



Power BI for Beginners



uOttawa

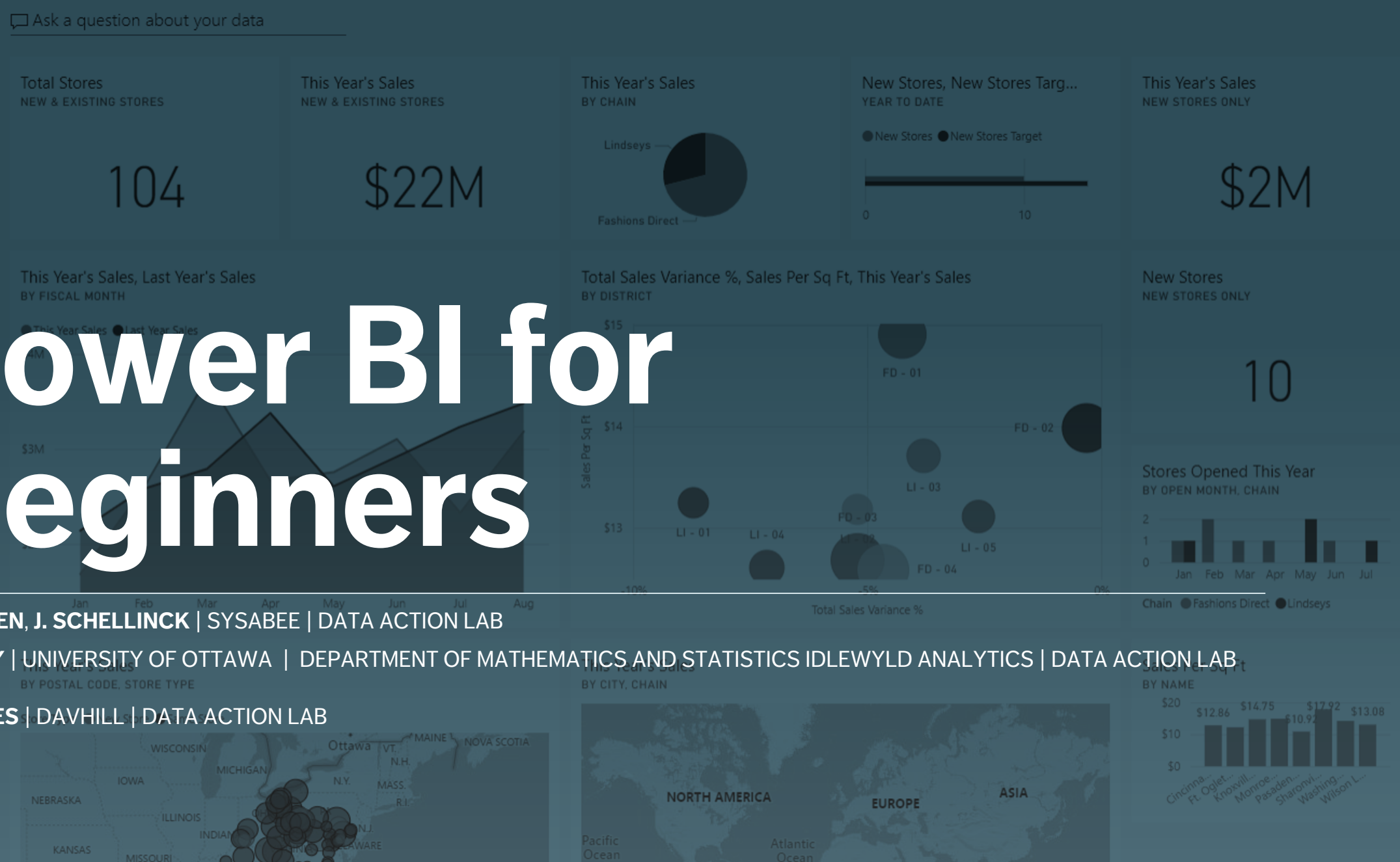
Institut de développement professionnel
Professional Development Institute

Power BI for Beginners

T. SHAEN, J. SCHELLINCK | SYSABEE | DATA ACTION LAB

P. BOILY | UNIVERSITY OF OTTAWA | DEPARTMENT OF MATHEMATICS AND STATISTICS IDLEWYLD ANALYTICS | DATA ACTION LAB

S. DAVIES | DAVHILL | DATA ACTION LAB



Instructor – Patrick Boily

Employment

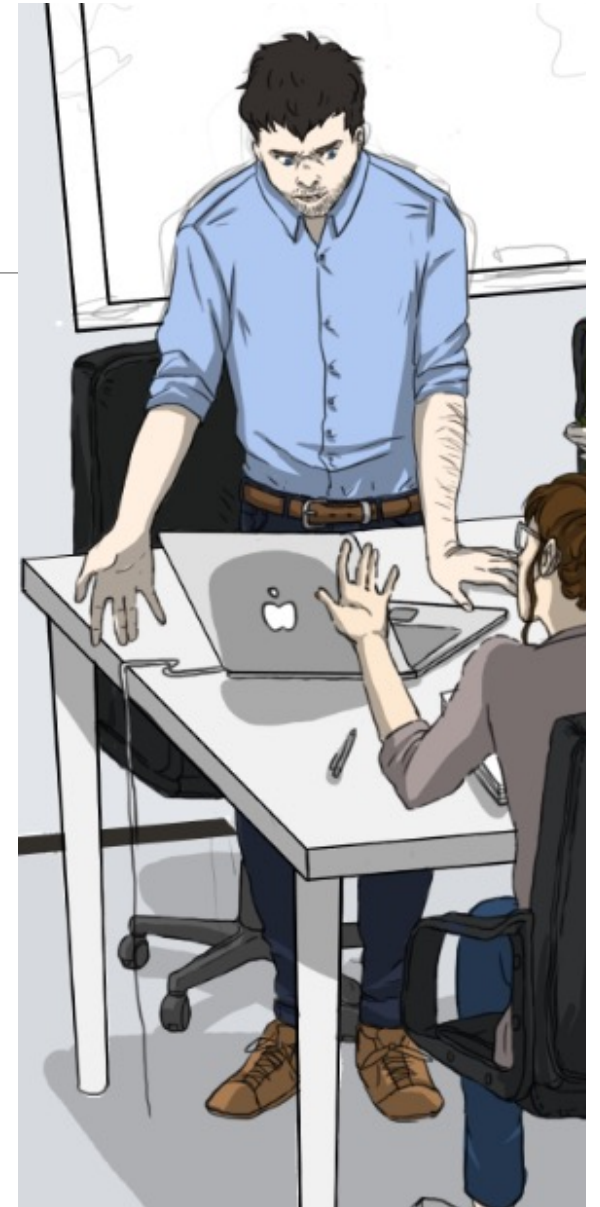
- Professor Math/Stat ['19 – now, uOttawa]
- President ['16 – now, Idlewyld Analytics]
- Manager and Senior Consultant ['12 – '19, CQADS, Carleton]
- Public Service ['08 – '12, ASFC | StatCan | TC | TPSGC]
- 60+ uni course; 250+ workshop days

Projects

- GAC; NWMO; CATSA; etc.
- 40+ projects

Specialization

- Data visualization; data cleaning (... unfortunately)
- Application of wide breadth of techniques to all kinds of data
- Mathematical/statistical modeling



Instructor – Tristan Shaeen

Employment/Experience

- AI Consultant ['21 – now, Sysabee, AI Guides]
- Instructor ['21 – now, Data Action Lab]

Projects

- Global Affairs Canada
- Small and medium enterprises
- Labour Market Information Council

Specialization

- Statistical training
- Data presentation and data storytelling



Course Material

Course Webpage:

<https://data-action-lab.com/pbifb>

Contact Info:

pboily@uottawa.ca
tshaeen@sysabee.com

Data Visualization Course Notes:

<https://www.practicedataviz.com>

Slack Workspace:

<https://dspdi.slack.com>

Course Description

Organizations have, and continue to accumulate, masses of data from multiple sources. This data, being largely unformatted, does not yield readily pertinent information. Microsoft tackled this issue by adding data analytics tools to their Microsoft Office 365 suite.

Power BI, the latest addition to Office 365, enables users to aggregate and interpret massive data in a user-friendly environment. With this data visualization tool, analysts build custom data analysis and dashboards with scheduled automated updates: empowering managers' decision making with accurate and intuitive real-time measures.

This fast-paced introductory course to Microsoft's Power BI application covers key concepts for delivering effective automated dashboards. This is a hands-on training session: participants learn Power BI's functionalities as they build an interactive report. Best practices for data visualizations and dashboards are described and applied through examples.

Learning Outcomes

At the end of this course, participants will be able to:

- understand the Power BI Solution workflow to properly use the different apps
- build an interactive report in Power BI Desktop app
- combine multiple data sources and create dynamic data visualizations
- *use storytelling tools: bookmarks, spotlight, focus, tooltip, axis hierarchy
- explore advanced functionalities to transform and enhance data with Power Query Editor and measures in DAX

Sister Courses

DATA SCIENCE ESSENTIALS

1. Non-Technical Aspects
2. Data Science Basics
3. Data Preparation
4. Data Engineering

DATA VISUALIZATION AND DASHBOARDS

1. Data Viz Concepts
2. Dashboarding
3. Storytelling with Data
4. Data Viz with ggplot2

INTRODUCTION TO MACHINE LEARNING

1. Statistical Learning
2. Classification
3. Clustering
4. Issues and Challenges

The Set-Up: Borealis Terraformers

Borealis Terraformers LLC is a terraforming company.

It does business, it transacts with consultants, it has employees, it pays them, it delivers products, it records its transactions.

It also has projects (Major Capital MC, Minor Capital MIC, Operations and Management O&M, and Salary SA), and departments.

The Plan: Course Components

Participant Activities (PA): follow along with the instructors.

Instructor Demos (ID): sit back, relax, and take it all in.

Behind the Scenes (BS): a summary of what has been prepared for you.

Dashboard Discussions (DD): let's talk about the dashboards.

Basic Notions (BN): non-Power BI stuff worth knowing about.

Exercises: take it one step further.

The Plan: Important Documents

We will be exploring Power BI's functionality by building a 6-page dashboard.

As we want to encourage you to play with the tool without fear that you will break it (or what we have planned), we have prepared 8 Power BI dashboard files (PBIX), at various stages of development, which you can load to re-enter the stream at any moment.

Download [PBI4B.zip](#) from the course website, and unzip the file to an easily accessible location on your hard drive, to which you will also download the course datasets.

[Step-by-step instructions](#) for the PA and ID tasks are also available.

The Plan: Course Outline

I. Power Query

1. Load Data (PA)
2. Transform Data (PA)

II. Preparation

3. Change Data Types (ID)
4. Link Fields with Data Models (ID)
5. Create a Filter (BS)

III. Exploration

6. Basic Data Visualization Notions (BN)
7. Load PBIX – 1 (PA)
8. Make and Format a Bar Chart (PA)
9. Make and Format a Donut Chart (ID)
10. Create a Table to Store Measures (ID)
11. DAX vs. M. vs. GUI (BN)
12. Create Calculated Measures (ID/PA)
13. Make and Format a Donut Chart (ID)
14. Make and Format a Treemap (BS)

The Plan: Course Outline

III. Exploration (cont.)

15. Create a Calculated Measure (BS)
16. Load and Explore PBIX – 2 (PA)
17. Create a Calculated Column (BS)
18. Format Decimal Places (BS)
19. Make and Format a Bar Chart (BS)
20. Make and Format a Line Chart (PA)
21. Create a Calculated Measure (ID)
22. Make and Format a Line Chart (ID)
23. Exploring the Data (DD)

IV. Situational Awareness

24. Basic Dashboard Notions (BN)
25. Measures vs. Columns (BN)
26. Load and Explore PBIX – 3 (PA)
27. Create a Calculated Column (ID)
28. Make and Format a Table (BS)
29. Make and Format a Column Chart (BS)
30. Load and Explore PBIX – 4 (PA)
31. Make and Format a Bar Chart (PA)
32. Make Slicers (PA)
33. Load and Explore PBIX – 5 (PA)

The Plan: Course Outline

IV. Situational Awareness (cont.)

- 34. Make and Format Column Charts (ID)
- 35. Load and Explore PBIX – 6 (PA)
- 36. Make and Format a Column Chart (PA)
- 37. Monitoring the Situation (DD)

V. Storybook

- 38. Basic Storytelling With Data Notions (BN)
- 39. Create a Calculated Column (ID)
- 40. Make and Format Small Multiples (ID)
- 41. Make and Format a Bar Chart (ID)

V. Storybook (cont.)

- 42. Load and Explore PBIX – 7 (PA)
- 43. Apply a Page Filter (PA)
- 44. Make and Format a Small Multiples Chart (PA)
- 45. Make and Format a Bar Chart (PA)
- 46. Annotate a Dashboard (ID)
- 47. Load and Explore PBIX – 8 (PA)
- 48. Convincing an Audience (DD)

VI. Miscellanea*

- 49. *Publish a Power BI Dashboard (BN)
- 50. *Integrate R in Power BI (BN)

The Tool: Power BI

Dashboarding tools are, for the most part, **story-driven** tools: Microsoft's [Power BI](#) is one such tool (download and install the latest version if this has not been done yet).

Its learning curve (reasonably steep, as with all new tools) is attenuated somewhat by its distinctly “Microsoft-ish” **point-and-click functionality**.

It allows dashboards to be easily **published** and **distributed** on the web (either internally and/or externally).

But it does not play nicely with MacOS and Linux (there are workarounds).

File Home Insert Modeling View Help

Paste Cut Copy Format painter
 Get data Excel Data SQL Enter data Datasource Recent sources
 Transform data Refresh data
 New visual Text box More visuals
 New measure Quick measure
 Sensitivity Publish

Clipboard Data Queries Insert Calculations Sensitivity Share

(home) ribbon

report button

data button

model button

Filters

Search

Filters on this page
Add data fields here

Filters on all pages
Add data fields here

Visualizations

Build visual

Values
Add data fields here

Drill through
 Cross-report Off
 Keep all filters On

Add drill-through fields here

Fields

Search

You haven't loaded any data yet. [Get data](#)

canvas

filter pane

visualizations

fields pane

The Data: Borealis Terraformers

Let's take a look at one dataset that we are going to use:

- [Data Set - Accounting.xlsx](#)

Download it to your hard drive (you may need to rename the file).

Code	Description
O&M	Operations and Maintenance
MC	Major Capital
MIC	Minor Capital
SA	Salary

Tab - Journal Voucher Type Code

Accounting Control Number	Journal Voucher Type Code	Accounting Effective Date	Journal Voucher Item Amount	Project Identifier
5000085	MC	01-Mar-18	\$173,516.11	PR007
5000086	SA	02-Mar-18	\$54,298.15	PR009
5000087	O&M	03-Mar-18	\$49,584.50	PR010
5000088	MIC	04-Mar-18	\$89,293.40	PR011
5000089	SA	05-Mar-18	\$93,866.67	PR012
5000090	O&M	06-Mar-18	\$47,942.67	PR013
5000091	MC	02-Apr-18	\$177,734.54	PR007
5000093	SA	03-Apr-18	\$84,391.34	PR009
5000094	O&M	04-Apr-18	\$21,520.07	PR010

Tab - Accounting Transactions

The Data: Borealis Terraformers

Let's take a look at another dataset that we are going to use:

- [Data Set - Projects.xlsx](#)

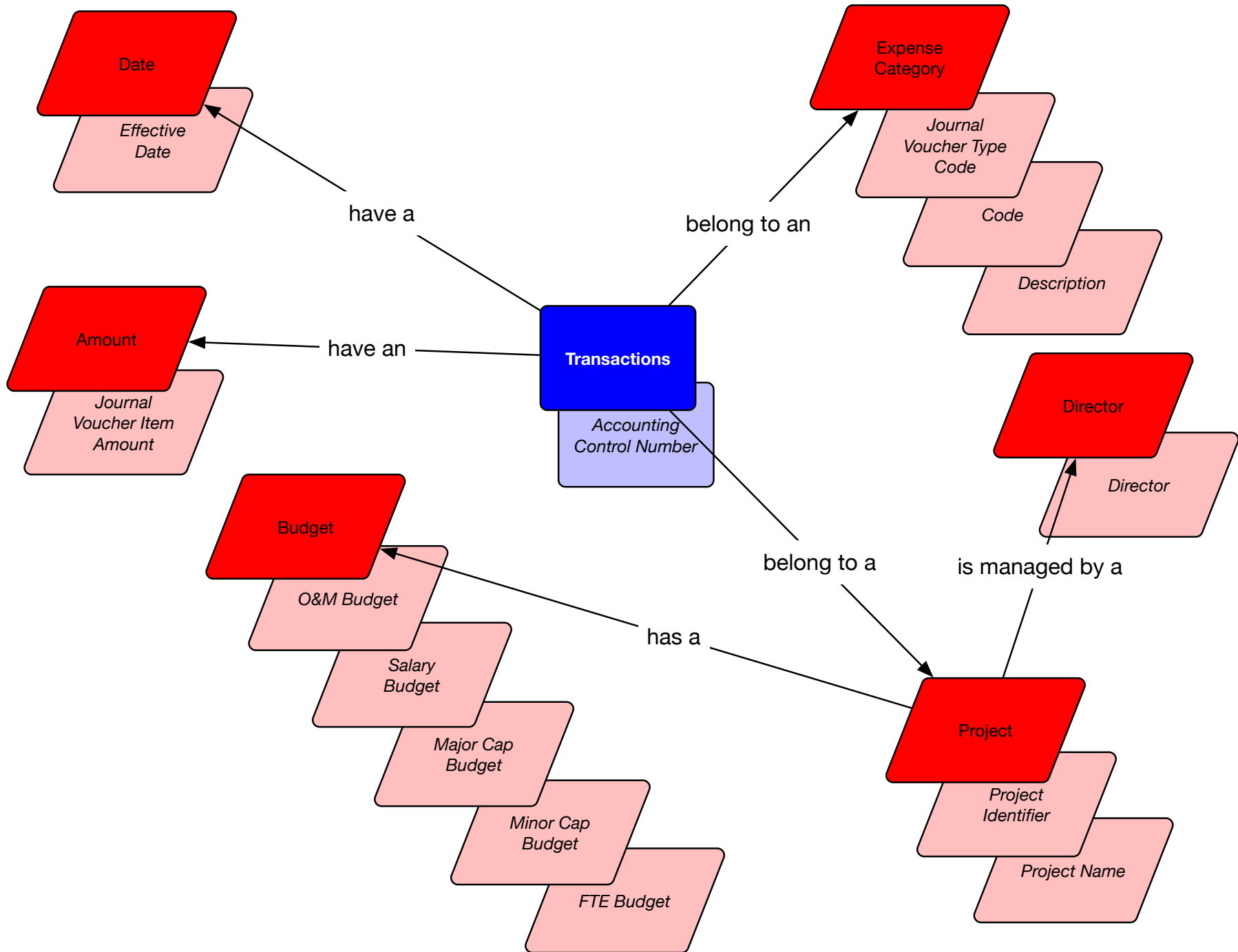
Download this one to your hard drive too, in the same location (you may also need to rename the file).

Project Identifier	Director	Project Name	O&M Budget	Salary Budget	Major Cap Budget	Minor Cap Budget	FTE Budget
PR001	A. Thakur	Parks	\$2,500,000	\$2,000,000	\$5,000,000	\$1,000,000	9.00
PR002	G. Bertrand	Buildings	\$5,000,000	\$4,000,000	\$5,000,000	\$5,000,000	6.00
PR003	C. Power	Emergency Response	\$3,000,000	\$7,000,000	\$800,000	\$3,000,000	6.00
PR004	H. Schlivofszky	Office	\$4,000,000	\$4,000,000	\$8,000,000	\$200,000	12.00
PR005	G. Bertrand	Roads	\$5,000,000	\$2,000,000	\$2,500,000	\$1,000,000	7.00
PR006	B. Bouraoui	Science	\$5,000,000	\$10,000,000	\$8,000,000	\$2,000,000	7.00
PR007	A. Thakur	Heritage	\$1,500,000	\$5,000,000	\$3,000,000	\$1,700,000	9.00
PR008	A. Thakur	Celebration	\$2,000,000	\$4,000,000	\$0	\$0	7.00
PR009	B. Bouraoui	Research	\$5,000,000	\$1,200,000	\$10,000,000	\$500,000	6.50
PR010	G. Bertrand	Upgrades	\$4,000,000	\$2,000,000	\$10,000,000	\$500,000	10.00

Tab – Project Tombstone

Project Code	Date	FTE (- out +)	Group- Level
PR001	01-Apr-18	2	AS-04
PR002	01-May-18	2	AS-05
PR003	01-Jun-18	2	ENG-01
PR004	01-Jul-18	4	PR-01
PR005	01-Aug-18	3	PA-03
PR006	01-Sep-18	2	AS-02
PR007	01-Oct-18	1	CR-03
PR008	01-Nov-18	3	FI-02
PR009	01-Dec-18	4	FO-03
PR010	01-Jan-19	2	CR-01
PR011	01-Feb-19	3	AS-03

Tab – Project FTE Count



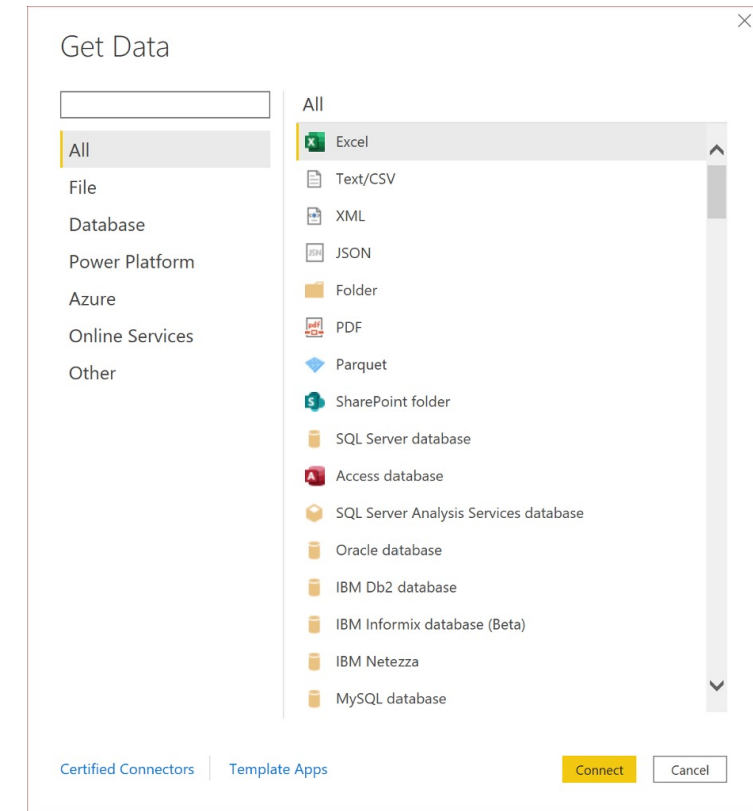
I. Power Query

POWER BI FOR BEGINNERS

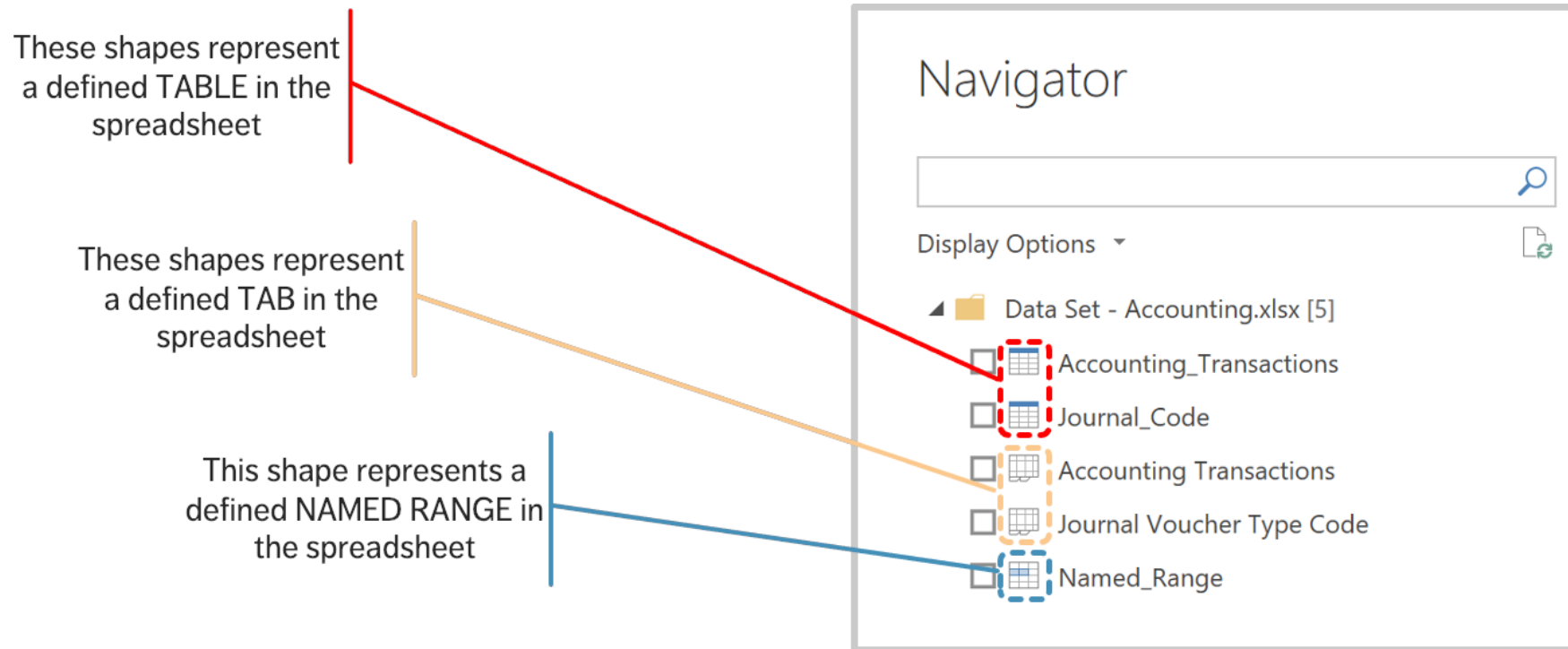
1. Load Data (PA)

We might want to “tweak” the data before loading it into Power BI. We can accomplish this using the **Power Query Interface** (see detailed instructions, p. 1).

1. Open Power BI.
2. Close the yellow “Hello” screen.
3. In the “Home” ribbon at the top of the Power BI screen, there is a clickable region named “Get Data” – activate it to bring up several data format options.
4. Among all the options, select “Excel”.
5. Click on `Data Set - Accounting.xlsx`, and select “Open”.



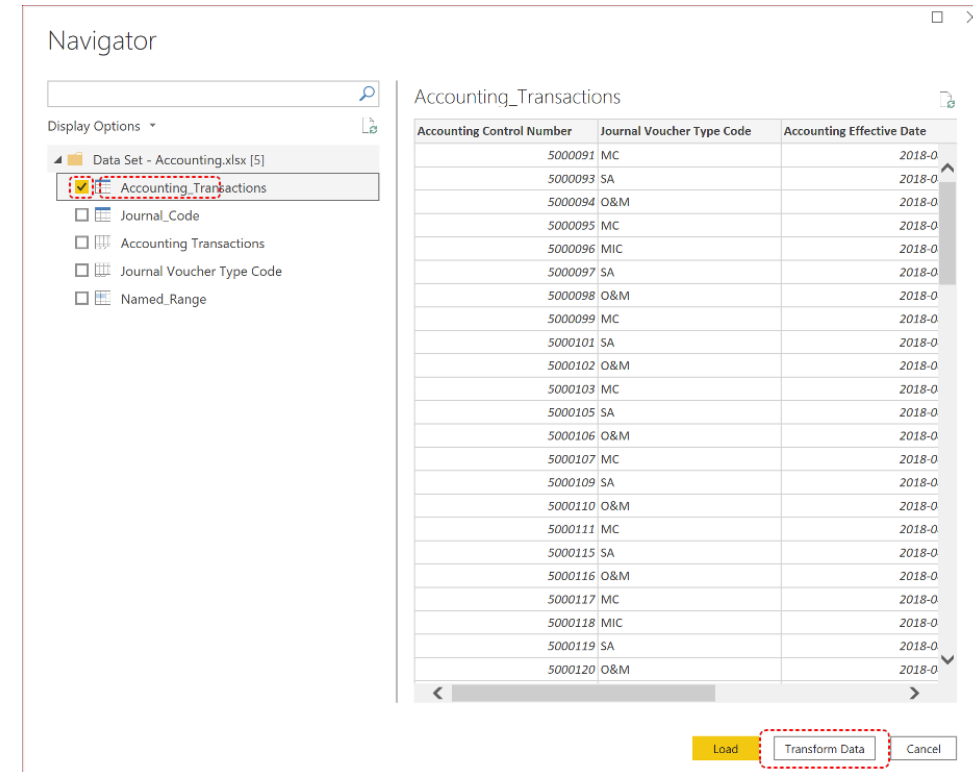
1. Load Data (PA)



2. Transform Data (PA)

We do not need to **transform data** at the source.

1. Click on the first TABLE (the one named “Accounting_Transactions”) without selecting the checkbox (yet) – this brings up a display of the table (clicking on the other options will bring up their displays);
2. Select the “Accounting_Transactions” checkbox (**don’t click on “Load” yet!**);
3. We want to tweak the data before loading it, so we edit the transformation by clicking on “Transform Data”.



2. Transform Data (PA)

Different menu options

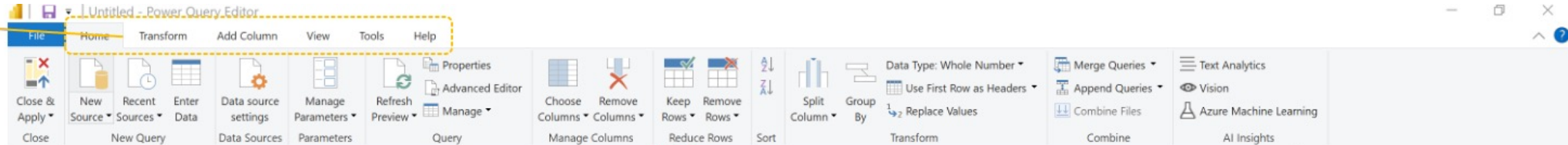
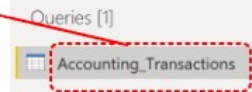


Table name



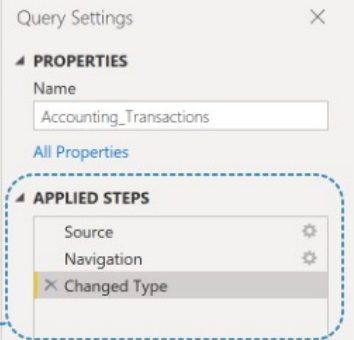
Column headings



Data type



Query steps



	Accounting Control Number	Journal Voucher Type Code	Accounting Effective Date	Journal Voucher Item Amount	Project Identifier
1	5000091	SA	2018-04-01	95272.38821	PR007
2	5000093	SA	2018-04-03	88744.07488	PR009
3	5000094	O&M	2018-04-04	41181.10754	PR010
4	5000095	MC	2018-04-05	133786.4107	PR011
5	5000096	MIC	2018-04-06	72761.06847	PR012
6	5000097	SA	2018-04-07	54583.08286	PR013
7	5000098	O&M	2018-04-08	34262.09853	PR014
8	5000099	MC	2018-04-09	103289.9061	PR015
9	5000101	SA	2018-04-11	65206.17838	PR017
10	5000102	O&M	2018-04-12	99554.48227	PR018
11	5000103	MC	2018-04-13	83245.94442	PR019
12	5000105	SA	2018-04-15	31877.1347	PR021
13	5000106	O&M	2018-04-16	82690.54607	PR022
14	5000107	MC	2018-04-17	92510.92242	PR023
15	5000109	SA	2018-04-19	54047.78618	PR025
16	5000110	O&M	2018-04-20	32539.0176	PR026
17	5000111	MC	2018-04-21	49166.55573	PR027
18	5000115	SA	2018-04-25	40947.33767	PR001
19	5000116	O&M	2018-04-26	58055.7985	PR002
20	5000117	MC	2018-04-27	43700.14912	PR003
21	5000118	MIC	2018-04-28	55246.76231	PR004
22	5000119	SA	2018-04-29	10126.17982	PR005
23	5000120	O&M	2018-04-30	10923.76181	PR006

2. Transform Data (PA)

We proceed with the following steps to **transform the data** (see detailed instructions, p. 1):

1. change the name of the table;
2. change the name of the “Accounting Effective Date” column to “Effective Date” and “Journal Voucher Item Amount” to “Item Amount”;
3. remove the dates from March 2018 in the “Effective Date” column;
4. close and apply the transformation;
5. save the PBIX file;
6. retrieve the "Project_Tombstone" table from “Data Set – Projects.xlsx”.

2. Transform Data (PA)

The screenshot displays the Power Query Editor interface. The main area shows a table with columns: Accounting Control Number, Journal Voucher Type Code, Effective Date, and Item Amount. The data is filtered for the year 2018. The 'Applied Steps' pane on the right is highlighted with a red dashed box, showing the following steps: Source, Navigation, Changed Type, Renamed Columns, and Filtered Rows. The 'Filtered Rows' step is currently selected.

Query Settings

PROPERTIES

Name: Accounting Transactions

APPLIED STEPS

- Source
- Navigation
- Changed Type
- Renamed Columns
- Filtered Rows

	Accounting Control Number	Journal Voucher Type Code	Effective Date	Item Amount
1	5000091	MC	2018-04-02	177734.53
2	5000093	SA	2018-04-03	84391.336
3	5000094	O&M	2018-04-04	21520.066
4	5000095	MC	2018-04-05	66386.592
5	5000096	MIC	2018-04-06	27923.453
6	5000097	SA	2018-04-07	74930.729
7	5000098	O&M	2018-04-08	69103.672
8	5000099	MC	2018-04-09	122469.62
9	5000101	SA	2018-04-11	56647.831
10	5000102	O&M	2018-04-12	98732.681
11	5000103	MC	2018-04-13	128975.27
12	5000105	SA	2018-04-15	14233.448
13	5000106	O&M	2018-04-16	64483.763
14	5000107	MC	2018-04-17	18201.479
15	5000109	SA	2018-04-19	26467.433
16	5000110	O&M	2018-04-20	19630.412
17	5000111	MC	2018-04-21	120028.03
18	5000115	SA	2018-04-25	52992.042
19	5000116	O&M	2018-04-26	57903.914
20	5000117	MC	2018-04-27	107511.80

5 COLUMNS, 999+ ROWS Column profiling based on top 1000 rows PREVIEW DOWNLOADED AT 10:25 PM

II. Preparation

POWER BI FOR BEGINNERS

3. Change Data Types (ID)

We proceed with the following steps (see the detailed instructions document):

1. go to the “Fields” pane and drop down on “Accounting Transactions”;
2. after clicking on “Item Amount” you will see that new options appear in the top Ribbon, namely, “Column Tools”;
3. this is where we go to **change the data type** for “Item Amount” from a decimal value to a currency; we also change “Effective Date” into a short date.

(see detailed instructions, p. 1)

4. Link Fields with the Data Model (ID)

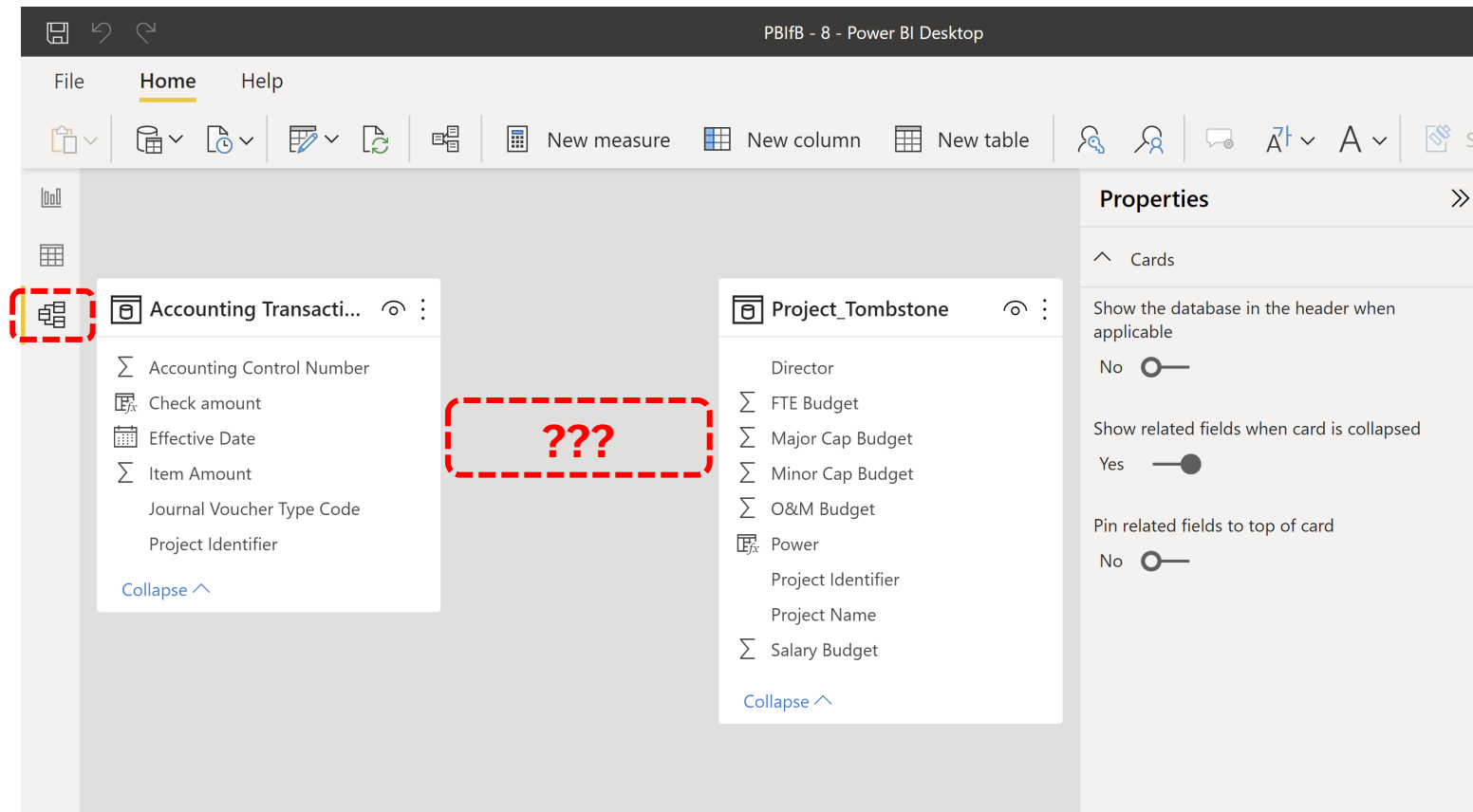
In the Model, the two tables are **linked** by the “Project Identifier” variable.

How did this happen?

We enter the “Data Model” view and remove the link. Now the two tables are unlinked, meaning that they cannot “talk” to one another.

Here is how we would link them (see detailed instructions, p. 1).

4. Link Fields with the Data Model (ID)



4. Link Fields with the Data Model (ID)

The screenshot shows the Power BI Desktop interface with the Data Model view. Two tables are visible: 'Accounting Transacti...' and 'Project_Tombstone'. The 'Accounting Transacti...' table has fields: Accounting Control Number, Check amount, Effective Date, Item Amount, Journal Voucher Type Code, and Project Identifier. The 'Project_Tombstone' table has fields: Director, FTE Budget, Major Cap Budget, Minor Cap Budget, O&M Budget, Power, Project Identifier, Project Name, and Salary Budget. A relationship line connects the 'Project Identifier' field in the 'Accounting Transacti...' table to the 'Project Identifier' field in the 'Project_Tombstone' table. The relationship is one-to-many, indicated by an asterisk (*) on the 'Accounting Transacti...' side and a '1' on the 'Project_Tombstone' side. A red dashed box highlights the relationship line. The Properties pane on the right shows settings for the selected relationship, including 'Show the database in the header when applicable' (No), 'Show related fields when card is collapsed' (Yes), and 'Pin related fields to top of card' (No).

4. Link Fields with the Data Model (ID)

Accounting Transactions

Accounting Control Number	Journal Voucher Type Code	Effective Date	Item Amount	Project Identifier	Check amount
5002154	SA	2018-04-01	\$98.01	PR016	
5003378	SA	2018-04-02	\$30,537.94	PR011	
5000093	SA	2018-04-03	\$84,391.34	PR009	

Project_Tombstone

Project Identifier	Director	Project Name	O&M Budget	Salary Budget	Major Cap Budget	Minor Cap Budget
PR001	A. Thakur	Parks	2500000	2000000	5000000	
PR002	G. Bertrand	Buildings	5000000	4000000	5000000	
PR003	C. Power	Emergency Response	3000000	7000000	800000	

Cardinality: Many to one (*:1)
Cross filter direction: Single

Make this relationship active
 Assume referential integrity
 Apply security filter in both directions

OK Cancel

5. Create a Filter (BS)

For the first part of this dashboard (Exploration 1, Exploration 2), we only use the data from 2018.

We create a **page filter** by setting the “Effective Date” to 2018.

III. Data Exploration

POWER BI FOR BEGINNERS

6. Pre-Analysis Use (BN)

Data visualization can be used to set the stage for analysis:

- **detecting anomalous entries**
invalid entries, missing values, outliers
- **shaping the data transformations**
binning, standardization, Box-Cox transformations, PCA-like transformations
- **getting a sense for the data**
data analysis as an art form, exploratory analysis
- **identifying hidden data structure**
clustering, associations, patterns informing the next stage of analysis

A CLASSIFICATION OF CHART TYPES

Data comparison charts

Data reduction charts

Comparison

Composition

Distribution

Evolution

Relationship

Profiling

Bars



Pie



Histogram



Line



Scatterplot



Grouped bars



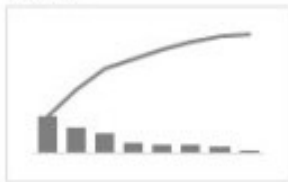
Dot plot



Bullet



Pareto



ID Scatterplot



Horizon



Connected Scatterplot



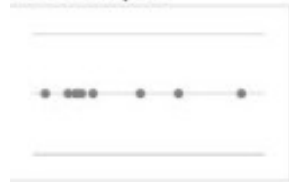
Cycle plot



Scatterplot matrix



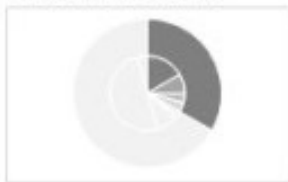
ID Scatterplot



Heat map



Multidimensional Pie



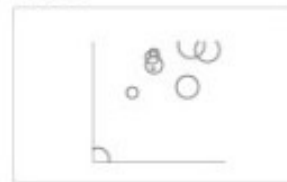
Boxplot



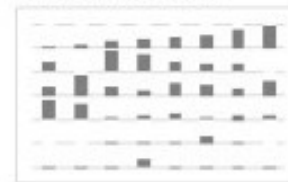
Step



Bubble



Reorderable matrix



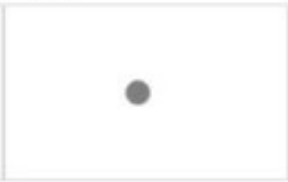
Horizon



Slope



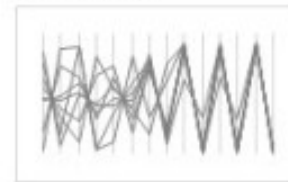
Alert



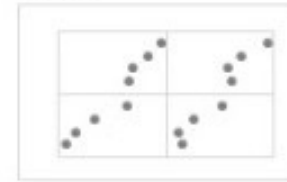
Connected Scatterplot



Parallel Plot



Trellis



6. Exploration and Visualization (BN)

Using visualizations as a tool to explore/understand the data

- high level of interactivity
- high level of detail
- **all** aspects of data should be represented (tables, columns, calculations etc.)
- no annotations or explanations required

Financial Data Exploration

Item Amount

\$6.16 | \$197,868.84

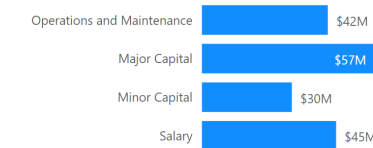
Effective Date

01/04/2018 | 31/12/2020

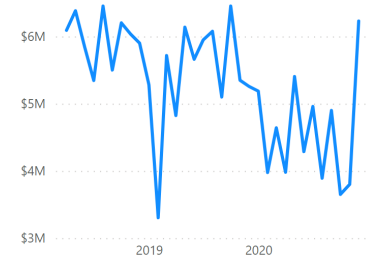
Project Identifier

- PR001
- PR002
- PR003
- PR004
- PR005
- PR006
- PR007
- PR008
- PR009
- PR010
- PR011
- PR012
- PR013

Item Amount by Description



Item Amount by Year, Quarter and Month



\$59.78K

Average of Item Amount

\$173.78M

Sum Item Amount

Journal Voucher Type Code	2018	2019	2020	Total
MC	\$18,110,444.61	\$21,810,187.90	\$17,448,129.75	\$57,368,762.27
PR001	\$687,677.21	\$1,792,024.46	\$907,127.55	\$3,386,829.23
PR002	\$788,825.39	\$565,031.07	\$813,175.69	\$2,167,032.15
PR003	\$1,517,664.95	\$612,091.00	\$1,093,131.35	\$3,222,887.30
PR004	\$800,174.27	\$719,551.46	\$1,155,498.57	\$2,675,224.30
PR005	\$611,844.01	\$1,559,623.99	\$505,962.54	\$2,677,430.55
PR006	\$869,847.19	\$1,142,078.50	\$567,309.21	\$2,579,234.90
PR007	\$1,254,247.56	\$1,202,463.46	\$1,121,613.47	\$3,578,324.48
PR009	\$536,301.11	\$1,466,714.57	\$654,848.18	\$2,657,863.87
PR010	\$1,025,185.44	\$1,124,411.66	\$810,384.12	\$2,959,981.22
PR011	\$1,323,665.62	\$947,916.20	\$951,129.63	\$3,222,711.45
PR012	\$894,949.35	\$1,321,602.78	\$1,142,398.09	\$3,358,950.22
PR013	\$810,720.06	\$1,397,946.44	\$943,871.63	\$3,152,538.13
PR015	\$1,115,244.24	\$1,238,919.57	\$1,211,122.76	\$3,565,286.57
PR017	\$1,163,245.06	\$1,346,151.02	\$595,533.30	\$3,104,929.39
PR018	\$888,426.84	\$1,297,179.23	\$1,177,356.88	\$3,362,962.95
PR019	\$942,777.50	\$1,028,710.89	\$748,386.14	\$2,719,874.53
PR022	\$842,076.88	\$697,992.57	\$1,105,900.34	\$2,645,969.79
PR023	\$1,219,843.67	\$1,143,895.90	\$1,115,052.77	\$3,478,792.34
PR027	\$817,728.27	\$1,205,883.13	\$828,327.52	\$2,851,938.92
MIC	\$8,733,325.92	\$11,316,310.76	\$9,855,321.54	\$29,904,958.22
PR001	\$488,147.03	\$447,373.91	\$493,012.00	\$1,428,532.94
PR002	\$288,526.70	\$794,250.21	\$275,485.45	\$1,358,262.36
PR003	\$249,707.20	\$301,928.04	\$339,914.44	\$891,549.68
Total	\$53,750,707.93	\$65,112,880.21	\$54,913,391.39	\$173,776,979.54

7. Load a PBIX File (PA)

Load and explore `PBIFB - 1.pbix` (tasks 1-5).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

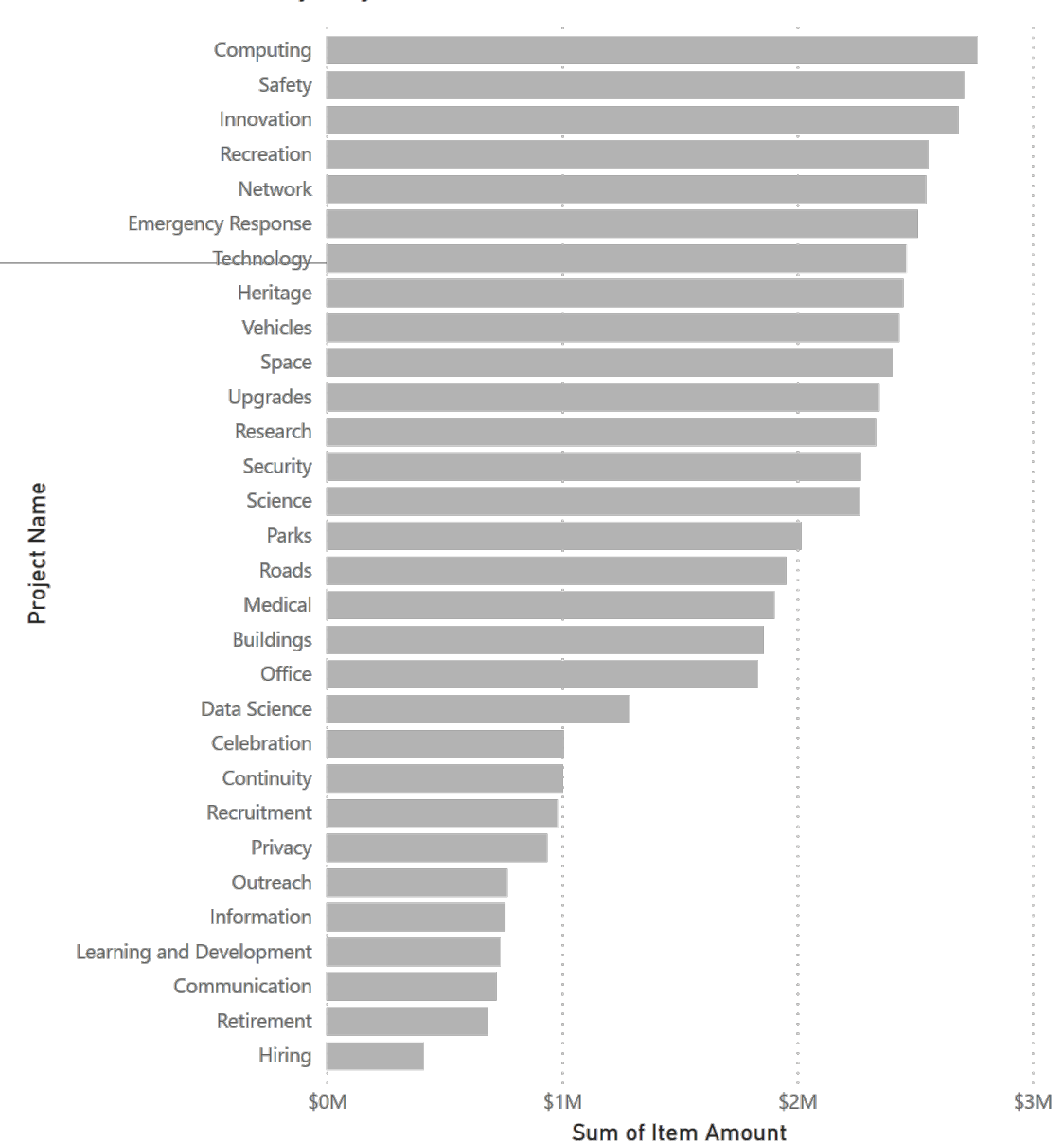
8. Make and Format a Bar Chart (PA)

We make a **bar chart** displaying the sum of “Item Amount” for all 2018 project entries, by “Project Name”.

We also format the chart to have grey bars.

(see detailed instructions, p. 2)

Sum of Item Amount by Project Name



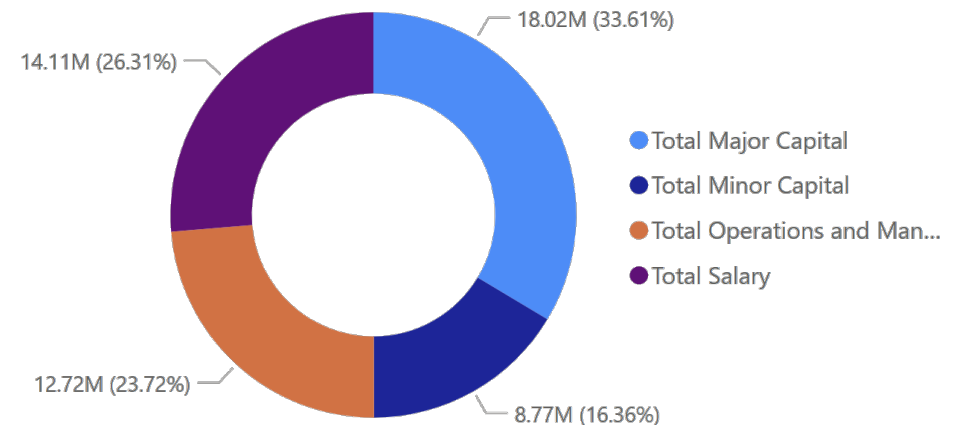
9. Make and Format a Donut Chart (ID)

We can create other types of charts, such as a **donut chart**.

(see detailed instructions document, p. 2)

We will revisit this chart when we talk about **measures**.

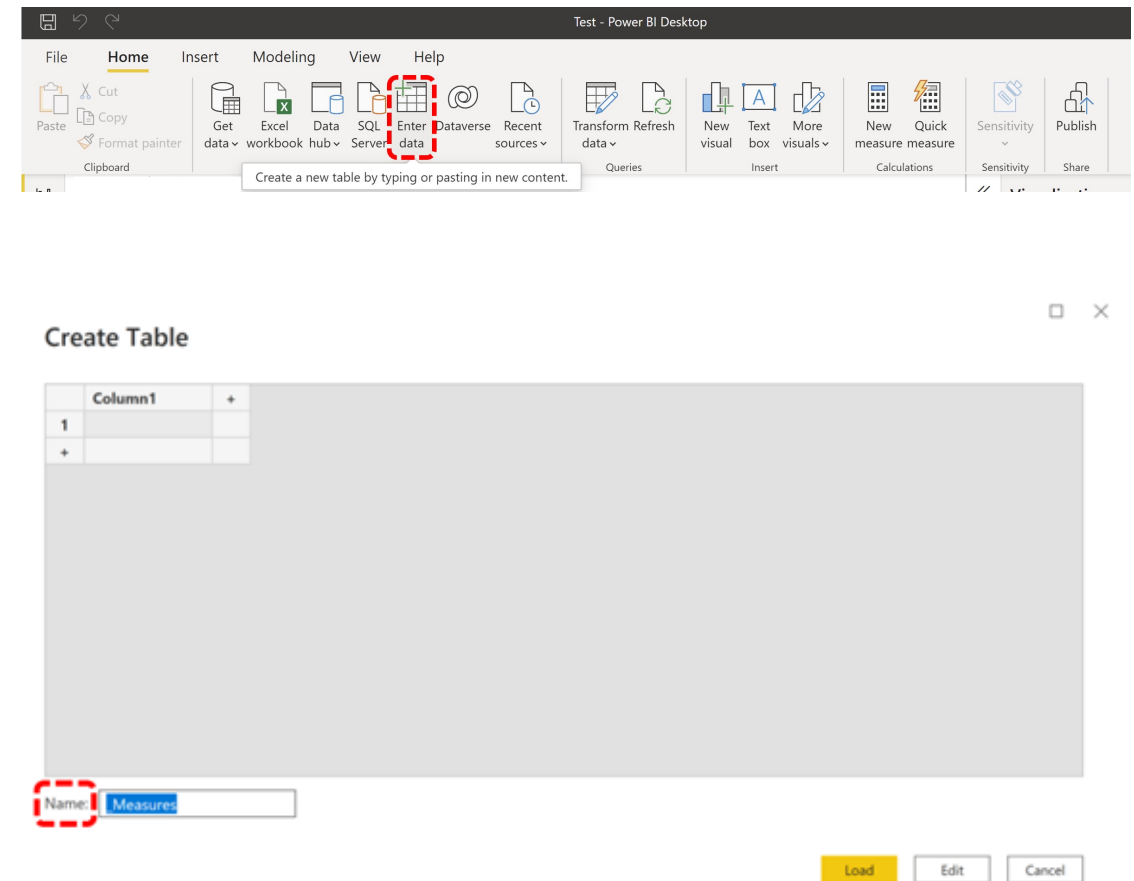
Total Major Capital, Total Minor Capital, Total Operations and Management and Total Salary



10. Create a Table to Store Measures (ID)

Before we build a first **measure**, we create a “_Measure” **table** in which the measures can reside.

(see detailed instructions, p. 2)



11. DAX vs. M vs. GUI (BN)

Power BI is really two products:

- data is imported through Power Query, which is used to manipulate/transform the data
- when ready, Power Query “pushes” the data into Power BI, for visualization and manipulations

Power Query uses the language “M” in the background; Power BI uses “DAX”.

Basic charts are created using the Power BI **Graphic User Interface** (GUI); for more complicated/sophisticated things, we need to use M and/or DAX.

11. DAX vs. M vs. GUI (BN)

What is M?

- M is the **data transformation engine** in Power BI (prior to loading data into the model)
- M contains commands to transform data and to return the results of the query and transformations to the Power BI data model
- normally, we use M Query to **query data sources, clean, and load** data
- instead of bringing 3 tables into Power BI, say, we can remove unneeded columns and merge the tables into a single table to load into the model (this reduces load and improves performance, which is crucial for larger datasets)

11. DAX vs. M vs. GUI (BN)

What is the **D**ata **A**nalysis **eX**pression (DAX) language?

- DAX is the common language used by SQL Server Analysis Services Tabular, Power BI, and Power Pivot in Excel
- DAX is the **analytical engine** in Power BI
- it is used once the data is loaded to create custom columns and tables (data) or measures (functions)
- it has some similarities to Excel functions, but much more powerful in general

12. Create Calculated Measures (ID/PA)

Measures are introduced when we want to focus on a column's **categories**.

For instance, we might want to create charts that focus on the various “Item Amount” categories :

- Total Major Capital
- Total Minor Capital
- Total Operations and Management
- Total Salary

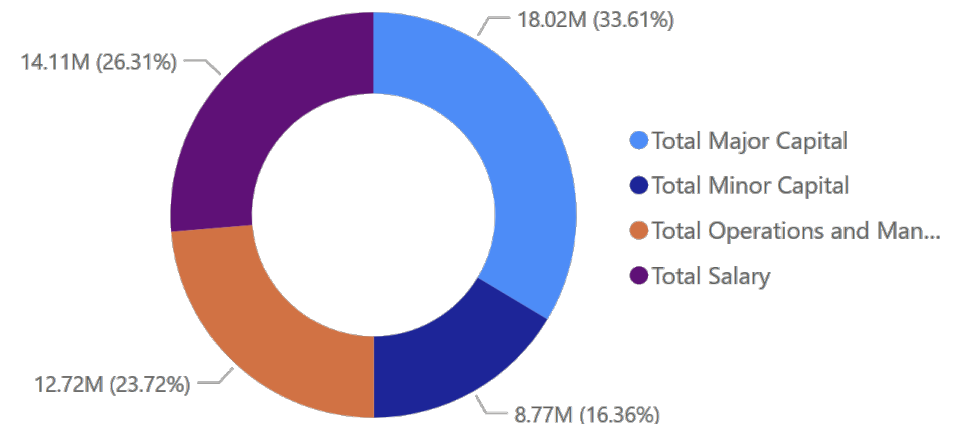
(see detailed instructions, pp. 2-3)

13. Make and Format a Donut Chart (ID)

We can now achieve the same **donut chart** as we had obtained when dragging “Journal Voucher Type Code” onto the “Legend” field.

The difference is that we can now reorder the categories as needed and use them for new measures/columns (see detailed instructions, p. 3).

Total Major Capital, Total Minor Capital, Total Operations and Management and Total Salary

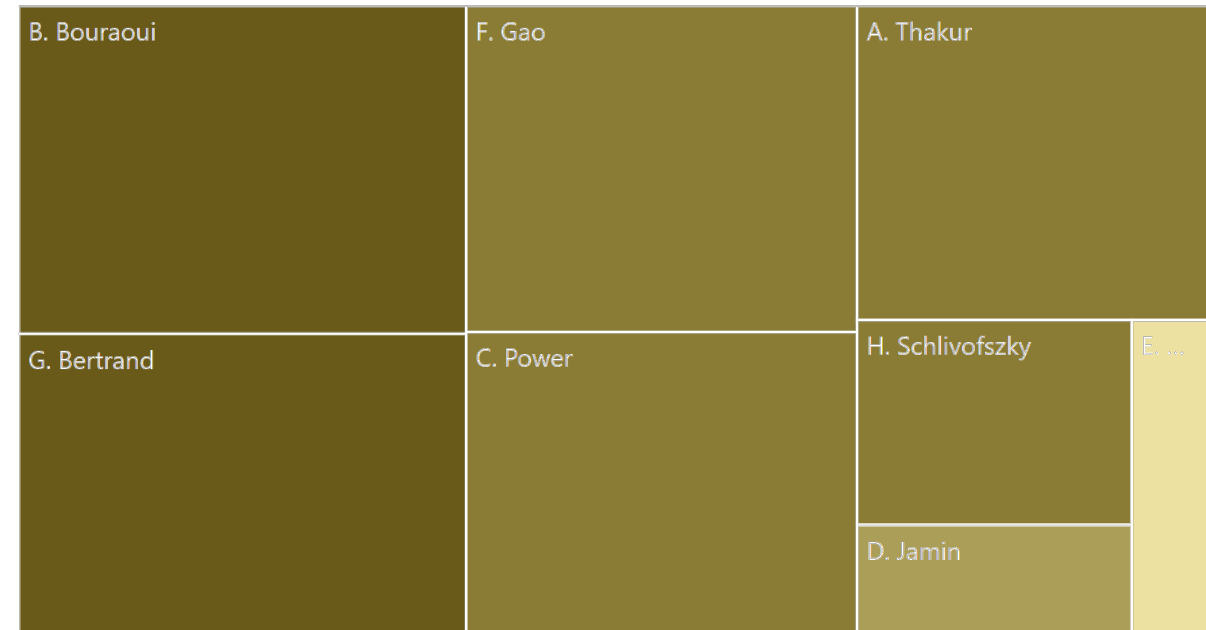


14. Make and Format a Treemap Chart (BS)

We can play around with the charts to get a better understanding of the data.

For instance, we could create a **treemap** showing the sum of “Item Amount” transactions by director.

Sum of Item Amount by Director



15. Create a Calculated Measure (BS)

It could also be handy to have a way to report the large transaction values as multiple of 1000\$.

We created a **calculated measure** that does so: “Item Amount \$k Measure”.

We will discuss measures further in a little while.

We create a new page for the dashboard, called “Exploration 2”, and we place a page filter on it to ensure that we are only using 2018 transactions.

16. Load a PBIX File (PA)

Load and explore `PBIFB - 2.pbix` (tasks 1-5, 8-10, 12-15).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

17. Create a Calculated Column (BS)

We can also act on the entire column to create a **new column**: we will do so with the same intent as the previous measure, “Item Amount \$k”.

Note that:

- “Item Amount \$k Measure” is a **measure** residing in the “_Measures” table
- “Item Amount \$k” is a **column** residing in the “Accounting Transactions” table

While they ostensibly relate to the same idea (and are both calculated using DAX formulas), they are emphatically **different Power BI entities** (more on this later).

18. Format Decimal Places (BS)

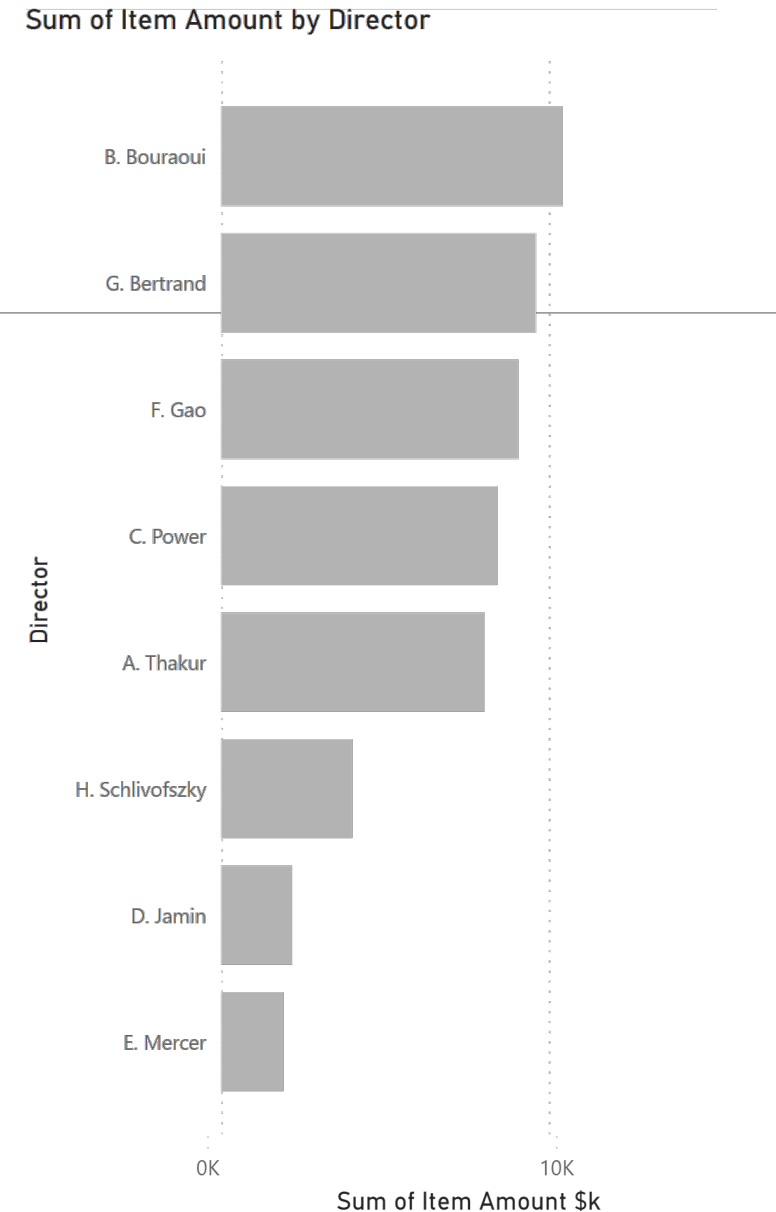
Power BI can format the data once it enters the model.

For instance, we can **format** the original “Item Amount” column and the calculated column “Item Amount \$k” (from the “Accounting Transactions” table) so that they are displayed with 2 **decimal places**.

19. Make and Format a Bar Chart (BS)

We create a **bar chart** showing the sum of “Item Amount \$k” for each director.

This is equivalent to the treemap chart of task 14 (except that the amounts are in 1000\$ of dollars).



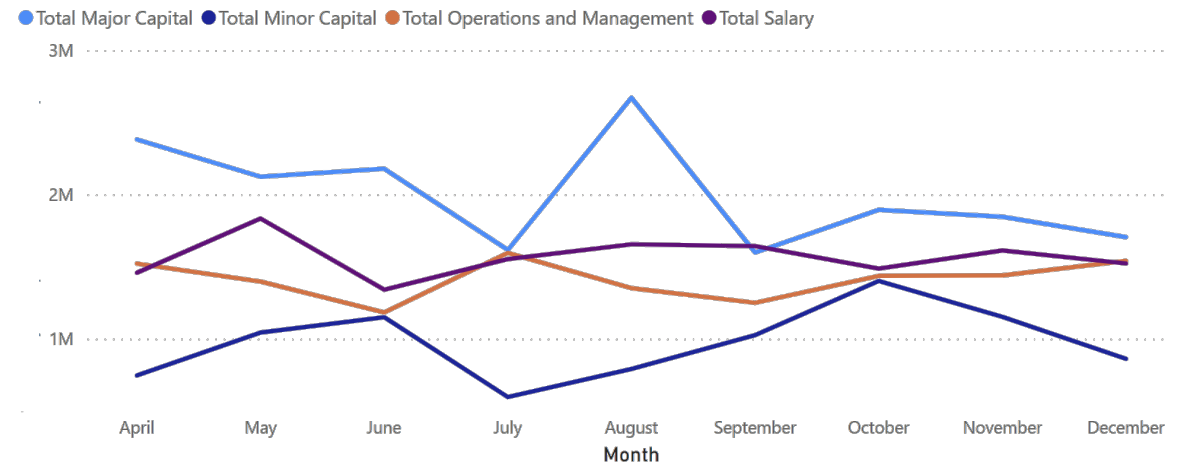
20. Make and Format a Line Chart (PA)

For some variables (dates, geography), we can create **hierarchies**.

We use such hierarchies to create a **line chart** (see detailed instructions, p. 3).

Take some time to play around with the hierarchies to drill down and up with the time series graph to become familiar with the concept.

Total Major Capital, Total Minor Capital, Total Operations and Management and Total Salary by Month



21. Create a Calculated Measure (ID)

There is a spike in the previous chart that seems like it would be worth exploring in more detail.

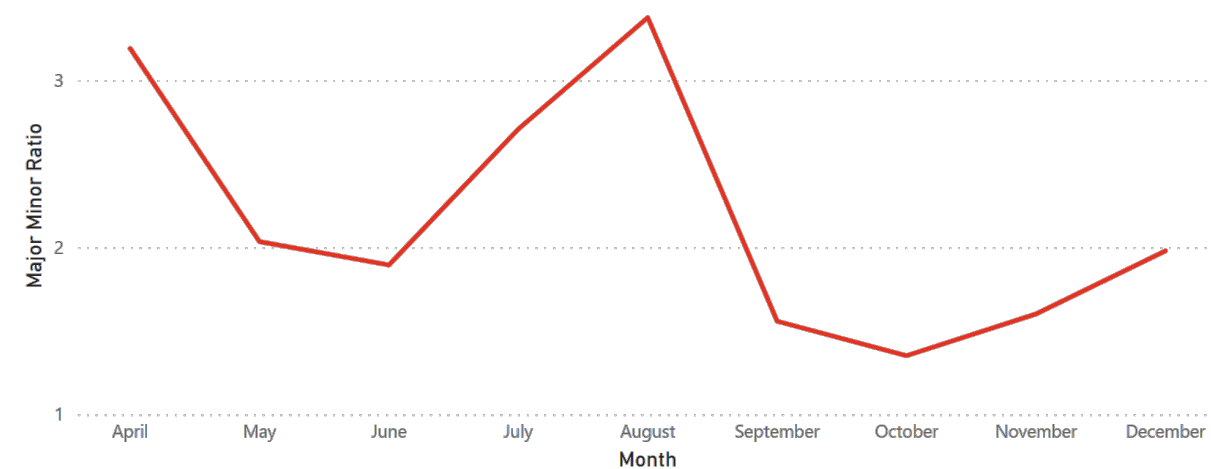
To do so, we create a **calculated measure** (built from two measures), the ratio of “Total Major Capital” to “Total Minor Capital”, denoted “Major Minor Ratio” (see detailed instructions, p. 3).

22. Make and Format a Line Chart (ID)

We create a new **line chart** displaying the “Major Minor Ratio” by Month, using the “Effective Date” hierarchy (see detailed instructions, p. 3).

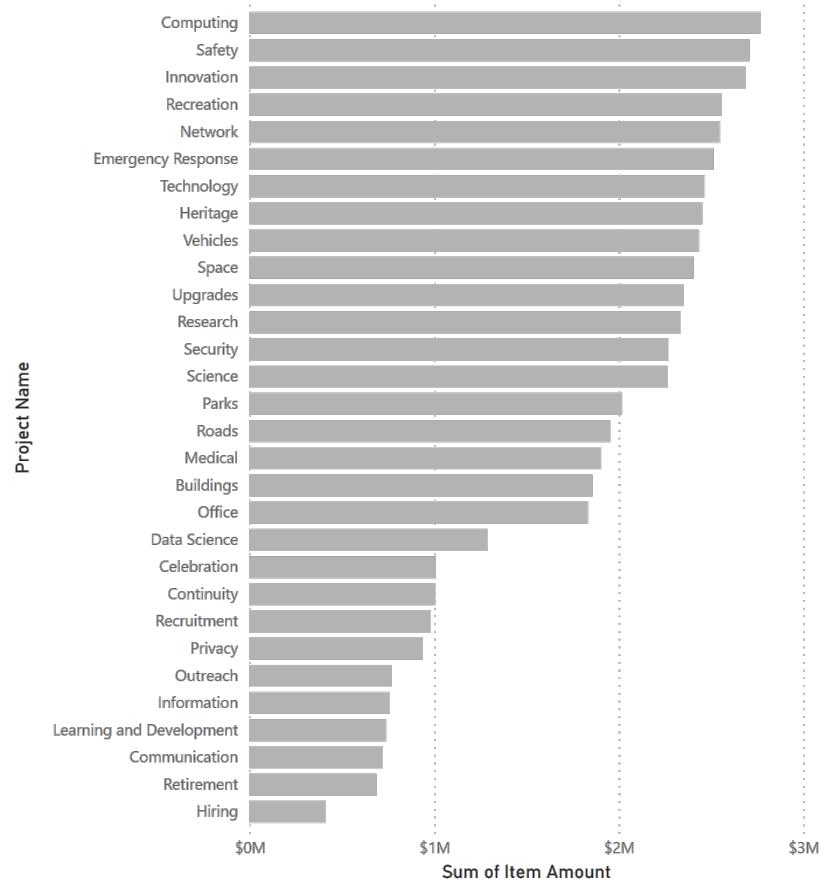
This “sombbrero” shape is unexpected... might it be worth monitoring the situation further?

Major Minor Ratio by Month

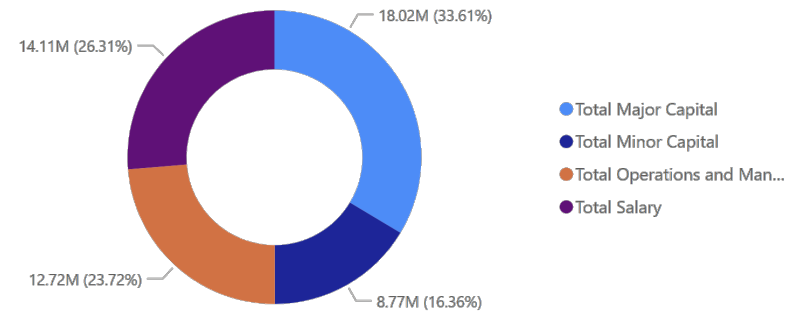


23. Exploring the Data (DD)

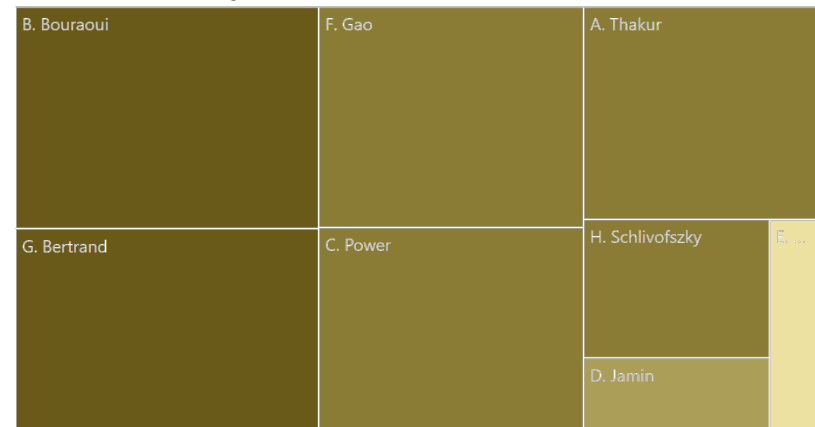
Sum of Item Amount by Project Name



Total Major Capital, Total Minor Capital, Total Operations and Management and Total Salary

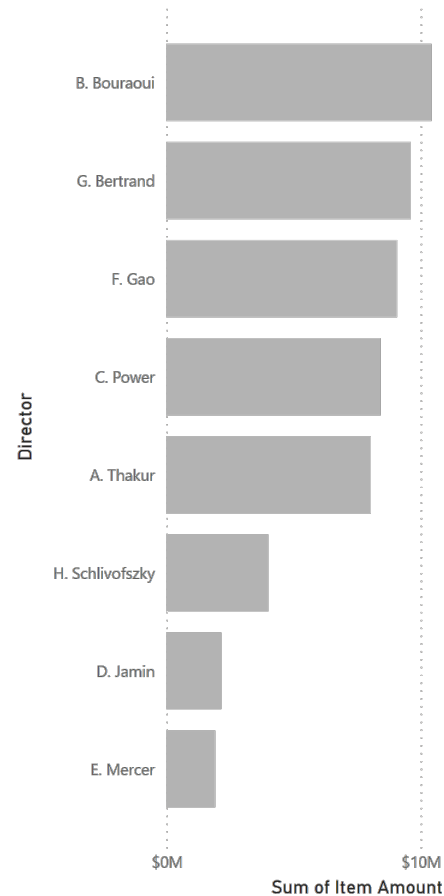


Sum of Item Amount by Director

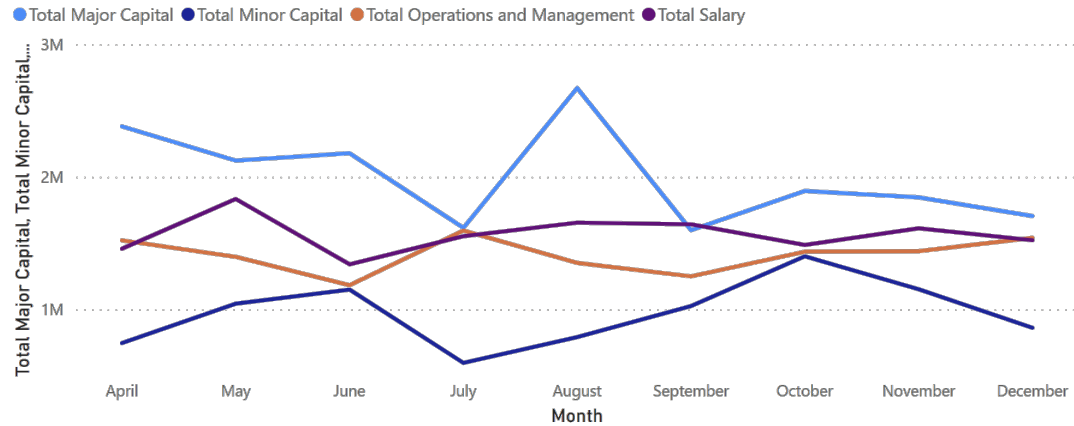


23. Exploring the Data (DD)

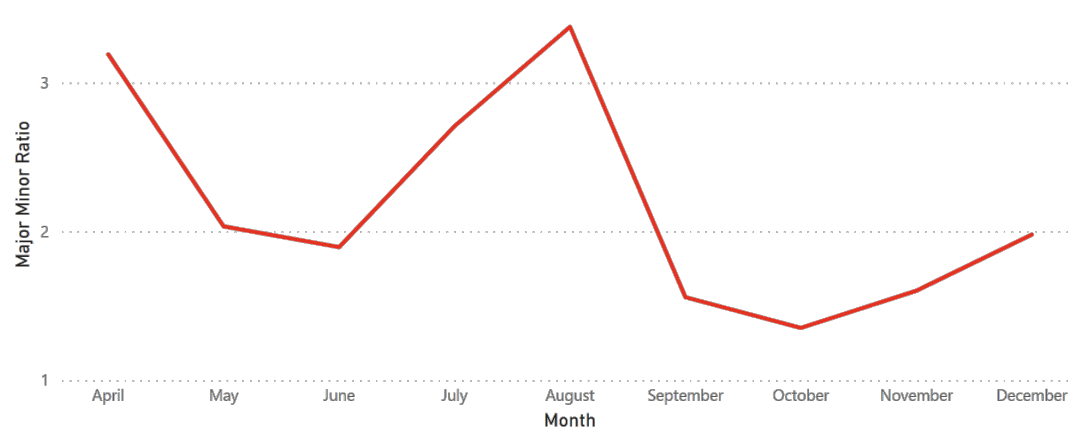
Sum of Item Amount by Director



Total Major Capital, Total Minor Capital, Total Operations and Management and Total Salary by Month



Major Minor Ratio by Month



Exercises

Data Exploration

1. Continue exploring the dashboard. Can you find anything interesting in the data?
2. Make and format the donut chart of task 13 using measures.
3. Make and format the treemap chart of task 14.
4. Create the calculated measure of task 15.
5. Create the calculated column of task 17.
6. Format to decimal places as in task 18.
7. Create new charts to help you explore the 2018 data.

IV. Situational Awareness

POWER BI FOR BEGINNERS

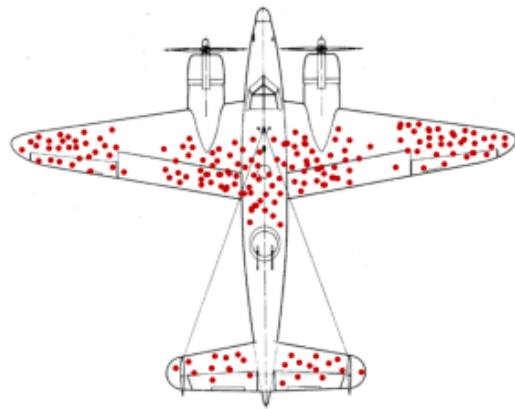
24. Dashboards (BN)

A **dashboard** is any visual display of data used to monitor conditions and/or facilitate understanding.

Examples:

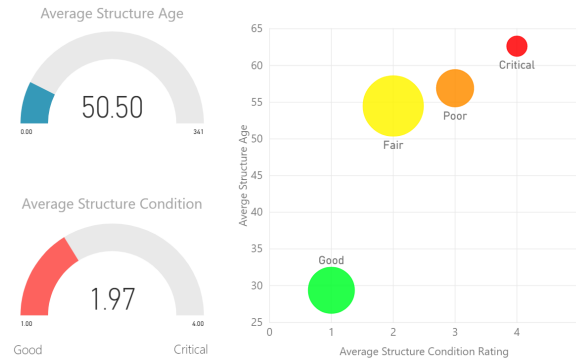
- interactive display that allows people to explore motor insurance claims by city, province, driver age, etc.
- PDF showing key audit metrics that gets e-mailed to a Department's DG on a weekly basis.
- wall-mounted screen that shows call centre statistics in real-time.
- mobile app that allow hospital administrators to review wait times on an hourly- and daily-basis for the current year and the previous year.

24. Defining Context (BN)



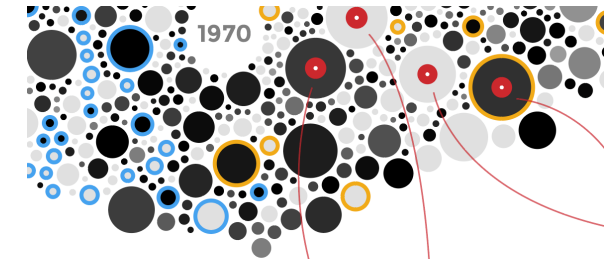
Directory of Federal Real Property (DFRP) Dashboard

You have selected 20,186 properties that contain 35,148 structures



Access to Information and Privacy (ATIP) search

You have currently selected 28,711 requests totaling 6,597,612 pages of information



The Beatles
No other artist or band has more songs in the Top 2000 as the Beatles. With 38 songs they are responsible for 14% of all titles before 1970. Nonetheless, only 5 years ago they still had 50 songs in the list.

- 4 Piano Man
Billy Joel 1974
- 5 Child in Time
Deep Purple 1972

Seconds

Minutes

Fraction of Hour

Hours

← Infographics/Data Viz →

← Dashboards →

← Reports and Exploration →

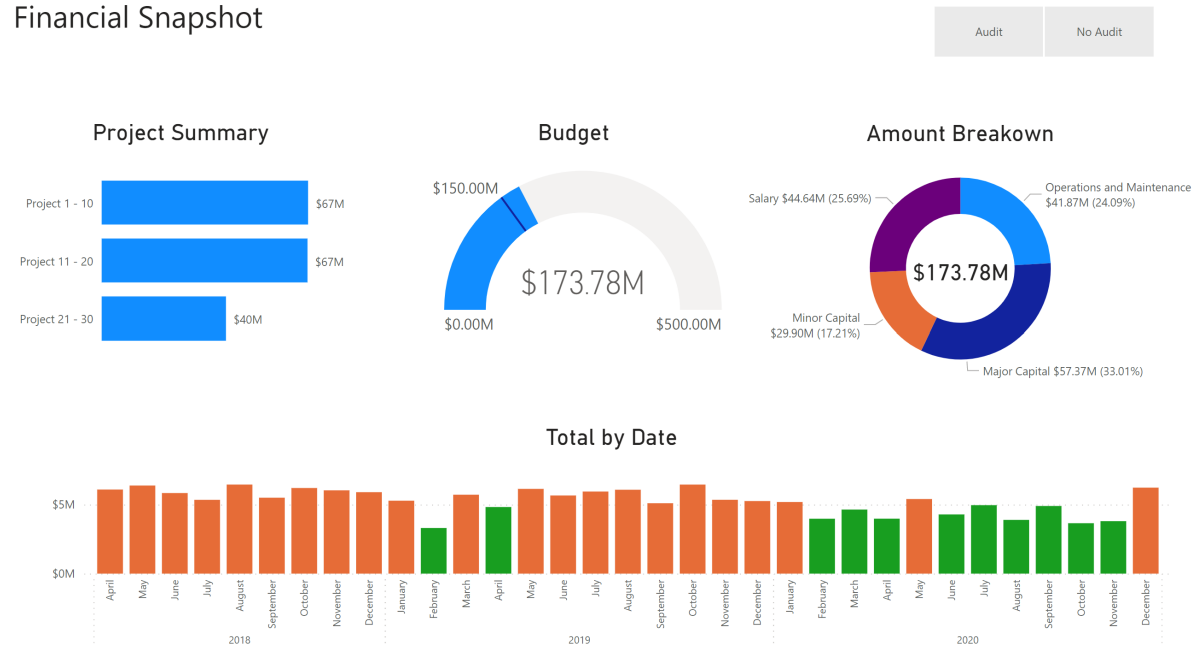
← Data Art →

24. Situational Awareness (BN)

Using visualizations as a tool to provide a snapshot of the data

- medium level of interactivity
- not “scripted” but well organized (e.g., categorized)
- summary data should be represented
- anomalies are highlighted
- often used for internal presentations

Financial Snapshot



25. Measures vs. Columns (BN)

In Excel, we add a calculation to a cell. In Power BI a calculation can “live” in one of three places (not including in Power Query – more on that in another course). We can do calculations that create:

1. a new **column** of data (a calculated column)
2. a new **data value** calculated solely to be used in a visualization (a calculated measure)
3. a new **data table** (a calculated table).

25. Measures vs. Columns (BN)

Calculated Columns are:

- additional **data columns** added to an existing data table
- evaluated for each row in the table, immediately after “Enter” is hit to complete the formula
- saved back into the model, therefore they take up space (with 1M data rows, a calculated column adds 1M new data points).

Calculated Measures are:

- evaluated only when used in a visual or when the visual is rendered (**function**)
- not “saved” anywhere (aside from the cache)
- preferred to calculated columns, but there are **trade-offs** with performance (report runtime vs. pre-processed), storage space, and the type of expressions that can be used.

25. Measures vs. Columns (BN)

When do we use calculated columns over measures? Sometimes either is an option, but in most situations **the computation needs determine the choice.**

A calculated **column** is used to do the following:

- place the calculated results in a slicer, or in the axis of a chart, or use the result as a filter condition in a DAX query;
- define an expression that is strictly bound to the current row (for example, “Cost * Volume” does not work on an average or on a sum of two or more columns);
- categorize text or numbers (for example, a range of values for a measure, a range of customer ages, such as 0–18, 18–25, etc.).

25. Measures vs. Columns (BN)

Typically, **measures** is used whenever a resulting calculation needs to be displayed in the values area in the plot area of a chart:

- for instance, in calculating the cost percentage on a certain selection of data;
- they can use data from many different tables and therefore don't "belong" to a table in the same way a calculated column is;
- it is good practice to create a separate "home" for our measures ("_Measures").

25. Measures vs. Columns (BN)

```
Total Amount = sum('Accounting Transactions'[Item Amount])
```

- the measure's name is "Total Amount".
- the operator "=" indicates the beginning of the formula; when calculated, it returns a result
- the function (in this case "sum") contains one argument, contained in the parentheses "()"
- the table from which we are taking the data is found before the brackets "[]"; in this case it is 'Accounting Transactions'.
- note that as the table name contains two words, it placed inside single quotations '. If the table name only had one word, it would not, i.e. Accounting_Transactions[Item Amount]
- the referenced column from the table is placed inside the "[]"; such as [Item Amount]

26. Load a PBIX File (PA)

Load and explore `PBIFB - 3.pbix` (tasks 1-5, 8-10, 12-15, 17-22).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

27. Create a Calculated Column (ID)

We can use DAX to apply **logical** operations.

Take a simple scenario in which we flag any transactions for which “Item Amount” is over \$100,000. We create a **calculated column** as follows:

- if the “Item Amount” is equal to or greater than \$100,000, then we add the word “Check”
- otherwise, we leave the value in the new column blank

(see the detailed instructions, p. 4)

Note that there is no filter on Effective Date year from this point on.

28. Make and Format a Table (BS)

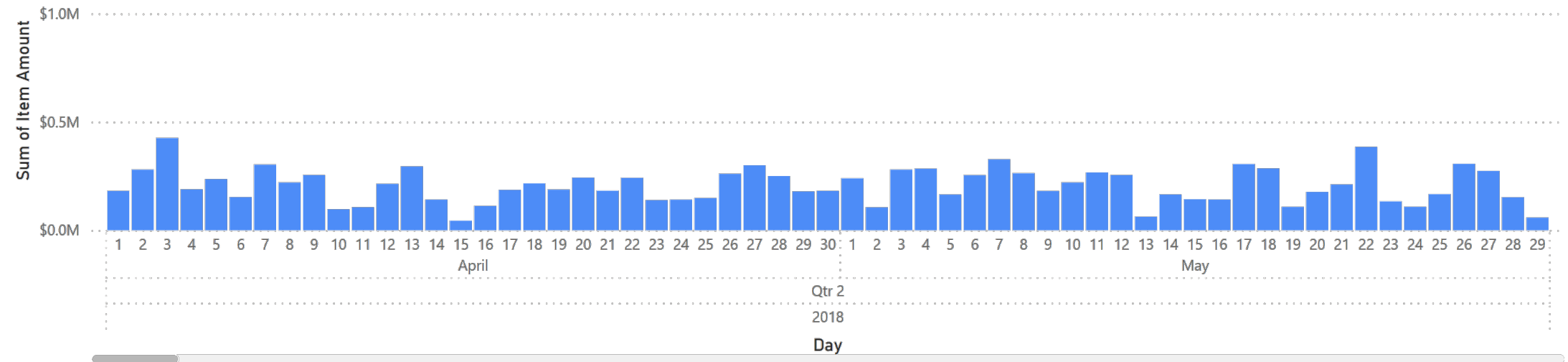
Visuals can also include **tables**.

Year	Quarter	Month	Day	Sum of Item Amount	Journal Voucher Type Code	Director	Project Name
2018	Qtr 2	April	1	\$142,784.27	MC	A. Thakur	Parks
2018	Qtr 2	April	1	\$8,200.00	MIC	C. Power	Emergency Response
2018	Qtr 2	April	1	\$30,726.24	MIC	G. Bertrand	Upgrades
2018	Qtr 2	April	1	\$98.01	SA	H. Schlivofszky	Retirement
2018	Qtr 2	April	2	\$177,734.54	MC	A. Thakur	Heritage
2018	Qtr 2	April	2	\$24,396.61	MIC	G. Bertrand	Buildings
2018	Qtr 2	April	2	\$46,988.90	O&M	B. Bouraoui	Innovation
2018	Qtr 2	April	2	\$30,537.94	SA	G. Bertrand	Vehicles
2018	Qtr 2	April	3	\$133,761.63	MC	C. Power	Emergency Response
2018	Qtr 2	April	3	\$152,362.31	MC	F. Gao	Computing
2018	Qtr 2	April	3	\$54,956.46	O&M	A. Thakur	Recreation
2018	Qtr 2	April	3	\$84,391.34	SA	B. Bouraoui	Research
2018	Qtr 2	April	4	\$84,577.96	MC	B. Bouraoui	Space
2018	Qtr 2	April	4	\$55,524.68	MIC	F. Gao	Network
Total				\$175,122,811.75			

29. Make and Format a Column Chart (BS)

There are enough transactions in the dataset to produce a daily **bar chart time series** (note the necessary scroller).

Sum of Item Amount by Year, Quarter, Month and Day



30. Load a PBIX File (PA)

Load and explore `PBIFB - 4.pbix` (tasks 1-5, 8-10, 12-15, 17-22, 27-29).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

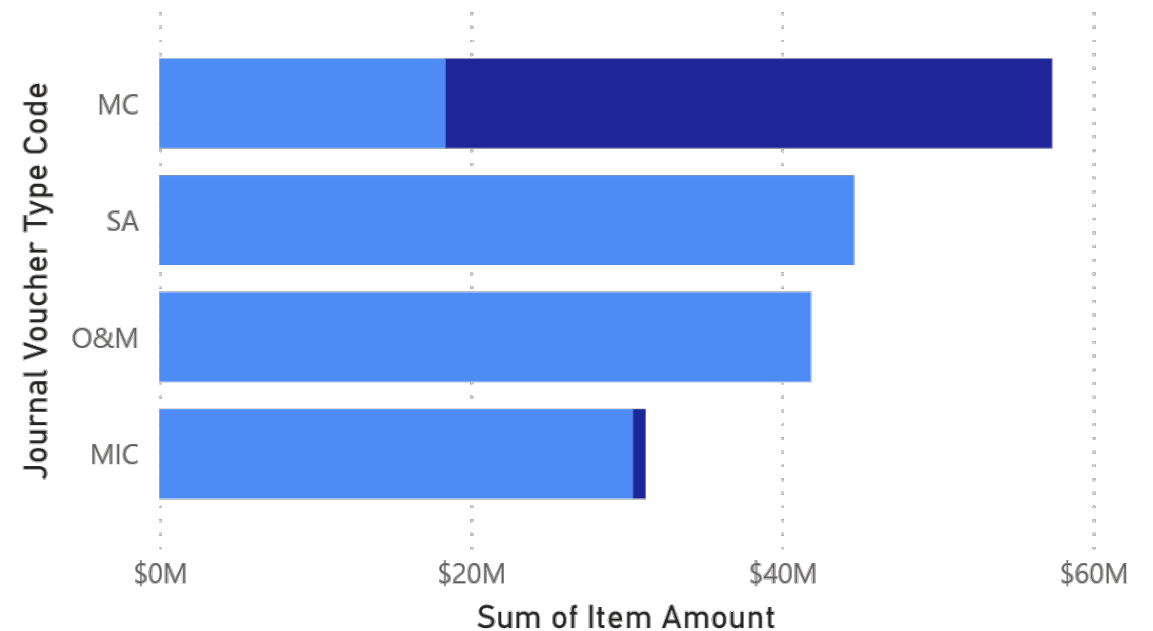
31. Make and Format a Bar Chart (PA)

We create a **bar chart** that uses the “Check amount” calculated column, for the various JVTC (see detailed instructions, p. 4).

Do you notice anything surprising?

Sum of Item Amount by Journal Voucher Type Code and Check amount

Check amount ● (Blank) ● Check



32. Make Slicers (PA)

We create a “Director” **slicer** and a “Journal Voucher Type Code” **slicer** for the “Monitoring 2” page (see detailed instructions, p. 4).

The “Check amount” irregularity from the previous bar chart suggests that it could be useful to monitor transactions in the Minor Capital (MIC) regime (especially for director C. Power).

Director ▼

- A. Thakur
- B. Bouraoui
- C. Power
- D. Jamin
- E. Mercer
- F. Gao
- G. Bertrand
- H. Schlivofszky

Journal Voucher T... ▼

- MC
- MIC
- O&M
- SA

33. Load a PBIX File (PA)

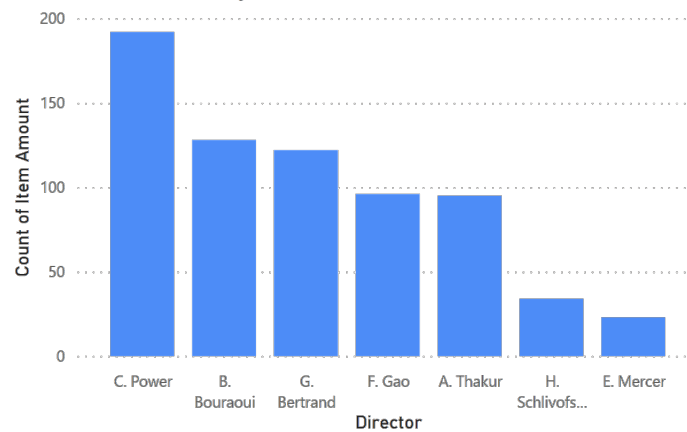
Load and explore `PBIFB - 5.pbix` (tasks 1-5, 8-10, 12-15, 17-22, 27-29, 31-32).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

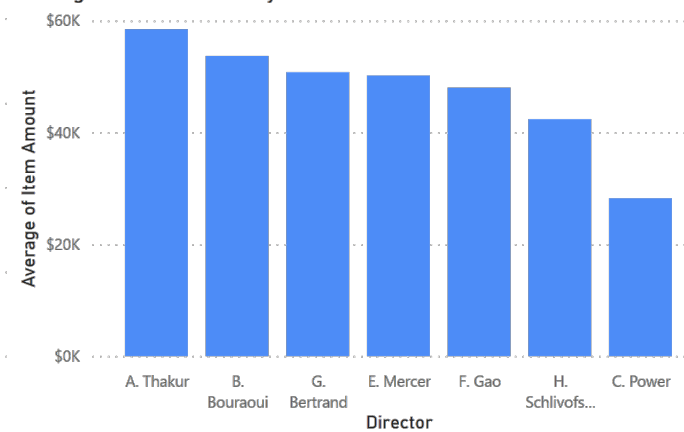
34. Make and Format Column Charts (ID)

We can compute various **statistics** for each of the directors: # transactions, average/standard deviation of “Item Amount”, etc. (see detailed instructions, pp. 4-5). Note that C. Power has **outlying** behaviour.

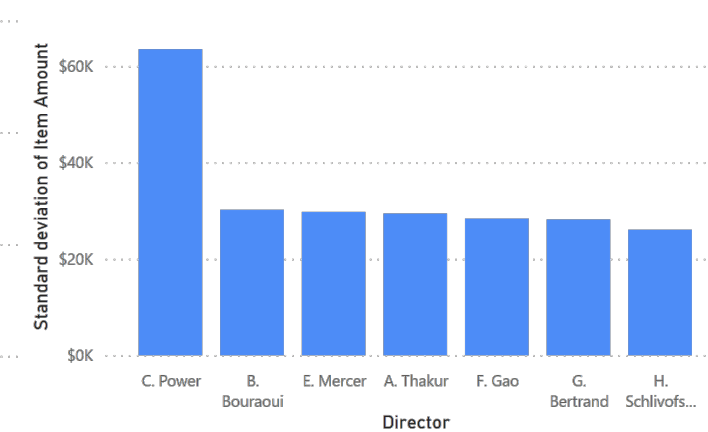
Count of Item Amount by Director



Average of Item Amount by Director



Standard deviation of Item Amount by Director



35. Load a PBIX File (PA)

Load and explore `PBIFB - 6.pbix` (tasks 1-5, 8-10, 12-15, 17-22, 27-29, 31-32, 34).

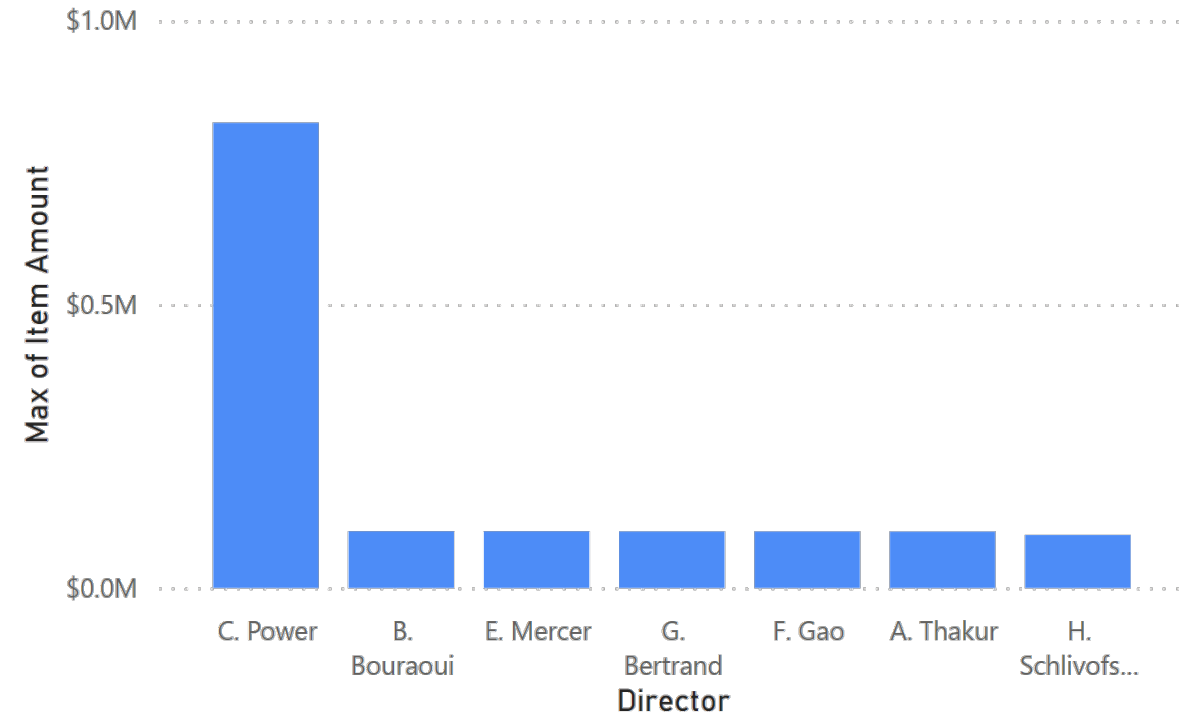
1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

36. Make and Format a Column Chart (PA)

We can compute various **statistics** for each of the directors: maximum “Item Amount”, in this case (see detailed instructions, p. 5).

Note that C. Power again has **outlying** behaviour.

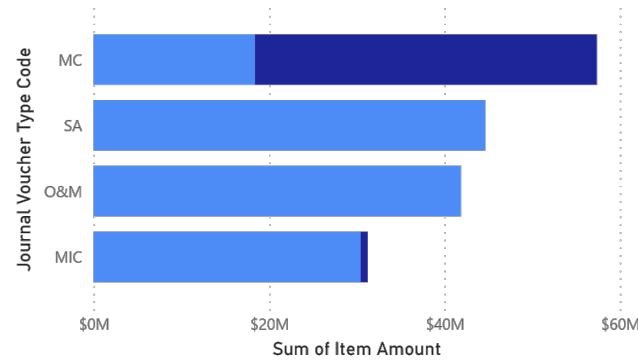
Max of Item Amount by Director



37. Monitoring the Situation (DD)

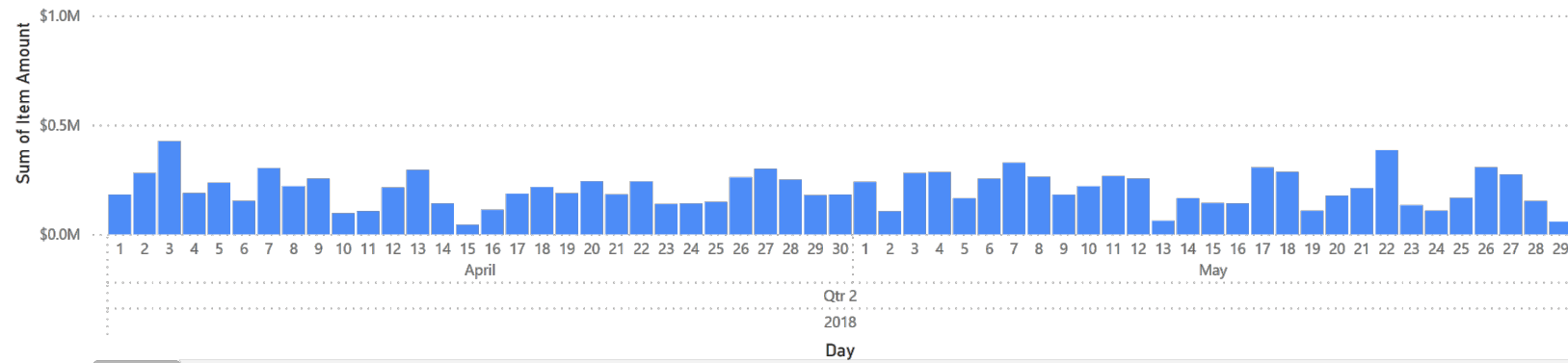
Sum of Item Amount by Journal Voucher Type Code and Check amount

Check amount (Blank) (Check)

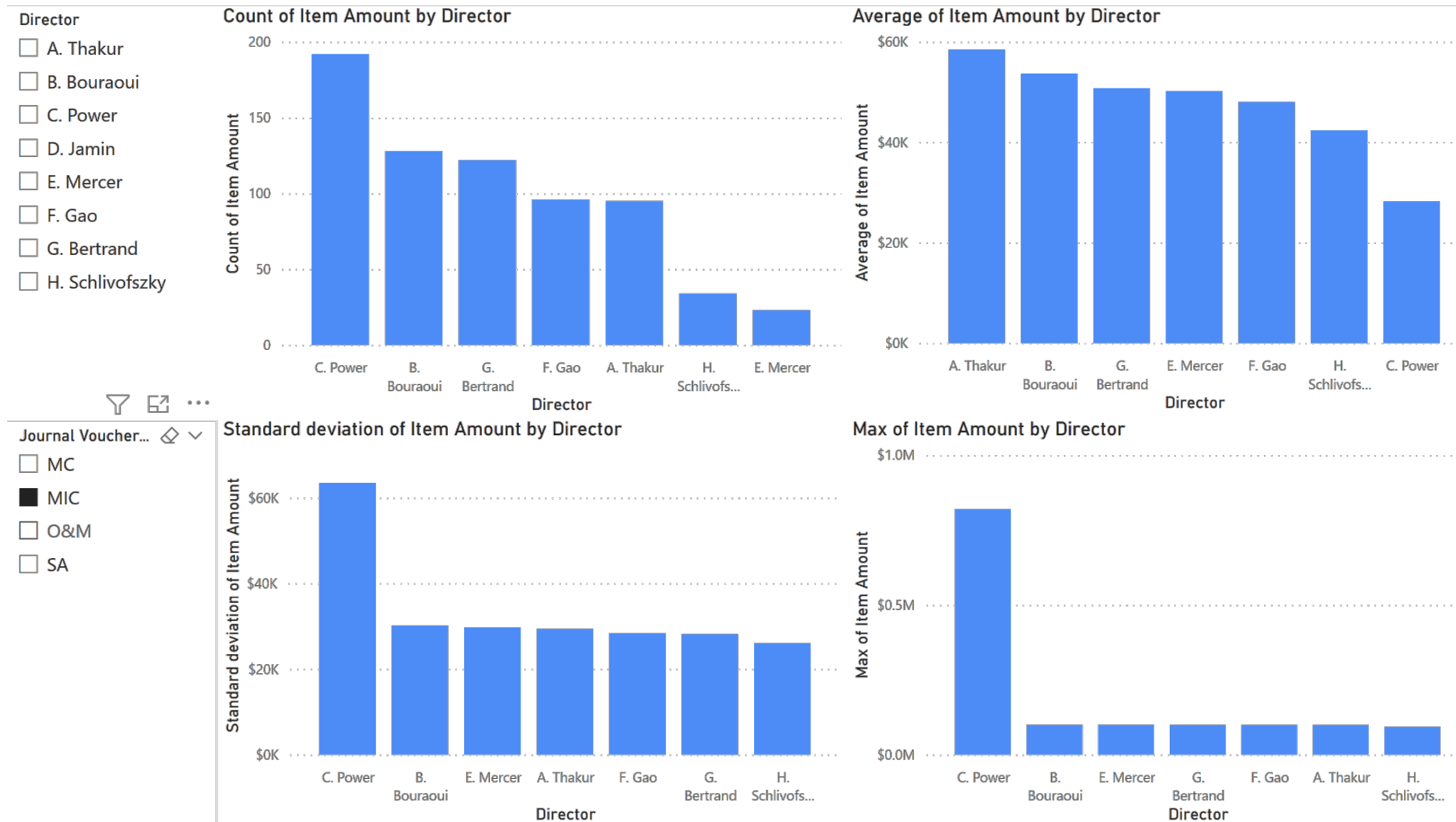


Year	Quarter	Month	Day	Sum of Item Amount	Journal Voucher Type Code	Director	Project Name
2018	Qtr 2	April	1	\$142,784.27	MC	A. Thakur	Parks
2018	Qtr 2	April	1	\$8,200.00	MIC	C. Power	Emergency Response
2018	Qtr 2	April	1	\$30,726.24	MIC	G. Bertrand	Upgrades
2018	Qtr 2	April	1	\$98.01	SA	H. Schlivofszky	Retirement
2018	Qtr 2	April	2	\$177,734.54	MC	A. Thakur	Heritage
2018	Qtr 2	April	2	\$24,396.61	MIC	G. Bertrand	Buildings
2018	Qtr 2	April	2	\$46,988.90	O&M	B. Bouraoui	Innovation
2018	Qtr 2	April	2	\$30,537.94	SA	G. Bertrand	Vehicles
2018	Qtr 2	April	3	\$133,761.63	MC	C. Power	Emergency Response
2018	Qtr 2	April	3	\$152,362.31	MC	F. Gao	Computing
2018	Qtr 2	April	3	\$54,956.46	O&M	A. Thakur	Recreation
2018	Qtr 2	April	3	\$84,391.34	SA	B. Bouraoui	Research
2018	Qtr 2	April	4	\$84,577.96	MC	B. Bouraoui	Space
2018	Qtr 2	April	4	\$55,524.68	MIC	F. Gao	Network
Total				\$175,122,811.75			

Sum of Item Amount by Year, Quarter, Month and Day



37. Monitoring the Situation (DD)



Exercises

Situational Awareness

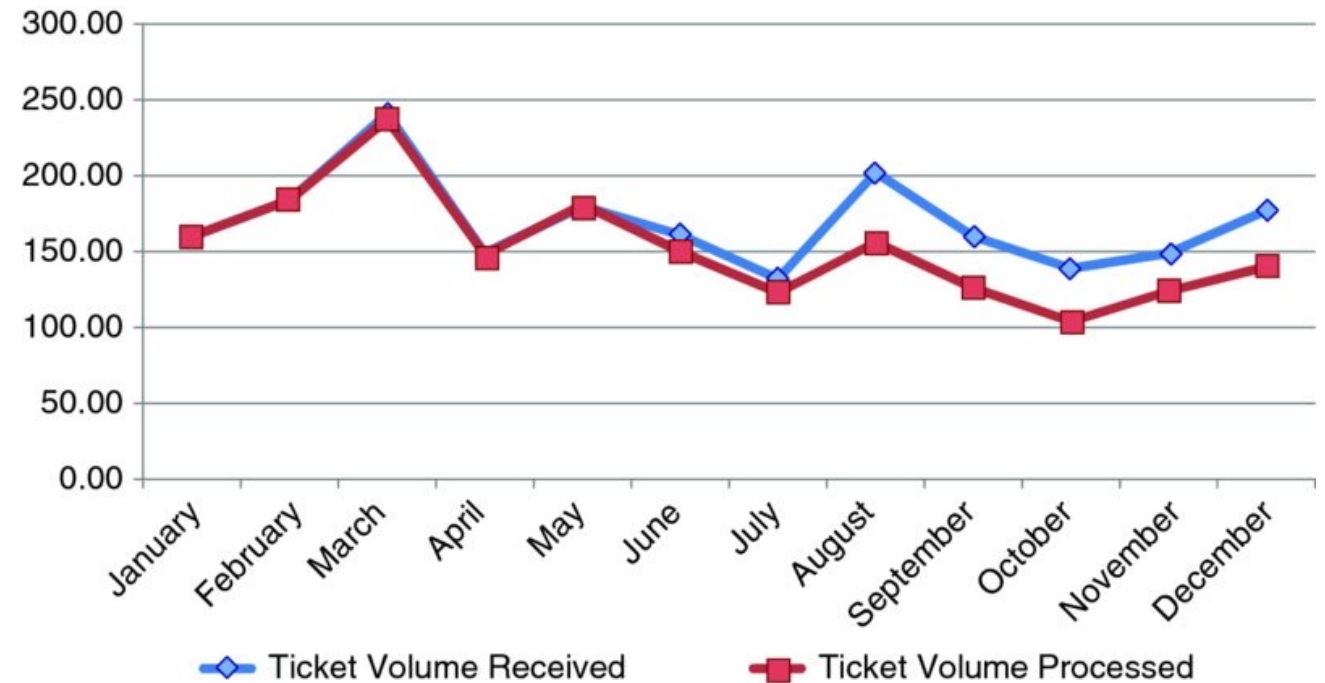
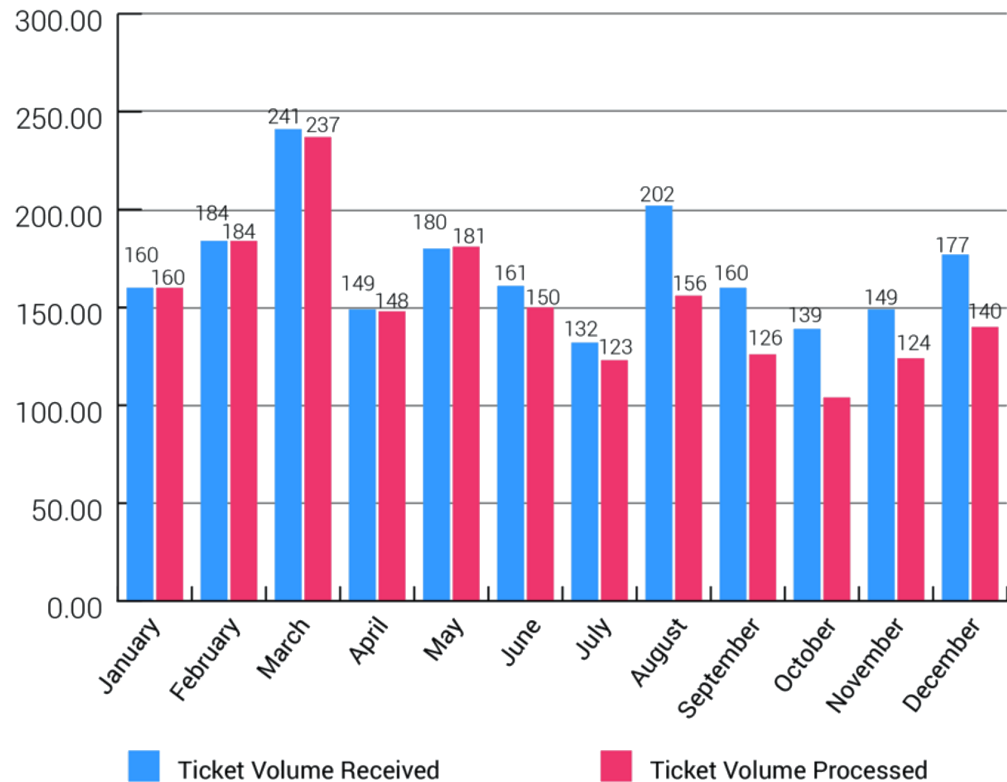
1. Continue exploring the dashboard. Can you find anything interesting in the data?
2. Make and format the table of task 28.
3. Make and format the column chart of task 29.
4. Create new charts, using calculated measures and columns as necessary, to help you monitor the situation in the dataset.

V. Storybook

POWER BI FOR BEGINNERS

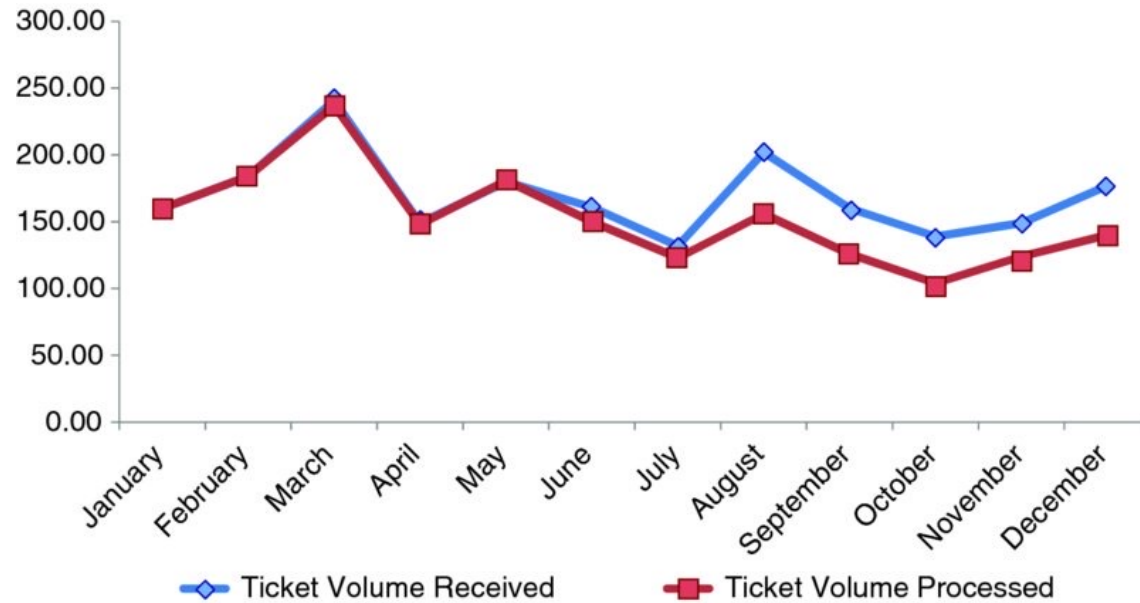
38. Evolving a Chart (BN)

TICKET TREND

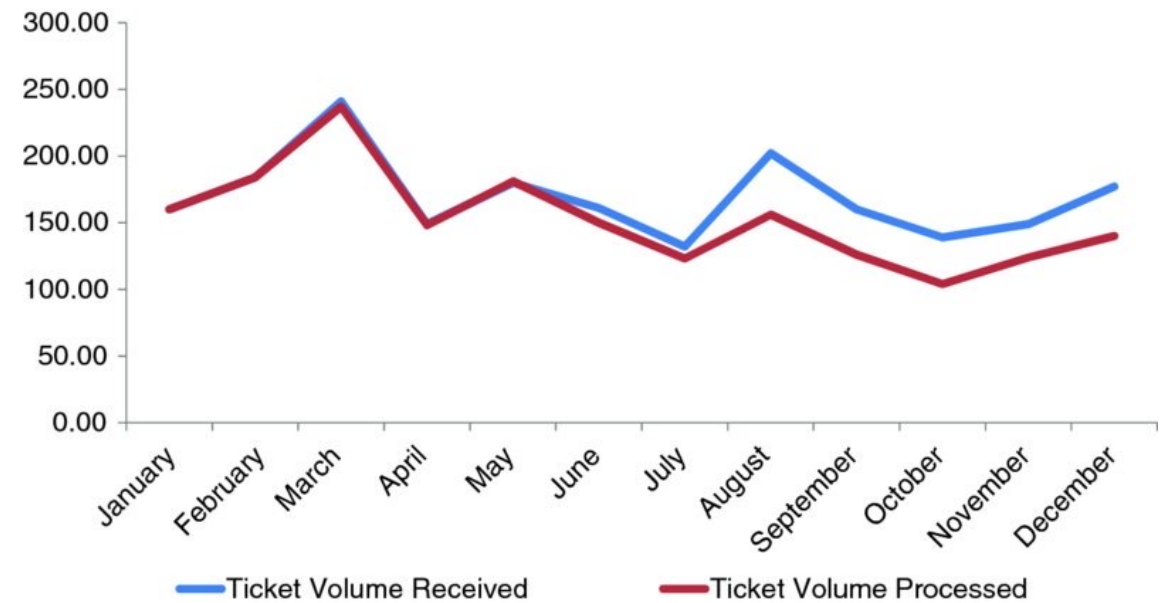


1. Change graph type (trope)

38. Evolving a Chart (BN)

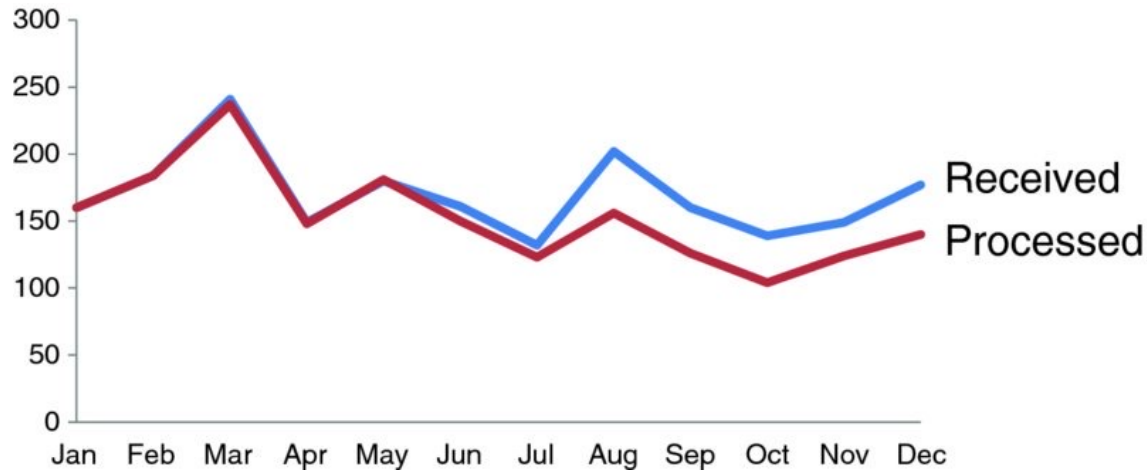


2. Remove border and gridlines

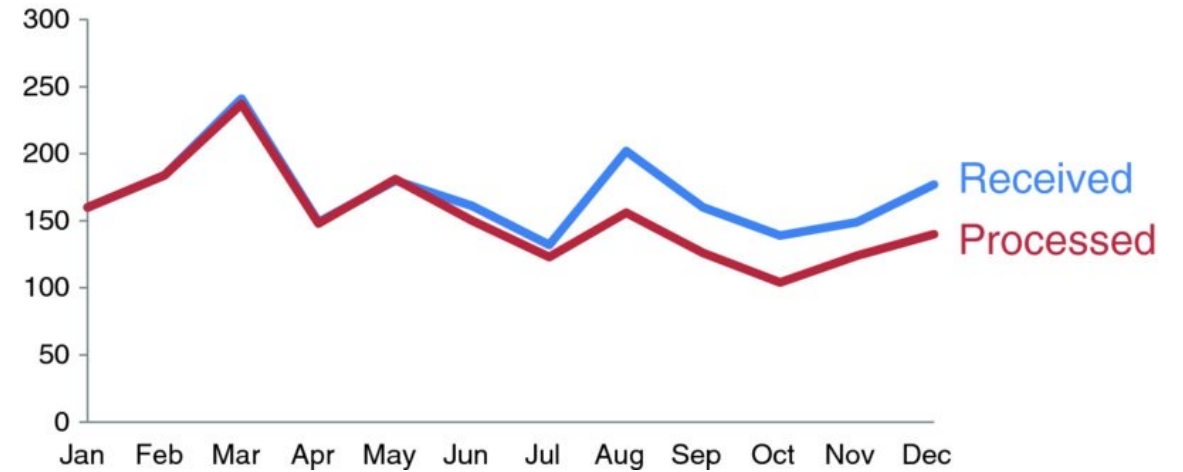


3. Remove markers

38. Evolving a Chart (BN)



4. Clean-up axis labels and legend

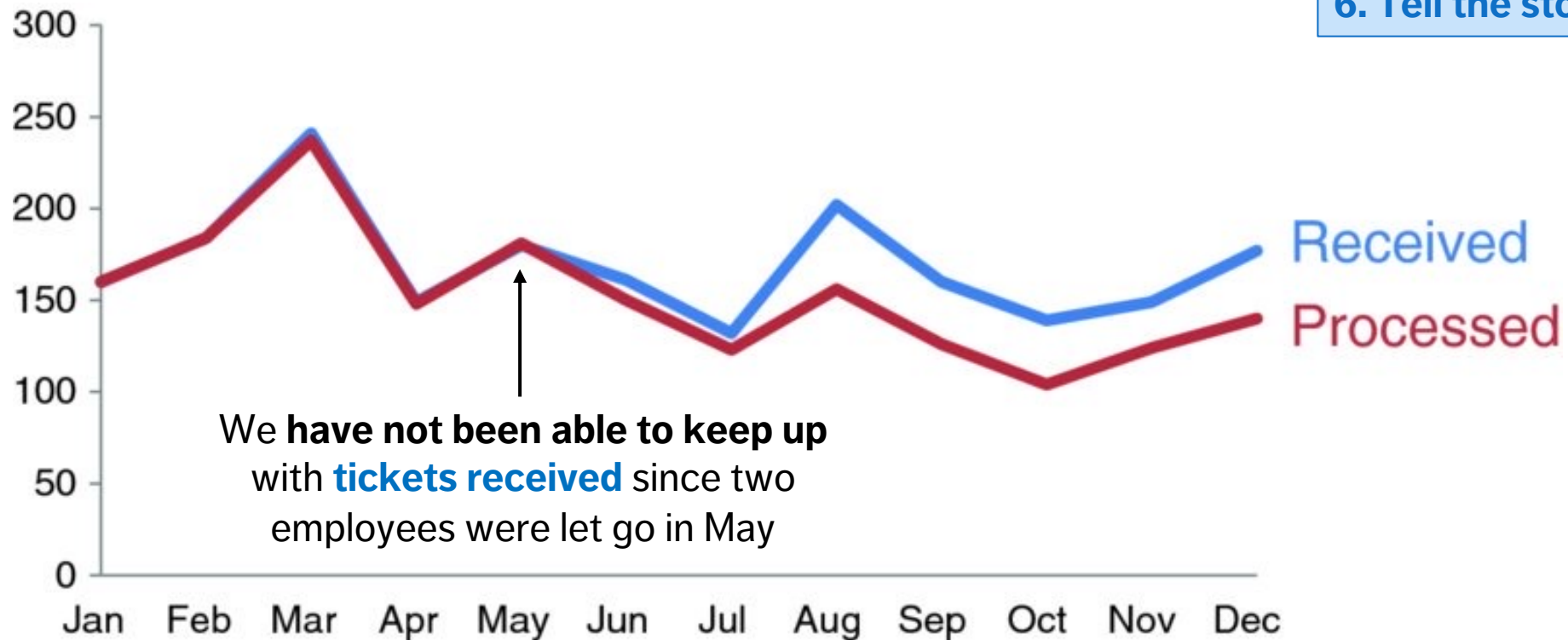


5. Colour code the lines

38. Evolving a Chart (BN)

Lag in Tickets Processed Since May Layoffs

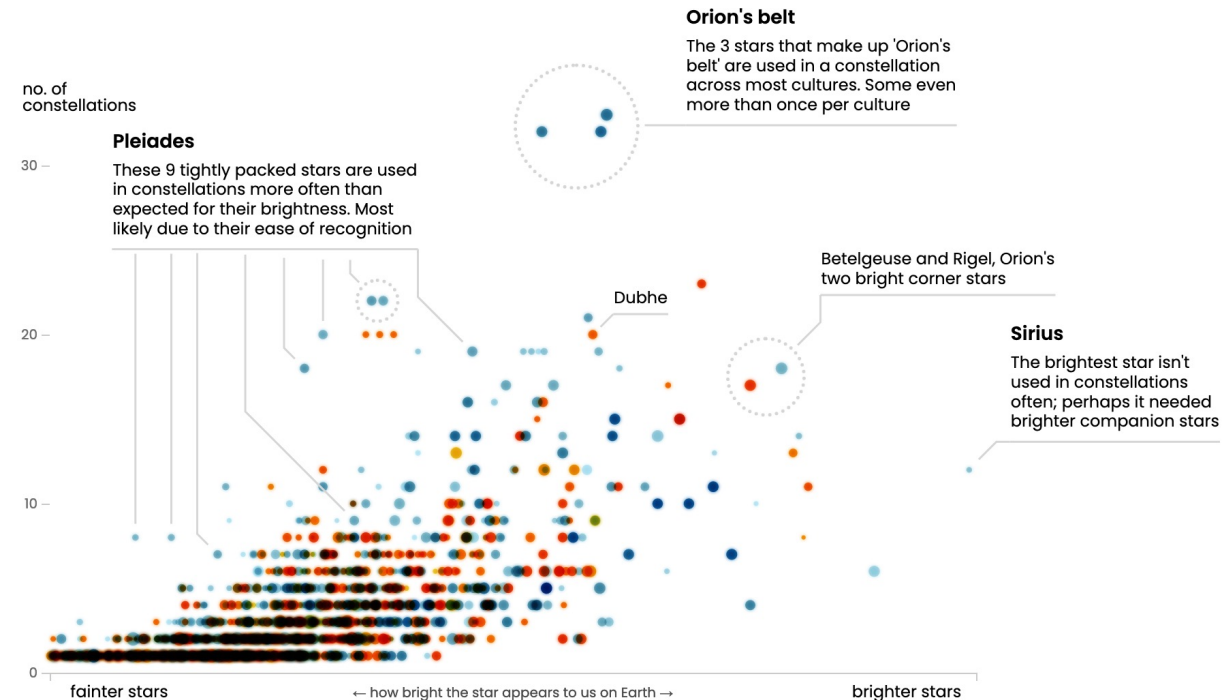
6. Tell the story



38. Storytelling with Data (BN)

Using visualizations as a tool to explain the data and communicate the story

- low level of interactivity
- low level of detail
- key aspects of data should be represented
- annotations and explanations drive the “story”



39. Create a Calculated Column (ID)

When we were monitoring the situation, we realized that there was a potential issue with C. Power transactions:

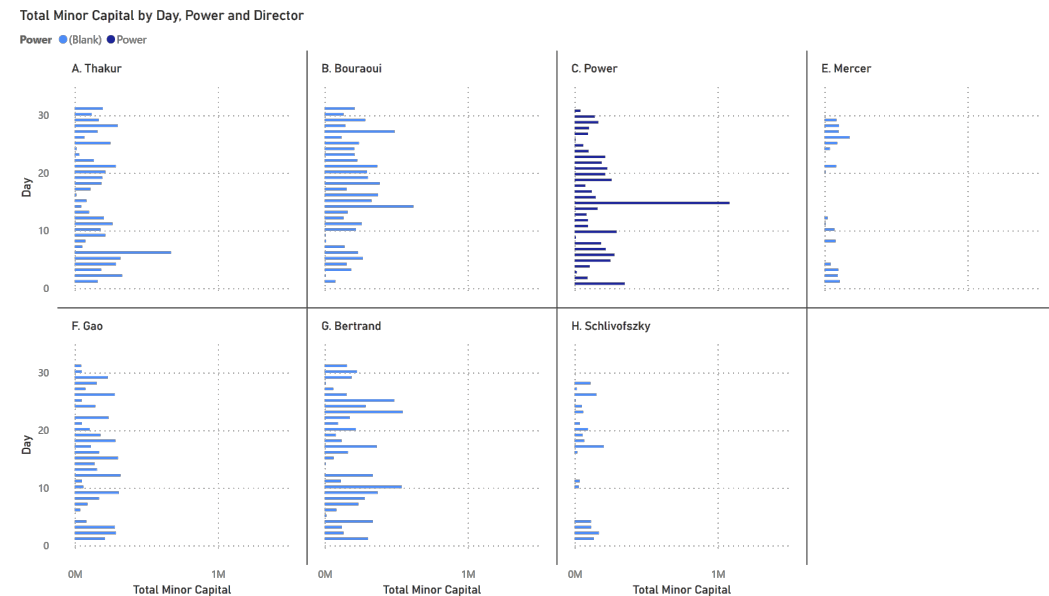
- gigantic 820,000\$ transactions coded as Minor Capital late in the data
- small average transaction value
- small standard deviation value

We create a “Power” **calculated column** (identifying all transactions assigned to this director) to assist with storytelling (see detailed instructions, p. 5).

40. Make and Format Small Multiples (ID)

We use this calculated measure to display a **bar chart small multiple**, displaying the total minor capital for each day of the month, for each director separately, with a different colour for C. Power (see detailed instructions, p. 5).

The profiles for 5 of the 7 directors show high daily transaction volumes, but there is an **anomaly!**



41. Make and Format a Bar Chart (ID)

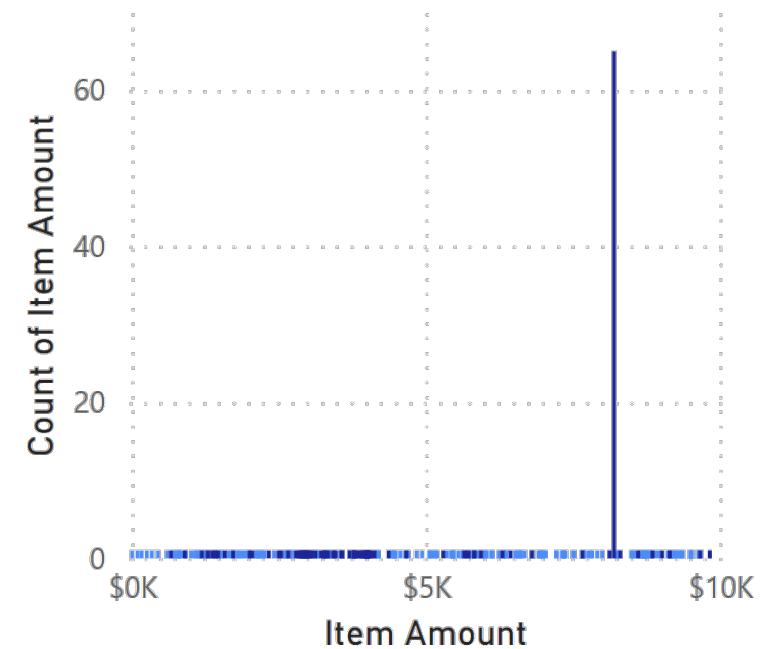
The last panel is empty; we create a visual that showcases the **frequency** of individual “Item Amount” values (see detailed instruction, pp. 5-6).

All values are unique, except for 8200\$, which appears in **64** transactions by ... C. Power – the game is afoot!

(this is easier to spot with a chart filter).

Count of Item Amount by Item Amount and Power

Power ● (Blank) ● Power



42. Load a PBIX File (PA)

Load and explore `PBIFB - 7.pbix` (tasks 1-5, 8-10, 12-15, 17-22, 27-29, 31-32, 34, 39-41).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

43. Apply a Page Filter (PA)

So we have discovered that small Minor Capital transactions (<10,000\$) are highly unusual in this dataset.

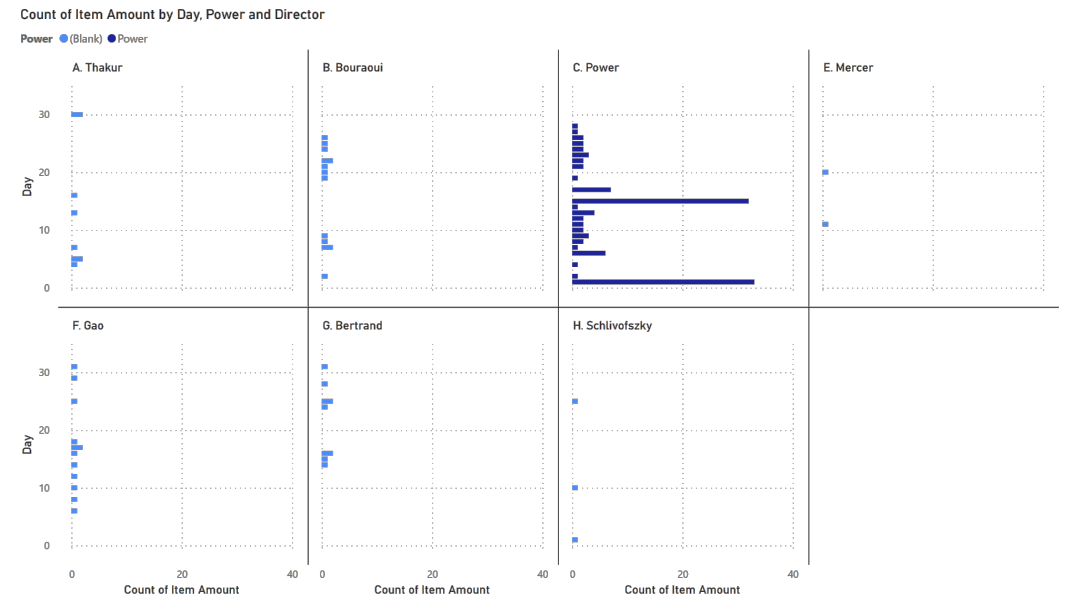
We apply a **page filter** to “Storybook 2” so that the corresponding charts are all affected by a 10,000\$ “Item Amount” limit (see detailed instructions, p. 6).

44. Make and Format Small Multiples (PA)

The odd nature of C. Power's small regime transactions (<10,000\$) is clear from the **small multiple storytelling bar chart**: the unusual transactions take place regularly (1st, 15th of every month) and no other director has even a fraction of the # of small transactions.

Cart him off to jail!

(see detailed instructions, p. 6)

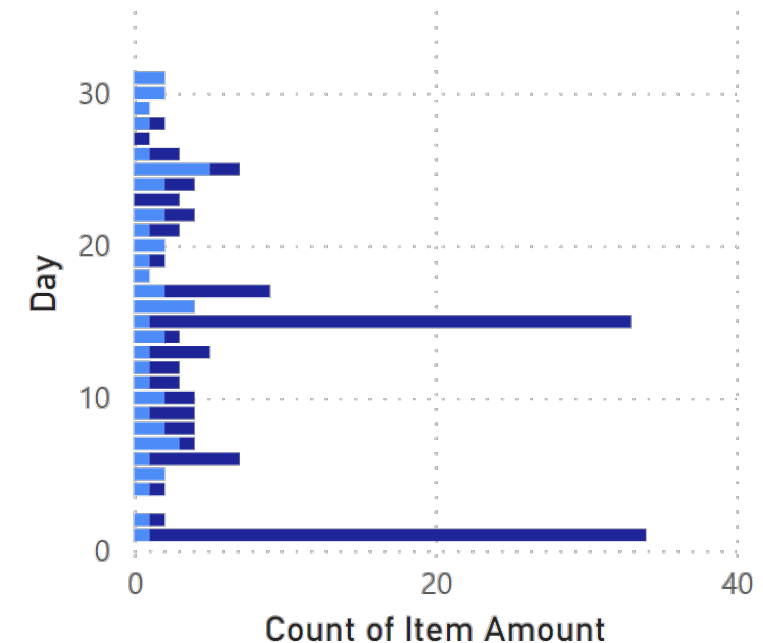


45. Make and Format a Bar Chart (PA)

The last panel is empty; we create a visual that showcases the **frequency** of daily “Item Amount” transactions, with an emphasis on C. Power’s contribution to the overall profile (see detailed instruction, p. 6).

Count of Item Amount by Day and Power

Power ● (Blank) ● Power



46. Annotate a Bar Chart (BN)

The best data stories are combinations of **text** and **visuals**.

Power BI is not necessarily the greatest tool for that last step (although it can do some of it, it does not do so naturally); don't hesitate to use other tools as needed.

47. Load a PBIX File (PA)

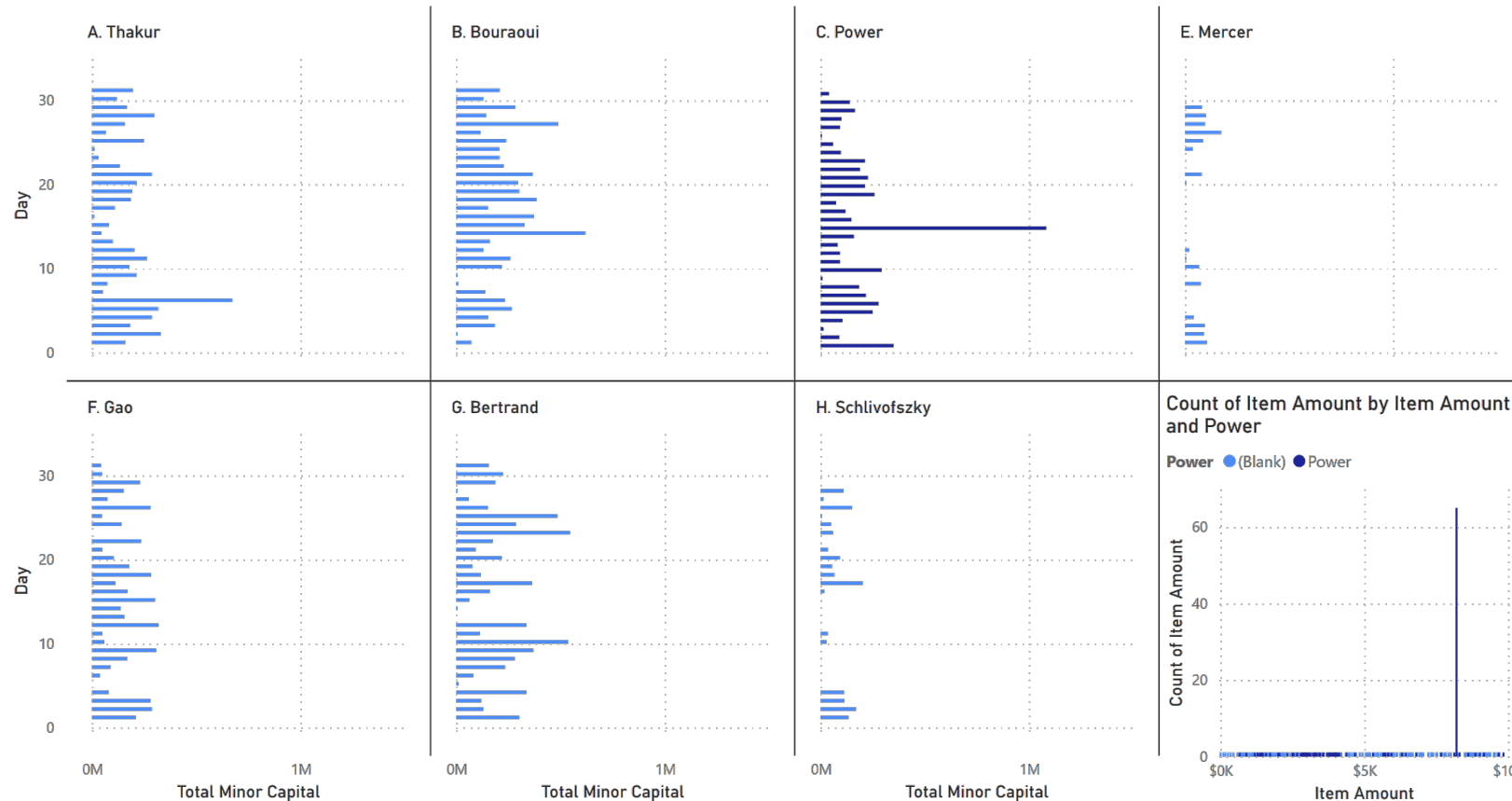
Load and explore `PBIFB - 8.pbix` (tasks 1-5, 8-10, 12-15, 17-22, 27-29, 31-32, 34, 39-41, 43-46).

1. Go to “Transform Data” in the “Home” Ribbon.
2. Click on “Data Source Settings”.
3. Highlight one of the data files.
4. Click on “Change Source”.
5. Click on “Browse” and navigate to the corresponding file’s location on your system.
6. Repeat for the other file.
7. Press “Close”.
8. Apply changes from the yellow warning message.

48. Convincing an Audience (DD)

Total Minor Capital by Day, Power and Director

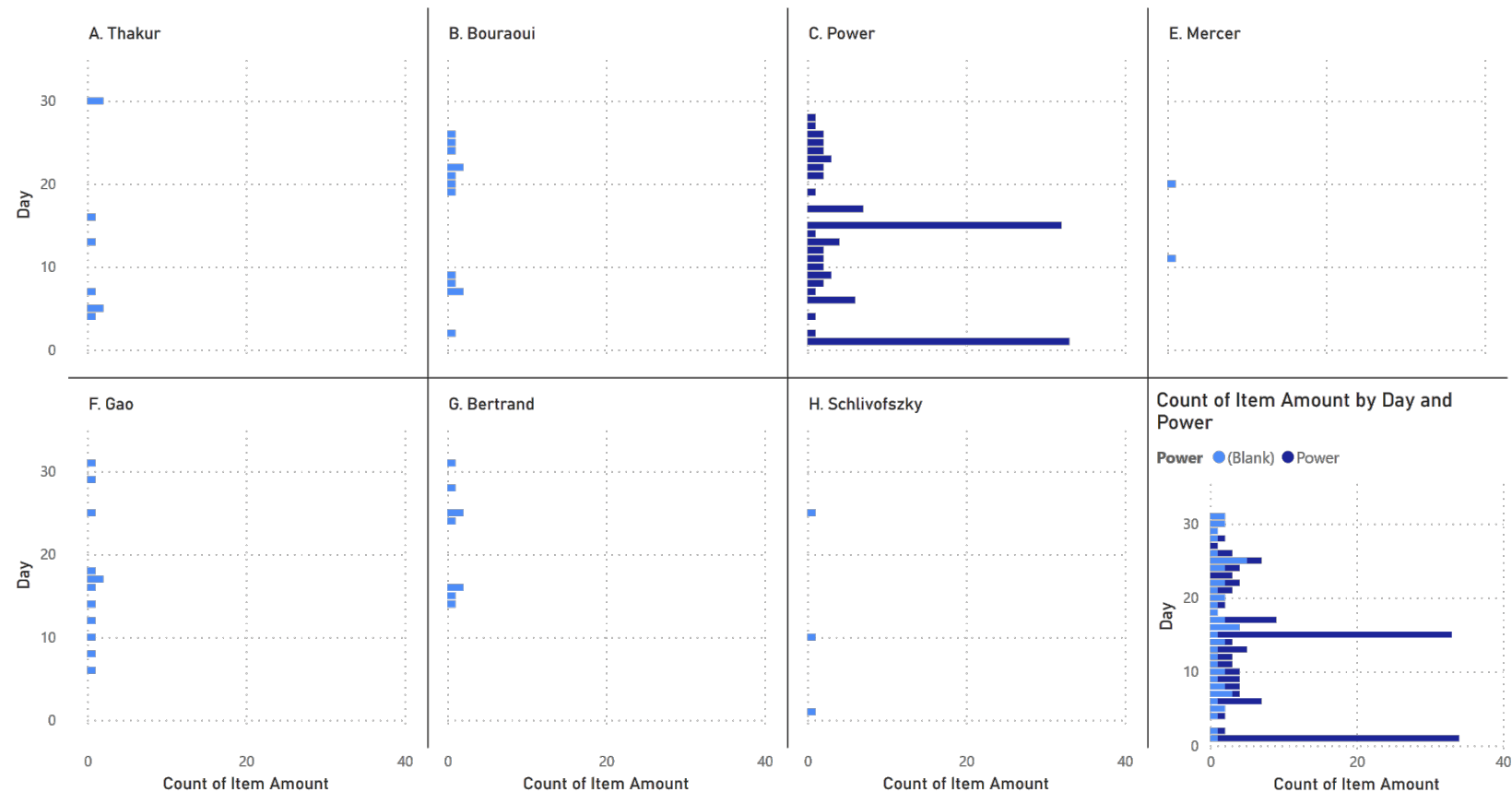
Power ●(Blank) ●Power



48. Convincing an Audience (DD)

Count of Item Amount by Day, Power and Director

Power ●(Blank) ●Power



Exercises

Storybook

1. Annotate the storybooks of tasks 48.
2. Create new storybooks for the data, and annotate them.

VI. Miscellanea*

POWER BI FOR BEGINNERS

49. Publish a Power BI Dashboard (BN)

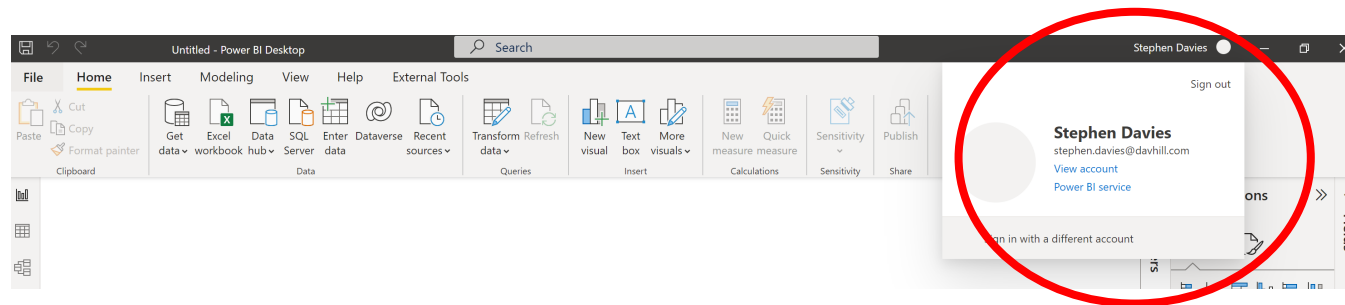
Once the dashboard is created, it can be “published” it to a website as an **iFrame** (a webpage inside a webpage).

This allows audiences to fully interact with the dashboard without the need to install Power BI on their computers.

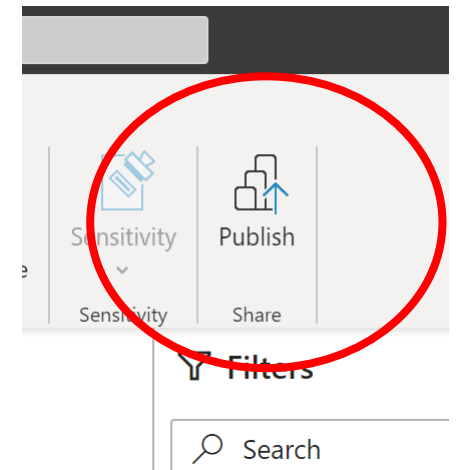
The dashboard can be published publicly, or to pushed to other organization members (individuals with a shared **Office 365** and/or **Azure** environments).

49. Publish a Power BI Dashboard (BN)

This can be done by logging into Power BI using a valid Microsoft credential (the IT department can determine if the regular windows login will work).



After hitting the “Publish” button, Power BI will ask to save the dashboard to a workspace (like an online folder).



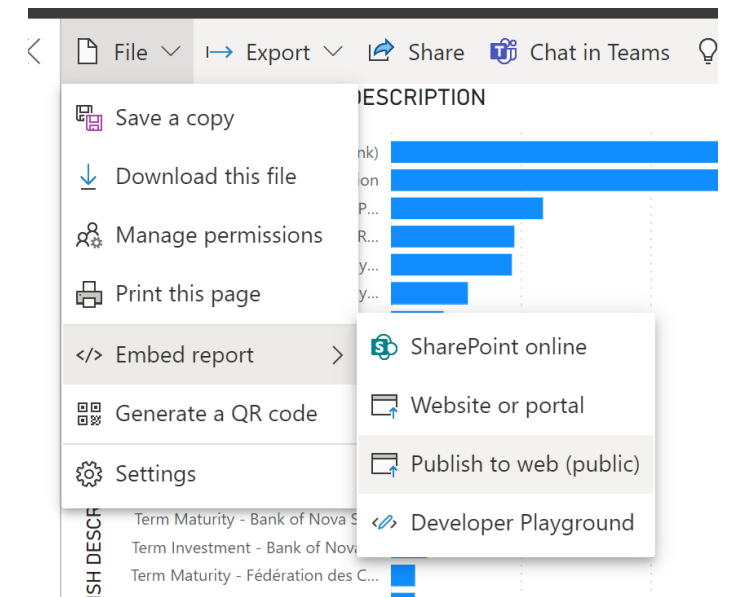
49. Publish a Power BI Dashboard (BN)

The next step is login to the online Power BI workspace.

IT Departments can provide guidelines to share the dashboard internally to an organization.

To publish to a public website (disclaimer ALL public links are searchable), the Power BI workspace needs to have this functionality enabled.

Navigate to the dashboard in the workspace, click on “File” and then “Embed Report” and finally “Publish to web (public)”.



49. Publish a Power BI Dashboard (ID)

At this point, the iFrame link can be copied and embedded into the HTML of the website of interest. The end user will then be able to see the (publicly available) dashboard on the website and interact with it as needed.

Success! Your report is ready to share

Link you can send in email

<https://app.powerbi.com/view?r=eyJrjoiNjY4OGRil>

Copy

HTML you can paste into a website

`<iframe title="ACFO Cohort 3 file 2 - Page 10" width`

Copy

Size

600 x 373.5 px

Placeholder image

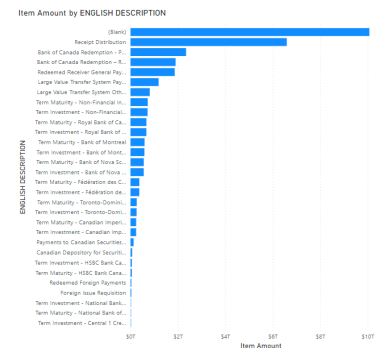


Upload

Delete

Default Page

Page 10



Microsoft Power BI

10 of 10

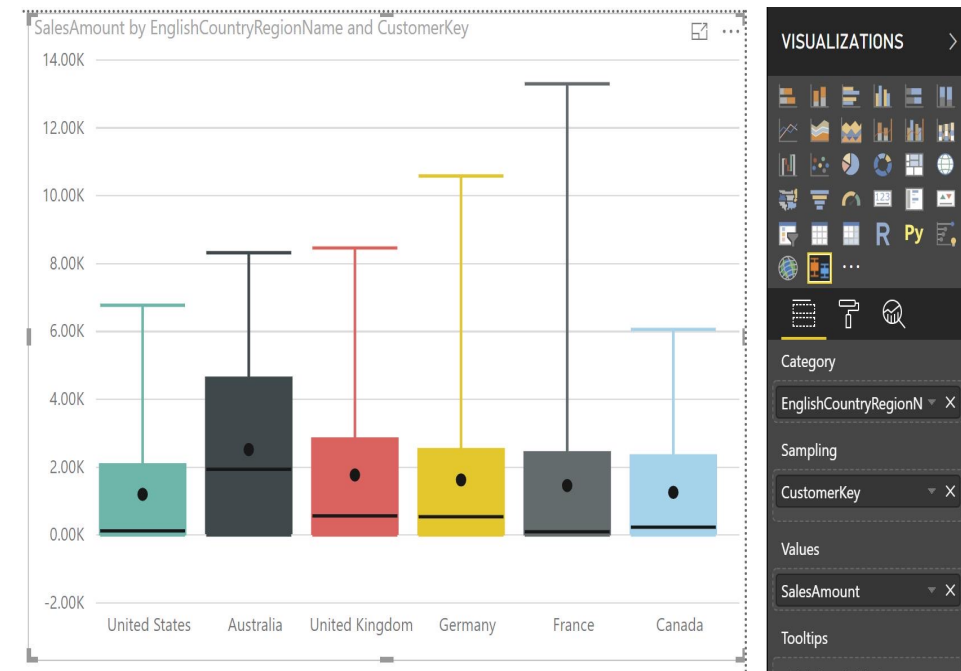
Close

50. Integrate R in Power BI (BN)

The programming languages R and Python can be used for data wrangling and visualizations.* Ensure that you have R downloaded onto your system and point PowerBI at your R installation.

Even beginners may require a visual that is not easily accessible through Power BI. To create an R chart, click on the 'R' button under the "Visualizations" panel.

[*Guy in a Cube does a great [introductory video](#).]



References

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References

P. Boily, S. Davies, J. Schellinck, [*The Practice of Data Visualization*](#). Data Action Lab, 2022.

P. Boily, J. Schellinck, [*Data Understanding, Data Analysis, and Data Science*](#). Data Action Lab, 2022.

A. Saxton, P. Leblanc. [*Guy in a Cube*](#). Guy in a Cube, LLC, 2022.

M. Russo, A. Ferrari, D. Perilli. [*sqlbi*](#). SQLBI, 2022.

N.B. The Microsoft resources found under the help ribbon in PowerBI can also be very helpful. There are links for [guided learning](#), [training videos](#), [documentation](#), [support](#), [a blog](#), and [community](#).