P3 ADAPTIVE

FOUNDATIONS

# Reference Card

# Power BI and PowerPivot:
# How the DAX Engine Calculates Measures

## 1

| ModelName | 2018 | 2019 |
|---|---|---|
| Mountain-200 | $4,735,493 | $4,425,566 |
| Road-250 | $2,771,195 | $957,793 |
| Road-650 | $348,431 | |

IMPORTANT: Every single measure cell is calculated independently, as an island! (That's right, even the Grand Total cells!) So when a measure returns an unexpected result, we should pick one cell and step through it, starting with Step 1 here...

**`Detect Filter Coordinates of Current Measure Cell:`**
Calendar[Year]=2019, Products[Model]="Road-250"
Those are the inital **filter context.**

## 2

### Calculate Alters Filter Context

If applicable <filters> from CALCULATE(), adding/removing/modifying coordinates and producing a new filter context.

## 3

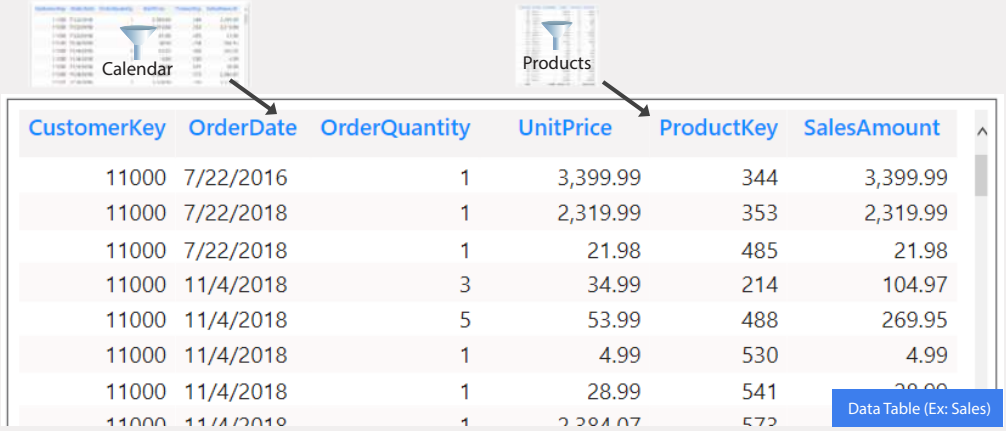
### Apply the Coordinates

In the filter context to each of the respective tables (Calendar and Products in this example). This results in a set of "active" rows in each of those tables.

## 4

### Filters Follow the Relationship(s)

If the filtered tables (Calendar and Products) are Lookup tables, follow relationships to their related Data tables and filter those tables too. Only Data rows related to active Lookup rows will remain active.




## 5

### Evaluate the Arithmetic

Once all filters are applied and all relationships have been followed, evaluate the arithmetic - SUM(), COUNTROWS(), etc. in the formula against the remaining active rows.

## 6

### Return Result

The result of the arthmetic is returned to the current measure cell in the pivot (or dashboard, etc.), then the process starts over at step 1 for the next measure cell.

# Exercises for Step 1 (Filter Context) of DAX Measure Evaluation Steps

In each of the 9 pivots below, identify the filter context (the set of coordinates from the pivot) for the circled cell. (We find that coordinate identification often trips people up, hence this exercise).

In 1-4, the Region[Country] column is on Rows, & Products[Category] on Columns. [Total Sales] is on Values.

**1**

| Country | Accessories | Bikes | Clothing | Total |
|---|---|---|---|---|
| Australia | $334,029 | $11,364,439 | $183,449 | **$11,881,916** |
| Canada | $252,900 | $2,450,599 | $138,823 | **$2,842,321** |
| France | $154,545 | $3,272,211 | $68,915 | **$3,495,671** |
| Germany | $155,460 | $3,645,491 | $62,348 | **$3,863,299** |
| United Kingdom | $194,163 | $4,253,725 | $83,270 | **$4,531,159** |
| United States | $634,680 | $11,660,745 | $346,243 | **$12,641,668** |
| **Total** | **$1,725,775** | **$36,647,211** | **$883,047** | **$39,256,034** |

**2**

| Country | Accessories | Bikes | Clothing | Total |
|---|---|---|---|---|
| Australia | $334,029 | $11,364,439 | $183,449 | **$11,881,916** |
| Canada | $252,900 | $2,450,599 | $138,823 | **$2,842,321** |
| France | $154,545 | $3,272,211 | $68,915 | **$3,495,671** |
| Germany | $155,460 | $3,645,491 | $62,348 | **$3,863,299** |
| United Kingdom | $194,163 | $4,253,725 | $83,270 | **$4,531,159** |
| United States | $634,680 | $11,660,745 | $346,243 | **$12,641,668** |
| **Total** | **$1,725,775** | **$36,647,211** | **$883,047** | **$39,256,034** |

**3**

| Country | Accessories | Bikes | Clothing | Total |
|---|---|---|---|---|
| Australia | $334,029 | $11,364,439 | $183,449 | **$11,881,916** |
| Canada | $252,900 | $2,450,599 | $138,823 | **$2,842,321** |
| France | $154,545 | $3,272,211 | $68,915 | **$3,495,671** |
| Germany | $155,460 | $3,645,491 | $62,348 | **$3,863,299** |
| United Kingdom | $194,163 | $4,253,725 | $83,270 | **$4,531,159** |
| United States | $634,680 | $11,660,745 | $346,243 | **$12,641,668** |
| **Total** | **$1,725,775** | **$36,647,211** | **$883,047** | **$39,256,034** |

**4**

| Country | Accessories | Bikes | Clothing | Total |
|---|---|---|---|---|
| Australia | $334,029 | $11,364,439 | $183,449 | **$11,881,916** |
| Canada | $252,900 | $2,450,599 | $138,823 | **$2,842,321** |
| France | $154,545 | $3,272,211 | $68,915 | **$3,495,671** |
| Germany | $155,460 | $3,645,491 | $62,348 | **$3,863,299** |
| United Kingdom | $194,163 | $4,253,725 | $83,270 | **$4,531,159** |
| United States | $634,680 | $11,660,745 | $346,243 | **$12,641,668** |
| **Total** | **$1,725,775** | **$36,647,211** | **$883,047** | **$39,256,034** |

In #5, we've swapped Region[Country] from Rows to Columns, and Products[Category] from Columns to Rows. We've also turned off display of grand totals.

**5**

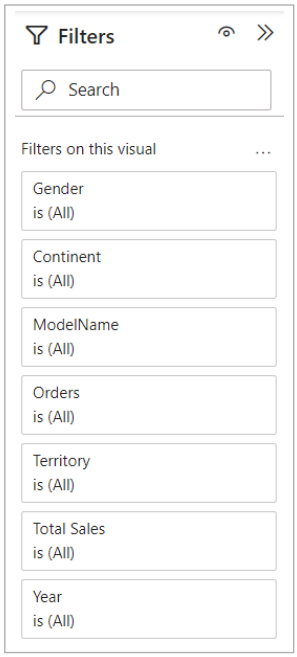
| CategoryName | Australia | Canada | France | Germany | United Kingdom | United States |
|---|---|---|---|---|---|---|
| Accessories | $334,029 | $252,900 | $154,545 | $155,460 | $194,163 | $634,680 |
| Bikes | $11,364,439 | $2,450,599 | $3,272,211 | $3,645,491 | $4,253,725 | $11,660,745 |
| Clothing | $183,449 | $138,823 | $68,915 | $62,348 | $83,270 | $346,243 |

# Exercises for Step 1 (Filter Context) of DAX Measure Evaluation Steps

In 6-8, Region[Continent] and Region[Region] are on Rows. Customers[Gender] is on Report Filters. In 6 and 7, Customers[Gender] Is not filtered, but in 8, it is filtered to "F". In 6-8, [Total Sales] and [Orders] are on Values.

| Gender | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Continent | Total Sales | Orders | Total Sales | Orders | Total Sales | Orders |
| **Europe** | **$5,853,119** | **3,957** | **$6,037,010** | **4,042** | **$11,890,128** | **7,999** |
| France | $1,647,581 | 1,232 | $1,848,090 | 1,252 | $3,495,671 | 2,484 |
| Germany | $2,082,635 | 1,245 | $1,780,663 | 1,239 | $3,863,299 | 2,484 |
| United Kingdom | $2,122,903 | 1,480 | $2,408,256 | 1,551 | $4,531,159 | 3,031 |
| **North America** | **$7,768,235** | **6,412** | **$7,715,754** | **6,530** | **$15,483,989** | **12,942** |
| Canada | $1,398,720 | 1,621 | $1,443,602 | 1,754 | $2,842,321 | 3,375 |
| Central | $232 | 3 | $3,357 | 6 | $3,589 | 9 |
| Northeast | $3,871 | 3 | $3,126 | 7 | $6,997 | 10 |
| Northwest | $2,481,162 | 2,043 | $2,463,580 | 2,015 | $4,944,743 | 4,058 |
| Southeast | $14,690 | 12 | $621 | 5 | $15,311 | 17 |
| Southwest | $3,869,560 | 2,730 | $3,801,468 | 2,743 | $7,671,028 | 5,473 |
| **Pacific** | **$6,232,197** | **3,373** | **$5,649,719** | **3,345** | **$11,881,916** | **6,718** |
| Australia | $6,232,197 | 3,373 | $5,649,719 | 3,345 | $11,881,916 | 6,718 |
| **Total** | **$19,853,551** | **13,742** | **$19,402,483** | **13,917** | **$39,256,034** | **27,659** |

6

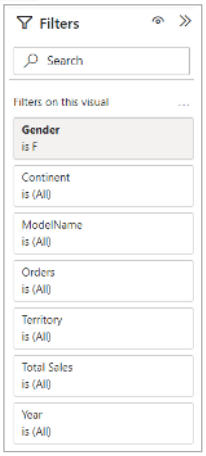



| Gender | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Continent | Total Sales | Orders | Total Sales | Orders | Total Sales | Orders |
| **Europe** | **$5,853,119** | **3,957** | **$6,037,010** | **4,042** | **$11,890,128** | **7,999** |
| France | $1,647,581 | 1,232 | $1,848,090 | 1,252 | $3,495,671 | 2,484 |
| Germany | $2,082,635 | 1,245 | $1,780,663 | 1,239 | $3,863,299 | 2,484 |
| United Kingdom | $2,122,903 | 1,480 | $2,408,256 | 1,551 | $4,531,159 | 3,031 |
| **North America** | **$7,768,235** | **6,412** | **$7,715,754** | **6,530** | **$15,483,989** | **12,942** |
| Canada | $1,398,720 | 1,621 | $1,443,602 | 1,754 | $2,842,321 | 3,375 |
| Central | $232 | 3 | $3,357 | 6 | $3,589 | 9 |
| Northeast | $3,871 | 3 | $3,126 | 7 | $6,997 | 10 |
| Northwest | $2,481,162 | 2,043 | $2,463,580 | 2,015 | $4,944,743 | 4,058 |
| Southeast | $14,690 | 12 | $621 | 5 | $15,311 | 17 |
| Southwest | $3,869,560 | 2,730 | $3,801,468 | 2,743 | $7,671,028 | 5,473 |
| **Pacific** | **$6,232,197** | **3,373** | **$5,649,719** | **3,345** | **$11,881,916** | **6,718** |
| Australia | $6,232,197 | 3,373 | $5,649,719 | 3,345 | $11,881,916 | 6,718 |
| **Total** | **$19,853,551** | **13,742** | **$19,402,483** | **13,917** | **$39,256,034** | **27,659** |

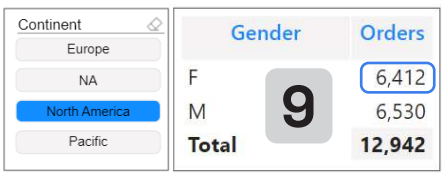
7

| Gender | F | | Total | |
|---|---|---|---|---|
| Continent | Total Sales | Orders | Total Sales | Orders |
| **Europe** | **$5,853,119** | **3,957** | **$5,853,119** | **3,957** |
| France | $1,647,581 | 1,232 | **$1,647,581** | **1,232** |
| Germany | $2,082,635 | 1,245 | **$2,082,635** | **1,245** |
| United Kingdom | $2,122,903 | 1,480 | **$2,122,903** | **1,480** |
| **North America** | **$7,768,235** | **6,412** | **$7,768,235** | **6,412** |
| Canada | $1,398,720 | 1,621 | **$1,398,720** | **1,621** |
| Central | $232 | 3 | **$232** | **3** |
| Northeast | $3,871 | 3 | **$3,871** | **3** |
| Northwest | $2,481,162 | 2,043 | **$2,481,162** | **2,043** |
| Southeast | $14,690 | 12 | **$14,690** | **12** |
| Southwest | $3,869,560 | 2,730 | **$3,869,560** | **2,730** |
| **Pacific** | **$6,232,197** | **3,373** | **$6,232,197** | **3,373** |
| Australia | $6,232,197 | 3,373 | **$6,232,197** | **3,373** |
| **Total** | **$19,853,551** | **13,742** | **$19,853,551** | **13,742** |

8




In 9, Region[Continent] is a Slicer. Consumers[Gender] is on Rows. [Orders] is on Values.




| Gender | Orders |
|---|---|
| F | 6,412 |
| M | 6,530 |
| **Total** | **12,942** |

9

## Answers

1) Region[Country] = "France", Products[Category] = "Bikes"
2) Region[Country] = "Germany"
3) Products[Category] = "Accessories"
4) No Filters
5) Same as #1!
6) Region[Continent] = "North America", Region[Region] = "Northwest"
7) Same as #6!
8) Region[Continent] = "North America", Customers[Gender] = "F"
9) Same as #8!

# Commonly-Used DAX Functions and Techniques

## CALCULATE ( ) Function

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

| | |
|---|---|
| <measure expression>: | [MeasureName]<br>SUM(Table[Column])<br>Any measure name or valid formula for a measure |
| "Simple"<filter>: | Sales[TransactionType ]=1<br>Products[Color]="Blue"<br>Calendar[Year]>=2009<br>Sales[TransType ]=1 \|\| [TransType ]=3 |
| Advanced<filter>: | ALL(...)<br>FILTER(...)<br>DATESBETWEEN(...)<br>Any other function that modifies filter context |
| Notes: | Raw <filter>'s override (replace) filter context from pivot<br>Raw <filter>'s must be Table[Column] <operator> <fixed value><br>Multiple <filter>'s arguments get AND'd together |

## ALL ( ) Function

ALL(<table>) or ALL(Table[Col1], Table[Col2], ...Table[ColN])

| | |
|---|---|
| Basic usage: | As a <filter> argument to CALCULATE()<br>Removes filters from specified table or column(s)<br>Strips those tables/columns from the pivot's filter context |
| Advanced usage: | Technically, ALL() returns a table<br>So it is also useable wherever a <table expr > is required<br>...such as the first argument to FILTER() |

## Common Date Calculations

| | |
|---|---|
| Year to Date: | CALCULATE(<measure>, DATESTYD(Calendar[Date]) |
| Qtr or Month to: date: | Substitute DATESQTD or DATESMTD for Quarter or Month to date |
| Previous Month: | CALCULATE(<measure>, DATEADD(Calendar[Date], -1, Month) |
| Prev QT/Year/Day: | Substitute "Quarter" or "Year" or "Day" for "Month" as last argument |
| 30-day Moving Avg: | CALCULATE(<measure>, DATESINPERIOD(Calendar[Date], MAX(Calendar[Date]), -30, Day)/30 |

## Time Intelligence with Custom Calendar

When Your Biz Calendar is Too Complex for the Built-In Functions

| | |
|---|---|
| =CALCULATE | (<measure expr>, FILTER(ALL(<Custom Cal Table>), <custom filter>), <optional VALUES() to restore filters on some Cal fields>) |

=CALCULATE([Sales], FILTER(ALL(Cal445), Cal445[Year]=MAX(Cal445[Year])-1))

=CALCULATE([Sales], FILTER(ALL(Cal445), Cal445[Year]=MAX(Cal445[Year])-1),VALUES(Cal445[MonthOfYear]))

## SWITCH( ) Function

Alternative to Nested IF's!

| | |
|---|---|
| =SWITCH(<value to test>, | <if it matches this value>, <return this value>,<br><if it matches this value>, <return this value>,<br>...more match/return pairspairs...,<br><if no matches found, return this optional "else" value>) |

Need Training? Advice? Or Help with a Project?
Contact Us:
Simple@p3adaptive.com

## FILTER ( ) Function

FILTER(<table expression>, <single rich filter>)

| | |
|---|---|
| <table expression>: | The Name of a Table, or any of the below...<br>VALUES(Table[Column]) - unique values of Table[Column] for current pivot cell<br>ALL(Table) or ALL(Table[Column])<br>Any expression that returns a table, such as DATESYTD()<br>Even another FILTER() can be used here for instance |
| <rich filter>: | Table[Column1] >= Table[Column2]<br>Table[Column] <= [Measure]<br>[Measure1] <> [Measure2]<br><true/false expr1> && <true/false expr2><br>Any expression that evaluates to true/false |
| Notes: | Commonly used as a <filter> argument to CALCULATE()<br>Useful when a richer filter test is required than "simple" filters can do<br>Never use FILTER when a "simple" CALCULATE() <filter> will work<br>Slow and eats memory when used on large tables<br>Use against small (Lookup) tables for better performance<br>Advanced usage: use anywhere a <table expr> is required |

## VALUES ( ) Function

VALUES(Table[Column])

| | |
|---|---|
| 1-column table, unique: (Most common usage) | Produces a temporary, single-column table during formula evaluation<br>That table contains ONLY the UNIQUE values of Table[Column].<br><br>EX: CALCULATE(<measure>, FILTER(VALUES(Customers[ Postal Code ]),]),...])<br><br>That allows us to iterate as if we had a PostalCode table, even though we don't! And then the formula above calculates <measure> only for those Postal Codes that "survive" the <filter expr> test inside the FILTER function. And therefore only includes the customers IN those postal codes! |
| Restoring a filter: (2nd most common usage) | CALCULATE([M], ALL(Table), VALUES(Table[Col1]))<br>...is roughly equiv to CALCULATE([M], ALLEXCEPT(Table,Table[Col1])) |
| Note: | VALUES(Table[Column]) returns filtered list even if Table[Column] isn't on pivot! |

## Forcing Grand/Sub Totals to Be the Sum of Their "Parts"

=SUMX(VALUES(Table[Column], <original measure>)

(Where the values of Table[Column] are the "small pieces" that need to be calculated individually and then added up.)

## Calc Columns That Reference "Previous" Row(s)

=CALCULATE([Measure],FILTER(<table>, Table[Col]=EARLIER(Table[Col])-1))

=CALCULATE(AVERAGE(Tests[Score]),FILTER(Tests, Tests[ID]=EARLIER(Tests[ID])-1))

## Suppressing Subtotals/Grand Totals

=IF(HASONEVALUE(Table[Column]), <measure expr for non non-totals>, BLANK())

## RANKX( ) Function

RANKX(<table expr>, <arithmetic expression>, <optional alternate arithmetic expression>, <optional sort order flag>, <optional tie tie-handling flag>)

| | |
|---|---|
| <table expression>: | RANKX(ALL(Table[Column]), <numericalexpr>)<br>EX: RANKX(ALL(Products[Name]), [TotalSales]) |
| Ascending Rank Order: | EX: RANKX(ALL(Products[Name]), [TotalSales ],,,Dense) |
| "Dense" Tie Handling: | EX: RANKX(ALL(Products[Name]), [TotalSales ],,1) |

## DIVIDE Function

Returns BLANK() Cells on " Div by Zero", No IF() or IFERROR() required!
=DIVIDE(<numerator>, <denominator>, <optional val to return when div by zero>)



P3 ADAPTIVE

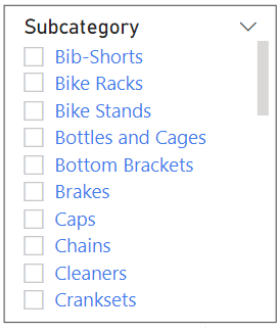
## Lookup/Dimension Tables

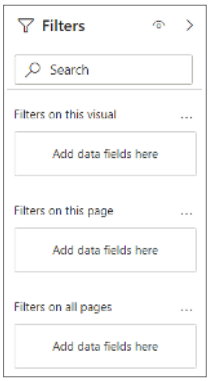
- Typically, WIDE (Many Columns)
- MOSTLY Text
- LOOKUP Information (E.g., Name, Address, Description, etc…)
- SLOW Changing (Updated Less Often)
- Does NOT typically contain Time Data
- The ONE side of a relationship

## Data/Fact Tables

- Typically, TALL (Many Rows)
- MOSTLY Dates and Numbers
- Do MATH against it (E.g., SUM, AVERAGE, MIN, MAX, etc…)
- Fast changing (Updated Often)
- MAY contain Time Data (E.g,. Order Date, Record Time, etc…)
- The MANY side of a relationship

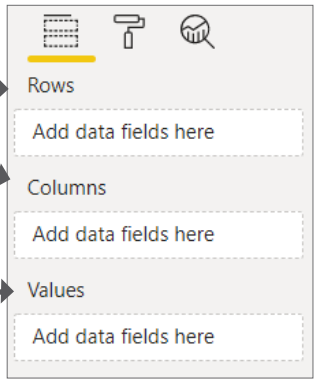
## Under "Ideal" Conditions, Data and Lookup Tables are Used Like THIS:



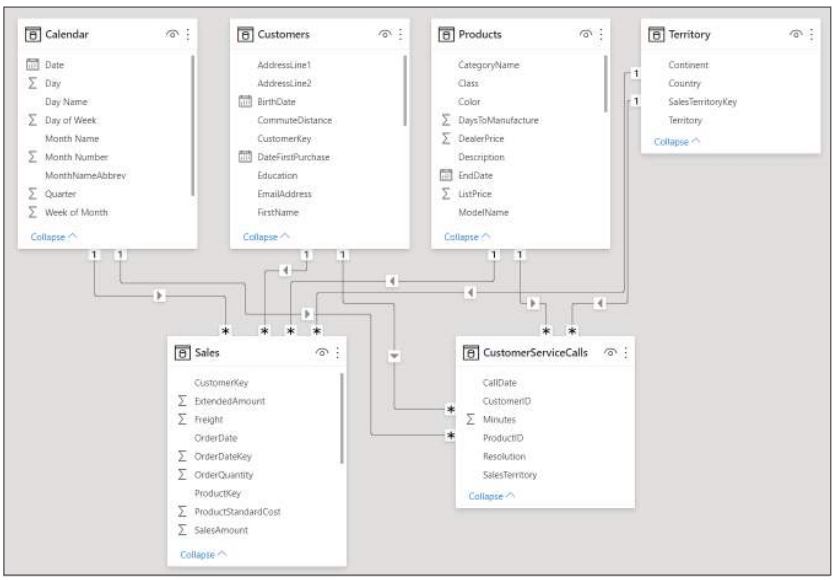

## Every field used in these places comes from Lookup tables.

(Note that these are the places that contribute to filter context during measure calculation!)




## And every field in the Values Area Comes from Data tables.

(Although we DO occasionally write measures against Lookup tables, such as days elapsed, products offered, etc.




Note:

- Data tables are "spliced together" ONLY by sharing one or more Lookup tables
- Now follow the field list guidelines above and you can compare Budget v Actuals (for instance) in a single pivot!
- Data tables are never related directly to each other!

Also:

- Useful trick: Arrange Lookup tables "up high" on the diagram and Data tables "down low."
- This lets us envision filters flowing "downhill" across relationships (relationships are "1 1-way")

## Make the formula font bigger!

(Hold CTRL key down and roll mouse wheel forward)


## Insert New Lines in Formulas:

=CALCULATE([Total],Table[Column]=6)


## When writing measures/calc column:

1) Always INCLUDE table names on column references.

**`Table[Column]`** YES **`[Column]`** NO

2) Always EXCLUDE table names when referencing other measures.

**`[Measure]`** YES **`Table[Measure]`** NO

By following this convention, you will ALWAYS immediately know the difference between a measure and a column reference, on sight, and that's a BIG win for readability and debugging.

**`NEVER write the same formaula twice!`**

For example, you should define basic measures like these, even for "simple" calculations like SUM:

```
[Total Sales]:= SUM(Table[Amount])        [Total Cost]:= SUM(Table[Cost])
```

And then references those measures whenever you are tempted to rewrite the SUM in another measure:

YES
```
[Total Margin]:=
[Total Sales] - [Total Cost]
```

NO
```
[Total Margin]:=
SUM(…) - SUM(…)
```

YES
```
[Year to Date Sales]:=
CALCULATE([Total Sales], DATESYTD (Dates[Date])
```

NO
```
[Year to Date Sales]:=
CALCULATE (SUM(…), DATESYTD(Dates[Date])
```

## Measures Are:

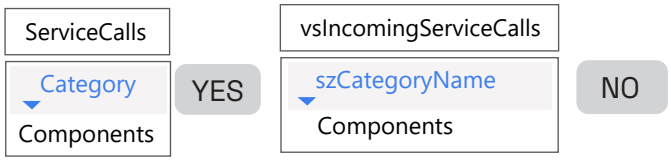
1. Used in cases when a single row can't give you the answer (typically aggregates like sum,
2. Only "legal" to be used in the Values area of a pivot
3. Never pre-calculated
4. ALWAYS re-calculated in response to pivot changes – slicer or filter change, drill down, etc.
5. Return different answers in different pivots
6. Not a significant source of file size increase
7. "Portable Formulas!!"

## Calculated Columns Are:

1. Used to "stamp" numbers or properties on each row of a table
2. "Legal" on row/column/filter/slicer of pivots
3. Useful for grouping and filtering, for instance
4. Also usable as inputs to measures
5. Pre-calculated and stored – making the file bigger
6. NEVER re-calculated in response to pivot changes
7. Only re-calculated on data source refresh or on change to "precedent" (upstream) columns

## Rename after import!

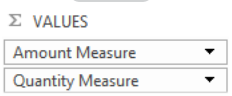
Overly-long and/or cryptically-named tables and columns make your formulas harder to read AND write, so it pays to rename immediately after import.



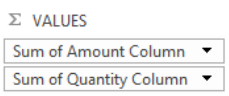

## NEVER Use Columns in Pivot Values Area

(Write the Measure/Calc Field Instead)

YES




NO

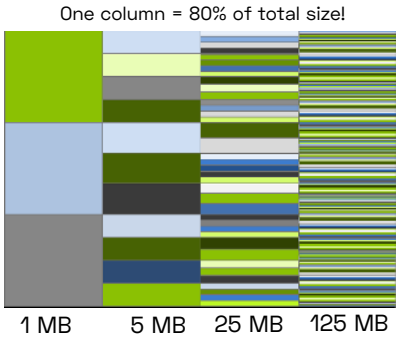



(See re-use & maintenance benefits in DAX Formulas for Power Pivot , Ch6)



P3 ADAPTIVE

# Reducing File Size




Power Pivot, Power BI Desktop, and SSAS Tabular all store and compresses data in a "column stripe" format, as pictured here.

Each column is less compressed than the one before*it. (* The compression order of the columns is auto-decided by the engine at import time, and not something we can see or control.)

This column-oriented storage is VERY unlike traditional files, databases, and compression engines.

Sometimes, a single column is "responsible" for a large fraction of the file's size (like the 125 MB pictured here.)

## Calculated Column Notes

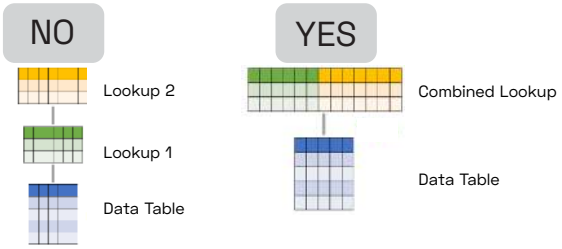
1. Calc columns bloat the file more than columns imported from a data source.
2. So consider implementing the calc column in the database (or use Power Query), then import it.
3. Unlike calc columns, measures do NOT significantly add file size!
4. So in "simple arithmetic" cases like [Profit Margin], it's best to just subtract one measure from another ([Sales]-[Cost]), and avoid adding a calc column to perform the subtraction (which you'd then SUM to create your measure).

## Words of Wisdom

1. If your file size is not a problem, don't worry about ANYTHING on this page. These tips are just for when you DO have a problem :)
2. The smaller the table is in terms of row count, the less these tips and tricks matter. A few extra columns in a 10k - row table are no big deal, but ONE extra column in a million-row table sometimes IS.
3. So focus on Data tables. Lookup tables = less crucial.
4. Large files also eat more RAM. If your computer is strained reduce file size.

## Avoid "Multi-Hop" Lookups (if Possible)

Combine "chained" lookup tables into one table:




## Separate Lookup Tables Offer BIG File Size Savings

| | ProductKey | OrderDate | CustomerKey | ExtendedAmount | ProductName | StandardCost | Color | ModelName |
|---|---|---|---|---|---|---|---|---|
| 1 | 336 | 7/1/2014 | 14501 | 699.0982 | Road-650 Black, 62 | 413.1463 | Black | Road-650 |
| 2 | 336 | 7/5/2014 | 25249 | 699.0982 | Road-650 Black, 62 | 413.1463 | Black | Road-650 |
| 3 | 346 | 7/1/2014 | 25863 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 4 | 346 | 7/1/2014 | 28389 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 5 | 346 | 7/1/2014 | 11003 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 6 | 346 | 7/9/2014 | 25861 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 7 | 346 | 7/9/2014 | 11238 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 8 | 346 | 7/10/2014 | 11002 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 9 | 346 | 7/17/2014 | 11010 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 10 | 346 | 7/26/2014 | 11026 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 11 | 346 | 7/27/2014 | 11006 | 3399.99 | Mountain-100 Silver, 44 | 1912.1544 | Silver | Mountain-100 |
| 12 | 310 | 7/1/2014 | 21768 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 13 | 310 | 7/2/2014 | 16624 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 14 | 310 | 7/5/2014 | 27601 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 15 | 310 | 7/6/2014 | 13590 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 16 | 310 | 7/10/2014 | 16522 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 17 | 310 | 7/11/2014 | 13563 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 18 | 310 | 7/12/2014 | 27671 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 19 | 310 | 7/14/2014 | 16482 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |
| 20 | 310 | 7/16/2014 | 27646 | 3578.27 | Road-150 Red, 62 | 2171.2942 | Red | Road-150 |

NO

The table pictured above combines Data table columns (OrderDate, CustomerKey, ExtendedAmount , and ProductKey ) with columns that should be "outsourced" to a Lookup table ( ProductName, StandardCost , Color, and ModelName can all be "looked up" from the ProductKey).

Instead, split the Lookup-specific columns out into a separate Lookup table, and remove duplicate rows (in that Lookup table) so that we have just one row per unique ProductKey.

| | ProductKey | ProductName | StandardCost | Color | ModelName | Category | SubCategory |
|---|---|---|---|---|---|---|---|
| 1 | 325 | Road-650 Red, 62 | 486.7066 | Red | Road-650 | Bikes | Road Bikes |
| 2 | 323 | Road-650 Red, 60 | 486.7066 | Red | Road-650 | Bikes | Road Bikes |
| 3 | 322 | Road-650 Red, 60 | 413.1463 | Red | Road-650 | Bikes | Road Bikes |
| 4 | 321 | Road-650 Red, 58 | 486.7066 | Red | Road-650 | Bikes | Road Bikes |
| 5 | 319 | Road-450 Red, 52 | 884.7083 | Red | Road-450 | Bikes | Road Bikes |
| 6 | 318 | Road-450 Red, 48 | 884.7083 | Red | Road-450 | Bikes | Road Bikes |
| 7 | 317 | Road-450 Red, 44 | 884.7083 | Red | Road-450 | Bikes | Road Bikes |
| 8 | 381 | Road-550-W Yellow, 38 | 605.6492 | Yellow | Road-550-W | Bikes | Road Bikes |
| 9 | 328 | Road-650 Red, 48 | 413.1463 | Red | Road-650 | Bikes | Road Bikes |

YES

RELATIONSHIP

| | OrderDate | CustomerKey | ExtendedAmount | ProductKey |
|---|---|---|---|---|
| 1 | 7/1/2014 | 14501 | 699.0982 | 336 |
| 2 | 7/1/2014 | 25863 | 3399.99 | 346 |
| 3 | 7/1/2014 | 28389 | 3399.99 | 346 |
| 4 | 7/1/2014 | 21768 | 3578.27 | 310 |
| 5 | 7/1/2014 | 11003 | 3399.99 | 346 |
| 6 | 7/2/2014 | 27645 | 3578.27 | 311 |
| 7 | 7/2/2014 | 11011 | 3399.99 | 344 |
| 8 | 7/2/2014 | 11005 | 3374.99 | 351 |
| 9 | 7/2/2014 | 16624 | 3578.27 | 310 |
| 10 | 7/3/2014 | 27621 | 3578.27 | 312 |
| 11 | 7/3/2014 | 27616 | 3578.27 | 312 |
| 12 | 7/3/2014 | 20042 | 699.0982 | 330 |
| 13 | 7/3/2014 | 16517 | 3578.27 | 314 |
| 14 | 7/3/2014 | 16351 | 3578.27 | 313 |
| 15 | 7/4/2014 | 27606 | 3578.27 | 314 |
| 16 | 7/4/2014 | 13513 | 3578.27 | 311 |
| 17 | 7/5/2014 | 27601 | 3578.27 | 310 |
| 18 | 7/5/2014 | 13591 | 3578.27 | 311 |
| 19 | 7/5/2014 | 25249 | 699.0982 | 336 |
| 20 | 7/5/2014 | 16483 | 3578.27 | 314 |
| 21 | 7/5/2014 | 16529 | 3578.27 | 311 |
| 22 | 7/6/2014 | 27612 | 3578.27 | 312 |
| 23 | 7/6/2014 | 27668 | 3578.27 | 311 |
| 24 | 7/6/2014 | 13264 | 3578.27 | 311 |
| 25 | 7/6/2014 | 13590 | 3578.27 | 310 |

YES

Duplicate removal makes a relationship possible with the Data table, AND makes the Lookup table small in terms of row count.

(Duplicate removal is performed in the database, or using Power Query – see Power Pivot Alchemy, chapter 5 for an example).

Our "big" table now has significantly fewer columns. On net, our file is potentially now MUCH smaller – because our largest table (Data table) has shed multiple columns. The small Lookup table is not significant, even if it contains 50+ columns.

## "Unpivot" ALSO Offers Big File Size Savings

| | Region | 1/1/2015 | 1/2/2015 | 1/3/2015 | 1/4/2015 | 1/5/2015 | 1/6/2015 | 1/7/2015 | 1/8/2015 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | North | 2106 | 4712 | 1996 | 4147 | 5044 | 1869 | 3004 | 8032 |
| 2 | South | 2470 | 1375 | 6133 | 7040 | 1951 | 1141 | 7871 | 1850 |
| 3 | East | 6283 | 3591 | 7646 | 2417 | 8487 | 6973 | 3520 | 3540 |
| 4 | West | 8383 | 2925 | 8109 | 7996 | 6916 | 4401 | 8315 | 5995 |

NO

| | Region | Normal Sales | Promotional Sales | Refunds | Bulk Sales | Cost of Goods |
|---|---|---|---|---|---|---|
| 1 | North | 2106 | 4712 | 1996 | 5044 | 4147 |
| 2 | South | 2470 | 1375 | 1850 | 1951 | 7040 |
| 3 | East | 6283 | 3591 | 1951 | 8487 | 2417 |
| 4 | West | 8383 | 2925 | 2106 | 6916 | 7996 |

NO

This "unpivot " transformation results in increased rows but fewer columns. Counterintuitively this can yield VERY significant file size reduction. (See Power Pivot Alchemy, Ch 5, for an example of performing this transformation with Power Query).

In the case of dates or months, this also removes the need for tedious formula repetition, AND enables time intelligence calcs.

| | Region | Date | Value |
|---|---|---|---|
| 1 | North | 1/1/2015 | 2106 |
| 2 | South | 1/1/2015 | 2470 |
| 3 | East | 1/1/2015 | 6283 |
| 4 | West | 1/1/2015 | 8383 |
| 5 | North | 1/2/2015 | 4712 |
| 6 | South | 1/2/2015 | 1375 |
| 7 | East | 1/2/2015 | 3591 |
| 8 | West | 1/2/2015 | 2925 |
| 9 | North | 1/3/2015 | 1996 |
| 10 | South | 1/3/2015 | 6133 |
| 11 | East | 1/3/2015 | 7646 |
| 12 | West | 1/3/2015 | 8109 |
| 13 | North | 1/4/2015 | 4147 |
| 14 | South | 1/4/2015 | 7040 |
| 15 | East | 1/4/2015 | 2417 |
| 16 | West | 1/4/2015 | 7996 |
| 17 | North | 1/5/2015 | 5044 |
| 18 | South | 1/5/2015 | 1951 |
| 19 | East | 1/5/2015 | 8487 |
| 20 | West | 1/5/2015 | 6916 |
| 21 | North | 1/6/2015 | 1869 |
| 22 | South | 1/6/2015 | 1141 |
| 23 | East | 1/6/2015 | 6973 |
| 24 | West | 1/6/2015 | 4401 |
| 25 | North | 1/7/2015 | 3004 |
| 26 | South | 1/7/2015 | 7871 |
| 27 | East | 1/7/2015 | 3520 |
| 28 | West | 1/7/2015 | 8315 |
| 29 | North | 1/8/2015 | 8032 |
| 30 | South | 1/8/2015 | 1850 |
| 31 | East | 1/8/2015 | 3540 |
| 32 | West | 1/8/2015 | 5995 |

YES

| | Region | Amount Type | Amount |
|---|---|---|---|
| 1 | North | Normal Sales | 2106 |
| 2 | North | Promotional Sales | 4712 |
| 3 | North | Refunds | 1996 |
| 4 | North | Bulk Sales | 5044 |
| 5 | North | Cost of Goods | 4147 |
| 6 | South | Normal Sales | 2470 |
| 7 | South | Promotional Sales | 1375 |
| 8 | South | Refunds | 1850 |
| 9 | South | Bulk Sales | 1951 |
| 10 | South | Cost of Goods | 7040 |
| 11 | East | Normal Sales | 6283 |
| 12 | East | Promotional Sales | 3591 |
| 13 | East | Refunds | 1951 |
| 14 | East | Bulk Sales | 8487 |
| 15 | East | Cost of Goods | 2417 |
| 16 | West | Normal Sales | 8383 |
| 17 | West | Promotional Sales | 2925 |
| 18 | West | Refunds | 2106 |
| 19 | West | Bulk Sales | 6916 |
| 20 | West | Cost of Goods | 7996 |

YES

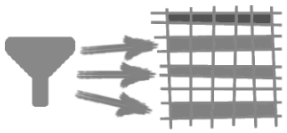
In this case you will need to use CALCULATE to write your "base" measures. EX:
CALCULATE(SUM(Table[Amount]), Table[Amount Type]="Refunds")

## What Makes a Valid Calendar/Dates Table?

| | Date | MonthShort | Day Name | Day of Week Number | Quarter |
|---|---|---|---|---|---|
| 1 | 7/1/2016 | Jul | Friday | 6 | 3 |
| 2 | 7/2/2016 | Jul | Saturday | 7 | 3 |
| 3 | 7/3/2016 | Jul | Sunday | 1 | 3 |
| 4 | 7/4/2016 | Jul | Monday | 2 | 3 |
| 5 | 7/5/2016 | Jul | Tuesday | 3 | 3 |
| 6 | 7/6/2016 | Jul | Wednesday | 4 | 3 |
| 7 | 7/7/2016 | Jul | Thursday | 5 | 3 |
| 8 | 7/8/2016 | Jul | Friday | 6 | 3 |

1. Must contain a column of actual Date data type, not just text or a number that looks like a date.
2. That Date column must NOT contain times – 12:00 AM is "zero time" and is EXACTLY what you want to see.
3. There CANNOT be "gaps" in the Date column. No skipped dates, even if your business isn't open on those days.
4. Must be "Marked as Date Table" via button on the Power Pivot window's ribbon (not applicable in Power BI Desktop).
5. May contain as many other columns as desired. Go nuts :)
6. Should not contain dates that "precede" your actual data – needless rows DO impact performance.
7. You MUST then use this as a proper Lookup table – don't use dates from your Data tables on Rows/Columns/Etc.!

## (Slightly) Advanced Concept: Filter Context

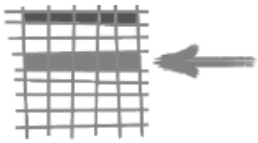


• You HAVE a Filter Context in a Measure / Calc Field.
• But you do NOT have a Filter Context in a Calc Column.
• Each cell in a Pivot's values area is calculated based on the filters (coordinates) specified for that cell.
• Those filters resolve to a set of multiple rows in the underlying data tables, rather than a single row.
• =[Column] is therefore illegal as a formula, or as part of a formula where a single value is needed.
• So this is why aggregation functions are required in measures – to "collapse" multiple values into one.

## Exception: Row Context in Measures

• Certain functions step through tables one row at a time, even when used within a Measure.
• Those "iterator" functions are said to create Row Contexts during their operation.
• Ex: FILTER( table, expr ) and SUMX( table, expr )
• In both examples, you CAN reference a column, within the expr argument, and use that column as a single value, within the expr argument.
• Note however that the column MUST "come from" the table specified in the table argument.
• Also note that this Row Context only exists within the evaluation of the iterator function itself (FILTER, SUMX, etc.) and does NOT exist elsewhere in the measure formula.

## (Slightly) Advanced Concept: Row Context



• You HAVE a Row Context in a Calculated Column.
• But you do NOT have a Row Context in a Measure
• A calc column is calculated on a row-by-row basis, so there's one row "in play" for each evaluation of the formula.
• So =[Column] resolves to a single value (the value from "this row"), w/out error.
• "The current row" is called Row Context
• You may only reference a "naked' column (naked = no aggregation fxn ), and have it resolve to a single number, date, or text value when you have a Row Context.

## Exception: Filter Context in Calc Columns

• Aggregation functions like SUM *always* reference the Filter Context
• Since there is no Filter Context in a calc column, =SUM([Column]) will return the sum of the ENTIRE column – you get the same answer all the way down.
• But you can tell the DAX engine to use a Row Context as if it were ALSO a Filter Context, by wrapping the aggregation function in a CALCULATE.
• EX: =CALCULATE(SUM[Column])) "respects" the context of each row, AND also relationships
• So in a Lookup table, you can use CALCULATE(SUM(Data[Col])) to get the sum of all "matching" rows from the related Data
• Furthermore, the DAX engine always "adds" a CALCULATE "wrapper" whenever you reference a Measure.
So =[ MySumMeasure ] ALSO respects Row Context and Relationships.