

## Data Analysis and Visualization Using Power BI

**Power BI** is a business analytics service provided by Microsoft. It offers interactive visualizations with self-service business intelligence capabilities, which end users can use to create reports and dashboards on their own without having to depend on any information technology staff or database administrator.

It is a service offered by Microsoft and had an initial release in 2011. It helps in building interactive visualizations by connecting to various data sources to help business users understand how their business is doing. It provides a suite of tools and services that allows users to connect to multiple data sources and explore data to generate meaningful insights.

Gartner recognised Microsoft as the leader in the '2019 Gartner Magic Quadrant for Analytics and Business Intelligence Platforms' due to the platform capabilities of Power BI. It has gained market share quickly over the last few years, backed by Microsoft's scale and market power.

Microsoft's Power BI transforms big data into insightful visualizations that can be absorbed at a glance. This improves your business decision-making at all levels.

### Power BI vs Tableau vs Excel

Let's take a look at the advantages and disadvantages of Power BI as compared with the two analytics tools: Tableau and Excel.

#### POWER BI VS TABLEAU VS EXCEL

	Power BI	Tableau	Excel
Performance	Can handle relatively smaller amount of data than tableau	Can handle vast quantities of data	Can handle very smaller datasets
Data Sources	Access to various servers and database sources	Access to various servers and database sources	Can connect to limited data sources
Data Shaping	Has a versatile query editor to perform a lot of tasks easily	Has limited data manipulation features	Data manipulation can be done on limited records
Application	Used by all types of users because of lower learning curve	Typically used by experienced data analysts	Used by all types of users
Pricing & Licensing	Power BI is priced lower, power BI has stringent licensing	Tableau has flexible licensing	Must be bought as part of office 365 or as standalone app

### Performance: Tableau > Power BI > Excel

Power BI can handle a relatively smaller amount of data as compared with Tableau, whereas Excel can handle only a maximum of million records without compromising on the performance quality.

### Data Sources: Power BI and Tableau > Excel

Power BI and Tableau can connect to a wide range of servers and data servers both on-premise and online, whereas Excel can connect to a limited number of data sources only.

### Data Shaping: Power BI > Tableau > Excel

As compared with Tableau, Power BI has a versatile query editor to perform a wide range of data manipulation tasks more efficiently. Excel also has excellent data shaping and manipulation features similar to Power BI, but they can be performed on limited data records only.

### Application: Power BI and Excel > Tableau

Power BI is used by all types of users because of its lower learning curve and easy-to-use interface, whereas Tableau has a higher learning curve and is generally preferred by experienced data analysts. Excel is also used by a wide range of users because of its user-friendly interface.

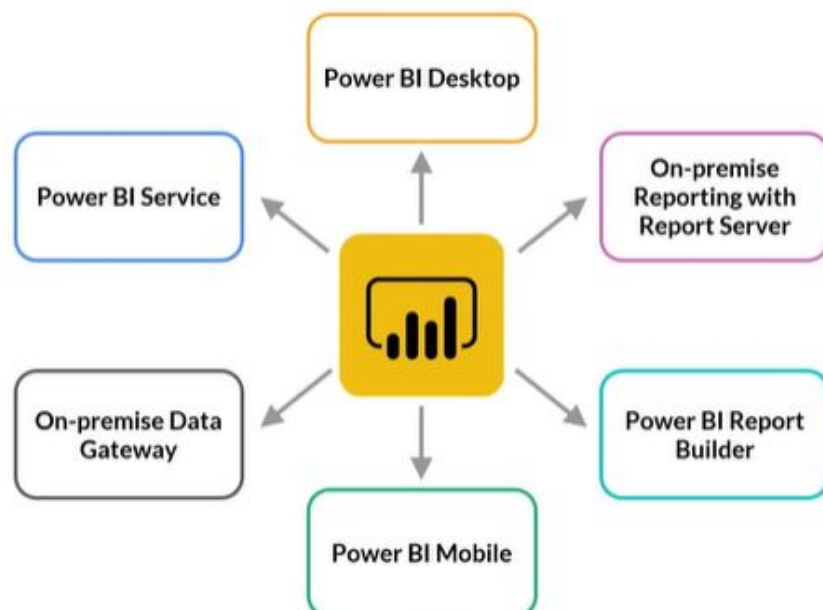
### Pricing and Licensing:

Power BI is priced lower than Tableau, but it has stringent licensing requirements, as it requires a work or school account to access its services. On the other hand, Tableau allows you to log in using any personal domains such as Gmail or Yahoo. Excel is part of the Office 365 apps, but it can be bought as a standalone app as well.

## Power BI Platform Services

Power BI offers different tools and services that can be used based on your needs.

### POWER BI TOOLS & SERVICES



**Power BI Desktop:** This is a Windows desktop application that helps in exploring data and building beautiful visualizations using its simple drag-and-drop functionality.

**Power BI Service:** This is an online service where users can publish and share reports built in Power BI Desktop. You need a work or school account to be able to use this service.

**On-Premise Data Gateway:** This allows users to connect to on-premise data sources and schedule regular refreshes of data once published to Power BI Service so that reports are up-to-date.

**Power BI Mobile:** This is an app that is available on Windows, iOS and Android devices. It allows users to view the reports shared using Power BI Service. Users can also view reports on their desktop browsers using the Power BI app available under Office 365 apps.

**Power BI Report Builder:** This is a Windows application similar to Power BI Desktop, which allows users to build beautiful visualizations. The main difference between both the applications is that this tool is optimised for paginated reports, i.e., reports that are formatted to fit well on a page.

**On-Premise Reporting With Report Server:** This allows users to publish and share reports or paginated reports built in Power BI Desktop or Report Builder within the organisation's firewall without having the need to publish them online like Power BI Service.

## Power BI Desktop Workflow and Interface

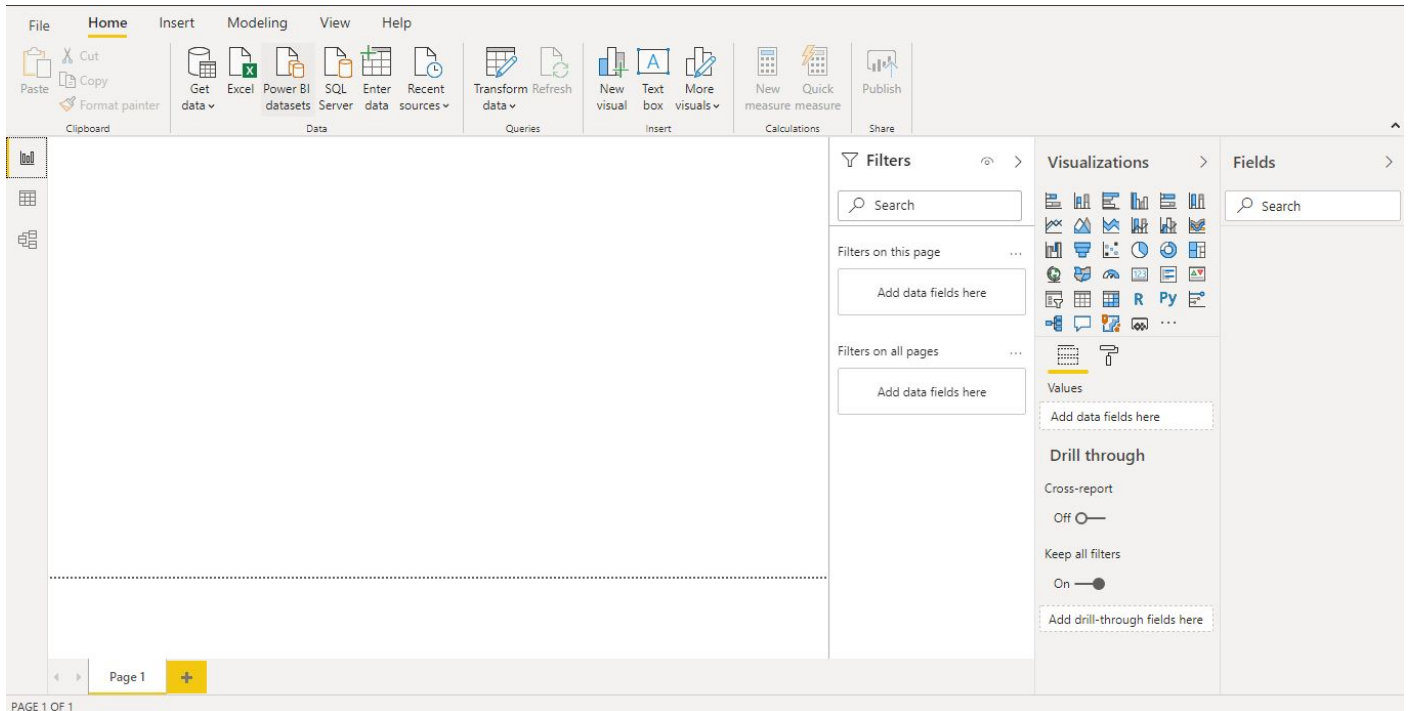
The top ribbon and different tabs in the Power BI interface look quite similar to those in Excel. Power BI Desktop has three views that can be accessed by selecting icons along the left side of the interface.

**Report view** allows you to create the visualizations needed for the report. Fields pane allows you to see different tables and columns in the dataset. **Visualizations pane** offers different types of charts to choose from. You can simply drag and drop the elements from the **Fields pane** on to the canvas to create visuals.

Filters Pane in the Report view offers three levels of filters for a report as mentioned below.

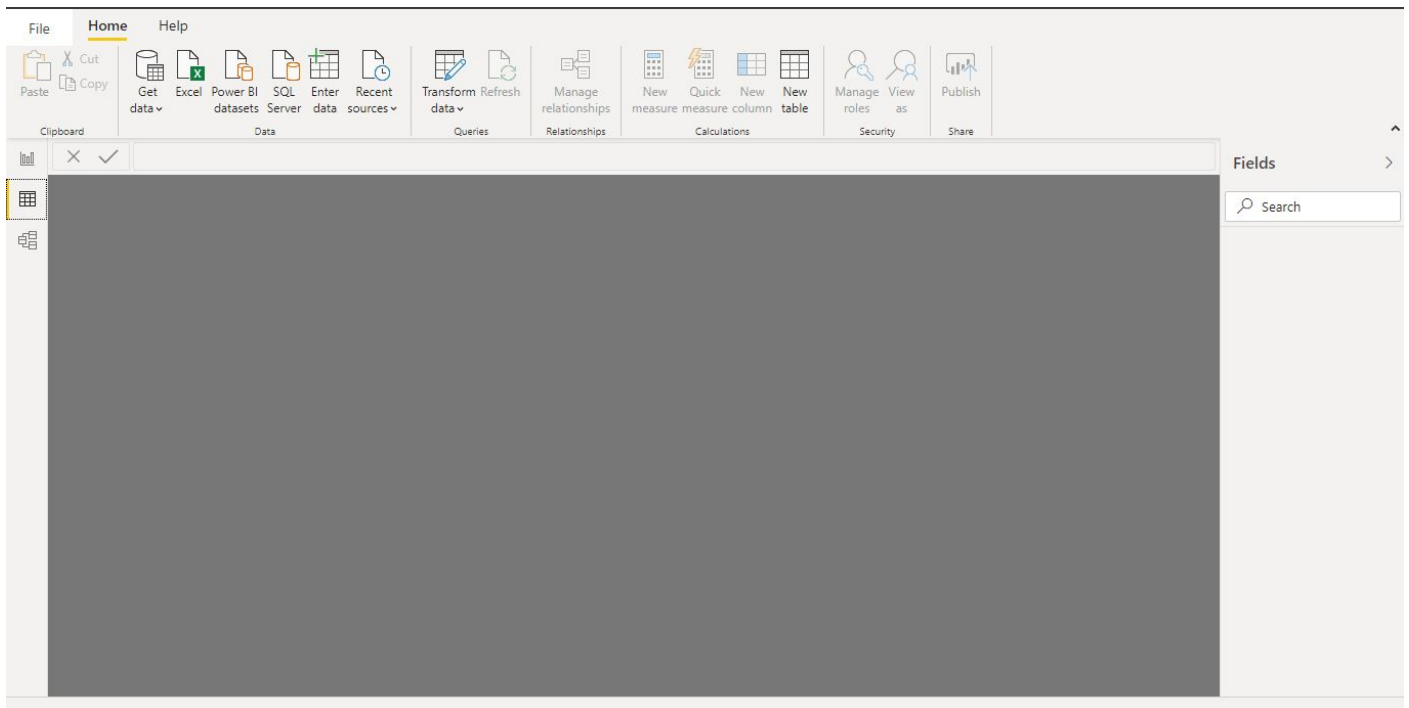
- **Visual-level:** It will filter data on an individual visualization only.
- **Page-level:** It will filter data on all the visualizations on the page.
- **Report-level:** It will filter the entire report involving all the pages and visualizations.

You can refer to the following image to understand the Report view in Power BI Desktop better.



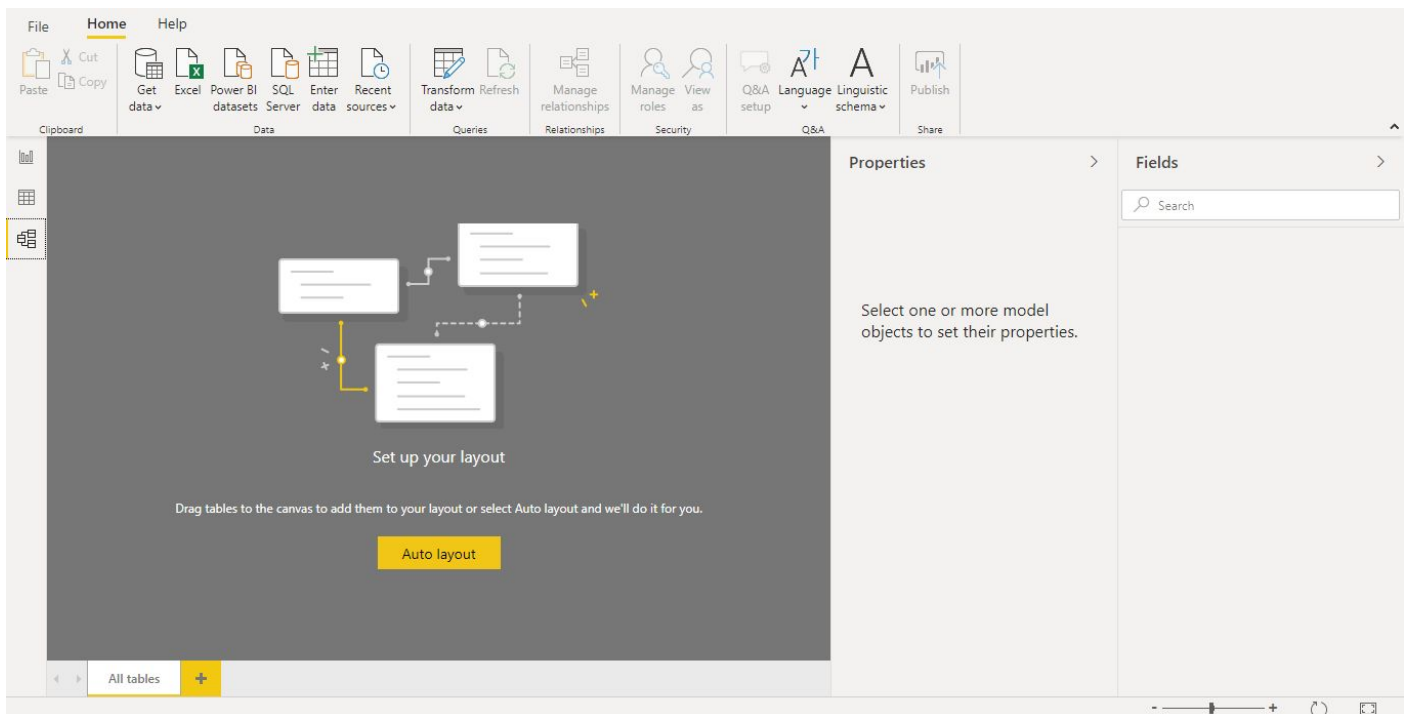
## Report View

**Data view** allows you to not only preview the data in the tables but also perform transformations on the existing data, such as changing the data type, renaming columns, hiding columns from appearing in the Report view, creating a new calculated column, etc. You can refer to the following image to understand the Data view in Power BI Desktop better.



## Data View

**Model view** contains the data schema and allows you to manage the relationships between the data tables. You can refer to the following image to understand the Model view in Power BI Desktop better.



**Model View**

It is always advisable to start with Data view, perform necessary transformations, then move to Model view to build relationships between tables and finally, to Report view.

The Power BI interface has a **Home tab** on the top, which contains some important and useful features. The first set of icons in the Home tab is related to data and helps in getting data from different sources. The **Queries section** contains a **Transform data** icon that opens the Power Query Editor. The **Insert section** contains a subset of icons from the Insert tab, which allows you to add new elements to the report. The **Calculations section** contains a subset of icons from the Modelling tab. The **Publish icon** gives you the option to share reports with others.

The **Insert tab** allows users to add new elements to the report, such as new pages, new visuals, AI visuals, Power Apps, etc.

The **Pages pane** at the bottom can be used to create new pages and navigate across different pages in the report.

The **Modeling tab** can be used to edit relationships between tables, create new measures using data analysis expressions (DAX), create new tables and columns and define the security roles and permissions for the report.

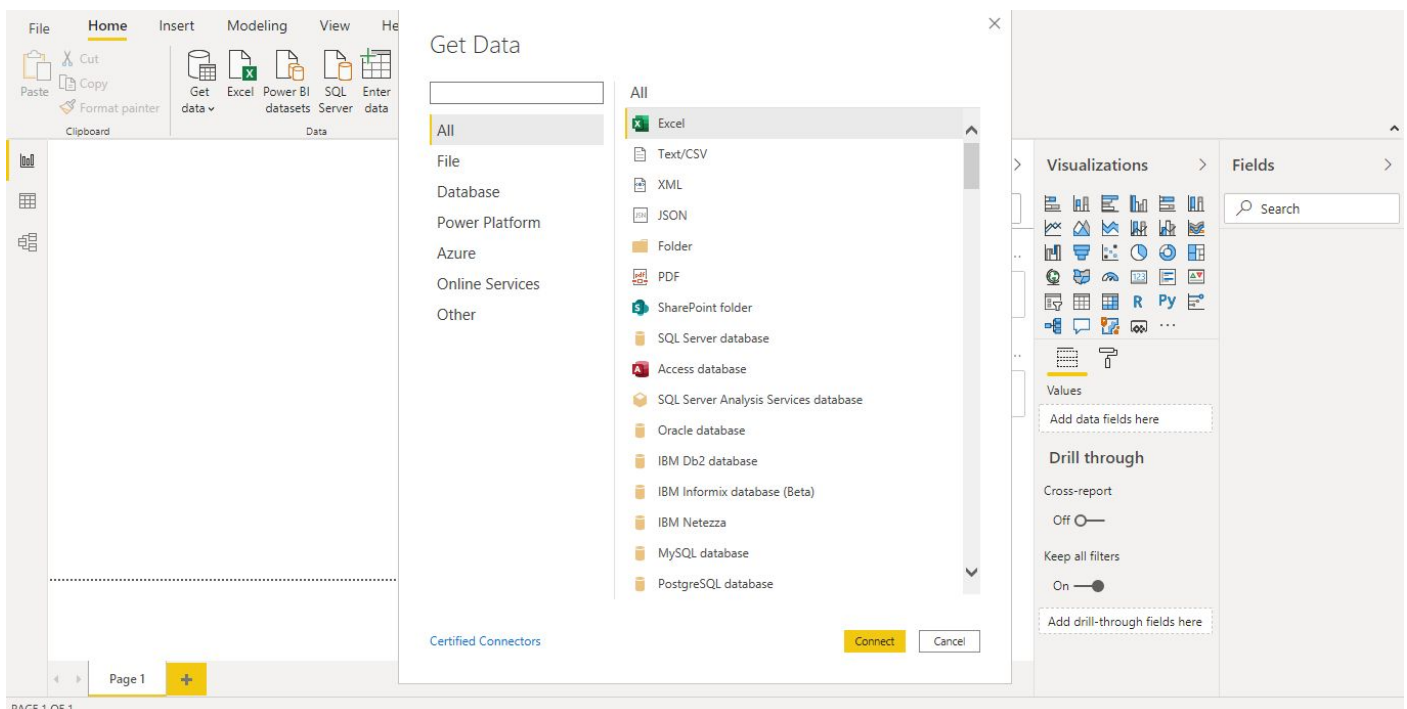
The **View tab** can be used to fix a theme for the report, define the layout of the report and set up page options. With the help of a performance analyzer, you can monitor the time taken by each visual to query the data and display the result.

The **Help** tab gives access to the documentation to explore and learn features in Power BI Desktop, connect with the Power BI community, etc.

## Connecting and Importing Data

Power BI divides the different data sources that you can connect to into six different categories, which are as follows:

- **File:** These are data sources that are available on your local system, and they host a few hundreds or thousands of records. Some common 'File' data sources are Excel, Text/CSV, JSON, PDF, etc.
- **Database:** Data sets with a large number of records are stored in databases. Power BI allows you to connect to various databases such as SQL Server database, Access Database, Oracle Database and so on.
- **Power Platform:** These are data sources that are hosted within the Power BI environment. They allow you to create multiple reports from the same dataset. Some of these power platforms are Power BI datasets, Power BI dataflows, and so on.
- **Azure:** It is a Microsoft web services platform. You can connect to various Azure-based data sources such as Azure SQL Database, Azure Table Storage and so on.
- **Online Services:** These include online data sources such as SharePoint Online List, Google Analytics, LinkedIn Sales Navigator (Beta) etc.
- **Other:** All other data sources excluding those discussed above fall into the 'Other' category. Some of them are Web, R script, Python script, Spark, etc.



### Data Import in Power BI Desktop

Power BI offers the following two options to import the dataset.

- **Import:** It will get all the required tables and columns by importing them into Power BI Desktop.
- **DirectQuery:** It will establish a live connection with a data source without importing or copying it to Power BI Desktop. It has limited functionality in terms of formatting data and is preferred to build real-time BI solutions for frequently changing data.

It is not possible to change the data connectivity mode from Import to DirectQuery. Unless required, it is recommended that you use Import and then schedule regular refresh using Power BI Gateway. The imported data appears on the right side under the Fields pane.

## Data Preparation in Power BI

You can perform data manipulation using the Power Query Editor in Power BI. You can also make all these changes programmatically using the Advanced Editor, and the steps to make these changes are coded in M query language or Power Query in the Advanced Editor.

Data view also enables you to make some of the basic changes such as performing data type transformations, renaming existing columns, creating new columns and so on. However, you should note that any changes that you make in Data view are not recorded in the Steps pane of the Power Query Editor.

It is a good practice to first check the data types and then proceed with other transformation steps for data analysis and visualization in Power BI.

The two primary ways of combining queries in Power BI are as follows:

**Merge Queries:** These are used to add additional columns from one table to another.

**Append Queries:** These are used to add additional rows of data from one table to another.

You can create measures in two ways: by manually writing DAX queries or using the Quick measure feature, which has pre-built DAX queries that can be further edited.

A DAX is a combination of functions, operators and constants, all of which can be used as formulas to generate desired values.

It is a formula language that works with relational data in Power BI Desktop. DAX has a library of over 200 functions, operators and constructs, providing immense flexibility in creating formulas to get the desired result for an analysis.

A few commonly used DAX functions are as follows:

- **CALCULATE:** This function is used to evaluate an expression in a context modified by the optional filters.



CALCULATE(<expression>,<filter1>,<filter2>,...)

- **FILTER:** This function is used to get the subset of an expression or a table.

FILTER(<table>,<filter>)

- **CALENDAR:** This function is used to get all the dates in a specified date interval.

CALENDAR(<start\_date>,<end\_date>)

DAX can be used for creating the following extensions in Power BI.

### 1. Calculated columns

A calculated column is an extension of an existing table and is computed using the DAX formula based on the data that has already been loaded to your data model.

### 2. Calculated tables

A calculated table allows you to create new tables from the already existing data imported into the Power BI model. The newly created table appears in the Fields pane, and it can be linked to other tables and used in reports/visualizations like any other table.

### 3. Calculated measures

A calculated measure is a formula that is applied in a specific context to derive a result from the data. It is used in cases where you want to calculate ratios, sums, weighted averages, etc.

All of these can be created in either Report view or Data view.

## Data Modelling

Data modelling in the Model view helps in building meaningful relationships between tables.

You can group your tables into either a fact table or a dimension table.

- **Fact tables** store data on measures or metrics.
- **Dimension tables** store data on different dimensions of the business.

It is a good practice to arrange the dimension tables at the top and the fact tables below them in the Model view while building relationships.

Power BI automatically detects relationships between data tables, which may not always be correct. In such cases, you can manage relationships from the Model view and establish new relationships based on your requirements.

The four relationship cardinalities available in Power BI are as follows:



1. **Many-to-one:** This is the most common type of relationship that exists when the column in a fact table consists of more than one instance of a value as compared with a dimension table, which consists of only a single instance of the value in a column.
2. **One-to-one:** This type of relationship exists when the columns in both the fact and dimension tables consist of only a single instance of a value.
3. **One-to-many:** This type of relationship exists when the column in a fact table consists of only a single instance of a value as compared with a dimension table, which consists of more than one instance of the value in a column.
4. **Many-to-many:** This type of relationship exists when the columns in both the fact and dimension tables consist of more than one instance of a value.

A **'Single'** cross filter direction creates a many-to-one relationship between the tables in a single direction. It is advisable to use this type of cross-filtering technique whenever you have a one-to-many or many-to-one relationship. The **'Both'** cross filter direction can be used when you have a one-to-one relationship between the tables.

Note that if the data types of the fields used on both sides of the relationship are different, then the relationship would not work.

You can also create multiple relationships between two tables with the help of a built-in function. For example, if you have two dates in the table to use, then you can link both the columns to the Date column in the Dates table and use the **USERELATIONSHIP** function to specify which relationship to use in the DAX measure.

## Best Practices in Power BI for Data Visualization

Before you start building the report, you should be able to answer the following questions.

- Who is your audience?
- What questions are they trying to answer or decide on?
- What are their needs?
- What value can they draw from the data for themselves?

If the focus of the report is to perform specific tasks such as checking whether a goal is met or not, then you should use fewer visualizations and KPIs or metrics. However, if the focus is broad, then you should group similar sets of visuals and drill down features using filters.

Now, **selecting the right visuals** to effectively answer the questions of the audience is extremely important. If you are wondering what is the right graph to use, then the answer is always the same, i.e., the graph that will be the easiest for your audience to read. You can refer to the following image to take a look at the visual reference guide.

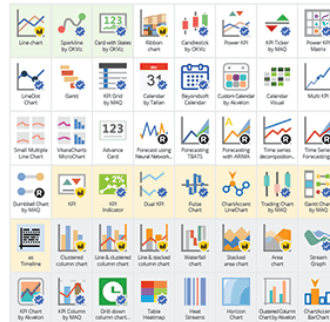
## COMPARISON

Display measures compared by their magnitude



## CHANGE OVER TIME

Display the changing trend of measures



## RANKING

Display measures by their rank order



## SPATIAL

Display measures over spatial maps



## FLOW

Display a flow or dynamic relations



## PART-TO-WHOLE

Display the parts of a measure



## DISTRIBUTION

Display the distribution of a measure



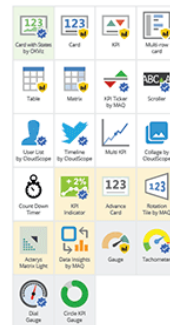
## CORRELATION

Display relations between measures



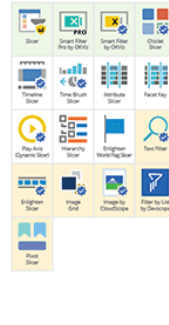
## SINGLE

Display single values



## FILTER

Control report filters



## NARRATIVE

Tell a story with data



Recommended There is a better alternative Don't use in the category Built-in visual Certified visual R required

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## Visuals Reference

Finally, it is recommended that you first **prepare a mock layout** of the report/dashboard on a piece of paper. This will enable you to brainstorm without the constraints of tools or your understanding of the tools. You can sketch some potential visuals and view them side by side to determine the best way to share your message with the audience. You tend to be less attached to your work product when you are working on paper rather than on a computer. And, this can make iteration easier for you. You are also free of limitations when you draw on a blank piece of paper, which allows you to easily identify new approaches when you feel stuck.

## Building Reports in Power BI

It is recommended that you use a fixed colour theme for the entire report, a colour that users are more accustomed to seeing in their daily lives. For example, you can use colours from a company's logo or website.

You will find two types of themes in Power BI, which are as follows:

**Built-in themes:** Here, you can select one of the predefined colour schemes that are already installed in Power BI.

**Custom themes:** In this option, you can create custom themes by making changes to the current theme and then saving it, or you can create your own theme using a JSON file.

The several formatting options that are available in Power BI reports use three icons: Fields icon, Format icon and Analytics icon. These icons are available under the Visualization pane. Based on the selected visualization, Power BI filters the elements that you can format, such as data colours, tooltips, axis properties and so on.

Apart from these default visuals, you can import more Power BI visuals from the following sources:

- **Microsoft AppSource:** This has validated visuals that are contributed by Microsoft and its community members.
- **Organizational Store:** This is developed and maintained by your organization's admins.
- **Import a visual from a file:** You can also import any custom visual that you built from a file.

Power BI also has an interesting feature that allows you to **group** two or more visuals to perform various activities such as moving and resizing all the visuals at once, which is similar to performing on a single object. This is helpful in the easy ordering of layers when you have to overlap visuals.

Another interesting feature in Power BI is that of hierarchies. **Hierarchies** allow you to drill down to additional relevant details in a visual. Power BI automatically created hierarchical levels within the Date column with Year as the top level consisting of Quarters as the second level, Quarters consisting of Months as the third level and Days within each month as the fourth level of the hierarchy. You can drill up or down based on the level that you want to view in the report.

You can also create hierarchies in Power BI by dragging and dropping different levels on top of each other depending on your requirements. This creates a new field that can be used to drill up or down to derive deeper insights/information from the data.

## AI Visuals in Power BI

Power BI offers three AI visuals to leverage AI features in simple charts such as bar and column. The AI visuals are as follows:

1. **Key influencers:** This automatically finds and ranks the factors that drive a metric based on their relative importance. It helps in understanding the factors that influence the specified target variable. The key influencers visual computes a multiplier based on each factor in the order of its importance.

Key influencers segment helps in determining a single factor influencing the target variable at a time. However, in many situations, more than one factor affects the target group. Top segments helps in such cases by considering the combinations of features/factors that influence the target variable. When you click on a segment, you can view the details of the factors that define the segment.

Note that key influencers can only consider a categorical variable as the target variable; continuous features are not supported in key influencers right now.

2. **Decomposition trees:** This resembles a tree with branches. It allows a user to break down a measure across multiple dimensions in any order using the drill down feature. It can be used to perform an ad-hoc analysis or a root cause analysis. It is a simpler version of the key influencers visualization.
3. **Q&A visuals:** This allows a user to ask natural language questions and get answers in the form of visuals. Power BI also provides suggestions on what you can ask your data model.

So, both the decomposition tree and Q&A visuals are more helpful for the end users and audience who want to explore and understand the data better.

## Bookmarks and Performance Analyzer

In Power BI, **bookmarks** allow you to capture the as-of-now view of a report page, including the visuals, filters, etc., and revert to that view of the page by choosing the saved bookmark. You can use this feature to observe the progress made in the development of a report by saving multiple bookmarks at different stages. You can save bookmarks showing the progression of insights as a story or showing different visuals in the same location.

When your Power BI report has multiple overlapping visuals, you can easily manage them by using the **Selection pane** feature. This feature lists all the elements in the page as a pane to easily layer the overlapping elements, group the elements or create nested groups and hide a few elements.

**Power BI Buttons** allow you to create buttons in your report. You can link the buttons to various actions such as selecting a bookmark, going back to a page and drilling through.

It is important to have a performance-optimized report. This can be achieved using the **Performance Analyzer** feature of Power BI. This feature records logs of the time taken to render a visual during user interactions. It helps in identifying the most or least resource-intensive visual elements in the report. The log information of each visual includes the amount of time spent to complete the following categories of tasks:

- **DAX query:** A DAX query indicates the time between a visual sending the query and the Analysis Services returning the results.
- **Visual display:** This indicates the time required for a visual to draw on the screen, including the time required to retrieve any web images or geocoding.
- **Other:** This indicates the time required by a visual for preparing queries, waiting for other visuals to complete or for performing other background processing.

## Power BI Service and Its Interface

Power BI Service allows you to collaborate with other users, share reports and publish them on the Power BI cloud application. You can access Power BI Service using <https://app.powerbi.com/>. You can log in with the same credentials that you used for signing in to Power BI Desktop to get started with Power BI Service.

The home page of Power BI Service is personalised based on the reports and dashboards that you create or receive from other users in an organization.

When you publish a report, it is uploaded to a Power BI cloud called a **Workspace**. You can also edit the current report and build a new report on the workspace. In Power BI, a workspace is a shared environment that enables users to access multiple reports and dashboards with both edit and read-only rights. **'My workspace'** is a personal workspace that allows you to access your personal reports and dashboards for any development-related work, such as editing reports or testing that you want to conduct. You can also build new reports in Power BI Service; however,

this feature has limited functionality. So, it is advised that you use Power BI Desktop for any development-related work.

Power BI offers the following two types of licensing:

- **Power BI Pro:** This allows users in the organization to create content. It also allows users to view the contents that are created by other users and the contents that are shared with them.
- **Power BI Premium:** This requires content creators to have the Power BI Pro licence. Content viewers can get free licences but with a premium workspace.

Typically, Power BI uses shared capacity, wherein workloads are run on computational resources that are shared across multiple customers. However, you can opt for dedicated capacity with Power BI premium licensing, wherein resources are not shared with other customers.

Power BI offers a limit of 10 GB per user for a given workspace for storing data sets, reports and dashboards. However, the premium version of a Power BI workspace offers more than 10 GB.

The **Report section** in a workspace displays all the reports that are published to that particular workspace from Power BI Desktop.

In the **Usage Metrics** section, you can check the logs to see who is viewing the reports, how many times they are viewing them, how many people are sharing the reports and other similar usage metrics for reports and dashboards within a workspace. Note that these reports are read-only reports, and you can save them for future reference.

Reports can be shared with other users by either using the share icon under the Reports section in a workspace or creating apps.

Before sharing the reports with other users in the organisation, you can use the following setting options to edit your reports:

- **Featured:** This promotes the reports under the Featured section on the home page.
- **Persistent filters:** By enabling this option, users can save filters in the report.
- **Visual options:** This allows you to hide visual headers in the reading mode.
- **Cross-filtering:** This allows you to filter out the data that you want to remove and focus on the data that you want to display. On the other hand, cross-highlighting highlights a subset of the visible data by dimming others from the view.
- **Export data:** This allows the end users to choose the type of data that they want to export, which has been used to build the report. This includes the following types: Summarized data, Summarized data and underlying data or None.
- **Filtering experience:** This allows users to search for and change the filter type between basic and advanced filtering.
- **Cross-report drill through:** This allows the same filter to be applied and reflected across all the reports built from the same dataset.
- **Comments:** This allows users to add comments to your reports.

- **Personalize visuals:** This allows users to modify visuals as per their requirements.

## Data Refresh and Row-Level Security

Under the **Datasets section** in a workspace, you have similar options as those under the Reports section.

**Data Gateway** allows you to connect to on-premise data sources to keep your reports updated in a secure manner.

There are two modes of connecting to data sources: **Standard Mode and Personal Mode**. Standard mode allows multiple users to connect to multiple data sources, whereas personal mode allows only a single user to connect to multiple data sources. Note that personal mode does not support DirectQuery.

You can schedule a data refresh after setting up a data gateway connection and adding the required data source credentials and parameters. You can also set the frequency of data refreshes and the time at which you want to schedule the data refresh. Power BI also sends notifications when the scheduled data refresh fails due to some error.

**Row-level security** helps in restricting access to certain users in Power BI. This can be done using the Manage Roles feature, which restricts access to data at the row level based on who is viewing it. You can assign users to the roles created in Power BI Service but not in Power BI Desktop. However, the workspace access level to data sets overrules the row-level security.

The **Security** option under the Datasets section allows you to extend the roles that you create in Power BI Desktop under the Manage Roles option. When you add members against the roles in Power BI Service, the assigned member can only view data and reports specific to their role.

You can also provide access to a particular data set by adding users under the **Manage Permissions** option in the Datasets section.

## Dashboards and Apps

**Power BI dashboards** are available only on Power BI Service. You need a Power BI Pro licence to create a dashboard in any workspace, except in My workspace. You can create a dashboard by pinning visualizations from one or two different reports. The visualizations in a dashboard are called **tiles**. Selecting a tile from a dashboard leads you to the source of its reports or data sets.

Reports can contain multiple pages, whereas a dashboard can contain only one page. Dashboards are useful when you want to combine the results from multiple reports and data sources into a single platform as shown in the image given below. This allows business owners or the senior management to make decisions based on a high-level view. A dashboard has limited features and functionalities; therefore, a report is generally preferred to a dashboard for a detailed understanding of insights from the given data.





### Dashboard From Multiple Reports

Once your reports are ready, you can create an app and specify the usernames with whom you want to share the reports. **Power BI Apps** allow you to combine multiple reports and dashboards at a single location. They make it convenient to share these multiple reports and dashboards in a workspace with other users by packaging them. An app is preferred to the share icon because it is easier to package multiple reports and dashboards at a single location and share them with other users at once. You can create an app and publish it to a location from where the users can access it.

You can also extract the HTML snippet for your report and embed it in other applications, such as Sharepoint and web pages, using the **Embed Code** option available in Power BI Service.

You can manage multiple features in apps such as hiding or unhiding reports, reordering them, resizing the navigation pane, adding a theme or a logo, etc.

You can also create sections in an app to group similar reports or dashboards under them. You can manage permissions by allowing specific users to access the underlying data sets of the reports, create a copy of the reports and share the app with specific individuals or the entire organization under the Permissions section in an app.

After creating an app, you will receive a specific URL that you can copy and send to the end users with whom want to share your reports or dashboards.

To continue your learning about Power BI, you can refer to the links provided below and stay connected with the Power BI Community.

### Stay connected and keep exploring!

- [Power BI Community](#)
- [Power BI Ideas](#)
- [Power BI Blog](#)



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