Microsoft Power Tools for Data Analysis #27-28
Data Models: Many To Many Relationships: Bridge Table or Excel Array Formula?
Notes from Video:

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1) **Many to Many Relationships**

i. A Many-To-Many Relationship exists when there are two tables, each with a Primary Key, and each table has a One-To-Many Relationship With the other table.

ii. The below picture illustrates Two Tables with a Many-To-Many-Relationship :

1. On the left is the dAuthors table with a unique list of Book Authors. On the right is the dBooks table with a unique list of Book Titles. The following picture illustrates the content of the two tables:

dAuthors

AuthorID	Author
BJ11	Bill Mr Excel Jelen
EF43	Mike excelisfun Girvin
BPQ1	Bill Power Query Poet Szysz

dBooks

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

2. The left dAuthors table has a One-To-Many Relationship with the dBooks table, where one author can author many books. The below picture illustrates that Author BPQ1 has authored three books.

dAuthors

AuthorID	Author
BJ11	Bill Mr Excel Jelen
EF43	Mike excelisfun Girvin
BPQ1	Bill Power Query Poet Szysz

dBooks

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

3. The right dBooks table has a One-To-Many Relationship with the dAuthors table, where one book can be authored by multiple authors. The below picture illustrates that Book DA22 has two authors.

dAuthors

AuthorID	Author
BJ11	Bill Mr Excel Jelen
EF43	Mike excelisfun Girvin
BPQ1	Bill Power Query Poet Szysz

dBooks

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

iii. Examples of Many-To-Many Relationships :

1. Authors and Book Titles
2. Finished Goods and Ingredients
3. Machines and Parts
4. Bank Accounts and Owners
5. House and Owners
6. Property Class and Property Type
7. Sales Promotions and Products
8. Sales Representatives and Orders

2) **Methods to deal with Many To Many Relationships** :

i. Excel Array Formulas, like the ones we saw in the video:

1. Data Setup:

dAuthors

AuthorID	Author
BJ11	Bill Mr Excel Jelen
EF43	Mike excelisfun Girvin
BPQ1	Bill Power Query Poet Szysz

dBooks

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

fSales

BookID	UnitsSold
CSE1	24
CSE1	12
BS43	72
GD14	132
BB43	144
BS43	96
BS43	36
BB43	60
DA22	120
DA22	108
CSE1	48
ME60	36
BS43	72
BB43	120
GD14	84
ME60	36
CSE1	132
BB43	72

Goal:

Create Two Reports with Formulas:

- Total Units by Book Title
- Total Units by Author

BookTitle	Total Units
60 Book Edition	72
Ctrl + Shift + Enter	216
Data Analysis	228
Excel with Mr Excel	396
Good Data	216
Power Query Basics	276
Total	1404

Author	Total Units
Bill Mr Excel Jelen	900
Bill Power Query Poet Szysz	720
Mike excelisfun Girvin	444

Fact Table Total: 1404

2. Formulas in cells D18 and I18, respectively:

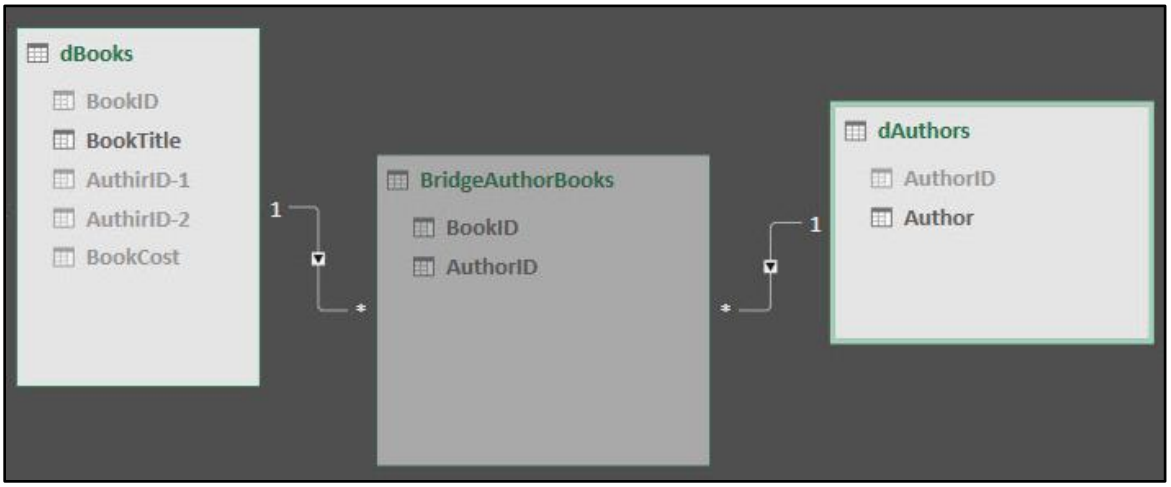
```
=SUMIFS($N$5:$N$22,$M$5:$M$22,INDEX($G$5:$G$10,MATCH(C18,$H$5:$H$10,0)))
```

SUMIFS(sum_range, criteria_range1, **criteria1**, [criteria_range2, criteria2], ...)

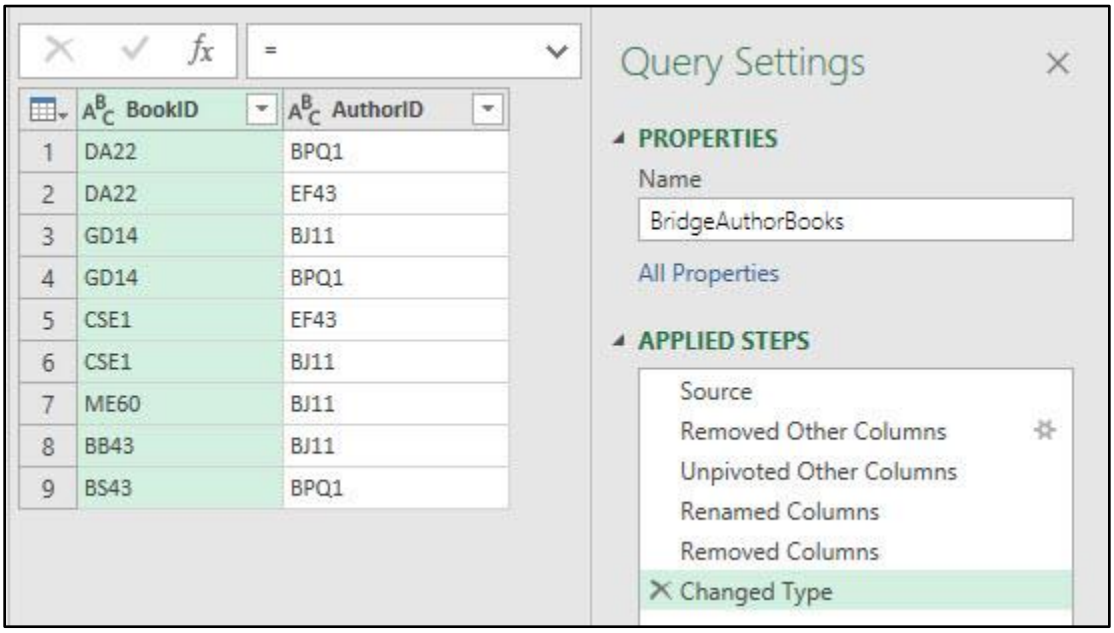
```
=SUMPRODUCT(
   SUMIFS(
      $N$5:$N$22,
      $M$5:$M$22,
      IF(($I$5:$I$10=F18)+($J$5:$J$10=F18),$G$5:$G$10)
))
```

ii. Bridge Table :

1. Bridge Table connects two or more tables where a Many-To-Many Relationship exists by creating a unique list of all combinations of the two Primary Keys, and is connected to the two other tables through two Many-To-One Relationships, as seen in the picture below:



2. The picture of the content of the Bridge Table can be seen here:



	BookID	AuthorID
1	DA22	BPQ1
2	DA22	EF43
3	GD14	BJ11
4	GD14	BPQ1
5	CSE1	EF43
6	CSE1	BJ11
7	ME60	BJ11
8	BB43	BJ11
9	BS43	BPQ1

3. Mode used to create Bridge Table:

BridgeAuthorBooks

```
let
    Source = Excel.CurrentWorkbook(){[Name="dBooks"]}[Content],
    #"Removed Other Columns" = Table.SelectColumns(Source,{"BookID", "AuthorID-1", "AuthorID-2"}),
    #"Unpivoted Other Columns" = Table.UnpivotOtherColumns(#"Removed Other Columns", {"BookID"}, "Attribute", "Value"),
    #"Renamed Columns" = Table.RenameColumns(#"Unpivoted Other Columns",{{"Value", "AuthorID"}}),
    #"Removed Columns" = Table.RemoveColumns(#"Renamed Columns",{"Attribute"}),
    #"Changed Type" = Table.TransformColumnTypes(#"Removed Columns",{{"BookID", type text},{"AuthorID", type text}})
in
    #"Changed Type"
```

iii. With a Bridge Table

1. Bridge Table & Bi-directional Filter. In Power BI, you can use Bi-directional Filters
    i. Any formula can use this Bi-directional Filter
    ii. Bi-directional Filters might make model ambiguous, meaning that if a filter has two choices to get to a table
2. Bridge Table and the DAX function CROSSFILTER :
    i. Each new formula that must filter from the Many Side to the One Side, must use the CROSSFILTER.
    ii. Put Bridge Table First, like: (CROSSFILTER(BridgeTableColumn(ManySide),PrimaryKeyColumn(OneSide))
    iii. DAX Formula for adding Units from Video:

=CALCULATE(SUM(fSales[Units]),CROSSFILTER(BridgeBookIDAuthorID[BookID],dBooks[BookID],Both))

iv. If you have an "unmatched item in a relationship" that is listed in the Fact Table but not the Dimension Table, the "CROSSFILTER Grand Total" will list the amount because the Grand Total cell un-filters the entire Fact Table. The example we used in the video showed a Fact Table with one unmatched BookID for $100.

Author	Total Units Cross Filter	Total Units Table Filter
Bill Mr Excel Jelen	900	900
Bill Power Query Poet Szysz	720	720
Mike excelisfun Girvin	444	444
Grand Total	**1,504**	**1,404**

3. Bridge Table as a Table Filter :
    i. Each new formula that must filter from the Many Side to the One Side, must use the Table Filter.
    ii. DAX Formula for adding Units from Video:

=CALCULATE(SUM(fSales[Units]),BridgeBookIDAuthorID)

iii. If you have an unmatched item in a relationship that is listed in the Fact Table but not the Dimension Table, "Table Filter Grand Total" will NOT list the amount because the Grand Total cell Filter Context removes all filters from the Bridge Table, and that Bridge Table does not have the unmatched Book ID – therefore, the Bridge Table Filter filters the Fact Table so that it does NOT include that record. The example we used in the video showed a Fact Table with one unmatched BookID for $100.

Author	Total Units Cross Filter	Total Units Table Filter
Bill Mr Excel Jelen	900	900
Bill Power Query Poet Szysz	720	720
Mike excelisfun Girvin	444	444
Grand Total	**1,504**	**1,404**

iv. Difference between CROSSFILTER and Expanded Table Filter in Grand Total Cell :

1) The Row Area filters come from the dAuthor Table, which contains 3 authors.
2) CROSSFILTER opens the relationship to go backwards across the Many-To-One Relationship, but when the Fact Table sits in the Grand Total Cell, all rows in the Fact Table are opened, including the unmatched item.
3) The Table Filter has the filter from the Bridge Table, which only has the 3 authors, so that filter is passed to the formula in the Grand Total cell, with the effect of filtering out the unmatched record.

3) **Many-To-Many may cause issues** :

i. Calculations can be non-additive, like in Row Totals here (they are supposed to be like this):

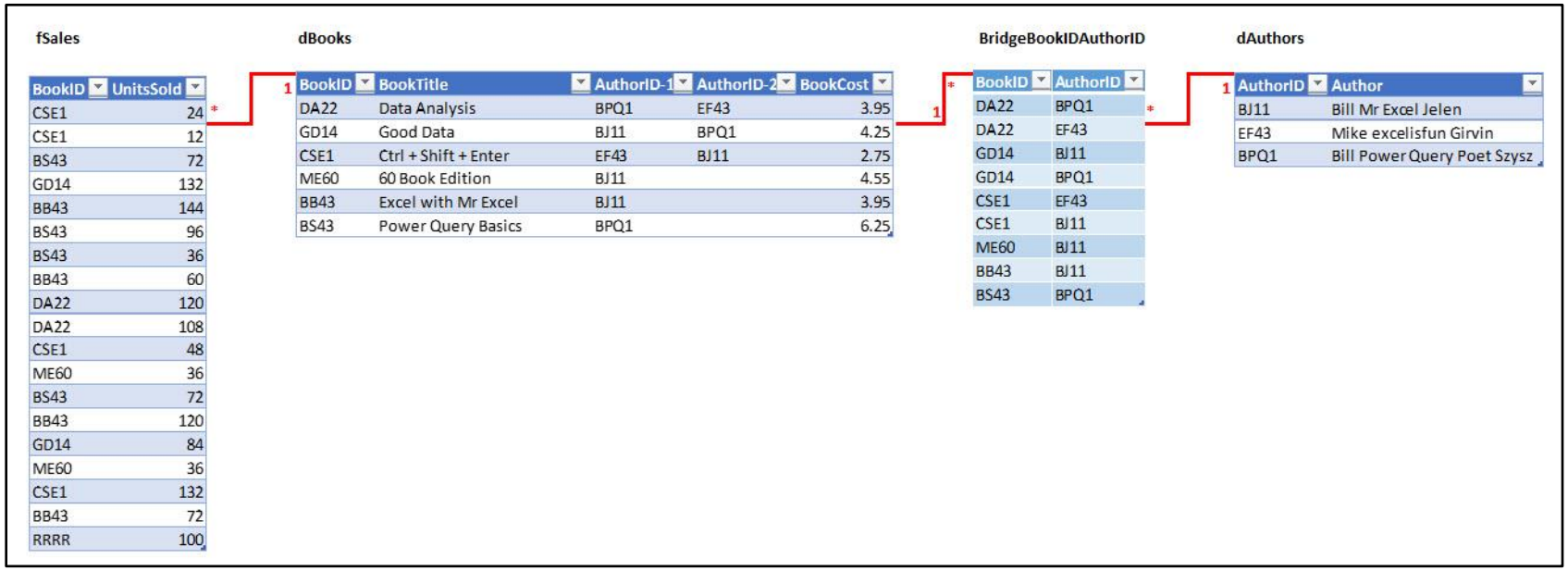
ii.

Total Units Table Filter	**Author**			
BookTitle	**Bill Mr Excel Jelen**	**Bill Power Query Poet S**	**Mike excelisfun Girvin**	**Grand Total**
60 Book Edition	72			72
Ctrl + Shift + Enter	216		216	216
Data Analysis		228	228	228
Excel with Mr Excel	396			396
Good Data	216	216		216
Power Query Basics		276		276
Grand Total	**900**	**720**	**444**	**1,404**

iii. For large Bridge Tables, the traversing of two relationships in opposite directions may increate calculation time.

4) **Here is a Visual Diagram that shows how a Bridge Table deals with a Many-To-Many Relationship** :

i. The Relationships and tables look like this:



fSales

BookID	UnitsSold
CSE1	24
CSE1	12
BS43	72
GD14	132
BB43	144
BS43	96
BS43	36
BB43	60
DA22	120
DA22	108
CSE1	48
ME60	36
BS43	72
BB43	120
GD14	84
ME60	36
CSE1	132
BB43	72
RRRR	100

dBooks

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

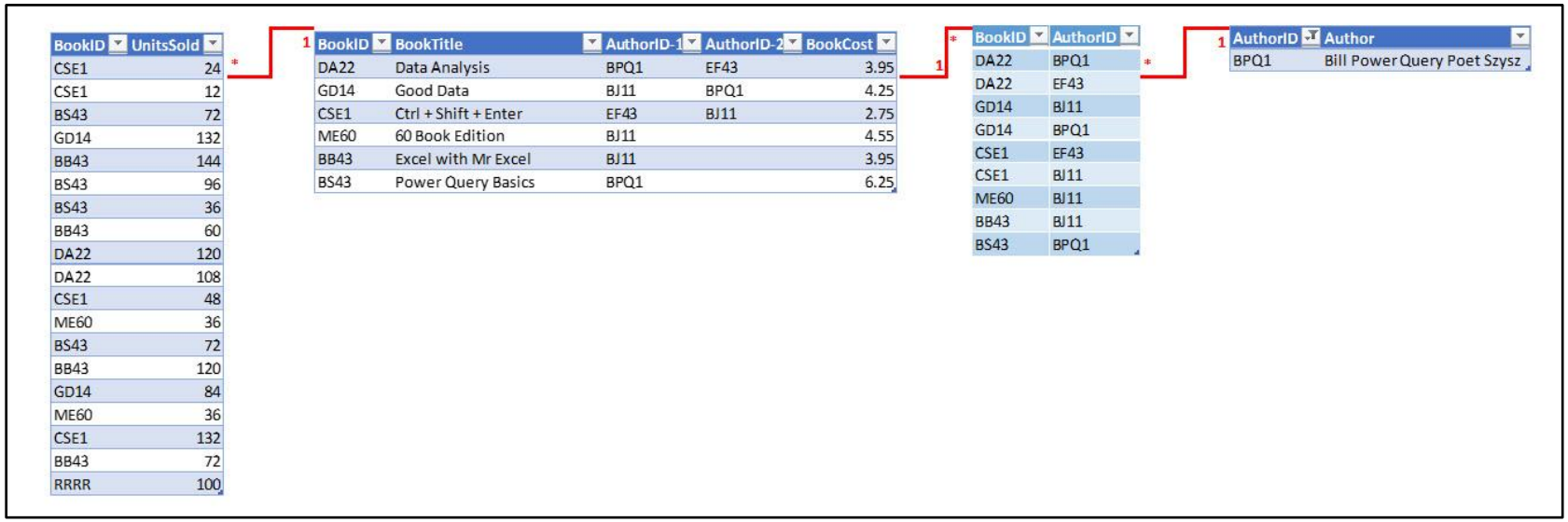
BridgeBookIDAuthorID

BookID	AuthorID
DA22	BPQ1
DA22	EF43
GD14	BJ11
GD14	BPQ1
CSE1	EF43
CSE1	BJ11
ME60	BJ11
BB43	BJ11
BS43	BPQ1

dAuthors

AuthorID	Author
BJ11	Bill Mr Excel Jelen
EF43	Mike excelisfun Girvin
BPQ1	Bill Power Query Poet Szysz

ii. In a Report or Visual, when a single Author is selected, the dAuthors Tables becomes filtered, as seen here:



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BS43	72
BB43	120
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CSE1	132
BB43	72
RRRR	100

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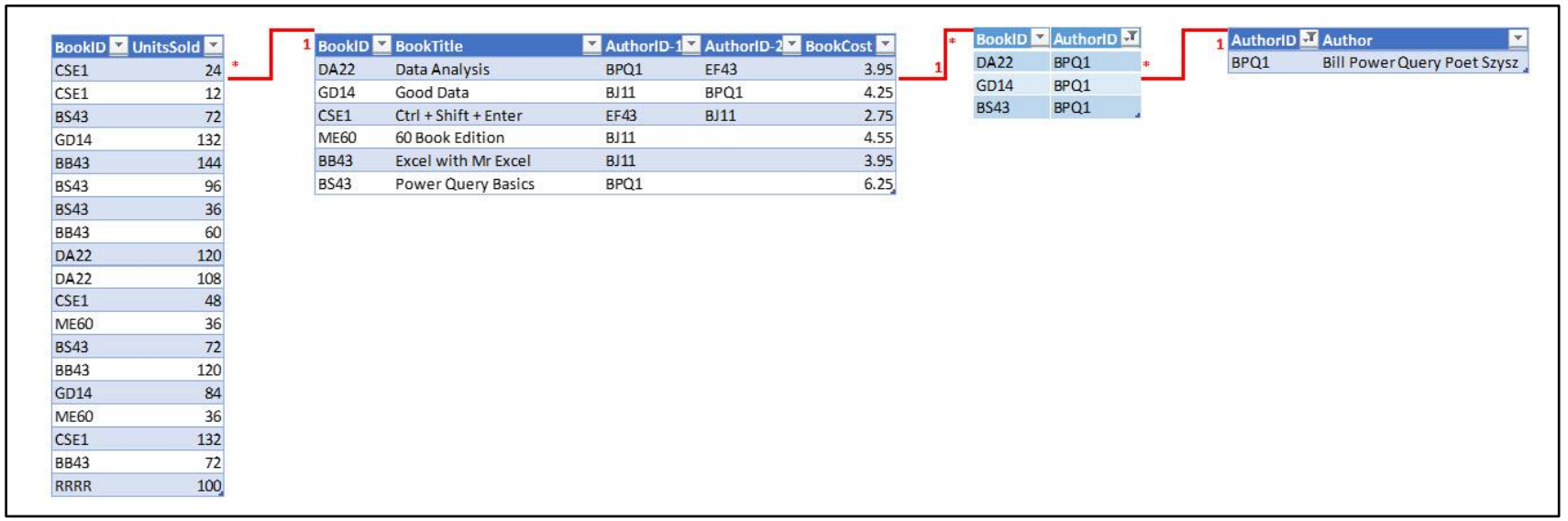
BookID	AuthorID
DA22	BPQ1
DA22	EF43
GD14	BJ11
GD14	BPQ1
CSE1	EF43
CSE1	BJ11
ME60	BJ11
BB43	BJ11
BS43	BPQ1

AuthorID	Author
BPQ1	Bill Power Query Poet Szysz

iii. The Default for Filter movement is from the One-Side to the Many-Side, so the dAuthors filter flows to the Bridge Table (BridgeBookIDAuthorID) and it becomes filtered so that just the books for that author are showing, as seen here:



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DA22	108
CSE1	48
ME60	36
BS43	72
BB43	120
GD14	84
ME60	36
CSE1	132
BB43	72
RRRR	100

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
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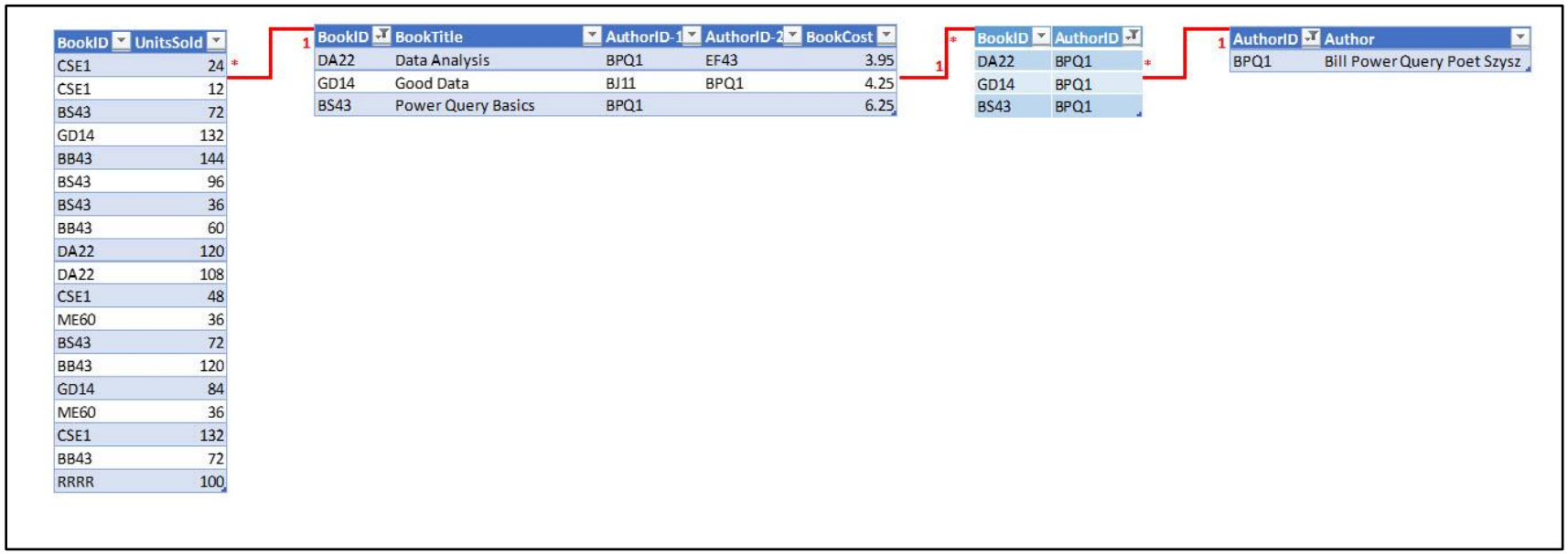
CSE1	Ctrl + Shift + Enter	EF43	BJ11	2.75
ME60	60 Book Edition	BJ11		4.55
BB43	Excel with Mr Excel	BJ11		3.95
BS43	Power Query Basics	BPQ1		6.25

BookID	AuthorID
DA22	BPQ1
GD14	BPQ1
BS43	BPQ1

AuthorID	Author
BPQ1	Bill Power Query Poet Szysz

iv. Whether you use the CROSSFILTER method, Table Filter method or Bi-Directional Filter method, the filter for books from the Bridge Table (BridgeBookIDAuthorID) propagates to the dBooks (book table) to show correct books for the selected author in the dAuthors table, as seen here:



BookID	UnitsSold
CSE1	24
CSE1	12
BS43	72
GD14	132
BB43	144
BS43	96
BS43	36
BB43	60
DA22	120
DA22	108
CSE1	48
ME60	36
BS43	72
BB43	120
GD14	84
ME60	36
CSE1	132
BB43	72
RRRR	100

BookID	BookTitle	AuthorID-1	AuthorID-2	BookCost
DA22	Data Analysis	BPQ1	EF43	3.95
GD14	Good Data	BJ11	BPQ1	4.25
BS43	Power Query Basics	BPQ1		6.25

BookID	AuthorID
DA22	BPQ1
GD14	BPQ1
BS43	BPQ1

AuthorID	Author
BPQ1	Bill Power Query Poet Szysz

v. The Default for Filter movement is from the One-Side to the Many-Side, so the selected books in the dBooks table flows to the Fact Table (fSales) and then the Measure can calculate the correct amount for this Many-To-Many Relationship, as seen here: