Microsoft

Microsoft Excel 2013

Building Data Models with PowerPivot

Alberto Ferrari and Marco Russo

Sample files on the web

Sample Chapter

ISBN: 978-0-7356-7634-3

Contents

Introduction

Microsoft Excel is the world standard for performing data analysis. Its ease of use and power make the Excel spreadsheet the tool that everybody uses, regardless of the kind of information being analyzed.

You can use Excel to store your personal expenses, your current account information, your customer information or a complex business plan, or even your weight-loss progress during a hard-to-follow diet. The possibilities are infinite—we are not even going to try to start enumerating all the kind of information you can analyze with Excel. The fact is that if you have some data to arrange and analyze, your chances are excellent that Excel will be the perfect tool to use. You can easily arrange data in a tabular format, update it, generate charts, PivotTables, and calculations based on it, and make forecasts with relatively limited knowledge of the software. With the advent of the cloud, now you can use Excel on mobile devices like tablets and smart phones, too, using Internet to have constant access to your information. Also, in earlier versions of Excel, there was a limit of 65,536 rows per single worksheet, and the fact that so many customers asked Microsoft to increase this number (which Microsoft did, raising the limit to 1 million rows in Excel 2007) is a clear indication that users want Excel to store and analyze large amounts of data.

Besides Excel users, there is another category of people dedicating their professional lives to data analysis: business intelligence (BI) professionals. BI is the science of getting insights from large amounts of information, and, in recent years, BI professionals have learned and created many new techniques and tools to manage systems that can handle the range of hundreds of millions or even billions of rows. BI systems require the effort of many professionals and expensive hardware to run. They are powerful, but they are expensive and slow to build, which are serious disadvantages.

Before 2010, there was a clear separation between the analysis of small and large amounts of data: Excel on one side and complex BI systems on the other. A first step in the direction of merging the two worlds was already present in Excel because the PivotTable tool had the ability to query BI systems. By doing that, data analysts could query large BI systems and get the best of both worlds because the result of such a query can be put into an Excel PivotTable, and thus they could use it to perform further analysis.

In 2010, Microsoft made a strong move to break down the wall between BI professionals and Excel users by introducing xVelocity, a powerful engine that drives large BI solutions directly inside Excel. That happened when Microsoft SQL Server 2008

R2 PowerPivot for Excel was released as a free add-in to Excel 2010. The goal was to make the creation of BI solutions so easy that Excel would start to be not only a BI client, but also a BI server, capable of hosting complex BI solutions on a notebook. They called it *self-service BI*.

Microsoft PowerPivot has no limits on the number of rows it can store: if you need to handle 100 million rows, you can safely do so, and the speed of analysis is amazing. PowerPivot also introduced the DAX language, a powerful programming language aimed to create BI solutions, not only Excel formulas. Finally, PowerPivot is able to compress data in such a way that large amounts of information can be stored in relatively small workbooks. But this was only the first step.

The second definitive step to bring the power of BI to users was the introduction of Excel 2013. PowerPivot is no longer a separate add-in of Excel; now it is an inherent part of the Excel technology and brings the power of the xVelocity engine to every Excel user. The era of self-service BI started in 2010, and it has advanced in 2013.

Because you are reading this introduction, you are probably interested in joining the self-service BI wave, and you want to learn how to master PowerPivot for Excel. You will need to learn the basics of the tool, but this is only the first step. Then, you will need to learn how to shape your data so that you can execute analysis efficiently: we call this *data modeling*. Finally, you will need to learn the DAX language and master all its concepts so you can get the best out of it. If that is what you want, then this is the book for you.

We are BI professionals, and we know from experience that building a BI solution is not easy. We do not want to mislead you: BI is a fascinating technology, but it is also a hard one. This book is designed to help you take the necessary steps to transform you from an Excel user to a self-service BI modeler. It will be a long road that will require time and dedication to travel, and you will find yourself making the adaptations you need to learn new techniques. However, the results you will be able to accomplish are invaluable.

The book is not a step-by-step guide to PowerPivot for Excel 2013. If you are looking for a *PowerPivot for Dummies* book, then this is not the book for you. But if you want a book that will go with you on this long, satisfying journey, from the first simple workbooks to the complex simulations you will be creating soon, then this is your ultimate resource.

When writing this book, we decided to focus on concepts and real-world examples, starting at zero and bringing you to mastering the DAX language. We do not cover every single feature, and we do not explain each operation in a "Click this, and then do that” fashion. On the other hand, we packed in this single book a huge amount of information so that, once you finished studying the book, you will have a great background in the new modeling options of Excel.

This last sentence highlights the main characteristic of this book: it is a book to study, not just to read. Get prepared for a long trip—but we promise you that it will be well worth it.

Who this book is for

The book is aimed at Excel users, project managers, and decision makers who wish to learn the basics of PowerPivot for Excel 2013, master the new DAX language that is used by PowerPivot, and learn advanced data modeling and programming techniques with PowerPivot.

Assumptions about you

This book assumes that you have a basic knowledge of Excel 2010 or Excel 2013. You do not need to be a master of Excel; just being a regular user is fine. We will cover what is needed to make the transition from Excel to PowerPivot, but we do not cover in any way the fundamentals of Excel, like entering a formula, writing a *VLOOKUP* function, or other basic functionalities.

No previous knowledge of PowerPivot is needed. If you already tried to build a data model by yourself, that is fine, but we will assume that you never opened PowerPivot before reading the book.

Organization of this book

The book is designed to be read from cover to cover. Trying to jump directly to the solution of a specific problem, skipping some content, will probably be the wrong choice. In each chapter, we introduce concepts and functionalities that you will need to understand the subsequent chapters. Moreover, we wrote some chapters knowing that you will need to read them more than once, because the theoretical background they provide is hard to take in at a first read.

The book is divided into 16 chapters:

Chapter 1, “Introduction to PowerPivot,” offers a guided tour of the basic features of PowerPivot for Excel 2013. By following a step-by-step guide, we show the main benefits of using PowerPivot for your analytical needs. We show how to create a simple Power View report as well.

Chapter 2, “Using the Unique Features of PowerPivot,” shows the features that are available only if you enable the PowerPivot for Excel add-in. This includes calculated columns, calculated fields, hierarchies, and some other basic features. It is the logical continuation (and conclusion) of Chapter 1.

In Chapter 3, ”Introducing DAX,” we start covering the DAX language, including its syntax and the most basic functions. We highlight the difference between a calculated column and a calculated field, and at the end, we show a first practical example of DAX usage.

Chapter 4, “Understanding Data Models,” is a theoretical chapter, covering the basics of data modeling and showing the different modeling options in a Power-Pivot database. We describe several concepts that are not evident for Excel users, like normalization and denormalization, the structure of a SQL query, how relationships work and why they are so important, the structure of data marts, and data warehouses.

In Chapter 5, “Publishing to SharePoint,” we cover the process of publishing workbooks to Microsoft SharePoint to do team BI. Moreover, we introduce the concept of PowerPivot for SharePoint being a server-side application that you can program and extend using Excel and PowerPivot.

Chapter 6, “Loading Data,” is dedicated to the many ways to load data inside PowerPivot. For each data source, we show the way it works and provide many hints and best practices for that specific source.

Chapter 7, “Understanding Evaluation Contexts,” and Chapter 8, “Understanding *CALCULATE*,” are the theoretical core of the book. There, we introduce the concepts of evaluation contexts, relationships, and the *CALCULATE* function. These are the pillars of the DAX language, and you will need to master them before writing advanced data models with PowerPivot.

Chapter 9, “Using Hierarchies,” shows how to create and manage hierarchies. It covers basic hierarchy handling, how to compute values over hierarchies, and finally, it shows how to manage parent/child hierarchies by using the concepts learned in Chapters 7 and 8.

Chapter 10, “Using Power View,” is dedicated to the new reporting tool in Excel 2013: Power View. There, we show the main feature of this tool, how to create simple Power View reports, and how to filter data and build reports that are pleasant to look at and provide useful insights in your data.

Chapter 11, “Shaping the Reports,” covers several advanced topics regarding reporting. It includes Key Performance Indicators (KPIs), how to write them, and how to use them to improve the quality of your reporting system. We also cover the Power View metadata layer in PowerPivot, drill-through, sets in Excel or in MDX, and perspectives.

Chapter 12, “Performing Date Calculations in DAX,” deals with time intelligence. Year to Date (YTD), Quarter to Date (QTD), Month to Date (MTD), working days versus non-working days, semiadditive measures, moving averages, and other complex calculations involving time are all topics covered here.

Chapter 13, “Using Advanced DAX,” is a collection of scenarios and solutions, all of which share the same background: they are hard to solve using Excel or in any other tool, whereas they are somewhat easier to manage in DAX, once you gain the necessary knowledge from the previous chapters in the book. All these examples come from real-world scenarios and are among the top requests we see when we do consultancy or look at forums on the web.

Chapter 14, “Using DAX as a Query Language,” is dedicated to using DAX as a query language (as you might guess). It covers the various functionalities of DAX when used to query a database. It also shows advanced functionalities, like reverse-linked and linked-back tables, which greatly enhance the capabilities of PowerPivot to build complex data models.

Chapter 15, “Automating Operations Using VBA,” discusses using Microsoft Visual Basic for Applications (VBA) to manage PowerPivot workbooks in a programmatic way, automating a few common tasks. We provide some code examples and show how to solve some of the common scenarios where VBA might be useful.

Chapter 16, “Comparing Excel and SQL Server Analysis Services,” compares the functionalities of the three flavors of PowerPivot technology: PowerPivot for Excel, PowerPivot for SharePoint, and SQL Server Analysis Services (SSAS). The goal of this final chapter is to give you a clear picture of what can be done with PowerPivot for Excel, when you need to move a step further and adopt PowerPivot for SharePoint, and what extra features are available only in SSAS.

CHAPTER 1

Introduction to PowerPivot

Microsoft PowerPivot for Microsoft Excel 2013 is a technology aimed at providing self-service business intelligence (BI), which is a real revolution inside the world of data analysis because it gives the final user all the power needed to perform complex data analysis without requiring the intervention of BI technicians. PowerPivot is an Excel add-in that implements a fast, powerful, in-memory database that can be used to organize data, detect interesting relationships, and provide the fastest way to browse information.

Some of the most interesting features of PowerPivot are the following:

- The ability to organize tables for the PivotTable tool in a relational way, freeing the analyst from the need to import data as Excel sheets before analyzing them.
- The availability of a fast, space-saving, columnar database that can handle huge amounts of data without the limitations of Excel sheets.
- DAX, a powerful programming language that defines complex expressions on top of the relational database. It makes it possible to define surprisingly rich expressions compared to those standards in Excel.
- The ability to integrate different sources of data, such as databases, Excel sheets, and data sources available on the Internet, and virtually any kind of data.
- Amazingly fast in-memory processing of complex queries over the whole database.

Some people might think of PowerPivot as a simple replacement for the PivotTable, while others might use it as a rapid development tool for complex BI solutions, and still others might believe that it is a real replacement for a complex BI solution. PowerPivot is not a replacement for large and complex BI solutions like the ones built on top of Microsoft Analysis Services, but it is much more than a simple replacement for the Excel PivotTable, and it is a great tool for exploring the BI world and implementing end-to-end BI solutions.

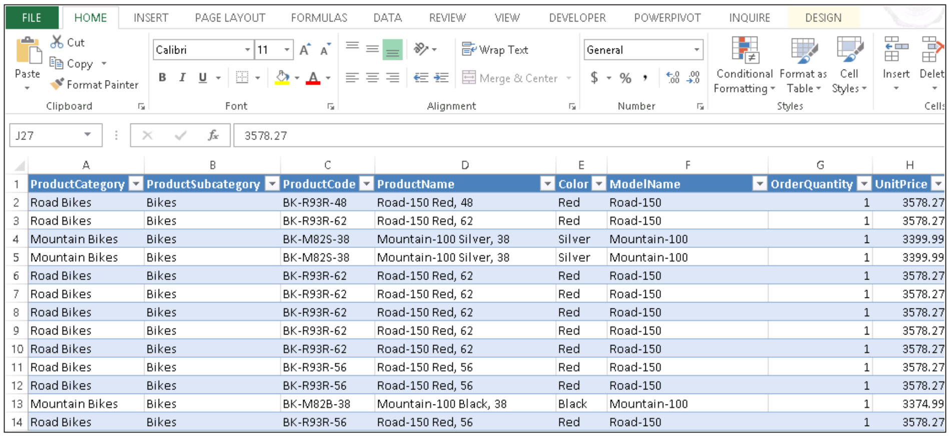
PowerPivot fills the gap between an Excel sheet and a complete BI solution, and it has some unique characteristics that make it appealing for both Excel power users and seasoned BI analysts. This book analyzes all the features of PowerPivot, but, as with any big project, we need to start from the beginning. This chapter starts with a simple introduction to the basic features of PowerPivot. We suggest that you follow the step-by-step instructions so you can see on your own computer the results that we show in the book. Later, in the following chapters, we will not use step-by-step instructions anymore because we think that it is better to focus the book on concepts rather than on "click Next" instructions for more advanced topics.

Even though this book is about PowerPivot for Excel 2013, it is a good idea to start with a short review of how PowerPivot was born and how it worked in Excel 2010, so you can better appreciate the new features and understand some of the peculiarities of this add-in.

Using a PivotTable on an Excel table

Let's start by going backward, into the past. Since the release of Excel 97, it has been possible to analyze data using PivotTables. Prior to the availability of PowerPivot, using PivotTables was the main way to analyze data. The PivotTable is an easy and convenient way to browse huge amounts of data that you collect into Excel sheets. This book does not explain in detail how the PivotTable tool works; there are a lot of good descriptions available from other sources. However, it's helpful to recall the main features of the PivotTable to compare them with those of PowerPivot.

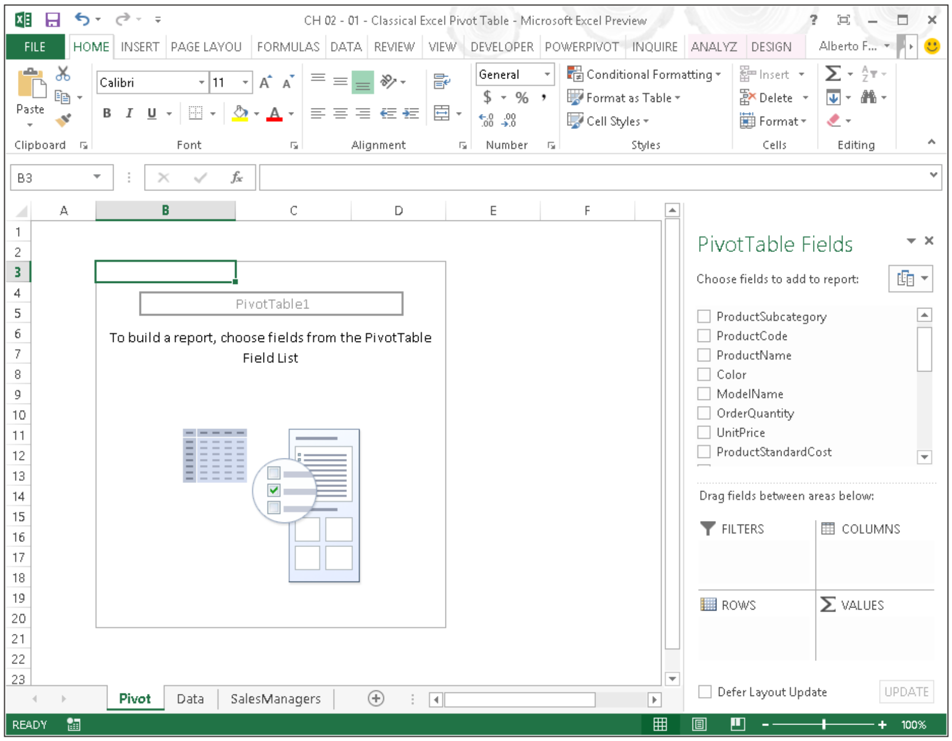
Suppose you have a standard Excel table, imported from a query run against a database, that contains all the data that you want to analyze. To get this data, you probably asked IT to provide some means to access the database and a specific query to retrieve the information. Your Excel sheet would look like the one in Figure 1-1. Because the table contains raw data, it is very difficult to analyze. You can look at this worksheet in the companion workbooks under the name "CH01-01-Classical Excel PivotTable.xlsx."



	A	B	C	D	E	F	G	H
1	ProductCategory	ProductSubcategory	ProductCode	ProductName	Color	ModelName	OrderQuantity	UnitPrice
2	Road Bikes	Bikes	BK-R93R-48	Road-150 Red, 48	Red	Road-150	1	3578.27
3	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
4	Mountain Bikes	Bikes	BK-M82S-38	Mountain-100 Silver, 38	Silver	Mountain-100	1	3399.99
5	Mountain Bikes	Bikes	BK-M82S-38	Mountain-100 Silver, 38	Silver	Mountain-100	1	3399.99
6	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
7	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
8	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
9	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
10	Road Bikes	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	1	3578.27
11	Road Bikes	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	1	3578.27
12	Road Bikes	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	1	3578.27
13	Mountain Bikes	Bikes	BK-M82B-38	Mountain-100 Black, 38	Black	Mountain-100	1	3374.99
14	Road Bikes	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	1	3578.27

FIGURE 1-1 Here, you see some sample data we can use to create a new PivotTable.

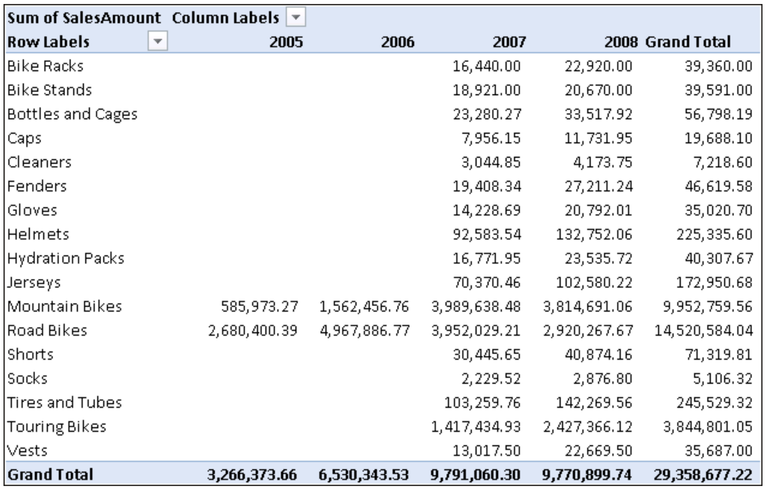
Now that you have all the data available in a sheet, you can choose to insert a PivotTable using the PivotTable button of the Insert tab of the Excel ribbon. The wizard prompts for the table to use as the source of the Pivot and for where to put the PivotTable, and then it provides the standard Excel PivotTable interface shown in Figure 1-2.



To build a report, choose fields from the PivotTable Field List

FIGURE 1-2 This is the standard PivotTable interface in Excel.

From here, you can choose to take the Year (to cite one example) and put it as a column and the ProductCategory as a row, displaying the SalesAmount at the intersection of rows and columns. After properly formatting your numbers, you get a nice report (as shown in Figure 1-3) showing how each category performed over time.



Sum of SalesAmount	Column Labels				
Row Labels	2005	2006	2007	2008	Grand Total
Bike Racks			16,440.00	22,920.00	39,360.00
Bike Stands			18,921.00	20,670.00	39,591.00
Bottles and Cages			23,280.27	33,517.92	56,798.19
Caps			7,956.15	11,731.95	19,688.10
Cleaners			3,044.85	4,173.75	7,218.60
Fenders			19,408.34	27,211.24	46,619.58
Gloves			14,228.69	20,792.01	35,020.70
Helmets			92,583.54	132,752.06	225,335.60
Hydration Packs			16,771.95	23,535.72	40,307.67
Jerseys			70,370.46	102,580.22	172,950.68
Mountain Bikes	585,973.27	1,562,456.76	3,989,638.48	3,814,691.06	9,952,759.56
Road Bikes	2,680,400.39	4,967,886.77	3,952,029.21	2,920,267.67	14,520,584.04
Shorts			30,445.65	40,874.16	71,319.81
Socks			2,229.52	2,876.80	5,106.32
Tires and Tubes			103,259.76	142,269.56	245,529.32
Touring Bikes			1,417,434.93	2,427,366.12	3,844,801.05
Vests			13,017.50	22,669.50	35,687.00
Grand Total	**3,266,373.66**	**6,530,343.53**	**9,791,060.30**	**9,770,899.74**	**29,358,677.22**

FIGURE 1-3 Here is an example of a report created with the PivotTable tool.

It is clear that by changing the way data is organized into rows and columns, you can easily produce different and interesting reports with an intuitive, fast interface that helps you navigate the information.

Figure 1-3 shows what a standard PivotTable looks like. Users all around the world have been utilizing this tool for many years with great success, analyzing their Excel data in many different ways and producing reports according to their needs.

One of the best characteristics of the PivotTable tool is its ease of use. Excel analyzes the source table, detects numeric values, and provides the ability to display their total slicing data over all other columns. Clearly, totals are aggregated using the *SUM* function because this is what is normally needed. If you want a different aggregation function, you can choose it using the various PivotTable options.

As easy as it is to use, PivotTables have some limitations:

- PivotTables can analyze only information coming from a single table stored in an Excel sheet. If you have different sheets, containing different information, there is not an easy way to correlate information coming from them.
- It is not always easy to get the source data into a format that is suitable for analysis. In the previous example, you saw a table that is extracted from a SQL query run against the *AdventureWorks* database and that you build to analyze data. The skills needed to build such a query are somewhat technical because you need to know the SQL syntax and the underlying database structure, and this often raises the problem of asking your IT department to develop such queries before you even start the analysis process.
- Because only one table can be analyzed at a time, you can often end up building the queries needed for a specific analysis and, if for any reason you want to perform a different analysis, then you will need to build different queries. For example, if you have a query that returns sales at the "month" level, you cannot use that same query to perform further analysis at the "day of week" level. To do that, you will need a new query. This, in turn, might involve the need to contact IT again, which can become expensive if IT charges based on the amount of work it performs.

When PivotTables are not enough, as is the case for medium-sized companies, it is very common to start a complete BI project with products like SQL Server Analysis Services, which will provide the same pivoting features on complex data structures known as *OLAP cubes*. OLAP cubes are difficult to build but provide the best solution to the complexity of free analysis of the company data. OLAP cubes will be discussed briefly later in this book, in Chapter 4, "Understanding Data Models"; at this point, it is enough to point out that they are the definitive solution to BI requirements, but they are expensive and still require great effort from the IT department.

Using PowerPivot in Microsoft Office 2013

PivotTables based on standard Excel tables are a pretty handy tool. Nevertheless, to let you analyze more complex data, Microsoft introduced a feature called “self-service BI.” The goal of this technology is to let you build complex data structures and analyze them with PivotTables, removing the current limitations of PivotTables. PowerPivot is the primary tool available from Microsoft to handle self-service BI, along with its companion Power View, which you will learn to use later in this chapter.

PowerPivot enables the user to analyze data without needing to contact IT to produce complex queries. Furthermore, it removes the limitation that a PivotTable can analyze only a single table because you will be able to query more tables at the same time, producing reports that easily integrate information coming from different sources.

Working with the *AdventureWorks* sample database

In order to provide examples, we will use the *AdventureWorks* database throughout this book. We have chosen *AdventureWorks* because it is well known, freely available on the web, and contains sample data that you can easily use for complex analysis. The database contains information about Adventure Works Cycles, which is a large multinational, fictitious company that manufactures and sells metal and composite bicycles to North American, European, and Asian commercial markets.

You can download the *AdventureWorks* database from *http://www.codeplex.com/SqlServerSamples,* where you will find different versions of the database, depending on the release of Microsoft SQL Server that you have installed. If you don’t have SQL Server on your PC, then you can use the Microsoft Access version of *AdventureWorks* that is provided in the companion material. Moreover, all the demos in this book are available in the companion material as Excel workbooks. Thus, you will be able to follow most of the examples even if you do not have access to a database.

Moreover, for the interested reader, Microsoft provides sample data in Excel workbooks that can be used to test PowerPivot at *http://tinyurl.com/PowerPivotSamples.* Even if we do not use these files in this book, you might be interested in loading them to have some data to perform your tests.

In 2010, PowerPivot for Excel 1.0 was released as an add-in for Excel 2010. PowerPivot is a powerful columnar database that does not work with classical Excel tables. Rather, it works with data stored inside its proprietary database, and it can be queried using the DAX language or a PivotTable. Although this information seems to be just a curiosity about the history of PowerPivot, it is in reality very important: for PowerPivot to work, the data should not be stored inside Excel tables, it needs to be stored inside the PowerPivot database. Keep this fact in mind; it will come in handy later.

Note The PowerPivot database is also referred to as the "Excel data model." The two terms relate to the very same technology: the Excel data model is, in reality, a PowerPivot database; and the PowerPivot database is stored inside the Excel workbook. In this book, we will refer to it using both names, depending on the context. If we believe that it is important to separate PowerPivot from Excel, then we will refer to it as the PowerPivot database; otherwise, we adhere to the more standard terminology and call it the Excel data model.

At the beginning, the PowerPivot database was somewhat separated from Microsoft Office, meaning that all its features were available only to users who decided to download and install the add-in. If an Excel workbook containing PowerPivot data was opened on a PC where the add-in was not installed, it simply did not work, even if the data contained in Excel sheets is always visible.

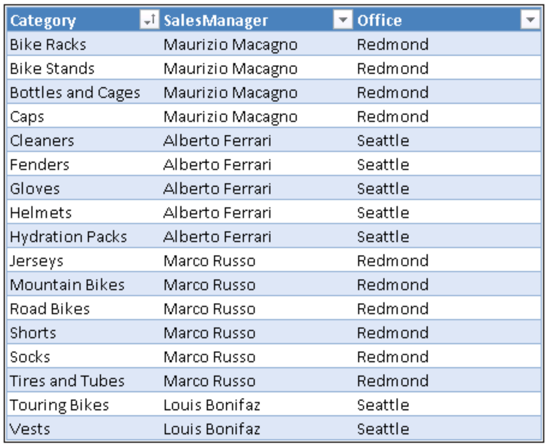
In Office 2013, PowerPivot comes preinstalled and should only need to be activated. Moreover, in Office 2013, the PowerPivot engine is fully integrated into the Excel code and starts to work even before being activated. Some features are immediately available, whereas others have to be manually activated, as you will learn later in this chapter.

In order to start using PowerPivot, we are going to take the easy way: we will create PowerPivot tables (remember—they are different from Excel tables) without even activating the add-in. This happens smoothly as soon as you activate some of the advanced features of Excel for the analysis of data, such as

- Power View reports
- Relationships between tables
- PivotTables over more than one table

Adding information to the Excel table

Let's start making the analysis slightly more complex. The dataset provided by our Excel table contains information about product categories. Assume that at AdventureWorks, each product category is assigned to a salesperson and this information is not stored in the database, so you don't have the option to modify the original query to grab this information. Because Excel is available, you can fill another Excel table with this information, as you can see in Figure 1-4.



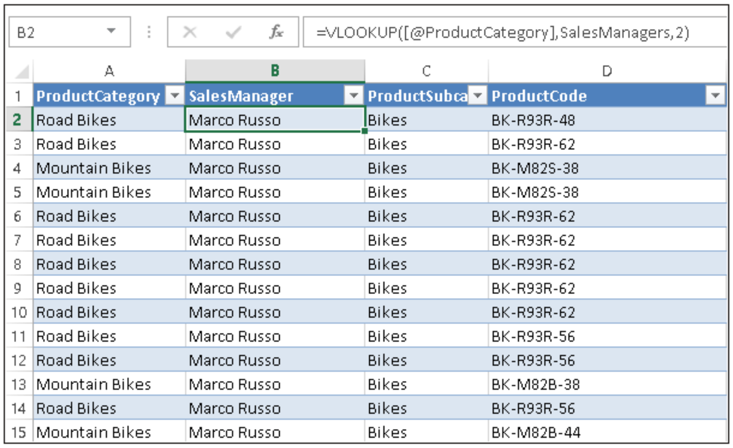
Category	SalesManager	Office
Bike Racks	Maurizio Macagno	Redmond
Bike Stands	Maurizio Macagno	Redmond
Bottles and Cages	Maurizio Macagno	Redmond
Caps	Maurizio Macagno	Redmond
Cleaners	Alberto Ferrari	Seattle
Fenders	Alberto Ferrari	Seattle
Gloves	Alberto Ferrari	Seattle
Helmets	Alberto Ferrari	Seattle
Hydration Packs	Alberto Ferrari	Seattle
Jerseys	Marco Russo	Redmond
Mountain Bikes	Marco Russo	Redmond
Road Bikes	Marco Russo	Redmond
Shorts	Marco Russo	Redmond
Socks	Marco Russo	Redmond
Tires and Tubes	Marco Russo	Redmond
Touring Bikes	Louis Bonifaz	Seattle
Vests	Louis Bonifaz	Seattle

FIGURE 1-4 The SalesManager Excel table will prove useful to show performance of managers instead of categories.

In order to use this new information in the PivotTable, you need to bring the SalesManager column into the original data model and, as you probably already know, VLOOKUP is invaluable here. Add a column to our original table with this formula:

```
=VLOOKUP([@ProductCategory],SalesManagers,2)
```

You will end up with a new dataset that now contains the sales manager, as you can see in Figure 1-5.



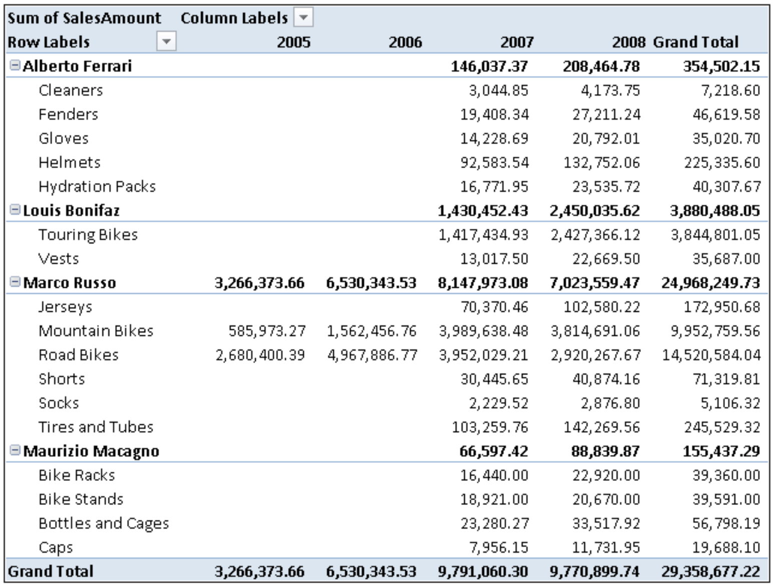
B2

=VLOOKUP([@ProductCategory],SalesManagers,2)

	A	B	C	D
1	ProductCategory	SalesManager	ProductSubca	ProductCode
2	Road Bikes	Marco Russo	Bikes	BK-R93R-48
3	Road Bikes	Marco Russo	Bikes	BK-R93R-62
4	Mountain Bikes	Marco Russo	Bikes	BK-M82S-38
5	Mountain Bikes	Marco Russo	Bikes	BK-M82S-38
6	Road Bikes	Marco Russo	Bikes	BK-R93R-62
7	Road Bikes	Marco Russo	Bikes	BK-R93R-62
8	Road Bikes	Marco Russo	Bikes	BK-R93R-62
9	Road Bikes	Marco Russo	Bikes	BK-R93R-62
10	Road Bikes	Marco Russo	Bikes	BK-R93R-62
11	Road Bikes	Marco Russo	Bikes	BK-R93R-56
12	Road Bikes	Marco Russo	Bikes	BK-R93R-56
13	Mountain Bikes	Marco Russo	Bikes	BK-M82B-38
14	Road Bikes	Marco Russo	Bikes	BK-R93R-56
15	Mountain Bikes	Marco Russo	Bikes	BK-M82B-44

FIGURE 1-5 Using VLOOKUP, we have been able to bring the sales manager into the original table.

With the new dataset, the PivotTable can be easily re-created, adding the SalesManager to the rows. This results in the desired report, as you can see in Figure 1-6.



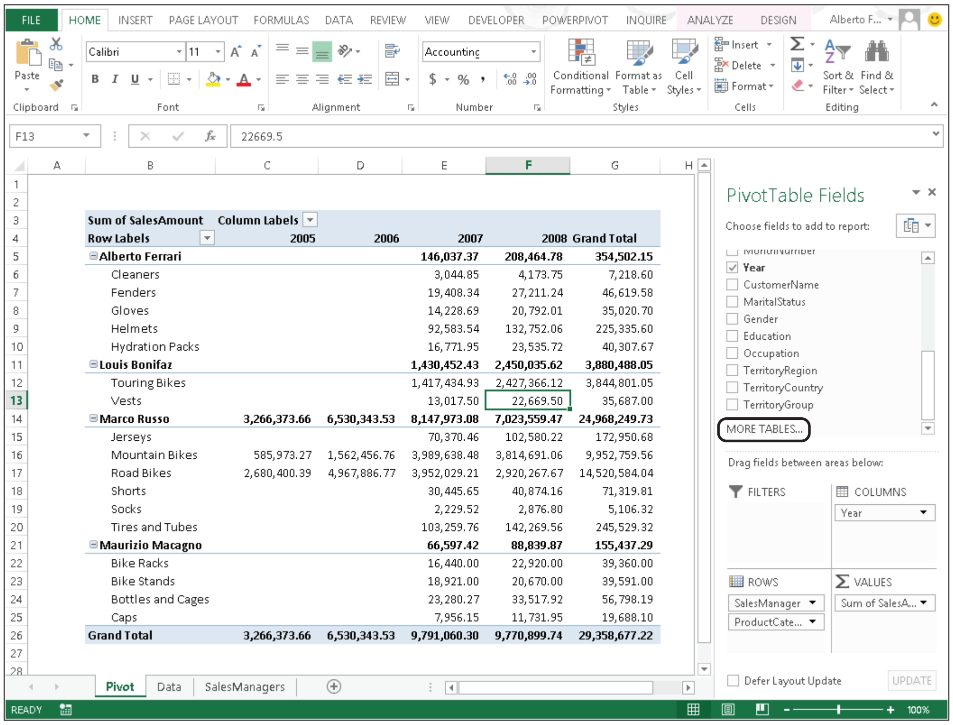
Sum of SalesAmount	Column Labels				
Row Labels	2005	2006	2007	2008	Grand Total
⊟Alberto Ferrari			**146,037.37**	**208,464.78**	**354,502.15**
Cleaners			3,044.85	4,173.75	7,218.60
Fenders			19,408.34	27,211.24	46,619.58
Gloves			14,228.69	20,792.01	35,020.70
Helmets			92,583.54	132,752.06	225,335.60
Hydration Packs			16,771.95	23,535.72	40,307.67
⊟Louis Bonifaz			**1,430,452.43**	**2,450,035.62**	**3,880,488.05**
Touring Bikes			1,417,434.93	2,427,366.12	3,844,801.05
Vests			13,017.50	22,669.50	35,687.00
⊟Marco Russo	**3,266,373.66**	**6,530,343.53**	**8,147,973.08**	**7,023,559.47**	**24,968,249.73**
Jerseys			70,370.46	102,580.22	172,950.68
Mountain Bikes	585,973.27	1,562,456.76	3,989,638.48	3,814,691.06	9,952,759.56
Road Bikes	2,680,400.39	4,967,886.77	3,952,029.21	2,920,267.67	14,520,584.04
Shorts			30,445.65	40,874.16	71,319.81
Socks			2,229.52	2,876.80	5,106.32
Tires and Tubes			103,259.76	142,269.56	245,529.32
⊟Maurizio Macagno			**66,597.42**	**88,839.87**	**155,437.29**
Bike Racks			16,440.00	22,920.00	39,360.00
Bike Stands			18,921.00	20,670.00	39,591.00
Bottles and Cages			23,280.27	33,517.92	56,798.19
Caps			7,956.15	11,731.95	19,688.10
Grand Total	**3,266,373.66**	**6,530,343.53**	**9,791,060.30**	**9,770,899.74**	**29,358,677.22**

FIGURE 1-6 The SalesManager column is now visible in the PivotTable.

This technique works fine, but if you now want to slice data using the Office column from the SalesManager table, you need to repeat the operation of using VLOOKUP to put the Office column in the original table. Even if it does not mean a huge amount of work in this specific example, it is better to move to the next level and learn some of the new features of Excel 2013.

Creating a data model with many tables

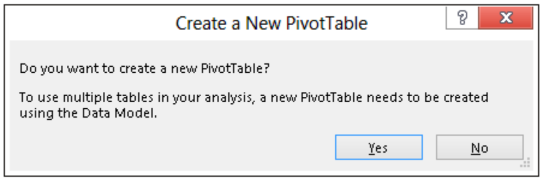
Instead of using VLOOKUP to populate a single dataset, as in the previous example, you now want to add the SalesManager table to the PivotTable, so that all its columns can be used. You are moving from a classical single-table analysis to a more advanced multi-table one. Doing this is very easy. At the bottom of the PivotTable fields list is the MORE TABLES… option (see Figure 1-7).



Sum of SalesAmount	Column Labels				
Row Labels	2005	2006	2007	2008	Grand Total
Alberto Ferrari			**146,037.37**	**208,464.78**	**354,502.15**
Cleaners			3,044.85	4,173.75	7,218.60
Fenders			19,408.34	27,211.24	46,619.58
Gloves			14,228.69	20,792.01	35,020.70
Helmets			92,583.54	132,752.06	225,335.60
Hydration Packs			16,771.95	23,535.72	40,307.67
Louis Bonifaz			**1,430,452.43**	**2,450,035.62**	**3,880,488.05**
Touring Bikes			1,417,434.93	2,427,366.12	3,844,801.05
Vests			13,017.50	22,669.50	35,687.00
Marco Russo	**3,266,373.66**	**6,530,343.53**	**8,147,973.08**	**7,023,559.47**	**24,968,249.73**
Jerseys			70,370.46	102,580.22	172,950.68
Mountain Bikes	585,973.27	1,562,456.76	3,989,638.48	3,814,691.06	9,952,759.56
Road Bikes	2,680,400.39	4,967,886.77	3,952,029.21	2,920,267.67	14,520,584.04
Shorts			30,445.65	40,874.16	71,319.81
Socks			2,229.52	2,876.80	5,106.32
Tires and Tubes			103,259.76	142,269.56	245,529.32
Maurizio Macagno			**66,597.42**	**88,839.87**	**155,437.29**
Bike Racks			16,440.00	22,920.00	39,360.00
Bike Stands			18,921.00	20,670.00	39,591.00
Bottles and Cages			23,280.27	33,517.92	56,798.19
Caps			7,956.15	11,731.95	19,688.10
Grand Total	**3,266,373.66**	**6,530,343.53**	**9,791,060.30**	**9,770,899.74**	**29,358,677.22**

FIGURE 1-7 The MORE TABLES... option lets you add more tables to a single PivotTable report.

If you click MORE TABLES..., you will see an information message that asks you to confirm whether you want to continue creating a new PivotTable. The dialog box, shown in Figure 1-8, contains some very useful information about what is happening, including a reference to something new: the data model.



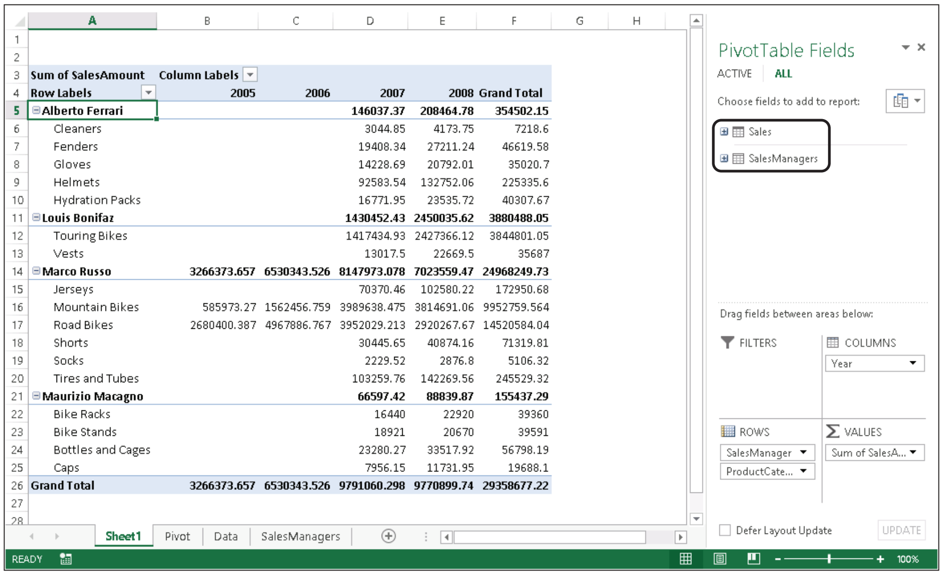
Create a New PivotTable

Do you want to create a new PivotTable?

To use multiple tables in your analysis, a new PivotTable needs to be created using the Data Model.

FIGURE 1-8 As simple as it is, this confirmation window contains a good deal of useful information.

If you click Yes, Excel creates a new PivotTable, with a structure that is identical to the current one but with more tables. You can see the result in Figure 1-9, where the field list now contains two tables.



Sum of SalesAmount	Column Labels				
Row Labels	**2005**	**2006**	**2007**	**2008**	**Grand Total**
Alberto Ferrari			**146037.37**	**208464.78**	**354502.15**
Cleaners			3044.85	4173.75	7218.6
Fenders			19408.34	27211.24	46619.58
Gloves			14228.69	20792.01	35020.7
Helmets			92583.54	132752.06	225335.6
Hydration Packs			16771.95	23535.72	40307.67
Louis Bonifaz			**1430452.43**	**2450035.62**	**3880488.05**
Touring Bikes			1417434.93	2427366.12	3844801.05
Vests			13017.5	22669.5	35687
Marco Russo	**3266373.657**	**6530343.526**	**8147973.078**	**7023559.47**	**24968249.73**
Jerseys			70370.46	102580.22	172950.68
Mountain Bikes	585973.27	1562456.759	3989638.475	3814691.06	9952759.564
Road Bikes	2680400.387	4967886.767	3952029.213	2920267.67	14520584.04
Shorts			30445.65	40874.16	71319.81
Socks			2229.52	2876.8	5106.32
Tires and Tubes			103259.76	142269.56	245529.32
Maurizio Macagno			**66597.42**	**88839.87**	**155437.29**
Bike Racks			16440	22920	39360
Bike Stands			18921	20670	39591
Bottles and Cages			23280.27	33517.92	56798.19
Caps			7956.15	11731.95	19688.1
Grand Total	**3266373.657**	**6530343.526**	**9791060.298**	**9770899.74**	**29358677.22**

PivotTable Fields

Choose fields to add to report: Sales, SalesManagers

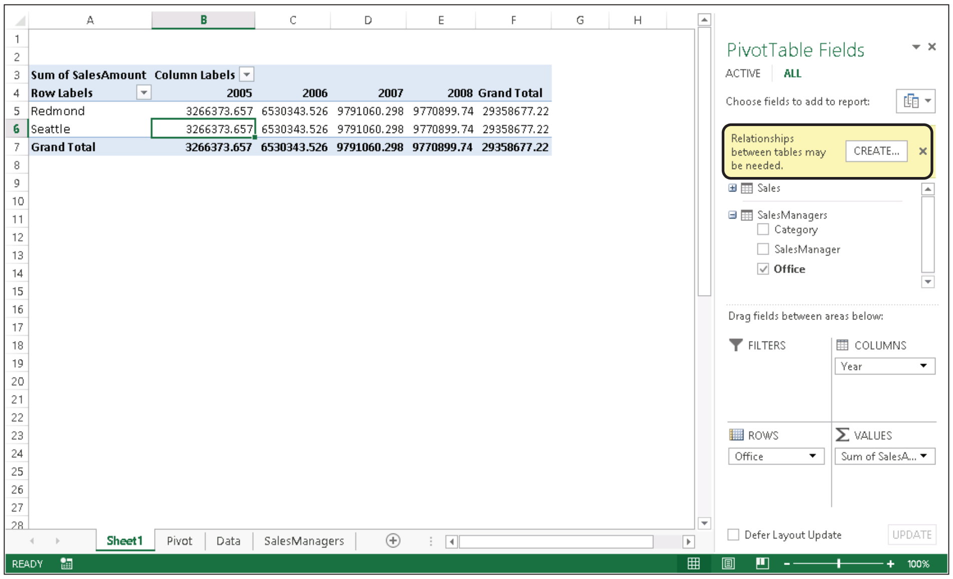
COLUMNS: Year

ROWS: SalesManager, ProductCate...

VALUES: Sum of SalesA...

FIGURE 1-9 The new PivotTable contains two tables in the field list.

Now remove SalesManager and ProductCategory from the rows and, after expanding the Sales-Managers table, add Office to the rows. The result is *not* what you might expect. In fact, as Figure 1-10 shows, it seems that all the offices (two, in this example) have exactly the same sales, which is clearly false. The PivotTable seems to detect the same wrong situation because a warning appears in the Field List: "Relationships Between Tables May Be Needed." There is also an inviting CREATE… button.



Sum of SalesAmount	Column Labels				
Row Labels	**2005**	**2006**	**2007**	**2008**	**Grand Total**
Redmond	3266373.657	6530343.526	9791060.298	9770899.74	29358677.22
Seattle	3266373.657	6530343.526	9791060.298	9770899.74	29358677.22
Grand Total	**3266373.657**	**6530343.526**	**9791060.298**	**9770899.74**	**29358677.22**

PivotTable Fields

Relationships between tables may be needed. CREATE...

Sales

SalesManagers: Category, SalesManager, ✓ Office

COLUMNS: Year

ROWS: Office

VALUES: Sum of SalesA...

FIGURE 1-10 Adding the Office column to the PivotTable shows incorrect results and a warning about relationships.

As you might imagine, creating the relationship is the key to make the PivotTable show correct values. However, before doing it, it is worth learning more about what a relationship is.

Understanding relationships

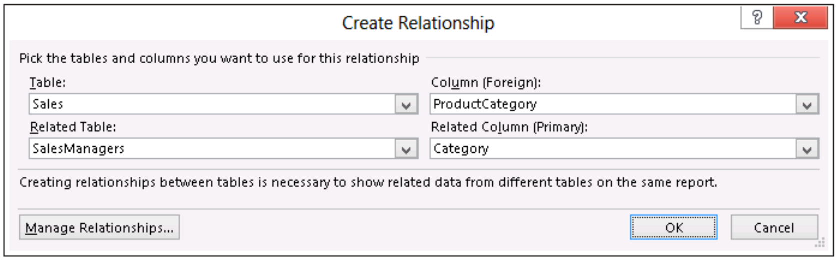
At this point, there are two tables: Sales and SalesManagers. Each sale concerns a product, and the product has a category. Each category has a sales manager, and the relationship between a category and its sales manager is stored in the SalesManagers table. In order to bring a sales manager's name into the sales table, you previously used VLOOKUP to search for the category name in the SalesManagers table and, after it found the category, grab the associated sales manager's name.

In more technical terms, we can say that there is a relationship between the Sales and the SalesManagers tables, based on the Category column. To be more precise, the relationship is defined as follows:

- **Source Table**: The source table from where the relationship starts. In this example, it is the Sales table, which contains only the ProductCategory column.
- **Foreign Key Column**: The column in the source table that contains the value to search. In this example, the column is ProductCategory, the category of the product, which we have used as the first parameter of VLOOKUP.
- **Related Table**: The table that contains the values to look for. In this example, the related table is the SalesManager table, which contains both the product category and the sales manager's name, along with that person's office.
- **Related Column**: The column in the related table containing the value that should match the foreign key column. In the example, the column is Category, in the SalesManager table.

Think of a relationship as a sort of automatic VLOOKUP. In fact, the parameters of a relationship are very similar to the parameters of VLOOKUP. The only information missing is the value of the column to retrieve because, once a relationship is in place, it allows you to retrieve any of the columns in the related table without needing to specify which ones (as was the case with VLOOKUP, which retrieved only a single column from the related table).

With this new information, click the CREATE… button and create the relationship, filling the boxes with the values shown in Figure 1-11.


Create Relationship

Pick the tables and columns you want to use for this relationship

Table: Sales

Column (Foreign): ProductCategory

Related Table: SalesManagers

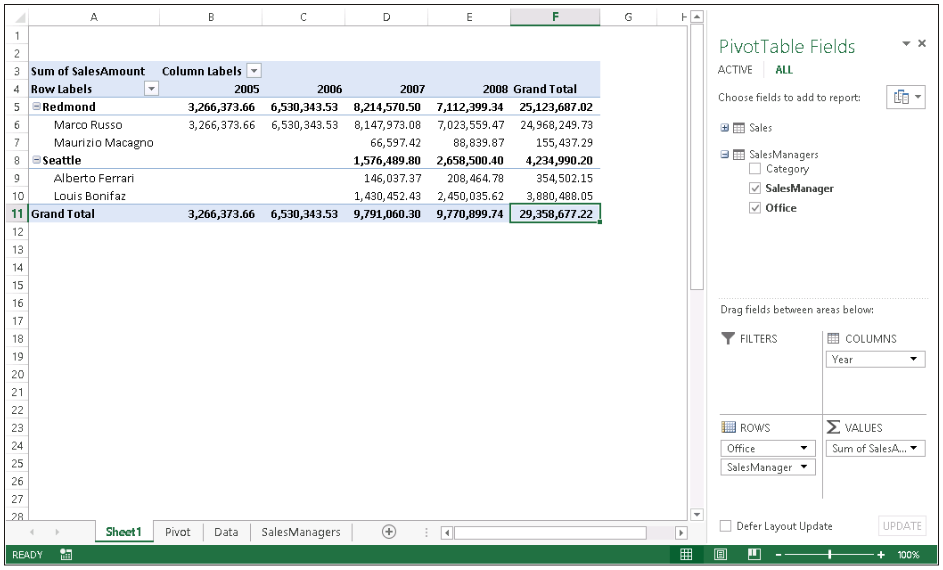
Related Column (Primary): Category

Creating relationships between tables is necessary to show related data from different tables on the same report.

FIGURE 1-11 Here are the correct parameters to enter to create the relationship.

Note PowerPivot for Excel 2010, the previous version of this add-in, had an engine that automatically detected relationships, making life easier in some cases. Unfortunately, the detection algorithm used a heuristic to check for the existence of relationships, and in some rare cases, it could detect the relationship incorrectly. For this reason, no automatic detection happens in Excel 2013; it is up to you to define the relationship. Although this characteristic might seem to be a downgrade, it really is a welcome development: it is always better to be safe when creating a relationship, and in this case, the human brain is much better than a heuristic algorithm.

Clicking OK will make Excel create the relationship and update the content of the PivotTable, which now shows correct values arranged by office. Figure 1-12 shows the result, where the SalesManager column from the SalesManagers table is placed on the rows.



Sum of SalesAmount	Column Labels				
Row Labels	2005	2006	2007	2008	Grand Total
Redmond	**3,266,373.66**	**6,530,343.53**	**8,214,570.50**	**7,112,399.34**	**25,123,687.02**
Marco Russo	3,266,373.66	6,530,343.53	8,147,973.08	7,023,559.47	24,968,249.73
Maurizio Macagno			66,597.42	88,839.87	155,437.29
Seattle			**1,576,489.80**	**2,658,500.40**	**4,234,990.20**
Alberto Ferrari			146,037.37	208,464.78	354,502.15
Louis Bonifaz			1,430,452.43	2,450,035.62	3,880,488.05
Grand Total	**3,266,373.66**	**6,530,343.53**	**9,791,060.30**	**9,770,899.74**	**29,358,677.22**

PivotTable Fields
ACTIVE ALL
Choose fields to add to report:
Sales
SalesManagers
☐ Category
☑ SalesManager
☑ Office
Drag fields between areas below:
FILTERS
COLUMNS: Year
ROWS: Office, SalesManager
VALUES: Sum of SalesA...
☐ Defer Layout Update UPDATE

FIGURE 1-12 The PivotTable shows the correct results once the relationship is set.

Relationships play a very important role in PowerPivot, and you will learn a lot more about them from this book. For now, it is enough to think of a relationship as a way to tie together two tables, using a column in both. If two columns share the same value for a specific row, then the relationship has a match, and the two rows are tied together.

But . . . wait! Didn't we just say that relationships are important in PowerPivot? Up to now, you have not used PowerPivot—you have simply used Excel features to create a PivotTable on more than one table. So why is this book about PowerPivot? The reason is simple: even if you have not explicitly used PowerPivot, Excel has created a PowerPivot data model, and the multiple-table PivotTable is, in reality, browsing that model. So let's look at the data model.

Understanding the data model

As Figure 1-8 previously demonstrated, the confirmation window asked you to create a new PivotTable using the data model. It did not explain what a data model is, nor why it is needed if you want to show more than one table in the PivotTable, but it was clear about the fact that the new PivotTable would use the data model. Thus, it is interesting to understand better what the data model is before diving into more advanced topics.

Excel tables are exactly what their name suggests: they are tables. You can have hundreds of tables in an Excel workbook, but each table is separated from the others. This is why you can create a PivotTable over a single table: adding more than one table to a PivotTable is meaningless because they share nothing. The key to turn a set of tables into a data model is the existence of relationships. If many tables are connected by relationships, then it is useful to show them all together inside a PivotTable because filtering a table, as a side effect, filters other, related tables as well.

In this example, putting a filter on the Office column of the SalesManagers table included a filter on the Sales table. In fact, rows with information about the Seattle office showed only values about categories that are handled by Seattle personnel. The reason why the Sales table is filtered by Office is because each sale is pertinent to a sales manager who works in an office. The relationship between the two tables makes this mechanism work. Thus, the following is true:

- A set of tables is nothing but a set of separate tables.
- A set of tables with relationships holding among them is a data model.

Excel 2013 introduced the concept of a data model as one of the tools available to users to analyze data. Each Excel table can belong to the data model: it is automatically added to the data model as soon as a relationship is defined on the table, either as the source or as the target of the relationship.

All this seems fine, but what has PowerPivot got in common with this description of a data model? The data model in Excel is, in reality, a PowerPivot data model. Whenever you add a table to the data model, you are really adding the table to the PowerPivot database that lives inside the Excel workbook.

The PowerPivot data model and the Excel table are two distinct entities. If you add an Excel table to the data model, you are not transforming the Excel table into a PowerPivot one. What happens is that the data in the Excel table is copied into a PowerPivot table. The two tables are then linked, so that if you update the original Excel table and refresh the PivotTable, the updates are imported into the PivotTable data model. But, from the point of view of storage, the data is really duplicated in two places: the original table in Excel and a copy in PowerPivot.

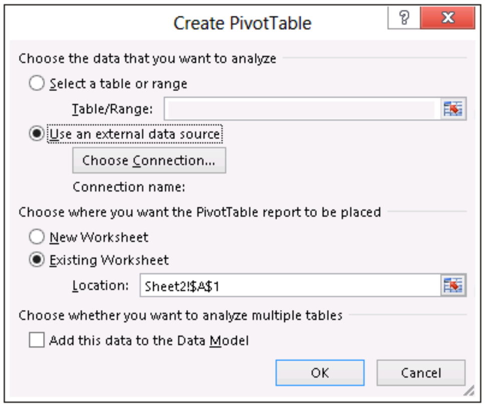
Creating a data model is very simple. It happens automatically as soon as Excel detects that it needs to create a data model to solve your specific needs. In this case, Excel turned the tables into a PowerPivot data model as soon as it was necessary to create a PivotTable with more than one table. To accomplish this task, Excel created a PowerPivot data model for use, effectively eliminating the need to completely understand what is happening under the surface.

Nevertheless, it is important to understand that by using these automatic features, you are using only a very small portion of the real power of PowerPivot. In order to exploit all PowerPivot features, you will need to learn how to work with the PowerPivot data model by itself, without simply relying on the automatic usage of the PowerPivot engine, as Excel does.

Querying the data model

In the previous section of this chapter, you learned that, by means of creating relationships among tables, you can create a PowerPivot data model inside your Excel workbook. Once the data model has been created for the first time, it can be queried with many PivotTables, without the need to add more tables to the same model. This section discusses how to perform this operation, which, although not very easy to find, is very convenient.

If you create a new PivotTable, Excel prompts you with the Create PivotTable dialog box, shown in Figure 1-13.


Create PivotTable

Choose the data that you want to analyze

○ Select a table or range

Table/Range:

● Use an external data source

Choose Connection...

Connection name:

Choose where you want the PivotTable report to be placed

○ New Worksheet

● Existing Worksheet

Location: Sheet2!$A$1

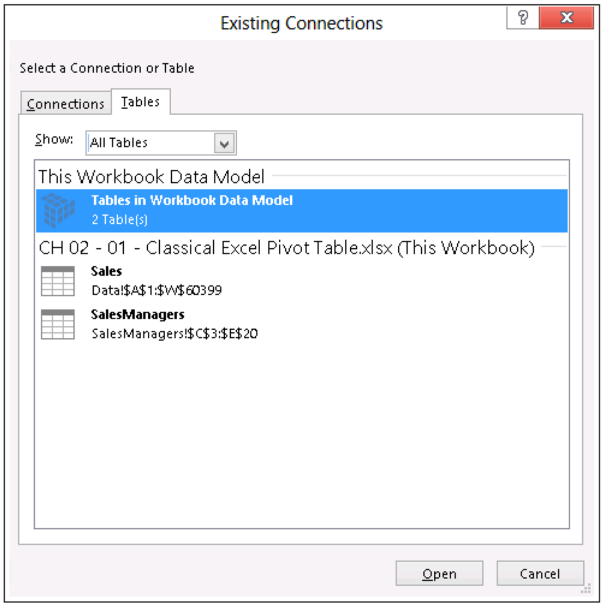
Choose whether you want to analyze multiple tables

☐ Add this data to the Data Model

OK Cancel

FIGURE 1-13 The Create PivotTable dialog box prompts you for the parameters of a new PivotTable.

From this dialog box, instead of choosing a range, as you are probably used to doing, you should choose Use An External Data Source and then click Choose Connection. Excel shows the external connection that can be used and, on the Tables tab, lists both the Excel tables and the data model, as shown in Figure 1-14.



This Workbook Data Model

Tables in Workbook Data Model
2 Table(s)

CH 02 - 01 - Classical Excel Pivot Table.xlsx (This Workbook)

Sales
Data!$A$1:$W$60399

SalesManagers
SalesManagers!$C$3:$E$20

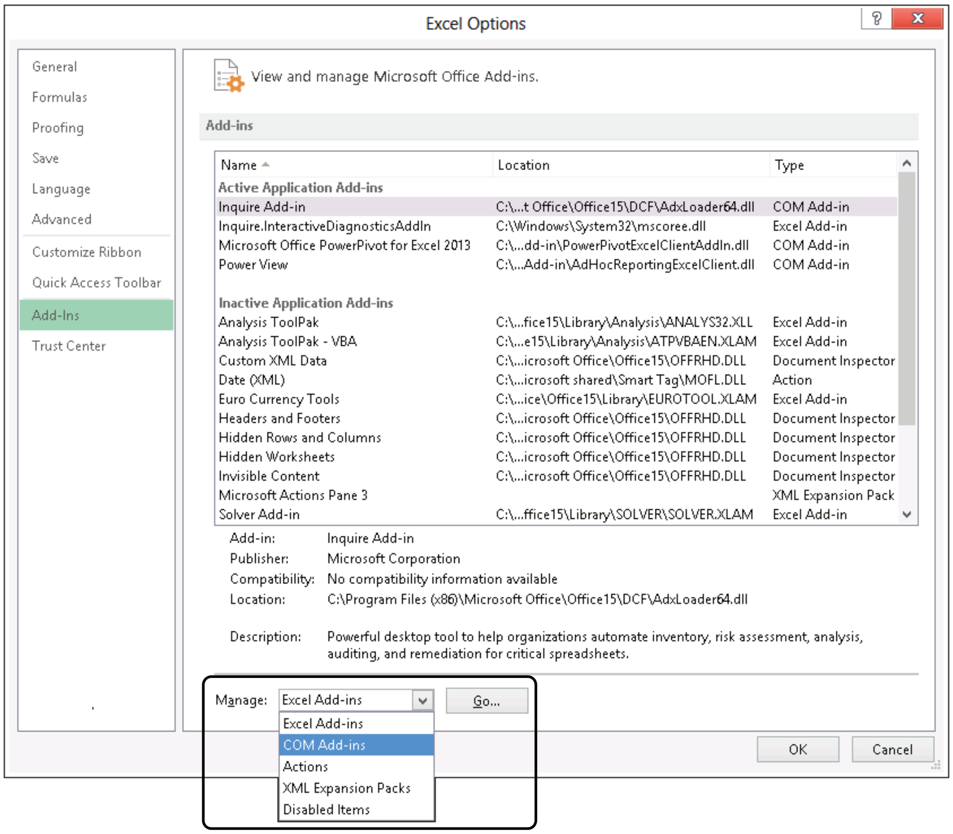
FIGURE 1-14 The list of external tables contains the Workbook data model, which is also the PowerPivot data model.

Selecting the Workbook data model and confirming everything up to the end of the PivotTable creation process leads you to a new PivotTable connected to the same data model that you previously created, based on the original Excel tables.

The PowerPivot add-In

In the previous sections of this chapter, you learned that the new features of Excel 2013 require you to create a PowerPivot data model to work with, and that this data model can be created without enabling the PowerPivot add-in, which comes preinstalled but disabled. Once the data model has been created, you can query it with a PivotTable (or, as you will see later in this chapter, with Power View). If, on the other hand, you want to look at the data model, Excel does not offer a way to analyze it or simply look at its content. In order to see the data model, you need to enable the PowerPivot add-in, as you are going to learn in this section.

To enable the PowerPivot add-in, you need to open the Excel options, select Add-Ins, and choose the COM Add-Ins, as shown in Figure 1-15.


Excel Options

General
Formulas
Proofing
Save
Language
Advanced
Customize Ribbon
Quick Access Toolbar
Add-Ins
Trust Center

View and manage Microsoft Office Add-ins.

Add-ins

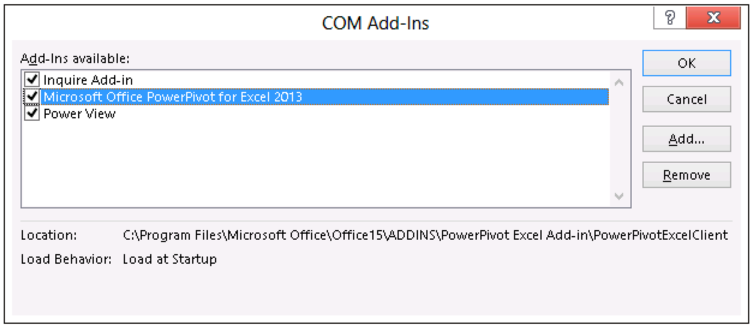
Name	Location	Type
Active Application Add-ins		
Inquire Add-in	C:\...t Office\Office15\DCF\AdxLoader64.dll	COM Add-in
Inquire.InteractiveDiagnosticsAddIn	C:\Windows\System32\mscoree.dll	Excel Add-in
Microsoft Office PowerPivot for Excel 2013	C:\...dd-in\PowerPivotExcelClientAddIn.dll	COM Add-in
Power View	C:\...Add-in\AdHocReportingExcelClient.dll	COM Add-in
Inactive Application Add-ins		
Analysis ToolPak	C:\...fice15\Library\Analysis\ANALYS32.XLL	Excel Add-in
Analysis ToolPak - VBA	C:\...e15\Library\Analysis\ATPVBAEN.XLAM	Excel Add-in
Custom XML Data	C:\...icrosoft Office\Office15\OFFRHD.DLL	Document Inspector
Date (XML)	C:\...icrosoft shared\Smart Tag\MOFL.DLL	Action
Euro Currency Tools	C:\...ice\Office15\Library\EUROTOOL.XLAM	Excel Add-in
Headers and Footers	C:\...icrosoft Office\Office15\OFFRHD.DLL	Document Inspector
Hidden Rows and Columns	C:\...icrosoft Office\Office15\OFFRHD.DLL	Document Inspector
Hidden Worksheets	C:\...icrosoft Office\Office15\OFFRHD.DLL	Document Inspector
Invisible Content	C:\...icrosoft Office\Office15\OFFRHD.DLL	Document Inspector
Microsoft Actions Pane 3		XML Expansion Pack
Solver Add-in	C:\...ffice15\Library\SOLVER\SOLVER.XLAM	Excel Add-in

Add-in:	Inquire Add-in
Publisher:	Microsoft Corporation
Compatibility:	No compatibility information available
Location:	C:\Program Files (x86)\Microsoft Office\Office15\DCF\AdxLoader64.dll
Description:	Powerful desktop tool to help organizations automate inventory, risk assessment, analysis, auditing, and remediation for critical spreadsheets.

Manage: Excel Add-ins

FIGURE 1-15 You will need to enable the PowerPivot add-in to use the new PowerPivot features.

Once you have selected COM Add-Ins, click Go to open the list of COM add-ins available, as you can see in Figure 1-16.


COM Add-Ins

Add-Ins available:
- [✓] Inquire Add-in
- [✓] Microsoft Office PowerPivot for Excel 2013
- [✓] Power View

Location: C:\Program Files\Microsoft Office\Office15\ADDINS\PowerPivot Excel Add-in\PowerPivotExcelClient
Load Behavior: Load at Startup

FIGURE 1-16 In the list of COM add-ins, you can enable or disable the PowerPivot add-in.

To enable the PowerPivot add-in, you simply have to select the Microsoft Office PowerPivot For Excel 2013 check box and then click OK. While you are here, it is a good idea to enable the Power View add-in (if it's disabled), which is going to come in handy shortly. To do this, simply select the

Power View check box. Power View is another great addition to your Excel analytical experience, and it works with the PowerPivot data model too.

Once the PowerPivot add-in has been enabled, you will see a new tab on the Excel ribbon named PowerPivot, which you can see in Figure 1-17.

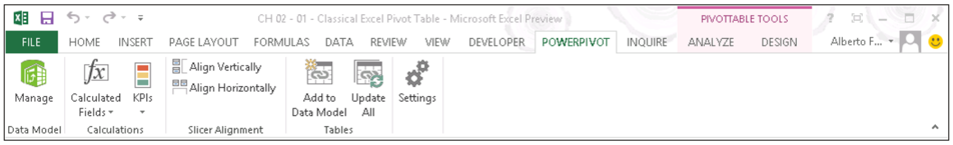
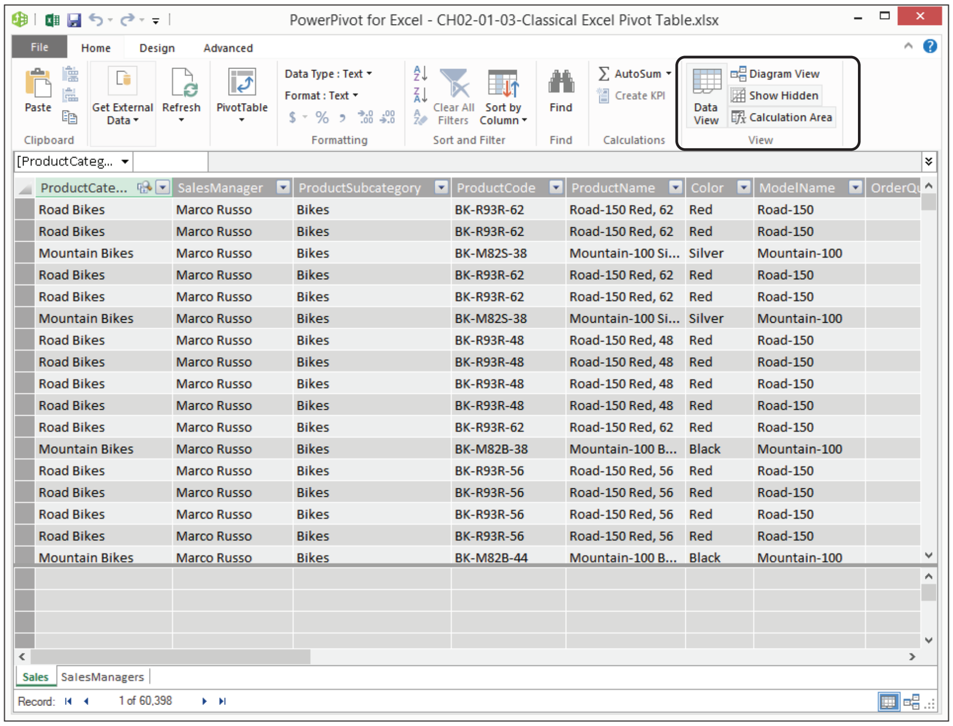


FIGURE 1-17 The PowerPivot tab on the Excel ribbon is enabled as soon as you enable the PowerPivot add-in.

From here, you will be able to use a wide number of exciting functions, which this book is going to explain. For now, we are interested only in opening the PowerPivot window and taking a very quick tour of the data model that you just created. In order to open the PowerPivot window, you need to click the Manage button on the ribbon, which opens the main PowerPivot window, as Figure 1-18 shows.



ProductCate...	SalesManager	ProductSubcategory	ProductCode	ProductName	Color	ModelName	OrderQu
Road Bikes	Marco Russo	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	
Mountain Bikes	Marco Russo	Bikes	BK-M82S-38	Mountain-100 Si...	Silver	Mountain-100	
Road Bikes	Marco Russo	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	
Mountain Bikes	Marco Russo	Bikes	BK-M82S-38	Mountain-100 Si...	Silver	Mountain-100	
Road Bikes	Marco Russo	Bikes	BK-R93R-48	Road-150 Red, 48	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-48	Road-150 Red, 48	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-48	Road-150 Red, 48	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-48	Road-150 Red, 48	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-62	Road-150 Red, 62	Red	Road-150	
Mountain Bikes	Marco Russo	Bikes	BK-M82B-38	Mountain-100 B...	Black	Mountain-100	
Road Bikes	Marco Russo	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	
Road Bikes	Marco Russo	Bikes	BK-R93R-56	Road-150 Red, 56	Red	Road-150	
Mountain Bikes	Marco Russo	Bikes	BK-M82B-44	Mountain-100 B...	Black	Mountain-100	

FIGURE 1-18 The PowerPivot window is the main window that lets you use PowerPivot advanced features.

The PowerPivot window opens by default in Data view, showing the content of the PowerPivot tables that are present in the model. You can browse the rows and, at the bottom of the window, you can see the tabs of the tables already loaded in the data model. For now, we are not interested in exploring all the features of this window. We want to use it to take only a brief look at the data model. In order to look at the data model, you need to click the Diagram View button on the ribbon.

As a result, the PowerPivot window switches from Data view to Diagram view is a very convenient way of visualizing the data model because, instead of focusing on the content of the tables, it shows the structure of the relationships, making it easier to represent relationships graphically, as shown in Figure 1-19.

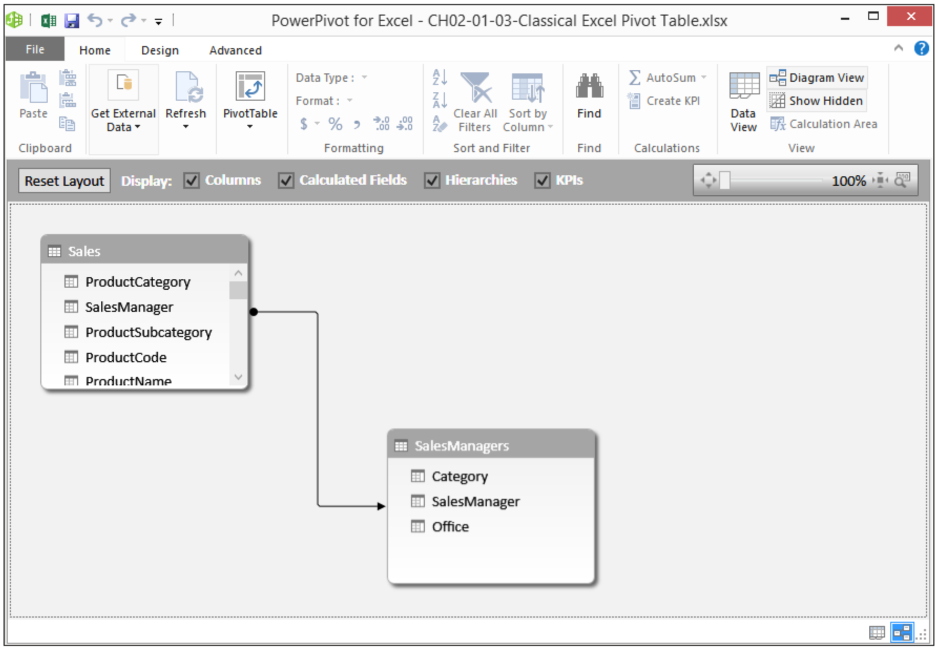


FIGURE 1-19 Diagram view lets you focus on the relationship structure of the data model.

The Diagram view is a canonical "boxes and arrows" representation of the relational model that is stored inside the data model. Each table is represented by a box, and if two tables are linked through a relationship, then there is an arrow running from the source table to the target table. Clicking a relationship highlights the columns that are part of that relationship.

You will learn how to use the many features of this window throughout this book; for now, you can simply close it. Starting from Chapter 3, "Introducing DAX," you will start using Diagram view to modify the data model. At the moment, we are more interested in taking you on a tour of the main features of Excel 2013 with PowerPivot than in describing them in detail.

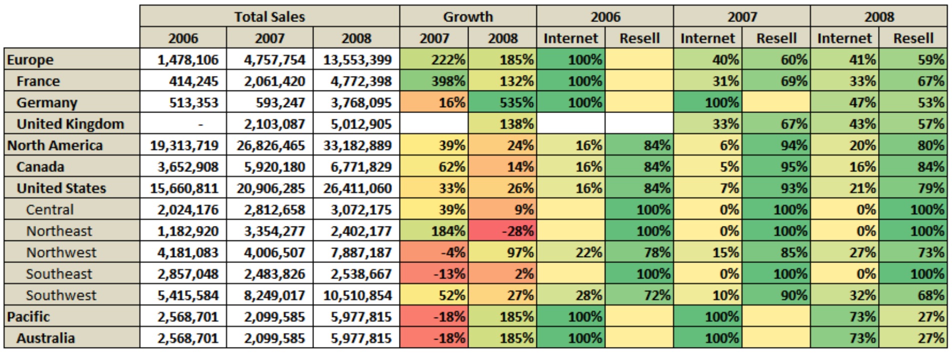
Using OLAP tools and converting to formulas

One of the new features of Excel, which is available on the data model but not on the single-table PivotTable, is the OLAP Tools section. This set of features was originally available only on PivotTables built on top of OLAP databases (hence its name), but because of the nature of the data model, which is in reality a PowerPivot database, the feature is now available with the data model too.

PivotTables are really powerful tools to explore data. Nevertheless, they very often serve as the first step in the production of complex reports that gather data from PivotTables, perform computations and formatting, and provide the final results in compact reports, sometimes called *dashboards*. Roughly speaking, a dashboard is nothing but a report containing several pieces of information (each one taken from a query to the database), resulting in a very compact representation of the company status.

Suppose that you want to produce a report containing total sales, the growth in percentage of total sales, and the percentage of Internet and reseller sales of the last three years. The report should contain information divided by region, so that you can use it to find which regions need your attention.

Figure 1-20 shows such a report in its final form, which you can find in the workbook "CH01-02-Dashboard.xlsx."



	Total Sales			Growth		2006		2007		2008	
	2006	2007	2008	2007	2008	Internet	Resell	Internet	Resell	Internet	Resell
Europe	1,478,106	4,757,754	13,553,399	222%	185%	100%		40%	60%	41%	59%
France	414,245	2,061,420	4,772,398	398%	132%	100%		31%	69%	33%	67%
Germany	513,353	593,247	3,768,095	16%	535%	100%		100%		47%	53%
United Kingdom	-	2,103,087	5,012,905		138%			33%	67%	43%	57%
North America	19,313,719	26,826,465	33,182,889	39%	24%	16%	84%	6%	94%	20%	80%
Canada	3,652,908	5,920,180	6,771,829	62%	14%	16%	84%	5%	95%	16%	84%
United States	15,660,811	20,906,285	26,411,060	33%	26%	16%	84%	7%	93%	21%	79%
Central	2,024,176	2,812,658	3,072,175	39%	9%		100%	0%	100%	0%	100%
Northeast	1,182,920	3,354,277	2,402,177	184%	-28%		100%	0%	100%	0%	100%
Northwest	4,181,083	4,006,507	7,887,187	-4%	97%	22%	78%	15%	85%	27%	73%
Southeast	2,857,048	2,483,826	2,538,667	-13%	2%		100%	0%	100%	0%	100%
Southwest	5,415,584	8,249,017	10,510,854	52%	27%	28%	72%	10%	90%	32%	68%
Pacific	2,568,701	2,099,585	5,977,815	-18%	185%	100%		100%		73%	27%
Australia	2,568,701	2,099,585	5,977,815	-18%	185%	100%		100%		73%	27%

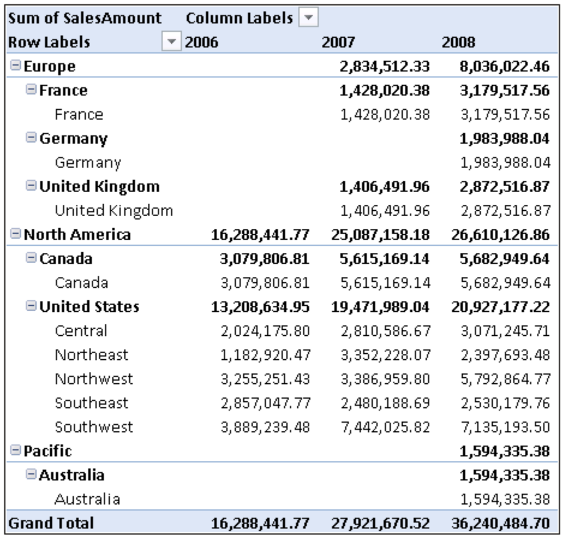
FIGURE 1-20 Here, you can see a simple dashboard created from a PivotTable.

We are not interested in these specific results; the focus here is on the technique. So, having a clear idea of the results you want to produce, let's take a closer look at the problems you will need to solve:

- The first issue concerns the geographical slicing. In the final report, you have data at the group, country, and region levels, but countries with only one region have been compacted to remove the region level, which is useless. This is something that the PivotTable will not handle by itself, even though it is a very common request for reports.
- The headers contain total sales and growth divided by year (and the selection of years in the two columns is different, since growth is not shown for 2006). Moreover, in the columns header, you want to show years divided by sales type (Internet and reseller). This mixed kind of slicing is not something that can be realized with a PivotTable.
- Data inside the cells is a mix of Internet and reseller sales for some cells (the total sales ones); other cells display the ratio of Internet or reseller sales to the total.
- Moreover, via the Conditional Formatting option in Excel, the report shows cells of various colors that will direct the reader's attention to the most interesting data. Clearly, the conditional formatting uses different formulas for different cells.

- Needless to say, you cannot produce such a report by using any type of PivotTable. Nevertheless, you surely can produce the original values needed to compute each single cell by using one or more PivotTables. All you need to do is to create some PivotTables that perform the computation and then use standard Excel formulas to move the original piece of data inside the dashboard.

You can start building this dashboard by creating the PivotTable shown in Figure 1-21, using a simple PivotTable that shows sales amounts from the FactResellerSales table.



Sum of SalesAmount	Column Labels		
Row Labels	**2006**	**2007**	**2008**
⊟Europe		**2,834,512.33**	**8,036,022.46**
⊟France		**1,428,020.38**	**3,179,517.56**
France		1,428,020.38	3,179,517.56
⊟Germany			**1,983,988.04**
Germany			1,983,988.04
⊟United Kingdom		**1,406,491.96**	**2,872,516.87**
United Kingdom		1,406,491.96	2,872,516.87
⊟North America	**16,288,441.77**	**25,087,158.18**	**26,610,126.86**
⊟Canada	**3,079,806.81**	**5,615,169.14**	**5,682,949.64**
Canada	3,079,806.81	5,615,169.14	5,682,949.64
⊟United States	**13,208,634.95**	**19,471,989.04**	**20,927,177.22**
Central	2,024,175.80	2,810,586.67	3,071,245.71
Northeast	1,182,920.47	3,352,228.07	2,397,693.48
Northwest	3,255,251.43	3,386,959.80	5,792,864.77
Southeast	2,857,047.77	2,480,188.69	2,530,179.76
Southwest	3,889,239.48	7,442,025.82	7,135,193.50
⊟Pacific			**1,594,335.38**
⊟Australia			**1,594,335.38**
Australia			1,594,335.38
Grand Total	**16,288,441.77**	**27,921,670.52**	**36,240,484.70**

FIGURE 1-21 This PivotTable is the starting point for this dashboard.

This PivotTable, together with a very similar one built on top of Internet sales, contains the basic information needed to build the dashboard. Now, since this is a PowerPivot workbook, you might expect to build a very complex DAX formula that will magically build the dashboard, but this is not the case. PivotTables are useful to explore data in an interactive way, but there is no need to push them too far from their natural inclinations. Once you have data available, Excel moves it inside the dashboard and performs further computations.

You can start building your dashboard based on the PivotTable that you just made, creating formulas that move information from the PivotTable to the dashboard. Nevertheless, PivotTables are dynamic by their very nature. They can change their size if new values appear inside the source tables. Thus, if you reference directly the cells inside a PivotTable, you are at risk of needing to update formulas as the source data is updated. It would be much better if you found a way to fix the PivotTable so that it cannot change its size dynamically.

Luckily, Excel has an option that will help you to convert the dynamic PivotTable in a set of static formulas that show the same data, but without the PivotTable's dynamic nature. You will lose the ability to navigate through your data, but on the other hand, you will gain the immobility of cells.

On the ANALYZE tab of the Excel ribbon, there is a button called OLAP Tools, which contains several features. One of these is Convert To Formulas, as you can see in Figure 1-22.

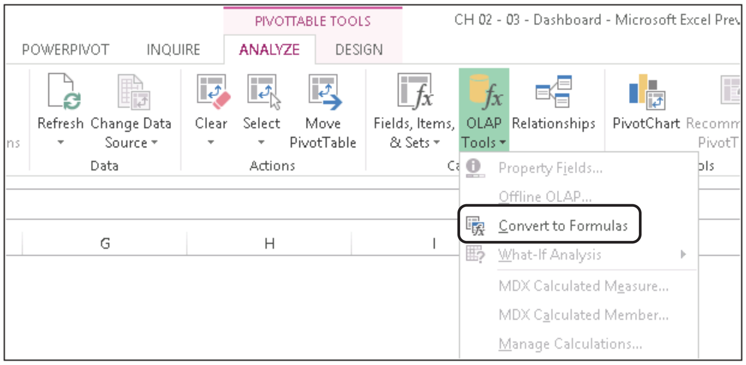


FIGURE 1-22 The Convert To Formulas option is available for PivotTables based on the data model.

If you choose this option, the PivotTable is deleted and returns as a standard Excel worksheet that contains a formula for each of the original cells (see Figure 1-23).

Sum of SalesAmount	Columns Labels			
Row Labels	2005	2006	2007	2008
Europe			2,834,512.33	8,036,022.46
France			1,428,020.38	3,179,517.56
France			1,428,020.38	3,179,517.56
Germany				1,983,988.04
Germany			1,406,491.96	1,983,988.04
United Kingdom			1,406,491.96	2,872,516.87
United Kingdom			1,406,491.96	2,872,516.87
North America		16,288,441.77	25,087,158.18	26,610,126.86
Canada		3,079,806.81	5,615,169.14	5,682,949.64
Canada		3,079,806.81	5,615,169.14	5,682,949.64
United States		13,208,634.95	19,471,989.04	20,927,177.22
Central		2,024,175.80	2,810,586.67	3,071,245.71
Northeast		1,182,920.47	3,352,228.07	2,397,693.48
Northwast		3,255,251.43	3,386,959.80	5,792,864.77
Southeast		2,857,047.77	2,480,188.69	2,530,179.76
Southwest		3,889,239.48	7,442,025.82	7,135,193.50
Pacific				1,594,335.38
Australia				1,594,335.38
Australia				1,594,335.38
Grand Total		16,288,441.77	27,921,670.52	36,240,484.70

FIGURE 1-23 The worksheet that contained PivotTable looks this way after Convert To Formulas has been applied.

Now it is worth taking a look at the formulas inside the cells. They are of two different types:

- **CUBEMEMBER**. This type of formula is used for the headers of both columns and rows. It returns an object, called a *member,* which is basically the value of a column in a table. For example, the formula inside the "2008" header contains

  ```
  =CUBEMEMBER("ThisWorkbookDataModel","[DimTime].[FiscalYear].&[2008]")
  ```

  This can be read as

  Return the value of the column FiscalYear in table DimTime where the value is "2008."

  The formula might be confusing because its return value is "2008" and we provide "2008" as the parameter, which doesn't seem to make sense. This has to do with the internals of PowerPivot, which reasons in terms of members and values of an OLAP cube. Moreover, it might be worth noting at this point that the syntax used for the expressions in CUBEMEMBER and CUBEVALUE is not DAX syntax—it is MDX. Excel still uses MDX to interact with PowerPivot.

- **CUBEVALUE**. This type of formula is used for the cells inside the table. Each cell asks for a value giving the set of members that form the coordinates of the requested value. For example, in the case of sales in North America for 2009, the coordinates are

  - [Measures].[Sum of SalesAmount]
  - [DimTime].[FiscalYear].&[2009]
  - [DimSalesTerritory].[SalesTerritoryGroup].&[North America]

  The result is the value of the measure SalesAmount in 2009 for North America.

Readers used to OLAP databases will recognize in these formulas the standard set of coordinates used to navigate over OLAP cubes. In fact, at the very end, PowerPivot stores its data inside cubes that are automatically processed by PowerPivot itself, which is something that we are going to show later in this chapter.

Now, it is not important to take this digression too far. The real interesting aspect of this is that the worksheet is now composed of formulas (the PivotTable disappeared) and the formulas can be moved wherever you want. Moreover, even if the source data changes, Excel will not change the position of any cell.

You can now create a new worksheet and proceed to write your dashboard, referencing the values inside this new set of cells. The only caution is that if a cube does not return any data, it is returned by `CUBEMEMBER` as an empty string. Thus, whenever you need to reference its value, you need to surround it with an `IF`, as in the cell Total Sales in Europe for 2006 in Figure 1-20, which contains this formula:

```
= IF( Internet!D5 = "", 0, Internet!D5 ) + IF( Resellers!D5 = "", 0, Resellers!D5 )
```

The only precaution to take when using values coming from an OLAP cube is to remember that empty values are empty strings, not numbers. The remaining part of the dashboard can be easily created by using standard Excel formulas and some formatting, all of which is already well known and documented.

Note Results from OLAP cubes are always strings, so the *ISBLANK* function in Excel will not help here.

The really interesting part of this section is not the dashboard itself, but the fact that, by converting a PivotTable into formulas, you can use data from PowerPivot as the first brick of a more complex workbook, which uses the original data to provide values, indicators, and other information that can be processed later with the full power of Excel at hand.

Understanding PowerPivot for Excel 2013

Now that you have used the PowerPivot data model for the first time, it is worthwhile to learn some basics about what the PowerPivot engine is before delving into all its features. This section of the chapter will give you a general understanding of this topic. It is not strictly required to use PowerPivot, at least at a basic level; however, we believe that it is interesting. You can consider it as a small digression, just to give you some general background on the topic of columnar databases.

PowerPivot for Excel 2013 is, in reality, the Tabular engine of SQL Server Analysis Services 2012, running in process inside Excel. The PowerPivot engine is called the xVelocity analytics engine, and it is a space-saving columnar database running completely in memory.

Most databases, including SQL Server, are row-oriented databases, and they are easy to understand because they work in a very natural way: every table of the database stores data row by row, exactly the way you see data on the screen.

For example, consider the following table of data:

ID_Author	FirstName	LastName	Blog	Posts
1	Alberto	Ferrari	http://sqlblog.com/blogs/alberto_ferrari	27
2	Maurizio	Macagno	http://adventureworks.com/blogs/mmacagno	43
3	Marco	Russo	http://sqlblog.com/blogs/marco_russo	38

A row-oriented database physically stores data row by row. For example, the second item in the list contains all the columns of the row describing Maurizio's data, in a way that can be expressed in this table:

Row ID	Row Data
1	1, Alberto, Ferrari, http://sqlblog.com/blogs/alberto_ferrari, 27
2	2, Maurizio, Macagno, http://adventureworks.com/blogs/mmacagno , 43
3	3, Marco, Russo, http://sqlblog.com/blogs/marco_russo, 38

The physical implementation depends on the database product. For example, SQL Server divides the storage space into pages and every page stores one or more rows. Other databases might use different techniques, but the important point is that data is stored row-wise.

In general, a row-oriented database requires a full scan of all the rows of a table if you want to query all the values of a single column of a table (that is, to compute an aggregation). The cost of a complete table scan is the same regardless of the number of columns requested.

A column-oriented database uses a different approach. Instead of considering the row of a table as the main unit of storage, it considers every column as a separate entity and stores data for every column in a separate way. For example, you might imagine that data of our initial table is logically stored in this way:

Column Name	Column Data
ID_Author	1, 2, 3
FirstName	Alberto, Maurizio, Marco
LastName	Ferrari, Macagno, Russo
Blog	http://sqlblog.com/blogs/alberto_ferrari, http://adventureworks.com/blogs/mmacagno, http://sqlblog.com/blogs/marco_russo
Posts	27, 43, 38

This makes it very fast to query data for a single column, but it requires a higher computational effort to retrieve data for several columns of a single row. The worst-case scenario is the request of all the columns from a row, which requires access to the storage of all the rows. For example, to retrieve Maurizio's data, Maurizio must be identified in the FirstName column. Because it is the second element in the column, getting the second element from every other column will retrieve all of Maurizio's data. Moreover, to calculate the total number of posts of all the authors, it will be necessary to access only the Posts column data.

From the point of view of data retrieval, a column-oriented database might be faster because data access is optimized for many query scenarios. In fact, the most frequent requests in an analytical system require data from only a few columns, usually to aggregate data from a column by grouping results according to the value of other columns.

In Figure 1-24, you can see a comparison between row-based and column-based storages.

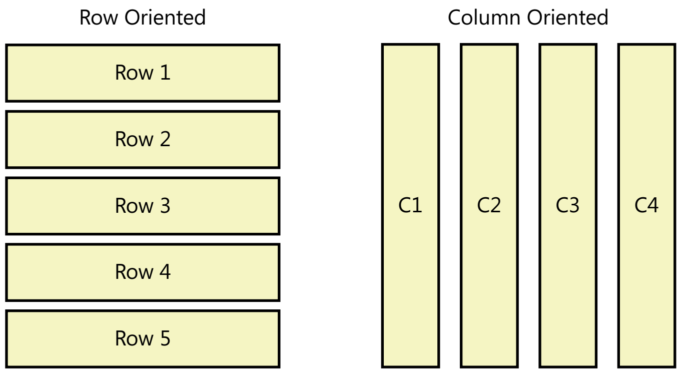


FIGURE 1-24 Row-oriented vs. column-oriented databases.

PowerPivot is also an in-memory database. This means that it has been designed and optimized on the assumption that the whole database is loaded into memory. To store more data and improve performance, data is kept compressed in memory as well, and it is dynamically uncompressed during each query.

Creating a Power View report

Power View is a great reporting tool that is integrated into Excel 2013 as an add-in. It needs to be activated following the very same procedure that you used previously to enable the PowerPivot add-in. Once it is activated, you will have the option to create Power View reports based on the PowerPivot data model.

Power View does not work with Excel tables; it only works with the data model. Thus, if you create a Power View report, all the tables you use in the report will be automatically added to the data model, same as with the PivotTable, when you added more than one table to the PivotTable report. Because Power View works only with the data model, when you create a Power View report, you don't have the option to choose the source of data—it is the data model by default. You can find the Power View reports built in this section in the companion workbook: "CH01-03-Power View Report.xlsx."

To create a Power View report once the add-in has been activated, you need to use the Power View button on the INSERT tab of the Excel ribbon, as shown in Figure 1-25.

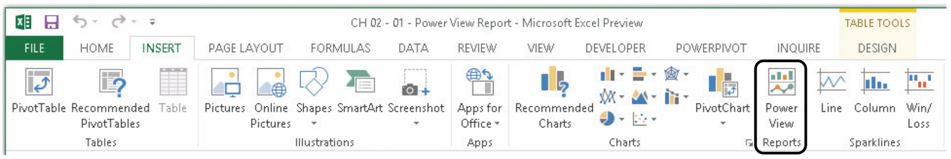
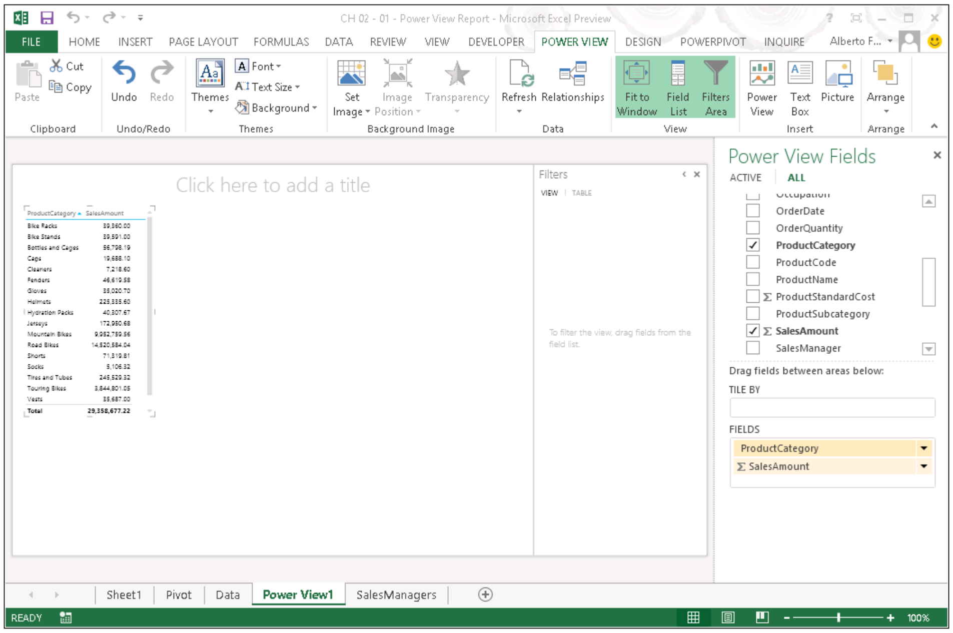


FIGURE 1-25 You can use the Power View button to create a new Power View report.

Note Power View requires the Silverlight component to be installed on your system. If you have never installed Silverlight, Power View will prompt you to do so, directing you to the website where you can download it. Once Silverlight is installed, Power View will work fine. You will need to use Microsoft Internet Explorer to download the correct version of Silverlight; downloading it using a different browser might not activate the correct version of Silverlight that Excel needs.

Now you will create a simple report using the same workbook created in this chapter. The Power View environment is designed to be simple: most of its features require a single mouse click to be activated, and you don't have all the configuration options available in classical Excel charts. The major benefit of Power View is that it can create beautiful reports with a minimum of effort.

Once the Power View report is opened, you will see an empty canvas on the left of the window and the list of tables in the data model in the right panel, which resembles the PivotTable Field list. To start creating your first report, expand the Sales table and select the ProductCategory column. You will see the list of categories in a new table in the canvas. Then, selecting the SalesAmount column, Power View will add the total sales amount to each row of the table, showing the total sales for each category. At this point, the Excel window will look like Figure 1-26.

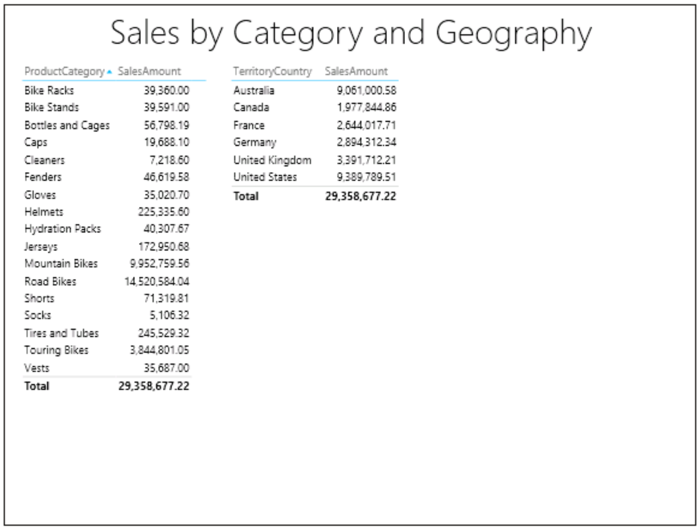

CH 02 - 01 - Power View Report - Microsoft Excel Preview
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DEVELOPER POWER VIEW DESIGN POWERPIVOT INQUIRE Alberto F...
Paste Cut Copy Undo Redo Themes Font Text Size Background Set Image Image Position Transparency Refresh Relationships Fit to Window Field List Filters Area Power View Text Box Picture Arrange
Clipboard Undo/Redo Themes Background Image Data View Insert Arrange
Click here to add a title
Filters
VIEW TABLE
To filter the view, drag fields from the field list.
Power View Fields
ACTIVE ALL
Occupation
OrderDate
OrderQuantity
✓ ProductCategory
ProductCode
ProductName
Σ ProductStandardCost
ProductSubcategory
✓ Σ SalesAmount
SalesManager
Drag fields between areas below:
TILE BY
FIELDS
ProductCategory
Σ SalesAmount
Sheet1 Pivot Data Power View1 SalesManagers
READY 100%

ProductCategory	SalesAmount
Bike Racks	39,360.00
Bike Stands	39,591.00
Bottles and Cages	56,798.19
Caps	19,688.10
Cleaners	7,218.60
Fenders	46,619.58
Gloves	35,020.70
Helmets	225,335.60
Hydration Packs	40,307.67
Jerseys	172,950.68
Mountain Bikes	9,952,759.56
Road Bikes	14,520,584.04
Shorts	71,319.81
Socks	5,106.32
Tires and Tubes	245,529.32
Touring Bikes	3,844,801.05
Vests	35,687.00
Total	**29,358,677.22**

FIGURE 1-26 The Power View report shows categories and sales.

The idea of Power View is to start with data and decide only later what format you want to use for them. For example, suppose that you are interested in creating a report that shows the total sales for each category (which you already did) and, beside them, a report that shows the sales divided by geographical area.

Because you already have completed the first step, you now need to create a new table containing the country of sale, along with the total sales amount. This can be easily done by clicking in the empty area of the Power View canvas and then selecting the TerritoryCountry column first, and then the SalesAmount column. At this point, your report should look like the one in Figure 1-27.



Sales by Category and Geography

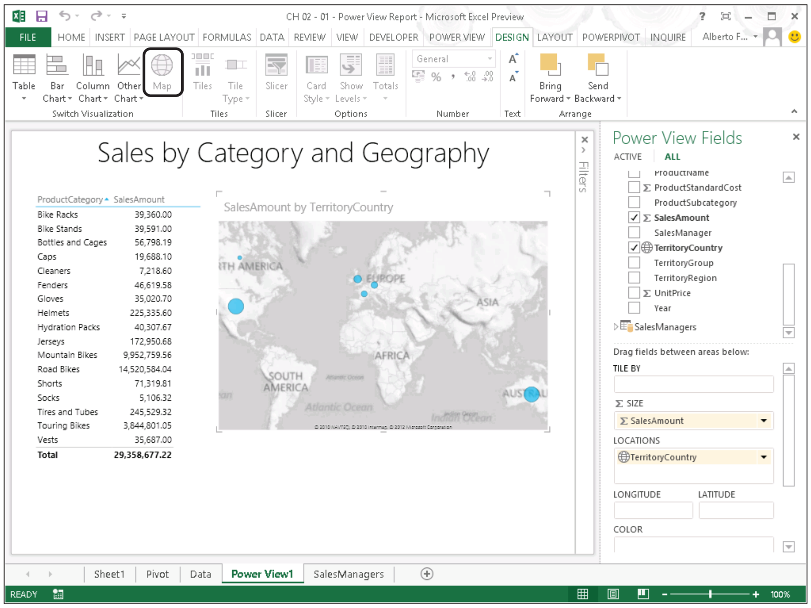
ProductCategory ▴	SalesAmount
Bike Racks	39,360.00
Bike Stands	39,591.00
Bottles and Cages	56,798.19
Caps	19,688.10
Cleaners	7,218.60
Fenders	46,619.58
Gloves	35,020.70
Helmets	225,335.60
Hydration Packs	40,307.67
Jerseys	172,950.68
Mountain Bikes	9,952,759.56
Road Bikes	14,520,584.04
Shorts	71,319.81
Socks	5,106.32
Tires and Tubes	245,529.32
Touring Bikes	3,844,801.05
Vests	35,687.00
Total	**29,358,677.22**

TerritoryCountry	SalesAmount
Australia	9,061,000.58
Canada	1,977,844.86
France	2,644,017.71
Germany	2,894,312.34
United Kingdom	3,391,712.21
United States	9,389,789.51
Total	**29,358,677.22**

FIGURE 1-27 The Power View report shows tabular data by default.

Although the data is there, it does not look very appealing. The tabular representation of information is less than wonderful—you need a way to show the same information with charts. Let's start with the geography. It would be much better to show the sales on a map. To perform this operation, simply select the table containing the TerritoryCountry and use the Map button on the DESIGN tab of the Excel ribbon, as shown in Figure 1-28. The table is immediately transformed into a map, where the total sales are shown by the size of the points on the map.

Tip You need an active Internet connection for the map to work because the map itself and the geographical resolution of the countries is created through the Bing web service.



Sales by Category and Geography

ProductCategory	SalesAmount
Bike Racks	39,360.00
Bike Stands	39,591.00
Bottles and Cages	56,798.19
Caps	19,688.10
Cleaners	7,218.60
Fenders	46,619.58
Gloves	35,020.70
Helmets	225,335.60
Hydration Packs	40,307.67
Jerseys	172,950.68
Mountain Bikes	9,952,759.56
Road Bikes	14,520,584.04
Shorts	71,319.81
Socks	5,106.32
Tires and Tubes	245,529.32
Touring Bikes	3,844,801.05
Vests	35,687.00
Total	**29,358,677.22**

Power View Fields
ACTIVE ALL

- [ ] ProductName
- [ ] Σ ProductStandardCost
- [ ] ProductSubcategory
- [x] Σ **SalesAmount**
- [ ] SalesManager
- [x] **TerritoryCountry**
- [ ] TerritoryGroup
- [ ] TerritoryRegion
- [ ] Σ UnitPrice
- [ ] Year

SalesManagers

Drag fields between areas below:

TILE BY

Σ SIZE
Σ SalesAmount

LOCATIONS
TerritoryCountry

LONGITUDE
LATITUDE

COLOR

FIGURE 1-28 The Map button transforms the tabular representation into a map.

At this point, you can follow the same procedure to transform the Categories table into a Column chart, resize it, and put it below the map. You have seen that the idea of Power View is first the data, then the graphical representation. The chart, at this point, looks like the one in Figure 1-29.

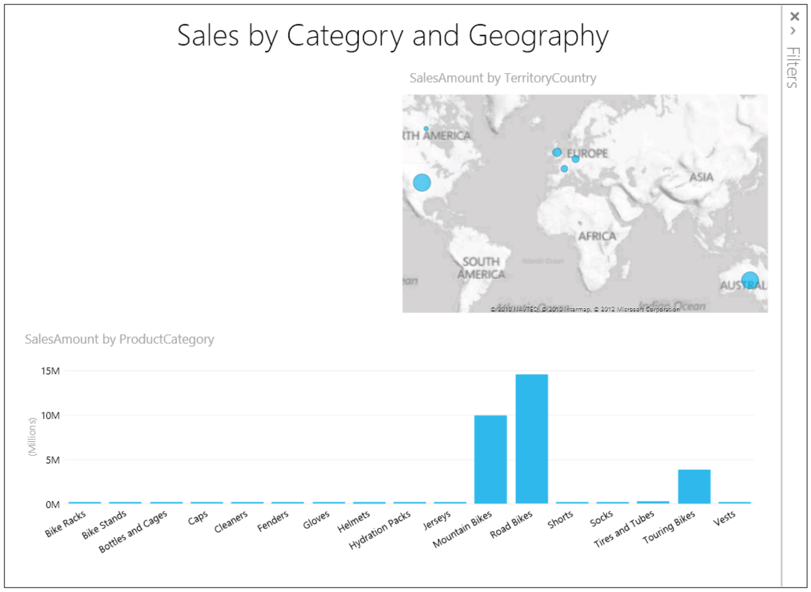
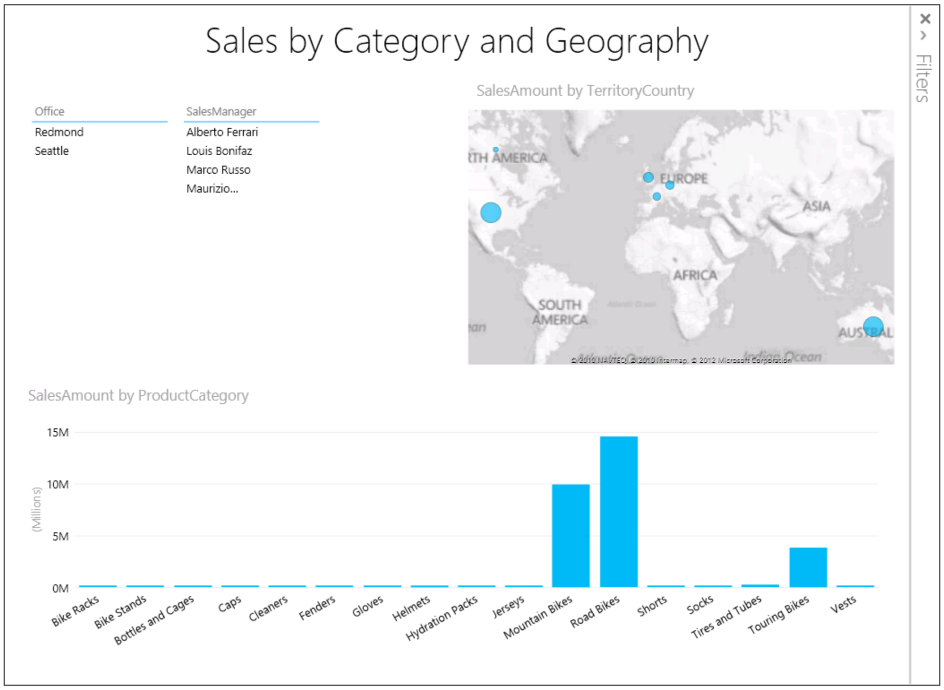


FIGURE 1-29 The Categories table is now a column chart.

Note Now that you started using it, it is worthwhile to discuss briefly what Power View is. Power View is a graphical data exploration tool designed to let you investigate data using charts instead of PivotTables. In this way, you can easily look at pictures instead of numbers, and when you discover something worth investigating further, then you can continue using a PivotTable, drilling down to explore the details. Power View is not a sophisticated charting environment. Its goal is to let you create charts very quickly and look at data in different formats in a simple way.

Now you can click on an empty space of the report and, following the same steps, add two tables: one with the Office column from the SalesManagers table and another one with the SalesManager column from the same table. As you might have noticed, you need to click on empty space to create a new table because if you have a table already selected, the columns on which you click will be added to the selected table.

The chart, at this point, has two tables, one map and a column chart, as you can see in Figure 1-30.



Office	SalesManager
Redmond	Alberto Ferrari
Seattle	Louis Bonifaz
	Marco Russo
	Maurizio...

FIGURE 1-30 The Categories table is now a column chart.

Finally, you can convert the last two tables into slicers, using the Slicer button on the DESIGN tab of the Excel ribbon. Converting a table into a slicer lets you use them to filter the report. As soon as you click a row of a slicer, the full report will show data using that slicer as a filter. In Figure 1-31, you can now see the final report, where we have selected the Seattle office and Alberto Ferrari as the Sales Manager.

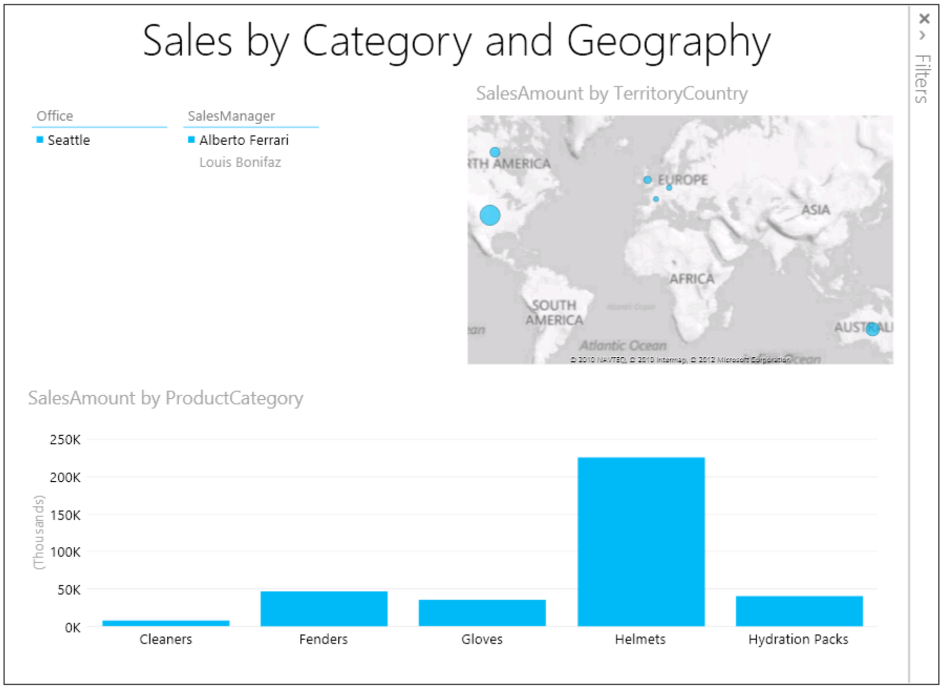


FIGURE 1-31 A report like this one can be created in a matter of a few seconds.

It is impossible to explain in a book the feeling of performing these steps live, but we are sure that the simplicity of these operations and how easy it was for you to create this report speak for themselves.

Creating beautiful graphical views of data is really simple with Power View. Remember that simplicity is the leitmotif of Power View. Do not even try to search the charting capabilities of Power View for the richness and complexity of Excel charts. Excel lets you create any type of chart by giving you thousands of different options. Power View goes in the opposite direction: a few mouse clicks are always enough to build beautiful charts, but if you need more configurability, then Power View is not the tool to use.

In order to be so easy to use, Power View requires the data model to contain some information about the content of your data and how to show it in the best way. You will learn a lot more about Power View and its interactions with the data model in Chapter 10, "Using Power View."