

# 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

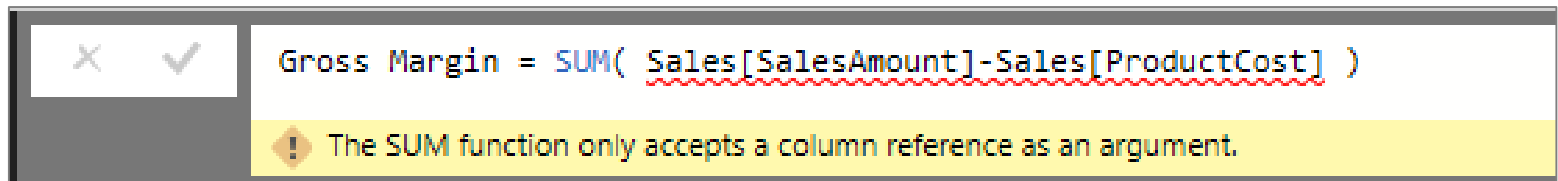
		Age = Floor( (TODAY()-Customers[BirthDate])/365, 1)			
Customer	Customer Type	Age	Age Group	Sales Region	State Name
Lucile Blake	One-time Customer	48	Ages 40 TO 49	Western Region	California
Rochelle Owen	One-time Customer	74	Ages 65 and over	Western Region	California
Corinne Finch	One-time Customer	73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



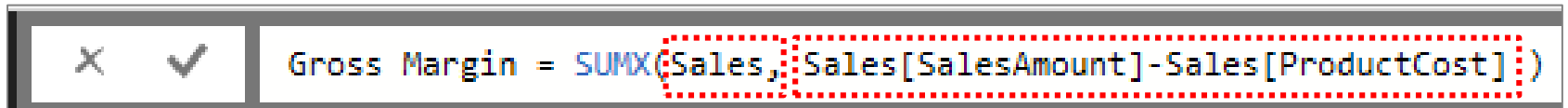


# Understanding Iterators Like SUMX

- 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
<b>Sales Region</b>	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
<b>Customer Type</b>	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



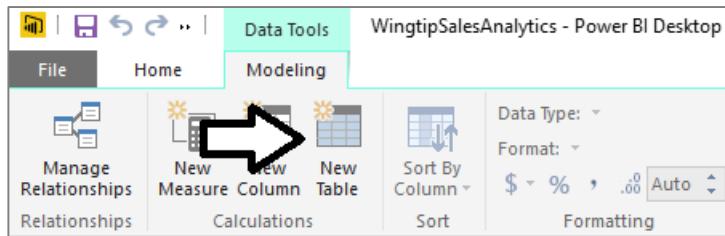
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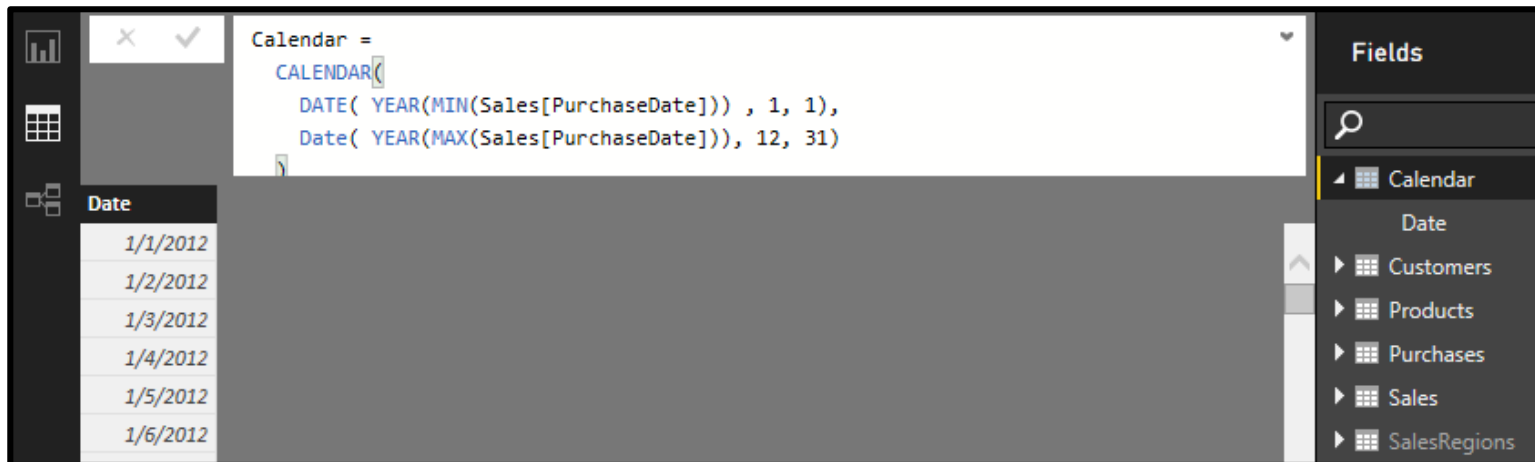


# Creating Calendar Table as Calculated Table

- 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 selected. The 'Sort By Column' dropdown menu is open, and 'MonthSort' is selected. The 'MonthSort' column is highlighted in yellow in the table view. The formula bar shows the DAX formula: `MonthSort = FORMAT('Calendar'[Date], "yyyy-MM")`. The table view shows the following data:

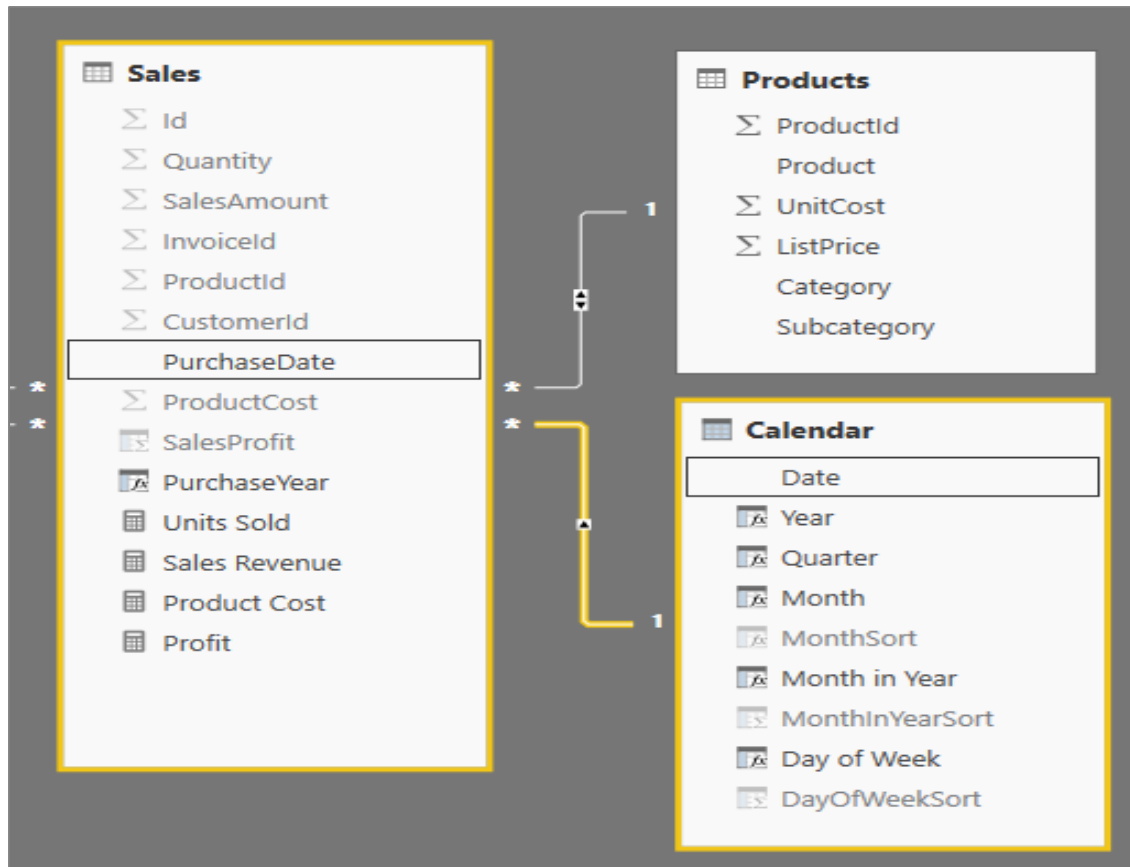
Date	Year	Quarter	Month	MonthSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01
1/2/2012	2012	2012-Q1	Jan 2012	2012-01





# 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	<b>\$1,943,986</b>
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	<b>\$5,356,177</b>
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	<b>\$10,274,251</b>
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	<b>\$12,156,103</b>
<b>Total</b>	<b>\$1,900,077</b>	<b>\$1,904,126</b>	<b>\$1,699,551</b>	<b>\$1,805,347</b>	<b>\$1,907,720</b>	<b>\$2,090,382</b>	<b>\$2,245,908</b>	<b>\$2,628,168</b>	<b>\$2,699,449</b>	<b>\$3,017,551</b>	<b>\$3,260,613</b>	<b>\$4,571,625</b>	<b>\$29,730,517</b>

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

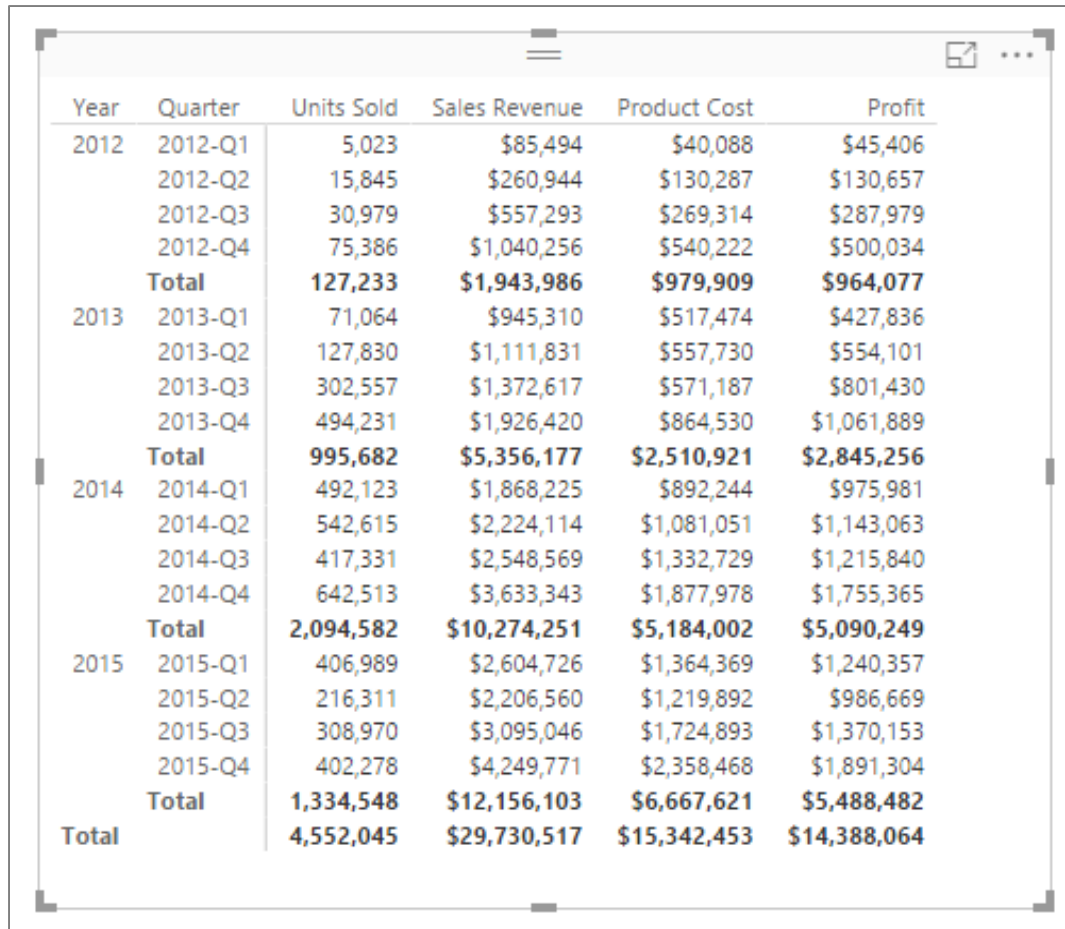
- Month in Year** for row labels and **Year** as column labels

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



# 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 sales data across five columns: Year, Quarter, Units Sold, Sales Revenue, Product Cost, and Profit. The rows are organized hierarchically by year (2012, 2013, 2014, 2015) and then by quarter (Q1, Q2, Q3, Q4). Each year section includes a 'Total' row. The data is presented in a light gray grid with black text. The visualization is framed by a thin gray border with small handles at the corners and top center.

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
	<b>Total</b>	<b>127,233</b>	<b>\$1,943,986</b>	<b>\$979,909</b>	<b>\$964,077</b>
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
	<b>Total</b>	<b>995,682</b>	<b>\$5,356,177</b>	<b>\$2,510,921</b>	<b>\$2,845,256</b>
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
	<b>Total</b>	<b>2,094,582</b>	<b>\$10,274,251</b>	<b>\$5,184,002</b>	<b>\$5,090,249</b>
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
	<b>Total</b>	<b>1,334,548</b>	<b>\$12,156,103</b>	<b>\$6,667,621</b>	<b>\$5,488,482</b>
<b>Total</b>		<b>4,552,045</b>	<b>\$29,730,517</b>	<b>\$15,342,453</b>	<b>\$14,388,064</b>



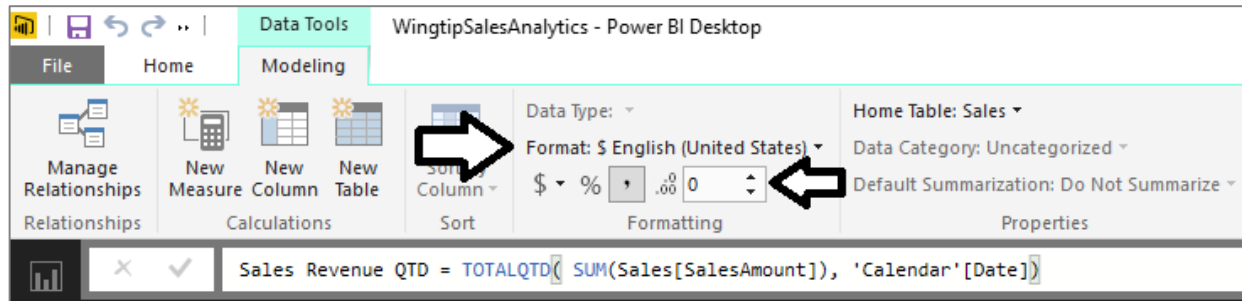
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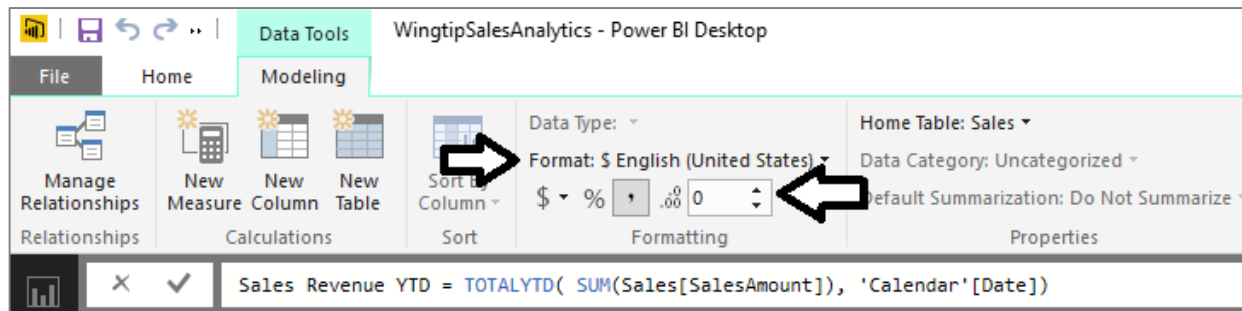


# Calculated Fields for QTD and YTD Sales

- TOTALQTD function calculates quarter-to-date totals



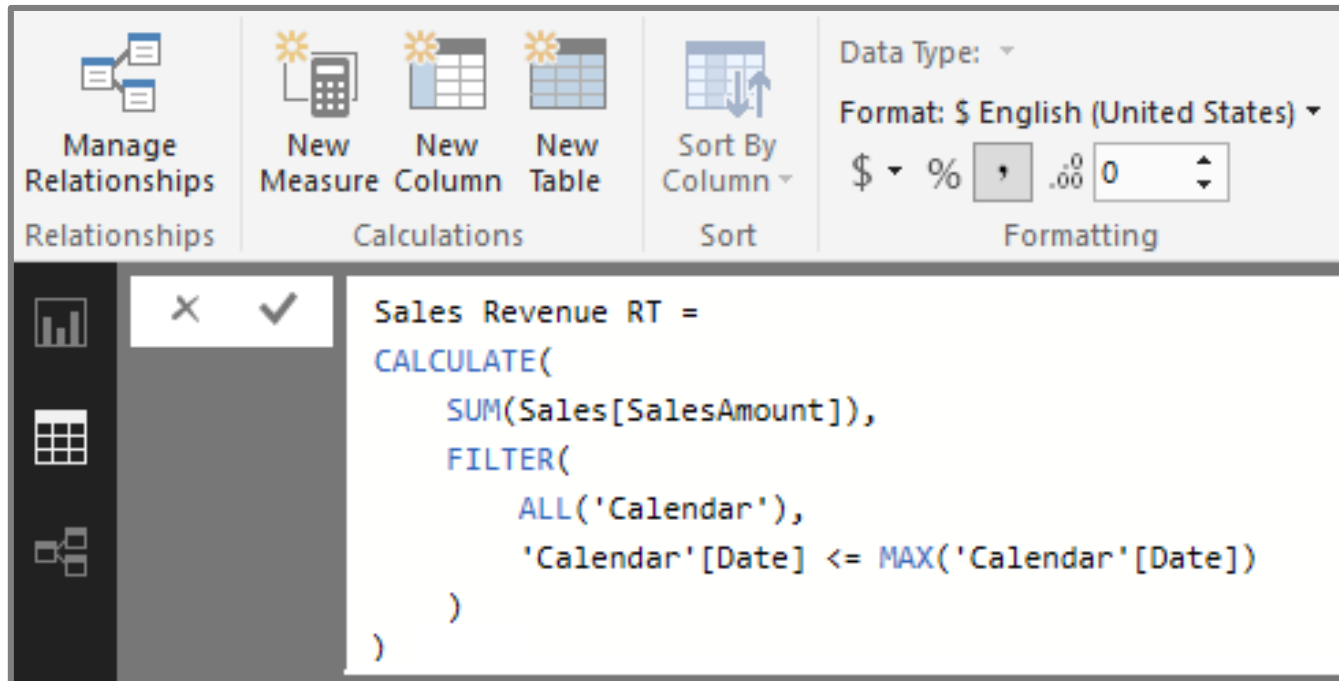
- TOTALYTD function calculates year-to-date totals





# 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 %
		<b>Total</b>	<b>\$1,868,225</b>	<b>142.79 %</b>
	2014-Q2	Apr 2014	\$661,588	5.24 %
		May 2014	\$748,193	13.09 %
		Jun 2014	\$814,333	8.84 %
	2014-Q3	<b>Total</b>	<b>\$2,224,114</b>	<b>253.81 %</b>
		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 %
		<b>Total</b>	<b>\$1,868,225</b>	
	2014-Q2	Apr 2014	\$661,588	5.24 %
		May 2014	\$748,193	13.09 %
		Jun 2014	\$814,333	8.84 %
		<b>Total</b>	<b>\$2,224,114</b>	
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
- ✓ Understanding the Evaluation Context
- ✓ Extending the Data Model using Calendar Tables
- ✓ Writing DAX Expressions with Time Intelligence
- ✓ Writing DAX Code with Contextual Awareness

