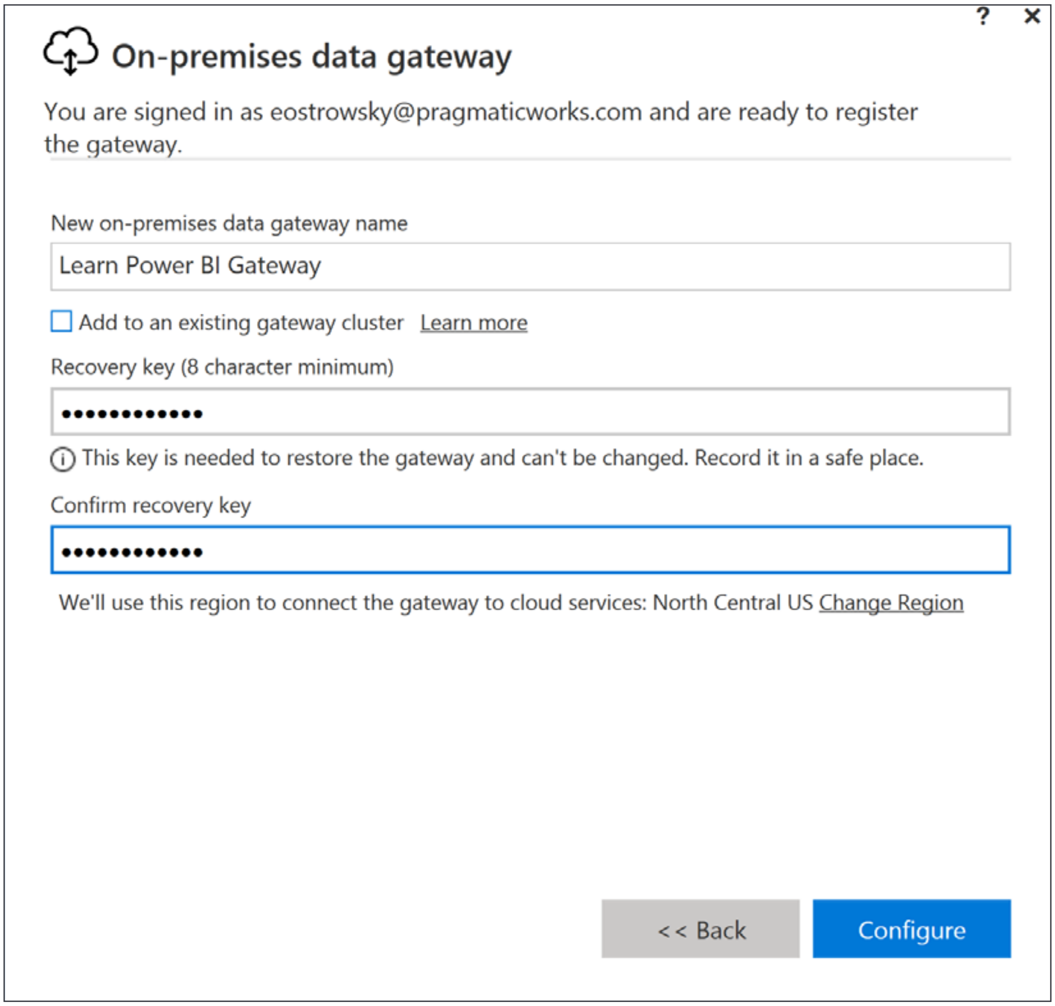
Connect to on-premises data sources with a Power BI gateway

Keep your dashboards and reports up to date by connecting to your on-premises data sources without the need to move the data. Query large datasets and take advantage of your existing investments. Get the flexibility you need to meet individual needs, and the needs of your organization.

Figure 7.12: Download options for Power BI data gateway

The largest difference between the on-premises data gateway and the on-premises data gateway in personal mode is that personal mode runs as a local application compared to a Windows service in on-premises mode. By installing in personal mode, you risk your data becoming stale if the application is not open when your PC starts, because the data is not available for refresh while the local machine is off. It is handy for those users who may not have admin access to their machine, or users who want easier data refreshes. It is recommended for ease of management and reliability that most users install the on-premises data gateway.

After installation, you'll need to provide your Power BI login credentials. Next, you'll need to name your gateway and provide a **Recovery key**, as shown in the following screenshot, *Figure 7.12*. The recovery key is used to encrypt your connection strings and your configuration. Make sure that this key is kept in a safe place and is backed up. If you wish to make this gateway highly available, you can select **Add to an existing gateway cluster**, allowing multiple machines to act as a single gateway to Power BI:



You are signed in as eostrowsky@pragmaticworks.com and are ready to register the gateway.

New on-premises data gateway name

Learn Power BI Gateway

☐ Add to an existing gateway cluster Learn more

Recovery key (8 character minimum)

•••••••••••••

This key is needed to restore the gateway and can't be changed. Record it in a safe place.

Confirm recovery key

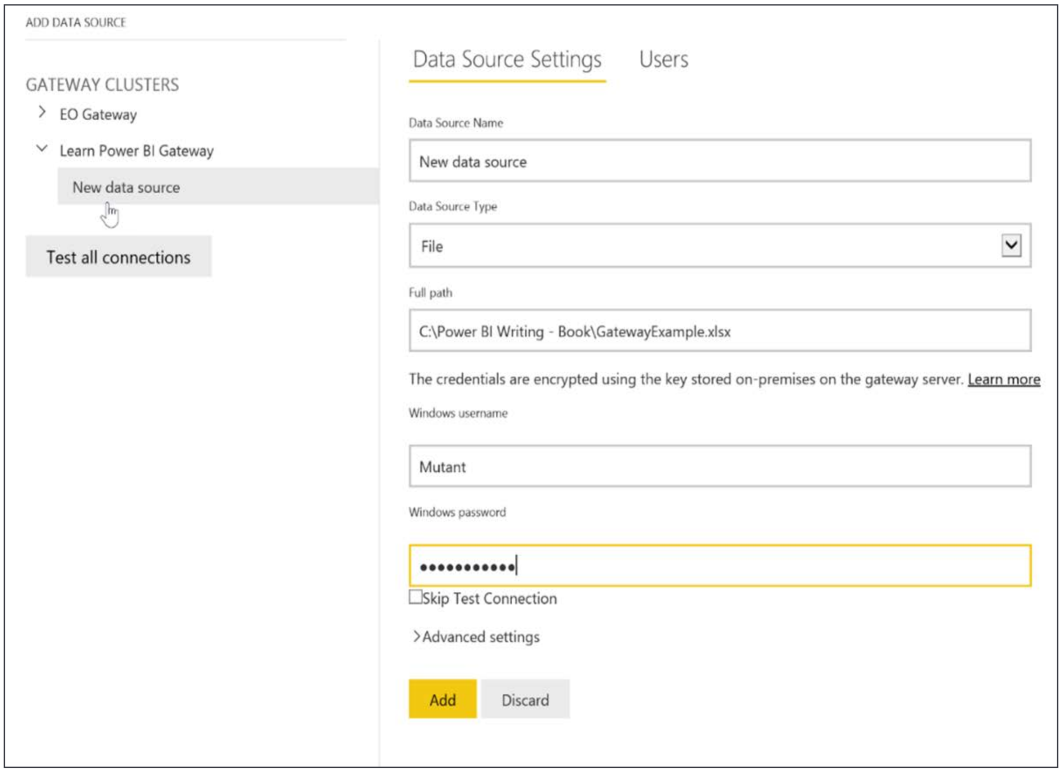
•••••••••••••

We'll use this region to connect the gateway to cloud services: North Central US Change Region

Figure 7.13: Configuring the data gateway

With the on-premises work now complete, you will need to complete the configuration on `PowerBI.com`. Click the settings gearbox from the top-right corner and select **Manage Gateways**. At that point, you should see the gateways on the left. You can add more administrators (who have permission to configure data sources that can use this connection) in the **Administrators** tab. Most importantly, you will want to test the gateway before proceeding.

Now, we need to create a connection to each of your files or databases used in your report that are on-premises. Click the **New data source** button from the top-left corner. Give the data source a name that will enable you to easily identify it later. Typically, that name should match the filename or database name to help with debugging later. For Excel files or any other type of files used in your report, select **File** from the **Data Source Type** drop-down box. Then, type the **Full path** for the filename or a network path (UNC path). Lastly, give the Windows credentials that are needed to access the file on the share or folder. Once you've selected **Add**, click **Test all connections** again to ensure you have a proper connection, as shown in the following screenshot:



Data Source Name: New data source

Data Source Type: File

Full path: C:\Power BI Writing - Book\GatewayExample.xlsx

The credentials are encrypted using the key stored on-premises on the gateway server. Learn more

Windows username: Mutant

Windows password: •••••••••••

Skip Test Connection

Advanced settings

Figure 7.14: Add and test your new connection

The **Users** tab also allows you to have more refined control of who can access this data source. Once you've saved those settings, you're ready to schedule the refresh. If you wish to just refresh the data immediately, select the ellipsis button next to the dataset and select **Refresh Now**. To schedule a refresh, click **Schedule Refresh**. This will take you to the dataset configuration screen. Expand the **Gateway Connection** section, select **Use an On-Prem Data Gateway**, and click **Apply**. You should see your gateway name in this section, with a status reading **Online**. If you don't see **Online**, check whether there are any proxy settings or firewall issues preventing Power BI from seeing your machine.

Next, expand the **Scheduled Refresh** section in the **Datasets** tab and switch the **Keep Your Data Up to Date** setting to **On**. You can then schedule the refresh to occur as often as every half an hour. Once you test the refresh, you can see the **Refresh History** in this same tab to see whether the data was successfully refreshed. You can also get email notifications of when refreshing fails.

If your data is already in Azure or OneDrive, then the on-premises gateway is not required. You just need to make sure the firewall will allow you to communicate with the Power BI service.

Summary

The Power BI service allows your users to see the same reports on a web or mobile platform with the same type of interactivity as they experience in Power BI Desktop. It also allows users to build reports quickly, straight from a web platform. Once your reports are deployed to the service, you can use row-level security to see data at a granular level, allowing a sales manager to only see their own territory, for example. The data can also be refreshed as often as every 30 minutes. If you're using on-premises data sources, then you can use the on-premises gateway to bring data from on-premises to the cloud.

In the next chapter, we will learn about Power BI dataflows, one of the newest and most powerful self-service options for Power BI users.

8
Data Cleansing in the Cloud with Dataflows

Power BI dataflows are a new self-service **extract, transform, load** (**ETL**) option in the Power BI service that allows you to use Power Query Editor online and leverage your transformational work in a reusable format, both individually and with other people. Dataflows help organizations unify data from disparate sources and prepare it for modeling. They provide the familiarity of the Power Query Editor experience using a GUI with M code in the background so that you can create reusable, scalable, and extensible data source solutions for your organization. Analysts can easily create dataflows using familiar self-service tools. Dataflows are used to ingest, transform, integrate, and enrich big data by defining data source connections, ETL logic, refresh schedules, and more. Power BI dataflows operate with a new model-driven calculation engine based on Microsoft's Common Data Model in the backend. Power BI dataflows make the process of data preparation more manageable, more deterministic, and less cumbersome for data analysts and report creators alike. In simplistic terms, Power BI dataflows allow analysts and report creators to create a self-service data mart solution with a few clicks.

In this chapter, we will get you started on your Power BI dataflow journey, covering the following topics on the way:

- Getting started with dataflows
- Creating a dataflow
- Using dataflows as a data source in the desktop

Let's start by covering the basics to build a strong foundation of knowledge that you can build on in your projects!

Getting started with dataflows

Power BI dataflows can be simple or complex depending on your needs—and licensing. Licensing and workspace capacity are key factors in how you can leverage Power BI dataflows. The following table displays a comparison of some of the core features of Power BI Pro and Power BI Premium.

Dataflow capability	**Power BI Pro**	**Power BI Premium**
Scheduled refresh	8 per day	48
Total storage	10 GB/user	100 TB/node
Dataflow authoring with Power Query Online	+Yes	Yes
Dataflow management within Power BI	Yes	Yes
Dataflows data connector in Power BI Desktop	Yes	Yes
Integration with Azure	Yes	Yes
Computed entities (in-storage transformations via M)	No	Yes
New connectors	Yes	Yes
Dataflow incremental refresh	No	Yes
Running on Power BI Premium capacity / Parallel execution of transforms	No	Yes
Dataflow linked entities	No	Yes
Standardized schema / Built-in support for the Common Data Model	Yes	Yes

For the sake of simplicity, we are giving the basic features with the Power BI Pro license; however, it may be worth a deeper dive into Microsoft's documentation to truly uncover all the dataflow features and administrative requirements needed to use all the Power BI Premium features (find out more at `https://docs.microsoft.com/en-us/power-bi/transform-model/dataflows/dataflows-introduction-self-service`).

Now, let's get started with creating a practical, reusable dataflow.

Creating a dataflow

A very common reason to use dataflows is the reusability of the data among team members. Consistency and having a single source of truth is the main goal for many analysts, and a great application of this is a **Date** table. For this exercise, a Pro license with no additional premium capacity is necessary. In this section, we will explore the Power BI service to see where dataflows are created and then use simple code to produce a dataflow that will work in many different data models.

Dataflows are created and managed in-app workspaces in Power BI, but the data you bring into a Power BI dataflow is stored as entities—basically flat tables—in the Common Data Model folders in Azure Data Lake Storage Gen2. These files are stored as CSVs with JSON files containing all the metadata and rules, which unify and standardize your self-service data warehouse. Once created, these dataflows then serve as a data source for Power BI reports, and can also be used with other Azure data services if you bring your own data lake.

In order to create a Power BI dataflow, you need a new workspace experience. This has been the default for some time now—you cannot use Power BI dataflows in much older workspaces. When creating the workspace, there are advanced options to set up dedicated dataflow storage capacity—in other words, to connect your own data lake for additional storage capacity and options within the Azure ecosystem. Be sure to read the extensive admin documentation if your goal is to use your own data lake as the backend storage, rather than leveraging the default experience. One key point is that you will want to ensure your capacity is set to the same region as your other Azure resources. Using `My Workspace` will never work, regardless of the region and capacity, because `My Workspace` is a personal folder that's not designed for sharing data organizationally.

First, create a new workspace in your version of Power BI. A key detail is that the creator of the dataflow is automatically the owner. Previously, ownership could not be transferred, but now there is an option to pass dataflow ownership to another Power BI user. However, please note that creating a dataflow makes you the owner of the dataflow by default. The dataflow owner is the primary admin for dataflow functionality and permissions.

Once the workspace is created (we've created one here called **Dataflow Test**), there is an option to **Get data** in the bottom-left corner of the pane that can be selected, as shown in *Figure 8.1*:

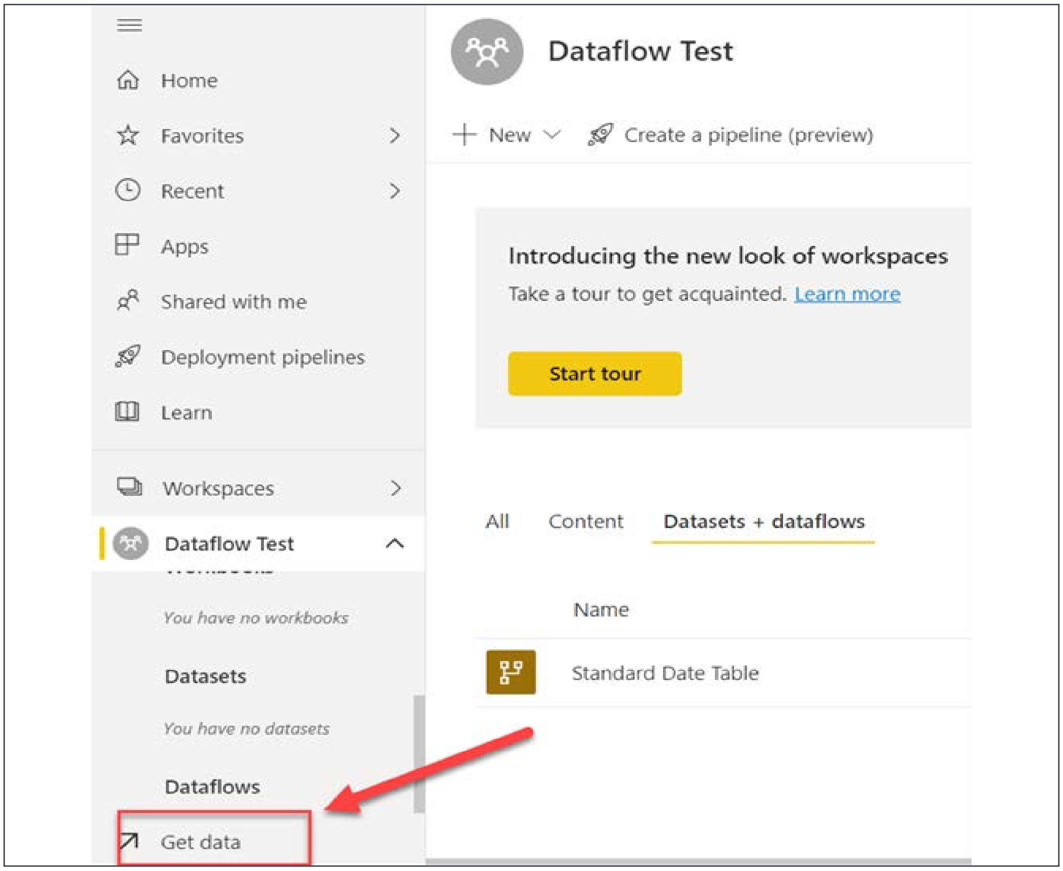
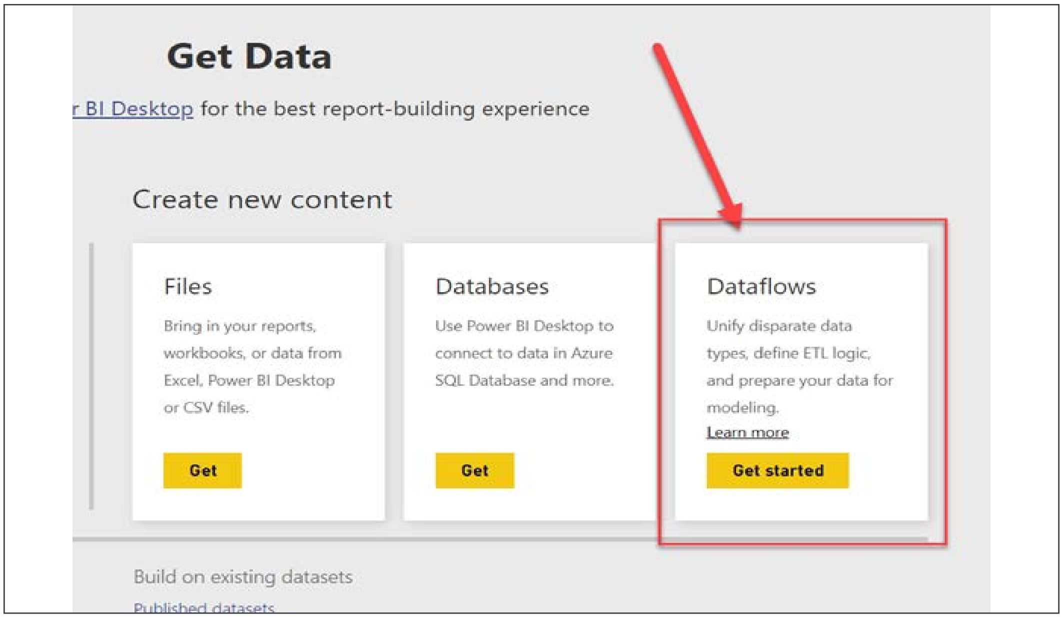


Figure 8.1: Use Get data in the Power BI service to locate the dataflow options

When this button is selected, various options appear. Choose **Dataflows**, as shown in *Figure 8.2*, to get started:



Get Data

r BI Desktop for the best report-building experience

Create new content

Files

Bring in your reports, workbooks, or data from Excel, Power BI Desktop or CSV files.

Databases

Use Power BI Desktop to connect to data in Azure SQL Database and more.

Dataflows

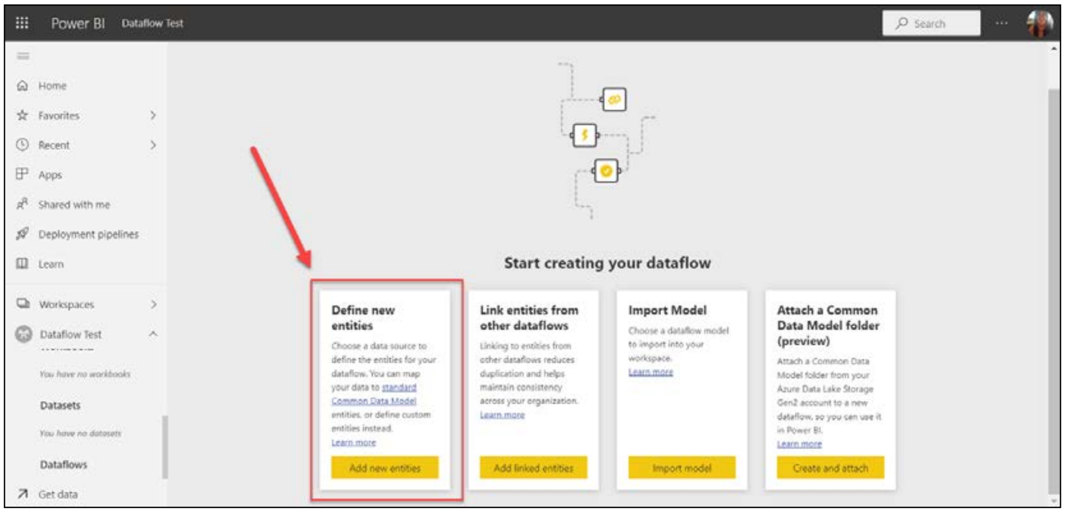
Unify disparate data types, define ETL logic, and prepare your data for modeling.
Learn more

Build on existing datasets

Published datasets

Figure 8.2: Get started creating your dataflow

After selecting **Get started**, more options appear:



You have no workbooks

You have no datasets

Start creating your dataflow

Define new entities

Choose a data source to define the entities for your dataflow. You can map your data to standard Common Data Model entities, or define custom entities instead.
Learn more

Link entities from other dataflows

Linking to entities from other dataflows reduces duplication and helps maintain consistency across your organization.
Learn more

Import Model

Choose a dataflow model to import into your workspace.
Learn more

Attach a Common Data Model folder (preview)

Attach a Common Data Model folder from your Azure Data Lake Storage Gen2 account to a new dataflow, so you can use it in Power BI.
Learn more

Figure 8.3: Dataflow options

It's worth describing the various options:

- **Define new entities**: Entities may be thought of as tables. In cases where entities are made from scratch, they are called **Computed entities**. Computed entities may be custom, or they can map to the **Common Data Model** standards.
- **Link entities from other dataflows**: **Linked entities** are basically tables that have branched off from existing computed entities in the same or different workspaces. They are branches that allow transformation, but one key point is that they do not store data. Linked entities point to other entities. Accordingly, if linked entities exist in the same workspace as the original entities, refreshes may be coordinated between them. However, different workspaces lead to different refresh schedules.
- **Import Model**: Import an existing dataflow from its locally stored JSON file.
- **Attach a Common Data Model folder (preview)**: This is the "bring your own data lake" option.

For the `Date` table dataflow, there is no need for an enterprise Power BI gateway, because it is a **Blank query** option and the M code will create the table in the Power Query Editor's native language. In almost all other cases, an Enterprise data gateway is needed, which means a Pro license is also needed. Power BI dataflows do not work in `My Workspace` or with a free license.

When defining the new entity, choosing the data source is the first step. For the M code scripted date table, selecting **Blank query**, one of the options towards the bottom, is key.

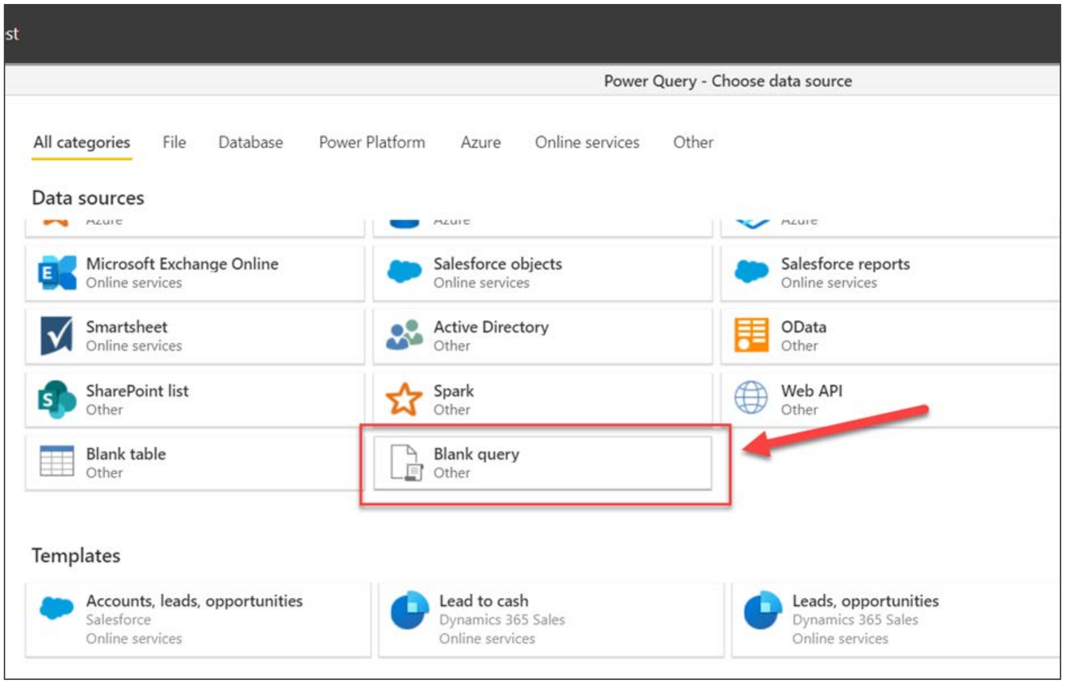


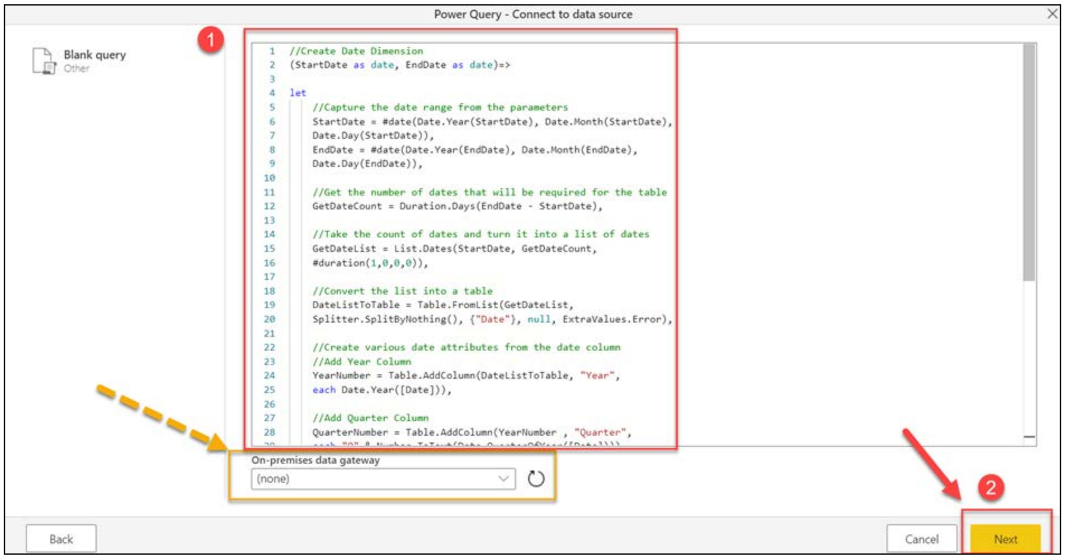
Figure 8.4: Choose the Blank query option to create this dataflow

At that point, copy the following script, which lets you create a date table, into the Power Query Editor:

> You can also go to `https://devinknightsql.com/2015/06/16/creating-a-date-dimension-with-power-query/` to access this code.

```
//Create Date Dimension
(StartDate as date, EndDate as date)=>

let
    //Capture the date range from the parameters
    StartDate = #date(Date.Year(StartDate), Date.Month(StartDate),
    Date.Day(StartDate)),
    EndDate = #date(Date.Year(EndDate), Date.Month(EndDate),
    Date.Day(EndDate)),

    //Get the number of dates that will be required for the table
    GetDateCount = Duration.Days(EndDate - StartDate),

    //Take the count of dates and turn it into a list of dates
    GetDateList = List.Dates(StartDate, GetDateCount,
    #duration(1,0,0,0)),

    //Convert the list into a table
    DateListToTable = Table.FromList(GetDateList,
    Splitter.SplitByNothing(), {"Date"}, null, ExtraValues.Error),

    //Create various date attributes from the date column
    //Add Year Column
    YearNumber = Table.AddColumn(DateListToTable, "Year",
    each Date.Year([Date])),

    //Add Quarter Column
    QuarterNumber = Table.AddColumn(YearNumber , "Quarter",
    each "Q" & Number.ToText(Date.QuarterOfYear([Date]))),

    //Add Week Number Column
    WeekNumber= Table.AddColumn(QuarterNumber , "Week Number",
    each Date.WeekOfYear([Date])),
    //Add Month Number Column
    MonthNumber = Table.AddColumn(WeekNumber, "Month Number",
    each Date.Month([Date])),

    //Add Month Name Column
    MonthName = Table.AddColumn(MonthNumber , "Month",
    each Date.ToText([Date],"MMMM")),

    //Add Day of Week Column
    DayOfWeek = Table.AddColumn(MonthName , "Day of Week",
    each Date.ToText([Date],"dddd"))

in

    DayOfWeek
```

For other data sources, selecting the **On-premises data gateway** is essential. After pasting, click **Next**:



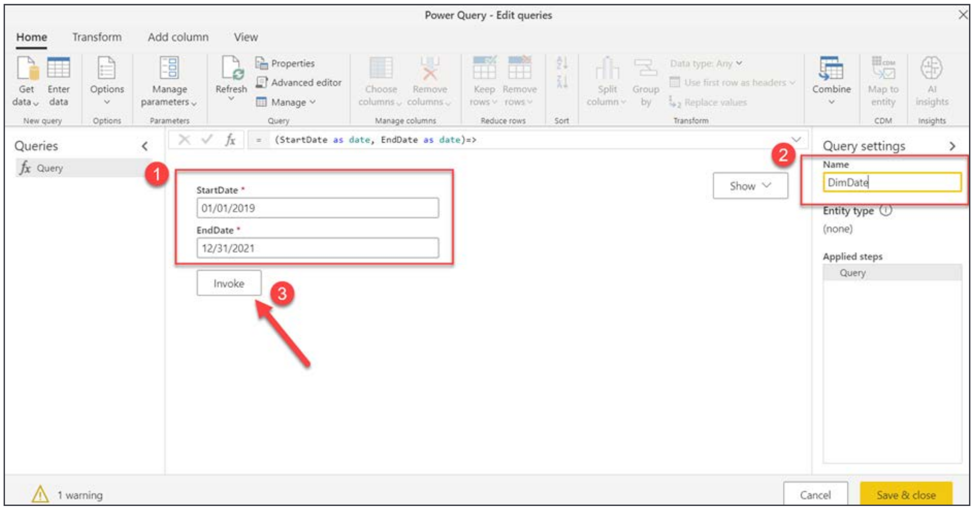
```
//Create Date Dimension
(StartDate as date, EndDate as date)=>

let
    //Capture the date range from the parameters
    StartDate = #date(Date.Year(StartDate), Date.Month(StartDate),
    Date.Day(StartDate)),
    EndDate = #date(Date.Year(EndDate), Date.Month(EndDate),
    Date.Day(EndDate)),

    //Get the number of dates that will be required for the table
    GetDateCount = Duration.Days(EndDate - StartDate),

    //Take the count of dates and turn it into a list of dates
    GetDateList = List.Dates(StartDate, GetDateCount,
    #duration(1,0,0,0)),

    //Convert the list into a table
    DateListToTable = Table.FromList(GetDateList,
    Splitter.SplitByNothing(), {"Date"}, null, ExtraValues.Error),

    //Create various date attributes from the date column
    //Add Year Column
    YearNumber = Table.AddColumn(DateListToTable, "Year",
    each Date.Year([Date])),

    //Add Quarter Column
    QuarterNumber = Table.AddColumn(YearNumber , "Quarter",
```

On-premises data gateway: (none)

Figure 8.5: Paste the M code and select Next

Clicking **Next** will take us to a screen where date parameters may be specified to determine the length of the table. Take the following steps:

1. Input a date range.
2. Name the query.
3. Select **Invoke** to create the date table:



```
= (StartDate as date, EndDate as date)=>
```

StartDate *
01/01/2019

EndDate *
12/31/2021

Name
DimDate

Entity type
(none)

Applied steps
Query

Figure 8.6: Set the data range and name the table

Once the date table is created as an entity, the data type can be set using the little icon in the top-left corner of the columns, as shown in *Figure 8.7*. The layout and options of the online Power Query Editor should generally mirror the Power Query Editor in Power BI Desktop:

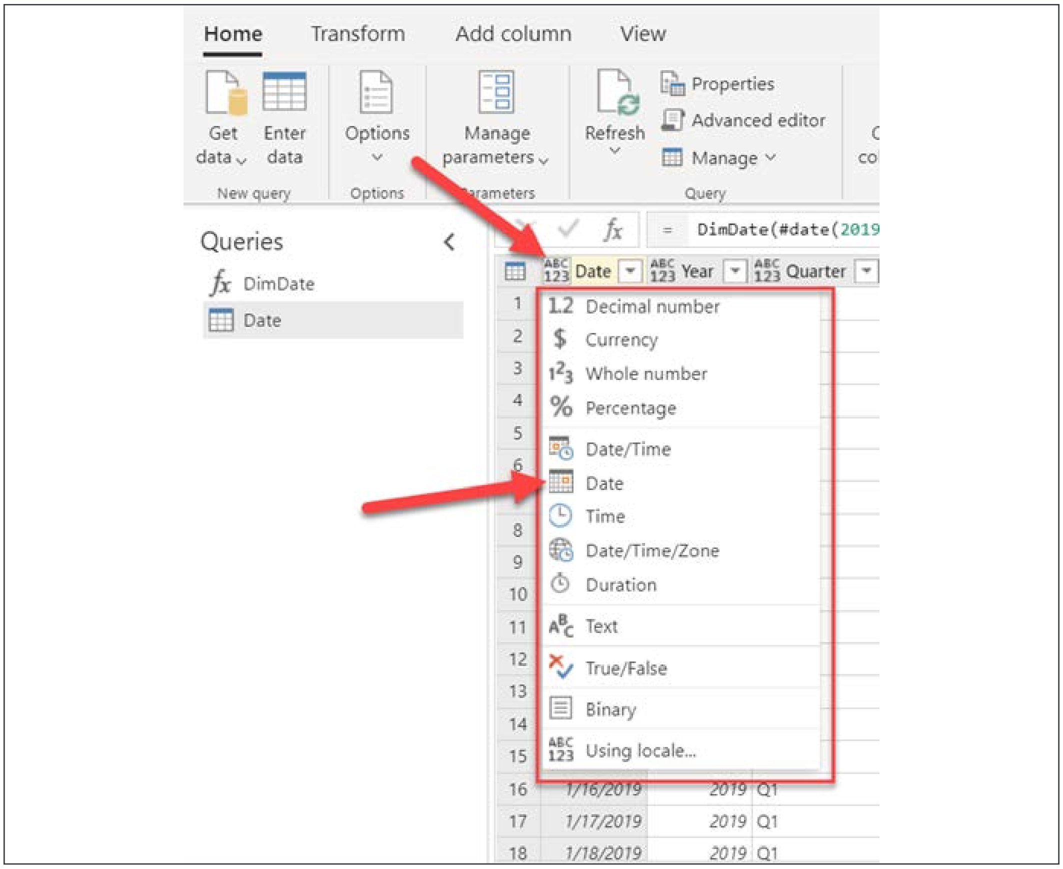
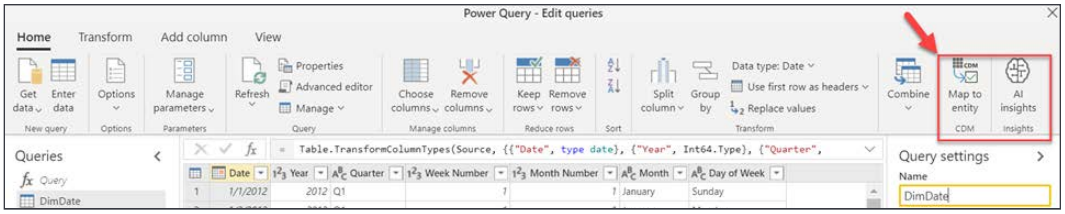


Figure 8.7: Set the data type on the column in the online Power Query Editor

The **graphical user interface** (**GUI**) is being updated regularly to make the dataflow experience more and more like the Power BI Desktop experience. It is worth taking time to look at the top ribbon with its **Home**, **Transform**, **Add column**, and **View** options to explore the GUI because many options are similar, and some are new, such as **Map to entity** and **AI insights**, as shown in *Figure 8.8*.

AI insights is fully leveraged under a Premium license and provides out-of-the-box artificial intelligence options to analyze your data with things such as sentiment analysis, key phrase extraction, language detection, and image tagging:

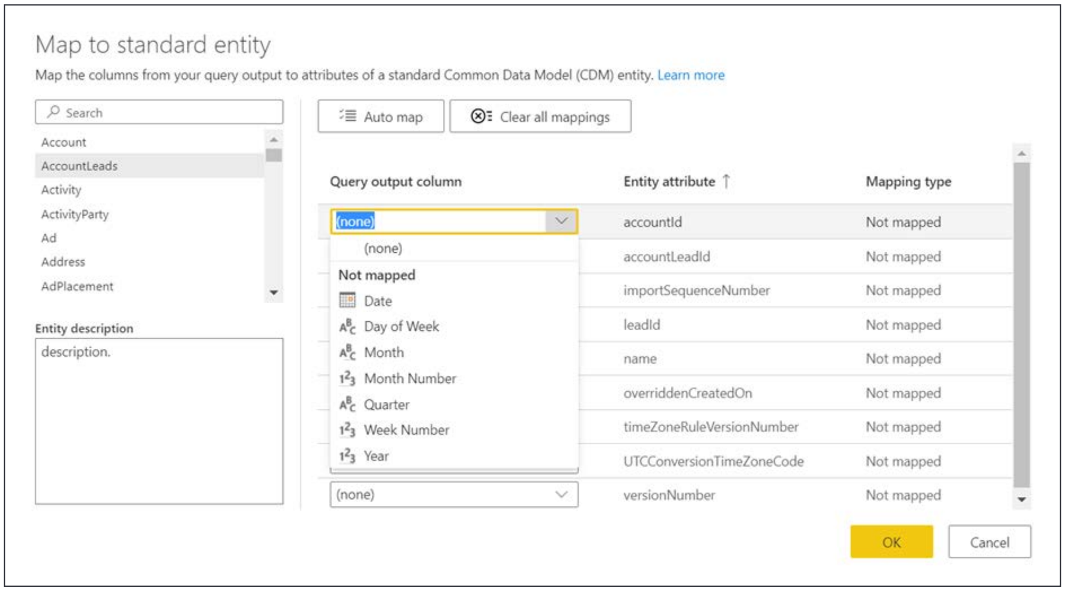


```
= Table.TransformColumnTypes(Source, {{"Date", type date}, {"Year", Int64.Type}, {"Quarter",
```

	Date	Year	Quarter	Week Number	Month Number	Month	Day of Week
1	1/1/2012	2012	Q1	1	1	January	Sunday

Figure 8.8: New options available for dataflows in Power BI Desktop that are not in the Power Query Editor

Here is the dialog box for the **Map to entity** option, which allows users to take the existing fields in the entities and map them to common data model attributes. Users can choose from a list of common tables (entities) and leverage that metadata if they want:



Map to standard entity

Map the columns from your query output to attributes of a standard Common Data Model (CDM) entity. Learn more

Entity description

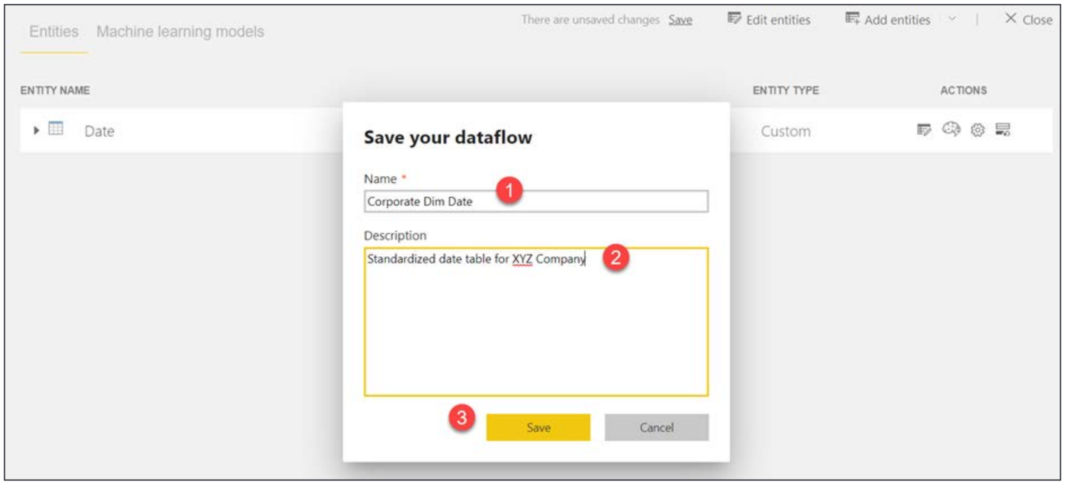
description.

Query output column	Entity attribute	Mapping type
(none)	accountId	Not mapped
	accountLeadId	Not mapped
	importSequenceNumber	Not mapped
	leadId	Not mapped
	name	Not mapped
	overriddenCreatedOn	Not mapped
	timeZoneRuleVersionNumber	Not mapped
	UTCConversionTimeZoneCode	Not mapped
(none)	versionNumber	Not mapped

Figure 8.9: New option to map dataflows to the Common Data Model structure

Map to entity does not apply to this date table, but it can be a useful option for other tables, such as sales or accounting tables, where the data types and tables are often very similar across companies, departments, and so forth.

After exploring the options, it is time to save the dataflow by selecting the **Save** button in the bottom-right corner. Saving will prompt you to enter a name, but does not actually finish the saving process because data is not fully loaded into the dataflow until after it is saved and refreshed:

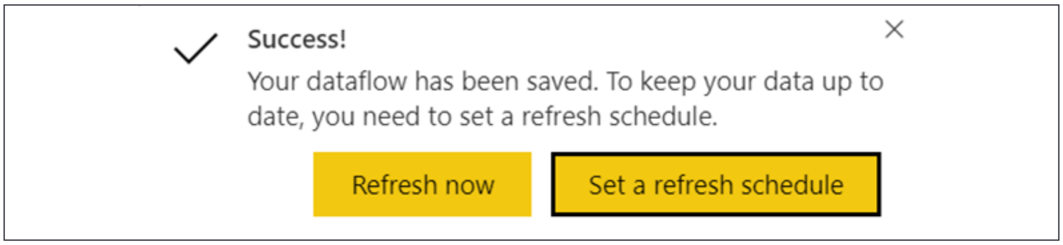


Name *
Corporate Dim Date

Description
Standardized date table for XYZ Company

Figure 8.10: Save the dataflow

A pop-up box like the one shown in *Figure 8.11* will appear to load the data and finalize the dataflow for use. **Refresh now** is a one-time option that manually loads the latest data. Dataflows can leverage multiple data sources and allow the unification of disparate sources. Under a Premium license, incremental data refreshes can be set with **Set a refresh schedule** to manage the performance impact of data sources that update at different times and rates:



Success!

Your dataflow has been saved. To keep your data up to date, you need to set a refresh schedule.

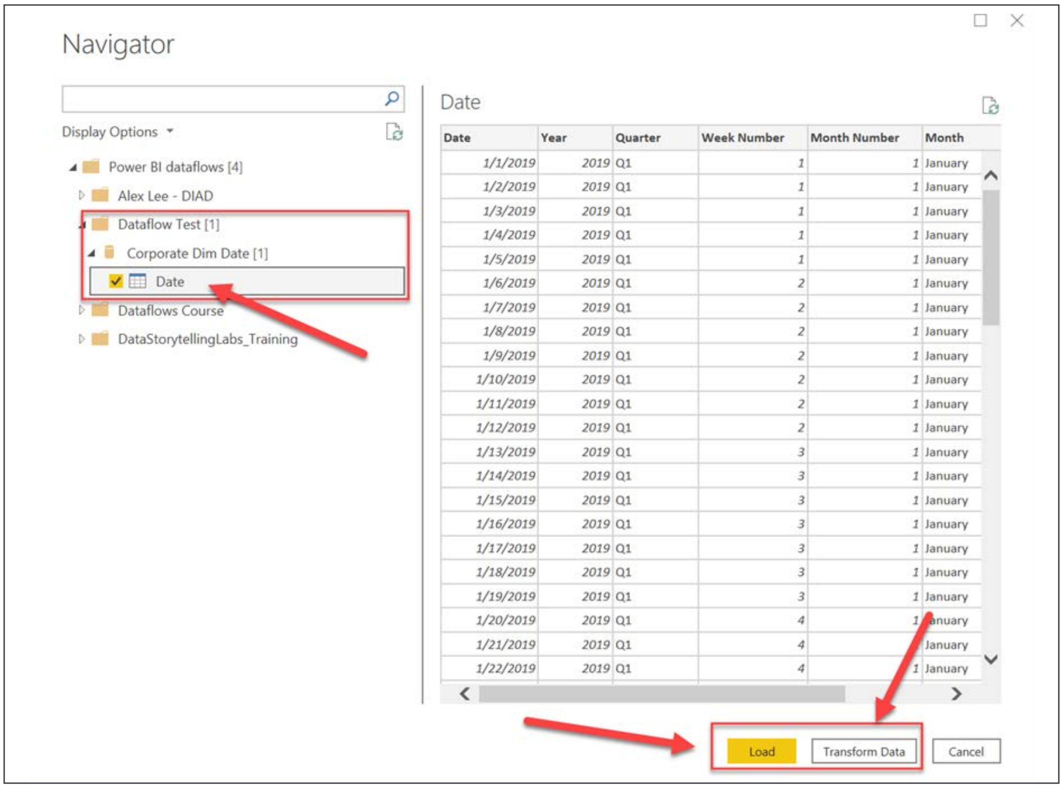
Figure 8.11: Pop-up with refresh options

If you miss the pop-up option, simply find the dataflow in your workspace and click on one of the refresh icons to set up a schedule or perform a single refresh.

Now that we've created a Power BI dataflow that will provide a consistent and standard date table for ourselves and others, we can easily connect to this data source from Power BI Desktop.

Using dataflows as a data source in Power BI Desktop

Power BI dataflows act like any other imported data source. In Power BI Desktop, simply select **Get data** and then connect to the Power BI Dataflows option. From there, all the available dataflows will be available and organized. Once we click **Get data** and select the dataflow option, a familiar dialog box will appear that shows all the available dataflows we can use. As shown in *Figure 8.12*, your table options appear in a list on the left-hand side. Expand the folders and choose the **Date** table, then select **Load** to immediately use the table, or select **Transform Data** if you have more work to do in the Power Query Editor:



Date	Year	Quarter	Week Number	Month Number	Month
1/1/2019	2019	Q1	1	1	January
1/2/2019	2019	Q1	1	1	January
1/3/2019	2019	Q1	1	1	January
1/4/2019	2019	Q1	1	1	January
1/5/2019	2019	Q1	1	1	January
1/6/2019	2019	Q1	2	1	January
1/7/2019	2019	Q1	2	1	January
1/8/2019	2019	Q1	2	1	January
1/9/2019	2019	Q1	2	1	January
1/10/2019	2019	Q1	2	1	January
1/11/2019	2019	Q1	2	1	January
1/12/2019	2019	Q1	2	1	January
1/13/2019	2019	Q1	3	1	January
1/14/2019	2019	Q1	3	1	January
1/15/2019	2019	Q1	3	1	January
1/16/2019	2019	Q1	3	1	January
1/17/2019	2019	Q1	3	1	January
1/18/2019	2019	Q1	3	1	January
1/19/2019	2019	Q1	3	1	January
1/20/2019	2019	Q1	4	1	January
1/21/2019	2019	Q1	4	[illegible]	January
1/22/2019	2019	Q1	4	1	January

Figure 8.12: Expand the folder options and choose the Date dataflow, then Load to use it immediately

It is important to remember that dataflows are not datasets. Datasets are semantic models on the top of data, whereas dataflows are built on top of the dataset in a reusable schema. Additionally, dataflows do not truly replace a data warehouse, but they do allow for lighter self-service "data warehousing" tasks for various integration scenarios.

Summary

Congratulations on exploring an exciting new option for reusable, standardized data that can bring great benefits to teams who need single sources of truth. In this chapter, we created a date table dataflow using M code and learned about the mechanics of using the Power Query Editor online.

9

On-Premises Solutions with Power BI Report Server

Throughout this book, we've focused on building reports that will ultimately be deployed to the web through the Power BI service or shown in the mobile application. In this chapter, we'll show you how to deploy reports to Power BI Report Server, which is likely being hosted on-premises at your company. For many companies, this is a must-have, since cloud deployments are often not allowed with their type of data or industry.

Power BI Report Server is an on-premises version of the Power BI service that gives you a subset of the features of the full service. Unlike the full service, which is sometimes daily updated with new features, the Power BI Service is updated every few months. There is also an additional Power BI desktop specially made for the server.

Make sure you fully explore the features of the server to ensure it has the critical features that you love. For example, you might find that a connector you can use in the Power BI service is not available on the server. The biggest notable missing feature is the lack of dashboards.

In this chapter, we will cover the following topics:

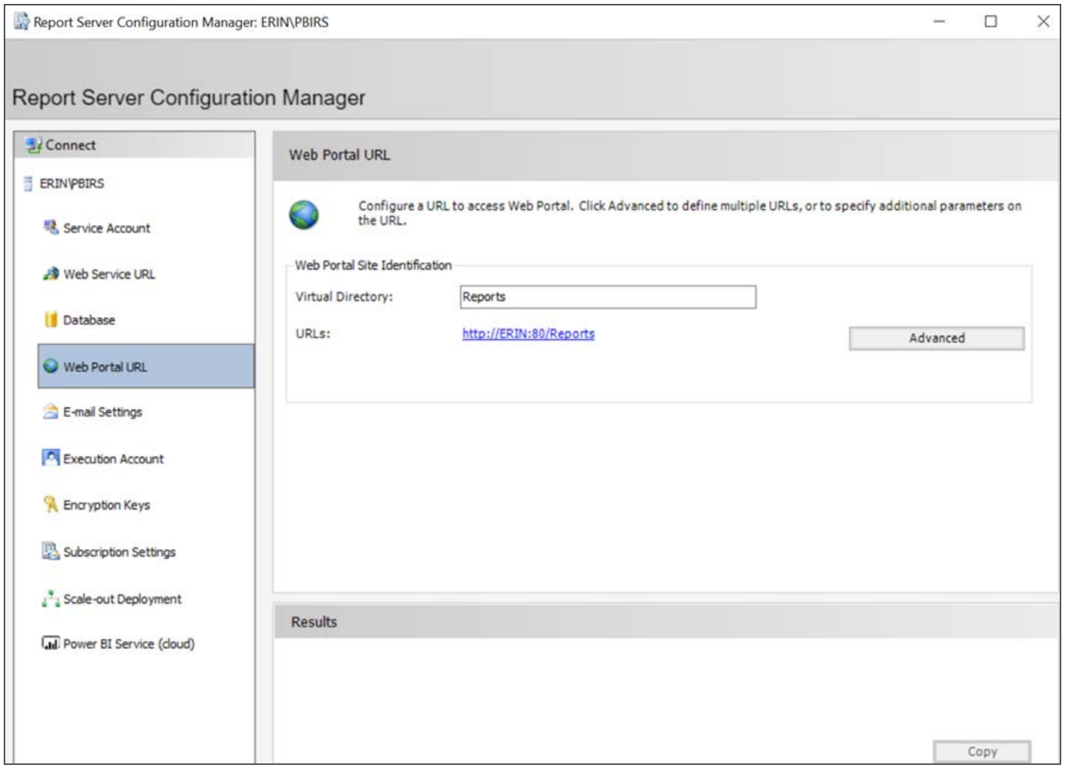
- Deploying to Power BI Report Server
- Securing reports
- Refreshing data

Deploying to Power BI Report Server

If you're a traditional BI developer who has built Reporting Services reports, you might feel right at home with Power BI Report Server, as the configuration and portals were largely borrowed from Reporting Services. The main difference is that you will not use Visual Studio to build reports. You're going to use a special Power BI desktop that is optimized for the server. The main reason for the separate desktop is to ensure that the desktop doesn't promote a feature that the server does not support. One key advantage of using this approach is that Report Server can also host your traditional Reporting Services reports, KPIs, and mobile reports.

Before deploying your report, you may want to create some folders to simplify finding your reports later. For example, creating a folder for finance, HR, inventory, IT, operations, and sales is a common starting point. Don't worry, you can always move the reports later if you've already deployed them. Once you've created a folder, if you feel it's needed, you can deploy your Power BI reports in one of two ways: from the Power BI desktop or by uploading.

Make sure you have a Power BI Desktop instance installed that supports Power BI Report Server and open the report that you wish to deploy. This flavor of Power BI Desktop also supports deploying to the cloud if you need a single experience, but note that you will be at least 3–4 months behind the main Power BI application. Next, click **File | Save As Power BI Server**. If this is your first time deploying your report to the server, everything will be blank. Simply type the Report Server HTTP address in the box to connect to the Power BI Report Server. It should look something like `http://servername/reports`. If you have a port number, you'll need to use something like `http://servername:portnumber/reports`. You can find the exact location to enter by going to your Report Server Configuration Manager tool from the server and copying the URL from the **Web Portal URL** section. The port in this screenshot is port **80**, which you don't have to enter as it is the default port:



Configure a URL to access Web Portal. Click Advanced to define multiple URLs, or to specify additional parameters on the URL.

Web Portal Site Identification

Virtual Directory: Reports

URLs: http://ERIN:80/Reports

Figure 9.1: Find the location using the Report Server Configuration Manager

If the desktop can successfully connect to the server, you will be prompted for the folder name that you want to deploy to and the name of the report you want to use. Typically, you don't want to use this opportunity to change the name of the report since it will become difficult to find your source report later. After clicking **OK**, the report will deploy and provide you with a link that will take you directly to the report that now resides on your server. From this point forward, you can click **Save** without going through this process and it will save directly to the server.

You can also upload the report directly in the browser. To do this, simply go to the folder you wish to upload the report to and click **Upload** in the top-right corner. You will then be prompted for the location of the folder, and then you're done. Power BI Report Server will scan to make sure that the report is compatible. For example, if you built the report on a very new version of Power BI Desktop that is using features that aren't supported in Power BI Report Server yet, then you will receive an error before the upload occurs. Once the report is deployed, any user with the appropriate access can also click the **Edit** button in Power BI Desktop to open the report up in the desktop so that they can make changes.

If you wish to move the report to a new folder, you can go to the report listing and click **Move** under the ellipsis button. You will be prompted for the folder you wish to move the report to, and then you're done. You can also do this under **Manage** under the same ellipsis.

In the **Manage** area of a report, you can also hide the report by clicking **Hide this Object**. This can be used to hide reports that are built on other reports, for example. It's important to note, though, that this is not a security mechanism. There's nothing to stop a user from seeing the report if they unhide the object.

The next step we will cover is securing the report.

Securing reports

You can secure a report in the **Manage** screen of a report or folder. To access this area, select a report folder or report, select the ellipsis button, and click **Manage**. Then, go to the **Security** tab. By default, reports and folders inherit security from their parent folder, but this can be undone quickly by clicking **Customize Security**.

Keep in mind that there's quite a bit of overlap in the roles that can be assigned, mainly due to the context of what you're securing (`My Reports` or the public folder of reports). The security roles that you can select are listed as follows:

- **Browser**: Can view the reports and folders, and subscribe to the reports.
- **Content Manager**: Can manage folders, reports, and resources.
- **My Reports**: Can publish reports and manage folders, reports, and resources in a user's `My Reports` folder.
- **Publisher**: Can publish reports on your Power BI Report Server.
- **Report Builder**: Can review any definitions or metadata about the report, as well as permissions.

You can also select the gear in the top-right corner of the screen and select **Site Settings** to secure the entire server. Even if you have rights to the folder or report, you may not have rights to the server, which creates a lot of confusion with system administrators and users trying to view their data. When you go to **Site Settings**, you can add a user to one of two roles: **System Administrator** or **System User**. The system administrator can manage the security on the server and the schedules, to name just a couple of options. The system user grants the user rights to log in to the server, and then requires security to view the folders and reports, as shown earlier in this section.

Scheduling data refreshes

Refreshing data in Power BI Report Server comes with a lot more caveats than using the Power BI cloud service. For example, refreshing is contingent on the data source that the report is using. Since you've installed this server inside your firewall, there's no need for a data management gateway to refresh the data either. As you create refreshing schedules, the server will simply create SQL Server Agent jobs to control the refreshes, such as Reporting Services. Because of this, SQL Server Agent must be started in order to create scheduled refreshes.

If you plan on refreshing data sources that are derived from files, make sure you use a network path for that file (`\\computername\sharename\file.csv`), not a local path (such as `C:\Downloads\File.csv`). You can do this in Power BI Desktop by going to the **Home** ribbon and selecting **Edit Queries | Data Source Settings**. Click **Change Source** and change any file references to a network path, such as `\\MyComputer\c$\Downloads\File.csv`.

Once you do that, publish the report to the server again. Then, select the report and select **Manage**. For most data sources, you will need to confirm the source of the data in the **Data Sources** tab. For flat files, confirm that you see the network path and type in the credentials for the machine that's holding those files. This will need to be a Windows Authentication username and password. Click **Test Connection** to confirm that a connection can be successfully achieved. If it tests successfully, click **Save**.

> If you find that there are popular times at which people want to refresh data, you can create shared schedules. Shared schedules can be found in the **Site Settings** administration panel (under the gear in the top-right corner) of the portal. By creating these, you will simplify the scheduling of future jobs for popular schedule times.

To schedule the refresh, click **Scheduled Refresh** in the report management area. Then, click **New Scheduled Refresh Plan** to create a new schedule. You can also use a shared schedule resource or a one-off schedule. Simply type the time you wish the refresh to occur and the refresh interval. While there are workarounds, the lowest grain of a scheduled refresh is typically hourly.

Test the job by selecting the job and clicking **Refresh Now**. If any errors occur, you will see the error inline in the **Status** column. For example, the following error would show as a **Data source error: Login failed for data source 'Unknown'**. This is not nearly enough information to debug with, so click the information icon next to the error to see a more actionable error, such as the following:

```
[0] -1055784932: Could not find file '\\desktop-l2qu18g\c$\OneDrive\
Documents\CountyClerksFL.csv'. The exception was raised by the
IDbCommand interface.
```

In many cases, doing a simple search online with the error message will lead you to documentation, blogs, and community forums with solutions that others have found already. In this instance, dozens of articles appear to help the user resolve the connection issue quickly.

Summary

In this short chapter, you learned how to take Power BI service practices on-site with Power BI Report Server. This server has many restrictions on what's available, so be careful that you have the right version of Power BI Desktop so that it matches your version of the server. As you've learned, the server resembles the Reporting Services server and uses SQL Server Agent to handle data refreshes.

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