

Modeling Data with Hierarchies and Time Intelligence



Agenda

- Creating Dimensional Hierarchies
- Understanding the Evaluation Context
- Extending the Data Model using Calendar Tables
- Writing DAX Expressions with Time Intelligence
- Writing DAX Code with Contextual Awareness



Dimensional Hierarchies

- Hierarchy created from two or more columns
 - All columns in hierarchy must be from the same table
 - Defines parent-child relationship between columns
 - Provides path to navigate through data
 - Provides path to drill down into greater level of detail



Pulling Columns for Hierarchy into Single Table

- Sometimes hierarchy columns are spread across tables
 - Use RELATED function from DAX to pull columns into single table

Sales Region = RELATED(SalesRegions[SalesRegion])					
Customer	Customer Type	Age	Age Group	Sales Region	State Name
Lucile Blake	One-time Customer	48	Ages 40 TO 49	Western Region	California
Rochelle Owen	One-time Customer	74	Ages 65 and over	Western Region	California
Corinne Finch	One-time Customer	73	Ages 65 and over	Western Region	California
Twila Massey	One-time Customer	25	Ages 18 TO 23	Western Region	California

- Then create hierarchy in the table with all the columns

Customer Geography	
Sales Region	
State	
City	
Zipcode	



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A Tale of Two Evaluation Contexts

- Row Context
 - Context includes all columns in iteration of current row
 - Used to evaluate DAX expression in calculated column
 - Only available in measures with iterator function (e.g. SUMX)
- Filter Context
 - Context includes filter(s) defining current set of rows
 - Used by default to evaluate DAX expressions in measures
 - Can be fully ignored or partially ignored using DAX code
 - Not used to evaluate DAX in calculated columns



Understanding Row Context

- Row context used to evaluate calculated columns

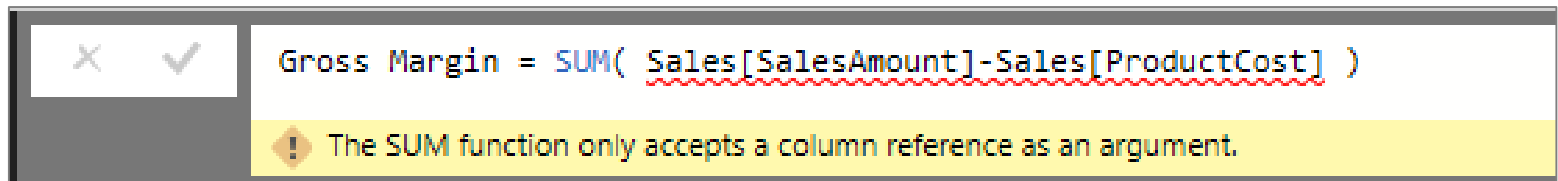
✕	✓	City = [City Name] & ", " & [State]			
	Age Group	Sales Region	State Name	SalesRegionSort	City
48	Ages 40 TO 49	Western Region	California	1	San Jose, CA
74	Ages 65 and over	Western Region	California	1	San Jose, CA
73	Ages 65 and over	Western Region	California	1	San Jose, CA
25	Ages 18 TO 23	Western Region	California	1	San Jose, CA
61	Ages 50 TO 65	Western Region	California	1	San Jose, CA
65	Ages 65 and over	Western Region	California	1	San Jose, CA

✕	✓	Age = Floor((TODAY()-Customers[BirthDate])/365, 1)			
Customer	Customer Type	Age	Age Group	Sales Region	State Name
Lucile Blake	One-time Customer	48	Ages 40 TO 49	Western Region	California
Rochelle Owen	One-time Customer	74	Ages 65 and over	Western Region	California
Corinne Finch	One-time Customer	73	Ages 65 and over	Western Region	California

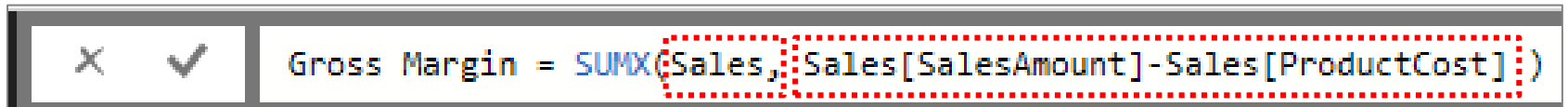


Understanding Iterators Like SUMX

- Standard aggregation functions (e.g. SUM) have no row context
 - You can use SUM to sum values of a single column
 - You cannot use SUM to sum results of an expressions



- Iterator functions (e.g. SUMX) iterate through rows in target table



- First argument accepts expressions that evaluates to table of rows
- Second argument accepts expression that is evaluated for each row



DAX Table Iterator Functions

- The following DAX functions create row context
 - AVERAGEX
 - COUNTAX
 - COUNTX
 - MAXX
 - MINX
 - SUMX



Understanding Filter Context

- Visuals apply various filters in different evaluation contexts

Month in Year	2012	2013	2014	2015	Total
January	\$6,306	\$164,334	\$385,275	\$512,822	\$1,068,737
February	\$48,815	\$126,501	\$358,244	\$597,684	\$1,131,244
March	\$53,958	\$243,676	\$381,309	\$532,123	\$1,211,067
April	\$52,601	\$300,872	\$381,157	\$602,751	\$1,337,381
May	\$61,756	\$334,948	\$438,261	\$647,276	\$1,482,241
June	\$76,756	\$321,715	\$378,749	\$608,448	\$1,385,668
July	\$104,408	\$287,800	\$359,744	\$620,316	\$1,372,268
August	\$111,167	\$298,483	\$457,312	\$678,499	\$1,545,461
September	\$110,716	\$376,207	\$505,332	\$613,971	\$1,606,229
October	\$145,999	\$362,943	\$602,448	\$620,735	\$1,732,125
November	\$156,751	\$340,228	\$545,572	\$590,220	\$1,632,770
December	\$147,593	\$331,526	\$581,977	\$686,814	\$1,747,910
Total	\$1,076,826	\$3,489,234	\$5,375,379	\$7,311,660	\$17,253,100

Filters on this evaluation

[Year] = 2015

[Month in Year] = "October"

- Filter context also affected by slicers and other filters

	Month in Year	2012	2013	2014	2015	Total
Sales Region	January	\$425	\$50,169	\$61,295	\$76,614	\$188,503
<input type="checkbox"/> Select All	February	\$13,891	\$40,133	\$63,670	\$101,542	\$219,236
<input type="checkbox"/> Central Region	March	\$19,121	\$58,411	\$73,839	\$84,180	\$235,551
<input type="checkbox"/> Eastern Region	April	\$19,128	\$53,711	\$67,919	\$91,762	\$232,520
<input checked="" type="checkbox"/> Western Region	May	\$22,939	\$64,259	\$78,668	\$109,689	\$275,555
	June	\$29,082	\$50,564	\$73,504	\$88,047	\$241,197
	July	\$34,809	\$62,971	\$69,053	\$80,749	\$247,582
	August	\$36,096	\$61,217	\$76,009	\$94,719	\$268,041
Customer Type	September	\$39,415	\$68,653	\$82,697	\$94,805	\$285,570
<input type="checkbox"/> One-time customer	October	\$51,994	\$69,122	\$99,344	\$84,177	\$304,637
<input checked="" type="checkbox"/> Repeat Customer	November	\$47,020	\$52,548	\$85,924	\$74,611	\$260,102
	December	\$50,580	\$66,260	\$102,088	\$94,877	\$313,804
	Total	\$364,500	\$698,018	\$934,009	\$1,075,771	\$3,072,298

Filters on this evaluation

[Year] = 2015

[Month in Year] = "October"

[Sales Region] = "Western Region"

[Customer Type] = "Repeat Customer"



Using the CALCULATE Function

- CALCULATE function provides greatest amount of control
 - First argument defines expression to evaluate
 - Second argument defines table on which to evaluate expression
 - You can evaluate expressions with or without current filter context

```
Pct of All Products =  
DIVIDE(  
    SUM( Sales[SalesAmount] ),  
    CALCULATE(  
        Sum (Sales[SalesAmount] ),  
        ALL(Products[Category], Products[Subcategory], Products[Product])  
    )  
)
```

```
Pct of Product Category =  
DIVIDE(  
    SUM( Sales[SalesAmount] ),  
    CALCULATE(  
        Sum (Sales[SalesAmount] ),  
        ALL( Products[Subcategory], Products[Product] )  
    )  
)
```



DAX Functions that Return a Table

- ALL
- ALLEXCEPT
- CALCULATETABLE
- DISTINCT
- FILTER
- RELATEDTABLE
- VALUES



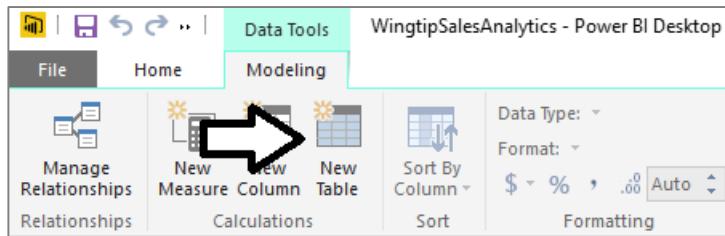
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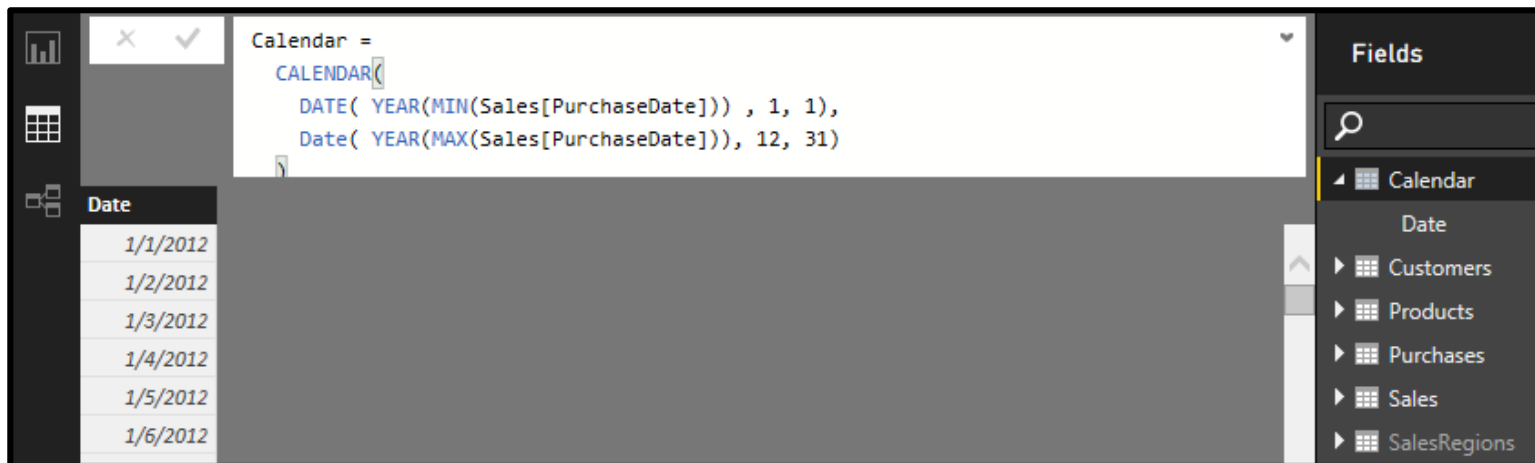


Creating Calendar Table as Calculated Table

- Use **New Table** command in ribbon



- Create calendar table using DAX **CALENDAR** function



Adding Columns to Calendar Table

- Creating the **Year** column

X ✓ Year = YEAR('Calendar'[Date])	
Date	Year
1/1/2012	2012
1/2/2012	2012
1/3/2012	2012

- Creating the **Quarter** column

X ✓ Quarter = YEAR('Calendar'[Date]) & "-Q" & FORMAT('Calendar'[Date], "q")			
Date	Year	Quarter	
01/01/2012	2012	2012-Q1	
01/02/2012	2012	2012-Q1	
01/03/2012	2012	2012-Q1	
01/04/2012	2012	2012-Q1	
01/05/2012	2012	2012-Q1	

- Creating the **Month** column

X ✓ Month = FORMAT('Calendar'[Date], "MMM yyyy")				
Date	Year	Quarter	Month	
1/1/2012	2012	2012-Q1	Jan 2012	
1/2/2012	2012	2012-Q1	Jan 2012	
1/3/2012	2012	2012-Q1	Jan 2012	



Configuring Sort Columns

- Month column will not sort in desired fashion by default
 - For example, April will sort before January, February and March
- Creating a sort column for the **Month** column
 - MonthSort** sorts alphabetically & chronologically at same time

MonthSort = FORMAT('Calendar'[Date], "yyyy-MM")				
Date	Year	Quarter	Month	MonthSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01
1/2/2012	2012	2012-Q1	Jan 2012	2012-01

- Configure **Month** column with **MonthSort** as sort column

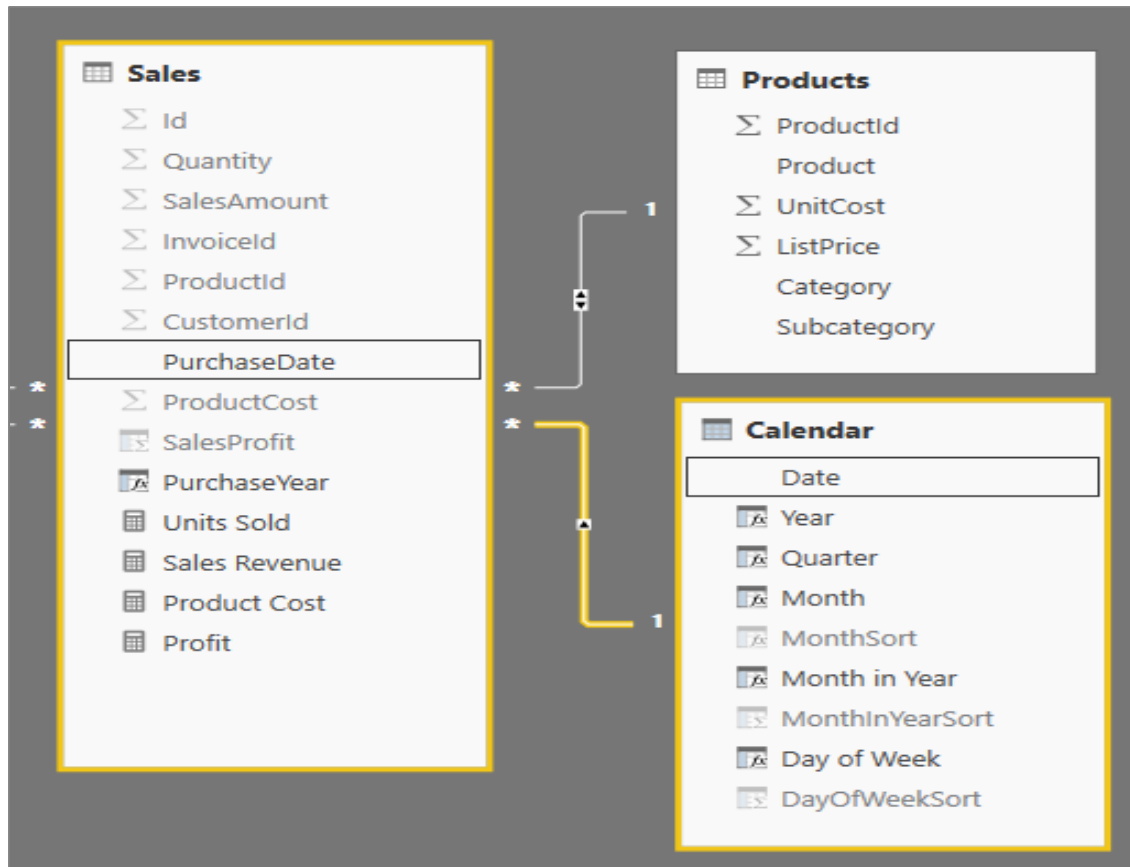
The screenshot shows the Power BI Desktop interface. In the 'Table' view, the 'Month' column is highlighted in yellow. A right-click context menu is open over the 'Month' column, and the 'Sort By Column' option is selected. The 'Sort By Column' dropdown menu is open, showing a list of columns: 'Month (Default)', 'Date', 'Year', 'Quarter', and 'MonthSort'. The 'MonthSort' option is selected, indicated by a green checkmark. In the background, the 'MonthSort' column is also highlighted in yellow. The formula bar at the top shows the DAX formula: `MonthSort = FORMAT('Calendar'[Date], "yyyy-MM")`. The data table below shows the same data as the previous table, with 'MonthSort' as the sort column.

Date	Year	Quarter	Month	MonthSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01
1/2/2012	2012	2012-Q1	Jan 2012	2012-01



Integrating Calendar Table into Data Model

- Calendar table needs relationship to one or more tables



Creating Visuals with a Calendar Table

- Year for row labels and **Month in Year** as column labels

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	\$3,063	\$33,218	\$49,213	\$40,434	\$83,840	\$136,670	\$144,244	\$197,952	\$215,097	\$239,513	\$376,503	\$424,240	\$1,943,986
2013	\$307,182	\$291,942	\$346,186	\$380,869	\$377,376	\$353,586	\$391,202	\$476,884	\$504,532	\$577,439	\$579,507	\$769,473	\$5,356,177
2014	\$629,969	\$609,637	\$628,618	\$661,588	\$748,193	\$814,333	\$788,469	\$869,143	\$890,958	\$988,789	\$999,574	\$1,644,980	\$10,274,251
2015	\$959,863	\$969,330	\$675,533	\$722,456	\$698,311	\$785,793	\$921,994	\$1,084,189	\$1,088,863	\$1,211,810	\$1,305,029	\$1,732,932	\$12,156,103
Total	\$1,900,077	\$1,904,126	\$1,699,551	\$1,805,347	\$1,907,720	\$2,090,382	\$2,245,908	\$2,628,168	\$2,699,449	\$3,017,551	\$3,260,613	\$4,571,625	\$29,730,517

- Month in Year** for row labels and **Year** as column labels

Month in Year ▲	2012	2013	2014	2015	Total
Jan	\$3,063	\$307,182	\$629,969	\$959,863	\$1,900,077
Feb	\$33,218	\$291,942	\$609,637	\$969,330	\$1,904,126
Mar	\$49,213	\$346,186	\$628,618	\$675,533	\$1,699,551
Apr	\$40,434	\$380,869	\$661,588	\$722,456	\$1,805,347
May	\$83,840	\$377,376	\$748,193	\$698,311	\$1,907,720
Jun	\$136,670	\$353,586	\$814,333	\$785,793	\$2,090,382
Jul	\$144,244	\$391,202	\$788,469	\$921,994	\$2,245,908
Aug	\$197,952	\$476,884	\$869,143	\$1,084,189	\$2,628,168
Sep	\$215,097	\$504,532	\$890,958	\$1,088,863	\$2,699,449
Oct	\$239,513	\$577,439	\$988,789	\$1,211,810	\$3,017,551
Nov	\$376,503	\$579,507	\$999,574	\$1,305,029	\$3,260,613
Dec	\$424,240	\$769,473	\$1,644,980	\$1,732,932	\$4,571,625
Total	\$1,943,986	\$5,356,177	\$10,274,251	\$12,156,103	\$29,730,517

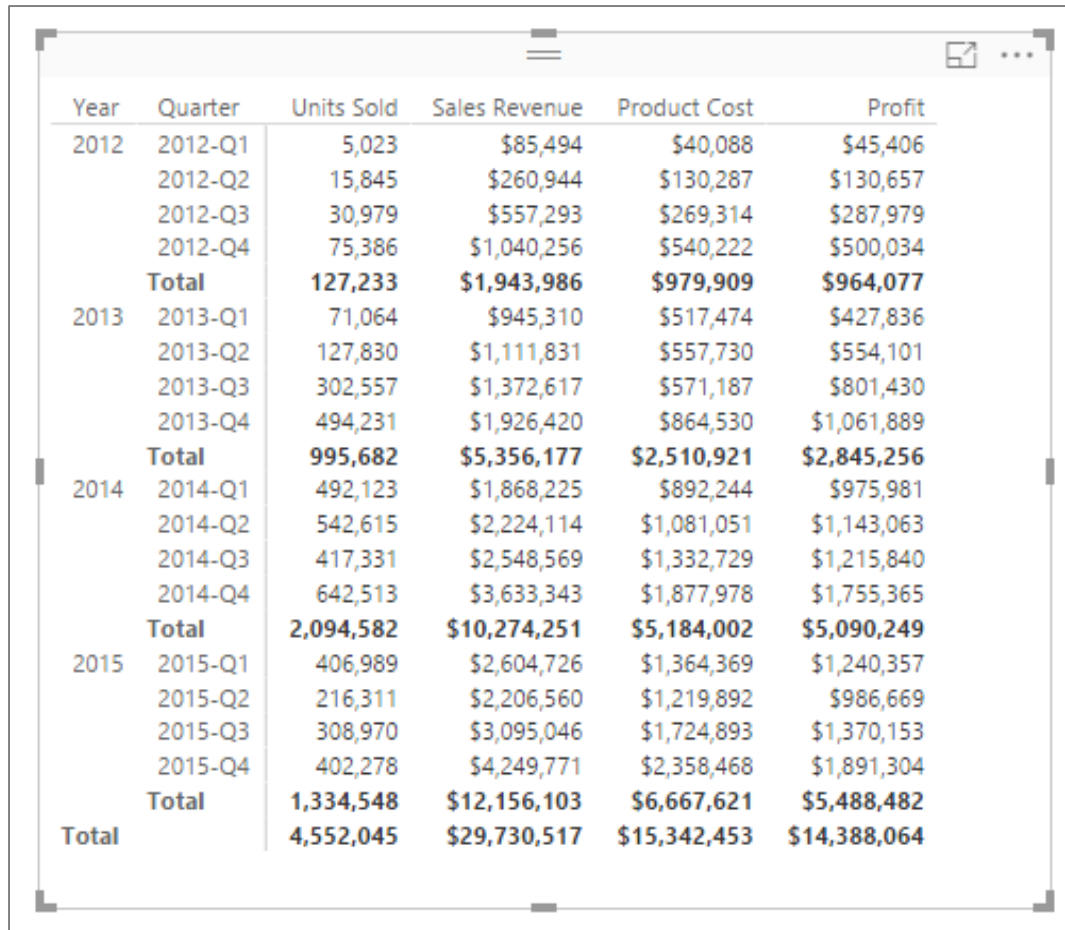
- Month in Year** for row labels and **Year** as column labels

Day of Week	2012	2013	2014	2015	Total
Mon	\$314,471	\$801,337	\$1,460,373	\$1,682,345	\$4,258,527
Tue	\$262,321	\$791,863	\$1,553,063	\$1,726,955	\$4,334,202
Wed	\$269,499	\$671,754	\$1,525,827	\$1,786,688	\$4,253,768
Thu	\$246,499	\$777,814	\$1,427,989	\$1,749,475	\$4,201,776
Fri	\$329,852	\$803,028	\$1,445,129	\$1,790,611	\$4,368,620
Sat	\$289,566	\$747,619	\$1,447,230	\$1,736,439	\$4,220,853
Sun	\$231,779	\$762,762	\$1,414,640	\$1,683,591	\$4,092,772
Total	\$1,943,986	\$5,356,177	\$10,274,251	\$12,156,103	\$29,730,517



Hierarchical Row Labels in a Matrix

- Dimensional hierarchy can be visualized using matrix



The image shows a screenshot of a data matrix visualization. The matrix displays financial data across five years (2012-2015) and four quarters per year. The columns represent different metrics: Year, Quarter, Units Sold, Sales Revenue, Product Cost, and Profit. The rows are organized hierarchically, with each year having a 'Total' row at the bottom of its group. The data is presented in a clean, professional format with a light gray background and dark text.

Year	Quarter	Units Sold	Sales Revenue	Product Cost	Profit
2012	2012-Q1	5,023	\$85,494	\$40,088	\$45,406
	2012-Q2	15,845	\$260,944	\$130,287	\$130,657
	2012-Q3	30,979	\$557,293	\$269,314	\$287,979
	2012-Q4	75,386	\$1,040,256	\$540,222	\$500,034
	Total	127,233	\$1,943,986	\$979,909	\$964,077
2013	2013-Q1	71,064	\$945,310	\$517,474	\$427,836
	2013-Q2	127,830	\$1,111,831	\$557,730	\$554,101
	2013-Q3	302,557	\$1,372,617	\$571,187	\$801,430
	2013-Q4	494,231	\$1,926,420	\$864,530	\$1,061,889
	Total	995,682	\$5,356,177	\$2,510,921	\$2,845,256
2014	2014-Q1	492,123	\$1,868,225	\$892,244	\$975,981
	2014-Q2	542,615	\$2,224,114	\$1,081,051	\$1,143,063
	2014-Q3	417,331	\$2,548,569	\$1,332,729	\$1,215,840
	2014-Q4	642,513	\$3,633,343	\$1,877,978	\$1,755,365
	Total	2,094,582	\$10,274,251	\$5,184,002	\$5,090,249
2015	2015-Q1	406,989	\$2,604,726	\$1,364,369	\$1,240,357
	2015-Q2	216,311	\$2,206,560	\$1,219,892	\$986,669
	2015-Q3	308,970	\$3,095,046	\$1,724,893	\$1,370,153
	2015-Q4	402,278	\$4,249,771	\$2,358,468	\$1,891,304
	Total	1,334,548	\$12,156,103	\$6,667,621	\$5,488,482
Total		4,552,045	\$29,730,517	\$15,342,453	\$14,388,064



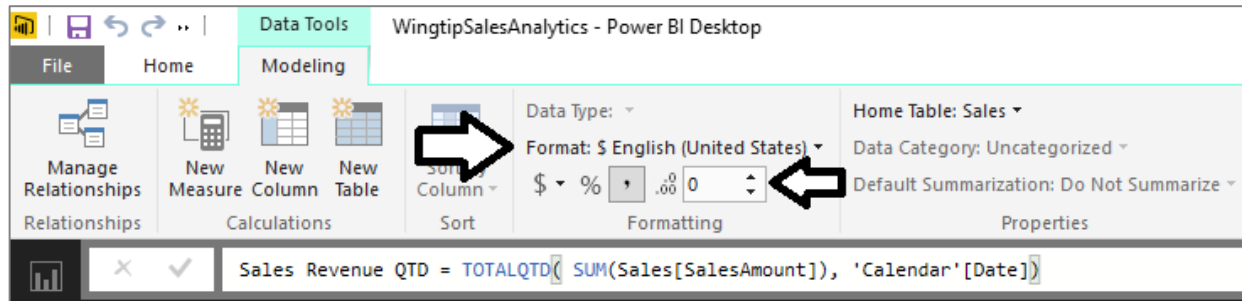
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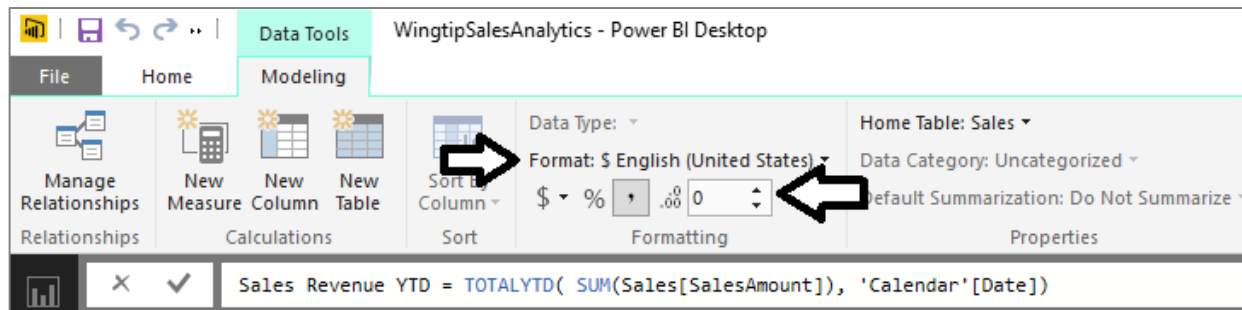


Calculated Fields for QTD and YTD Sales

- TOTALQTD function calculates quarter-to-date totals

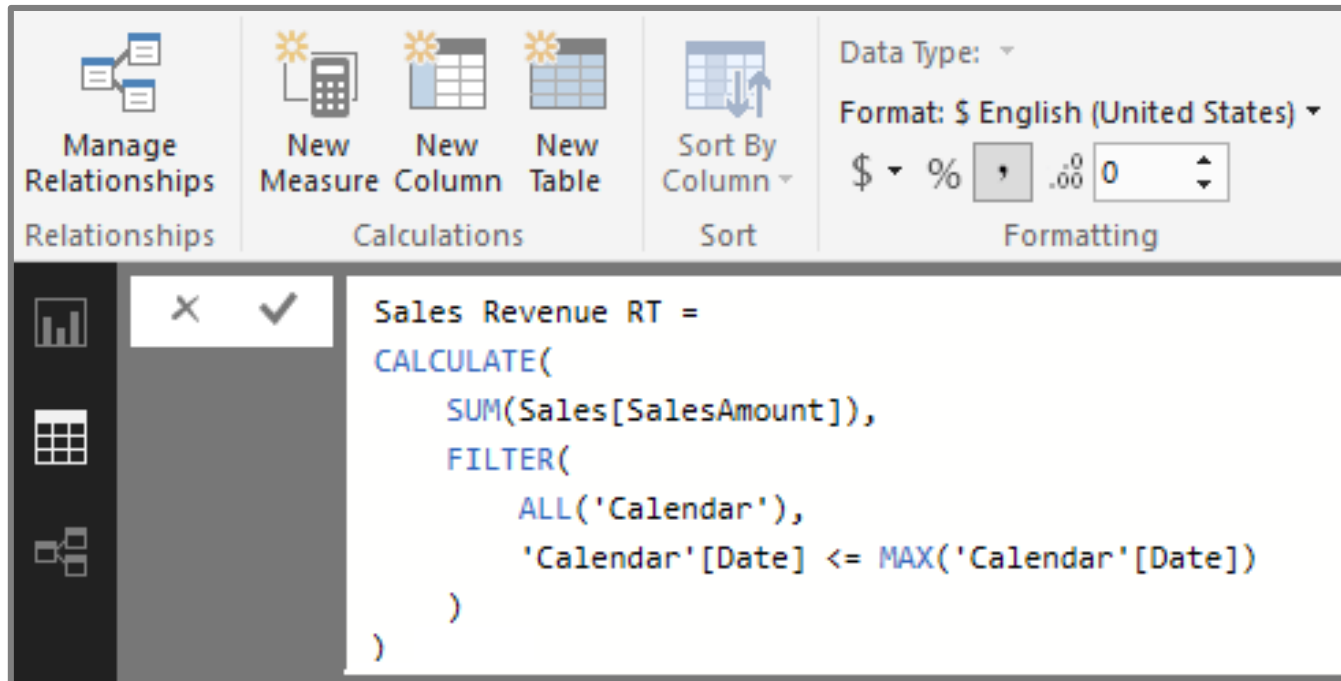


- TOTALYTD function calculates year-to-date totals



Creating Running Total using CALCULATE

- Calculate a running total of sales revenue across years
 - This must be done using **CALCULATE** function



Matrix Visual with To-Date Running Totals

- Running totals calculated using DAX

Year	Quarter	Month	Sales Revenue	Sales Revenue QTD	Sales Revenue YTD	Sales Revenue RT
2014	2014-Q1	Jan 2014	\$629,969	\$629,969	\$629,969	\$7,930,132
		Feb 2014	\$609,637	\$1,239,606	\$1,239,606	\$8,539,770
		Mar 2014	\$628,618	\$1,868,225	\$1,868,225	\$9,168,388
	2014-Q2	Apr 2014	\$661,588	\$661,588	\$2,529,812	\$9,829,976
		May 2014	\$748,193	\$1,409,780	\$3,278,005	\$10,578,168
		Jun 2014	\$814,333	\$2,224,114	\$4,092,338	\$11,392,502
	2014-Q3	Jul 2014	\$788,469	\$788,469	\$4,880,807	\$12,180,970
		Aug 2014	\$869,143	\$1,657,611	\$5,749,950	\$13,050,113

- Question: when did Wingtip reach \$10,000,000 in sales

Year	Quarter	Month	Sales Revenue	Sales Revenue QTD	Sales Revenue YTD	Sales Revenue RT
2014	2014-Q1	Jan 2014	\$629,969	\$629,969	\$629,969	\$7,930,132
		Feb 2014	\$609,637	\$1,239,606	\$1,239,606	\$8,539,770
		Mar 2014	\$628,618	\$1,868,225	\$1,868,225	\$9,168,388
	2014-Q2	Apr 2014	\$661,588	\$661,588	\$2,529,812	\$9,829,976
		May 2014	\$748,193	\$1,409,780	\$3,278,005	\$10,578,168
		Jun 2014	\$814,333	\$2,224,114	\$4,092,338	\$11,392,502
	2014-Q3	Jul 2014	\$788,469	\$788,469	\$4,880,807	\$12,180,970



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Sales Growth PM Measure - First Attempt

- Create a measure named Sales Growth PM

```
Sales Growth PM =  
DIVIDE(  
    SUM(Sales[SalesAmount]) -  
    CALCULATE(  
        SUM(Sales[SalesAmount]),  
        PREVIOUSMONTH(Calendar[Date])  
    ),  
    CALCULATE(  
        SUM(Sales[SalesAmount]),  
        PREVIOUSMONTH(Calendar[Date])  
    )  
)
```

- Use measure in matrix evaluating month and quarter
 - Measure returns correct value when filtered by Month
 - Measure returns large, erroneous value when filtered by Quarter

Year	Quarter	Month	Sales Revenue	Sales Growth PM
2014	2014-Q1	Jan 2014	\$629,969	-18.13 %
		Feb 2014	\$609,637	-3.23 %
		Mar 2014	\$628,618	3.11 %
		Total	\$1,868,225	142.79 %
	2014-Q2	Apr 2014	\$661,588	5.24 %
		May 2014	\$748,193	13.09 %
		Jun 2014	\$814,333	8.84 %
2014	2014-Q3	Total	\$2,224,114	253.81 %
		Jul 2014	\$788,469	-3.18 %



Using the ISFILTERED Function

- ISFILTERED function used to determine when perform evaluation

```
Sales Growth PM =  
IF(  
  ( ISFILTERED(Calendar[Month]) && NOT(ISFILTERED(Calendar[Date])) ),  
  DIVIDE(  
    SUM(Sales[SalesAmount]) -  
    CALCULATE(  
      SUM(Sales[SalesAmount]),  
      PREVIOUSMONTH(Calendar[Date])  
    ),  
    CALCULATE(  
      SUM(Sales[SalesAmount]),  
      PREVIOUSMONTH(Calendar[Date])  
    )  
  ),  
  BLANK()  
)
```

- Expression returns Blank value when evaluation context is invalid

Year	Quarter	Month	Sales Revenue	Sales Growth PM
2014	2014-Q1	Jan 2014	\$629,969	-18.13 %
		Feb 2014	\$609,637	-3.23 %
		Mar 2014	\$628,618	3.11 %
		Total	\$1,868,225	
	2014-Q2	Apr 2014	\$661,588	5.24 %
		May 2014	\$748,193	13.09 %
		Jun 2014	\$814,333	8.84 %
		Total	\$2,224,114	
	2014-Q3	Jul 2014	\$788,469	-3.18 %
		Aug 2014	\$869,143	10.23 %



Simulating KPIs with Power BI Desktop

- KPIs are not directly support in data model
 - But you can create something similar using measures

```
Sales Growth PM Eval =  
IF( ISNUMBER([Sales Growth PM]),  
    SWITCH(TRUE(),  
        ([Sales Growth PM] >= 0.2), "EXCELLENT",  
        ([Sales Growth PM] >= 0.1), "GOOD",  
        ([Sales Growth PM] >= 0), "OK",  
        ([Sales Growth PM] < 0), "BAD"  
    )  
)
```

Year	Quarter	Month	Sales Revenue	Sales Growth PM	Sales Growth PM Eval
2014	2014-Q1	Jan 2014	\$629,969	-18.13 %	AWFUL
		Feb 2014	\$609,637	-3.23 %	BAD
		Mar 2014	\$628,618	3.11 %	OK
		Total	\$1,868,225		
	2014-Q2	Apr 2014	\$661,588	5.24 %	OK
		May 2014	\$748,193	13.09 %	GOOD
		Jun 2014	\$814,333	8.84 %	OK
		Total	\$2,224,114		
	2014-Q3	Jul 2014	\$788,469	-3.18 %	BAD
		Aug 2014	\$869,143	10.23 %	GOOD
		Sep 2014	\$890,958	2.51 %	OK
		Total	\$2,548,569		



Summary

- ✓ Creating Dimensional Hierarchies
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