Using Excel's Data Table and Chart Tools Effectively in Finance Courses

Chengping Zhang
George Fox University

Data Table and Chart tools in Microsoft Excel provide data visualization. Incorporating Data Table and Chart into finance teaching not only helps students understand finance concepts intuitively and more efficiently, but also sharpens students' Excel skills and thus makes them more marketable in a competitive job market. This paper demonstrates how to use Data Table and Chart effectively in various finance courses to help professors teach and students learn some key finance concepts and theories. Professors in other business disciplines are encouraged to integrate Data Table and Chart tools into other business courses.

INTRODUCTION

In addition to communication, analytical thinking, teamwork, and critical thinking skills, accreditation standards often include a mastery of information technology as a desired learning goal for undergraduate and graduate programs. For example, Association to Advance Collegiate Schools of Business (AACSB) International Standard 9 states that business programs at the bachelor's, master's, and doctoral level would normally include learning experiences that enable students to use current technologies in business and management contexts[1]. Excel is one of the technologies that is widely used in the business world and Excel skills are continually ranked high by current and prospective employers.

To meet the accreditation standards, business schools should encourage instructors in different disciplines to integrate Excel into teaching and prepare students with desired Excel skills. This paper illustrates how to incorporate Excel into finance teaching. Specifically, I will present detailed examples to demonstrate how Excel's Data Table and Chart can help finance instructors teach some important concepts and theories in various finance courses at both undergraduate and graduate levels, including Introduction to Financial Management, Corporate Finance, Portfolio Management, Investments, Risk Management, and Financial Derivatives.

The benefit of integrating Excel tools into finance teaching can be enormous. First and most importantly, Data Table and Chart tools provide data visualization, which helps students understand finance concepts intuitively and more efficiently. Second, going through these useful Excel tools in different classes makes students more proficient in Excel and, in turn, makes students more marketable in the competitive job market. Another benefit of using Excel in the classroom is that it can keep students more engaged in the learning process. Carini, Kuh, and Klein (2006) show that student academic performance and learning outcomes are positively correlated with student engagement. In my experience, students enjoy Excel-integrated lectures more, focus better, and spend more time on various subjects than they would otherwise.

This paper is organized as follows. The next section briefly introduces Excel's Data Table and Chart tools, followed by three sections that are headed by course names. In each of these three sections, I use some detailed examples to illustrate how to use Data Table and Chart tools to enhance teaching and learning experience. The last section concludes the paper.

DATA TABLE AND CHART

Excel has been used as an effective teaching tool in the classroom. Arnold and Henry (2003) use Excel and VBA to simulate the stochastic processes of option prices. The simulation can help students visualize and understand the intimidating concept - stochastic processes. Strulik (2004) proposes an approach using Excel to solve the basic models of neoclassical growth and real business cycles in a macroeconomics class. Some scholars have also shown how a specific Excel tool can be used to teach various subjects. For example, Patterson and Harmel (2003) suggest a use of Excel's Solver add-in to solve the challenging traveling sales-man problem (TSP). McDermott (2009) presents a teaching note and an accompanying classroom exercise demonstrating how to build an Excel spreadsheet model and use Solver to conduct return-based style analysis in an investment course.

Besides Solver add-in, Microsoft Excel comes with several useful what-if analysis tools, including Data Table, Scenario Manager, and Goal Seek. Zhang (2014) briefly demonstrates how to incorporate each of these powerful Excel tools into finance teaching. But Data Tale tool is worth more attention as it is a very effective and efficient tool in performing a sensitivity analysis. Finance professors often need to explain to students the relationship between two or more financial variables, such as how the bond price changes when the required rate of return and/or time to maturity change. What is the trade-off between portfolio risk and return? What is the impact of stock volatility on option prices? Data Table is an ideal tool to answer these type of questions. With the help of the Chart feature in Excel, we can also visualize these relationships after we create the data tables.

We can create one- or two-input[2] data tables in Excel. One-input data table allows us to test how changes in one variable affect the output of one or more Excel formulas. A two-input data table can show how the output changes when two input variables vary at the same time. But a two-input data table can be applied to only one formula. If the values of an input variable are organized in a column, the variable is then a column input. Similarly, if its values are organized in a row, the input variable is a row input.

After we generate the data tables in Excel, we often use the Chart feature to plot the data to enhance visualization of complex concepts or important relationships between financial variables. Data Table tool, when combined with the use of Chart feature in Excel, can help professors teach finance more effectively, and help students learn finance intuitively and more efficiently. In the following, I provide some detailed examples to demonstrate how to incorporate Data Table and Chart tools into a variety of finance courses.

Introduction to Financial Management / Corporate Finance Course

There are some fundamental relationships in Introduction to Financial Management and Corporate Finance courses. These relationships are usually nonlinear and students often have difficult times grasping them. By presenting information in tables and graphs, Data Table and Chart tools can help students visualize and understand these relationships. The following example illustrates the step-by-step use of the Data Table tool in examining the present value versus time period and interest rate relationships.
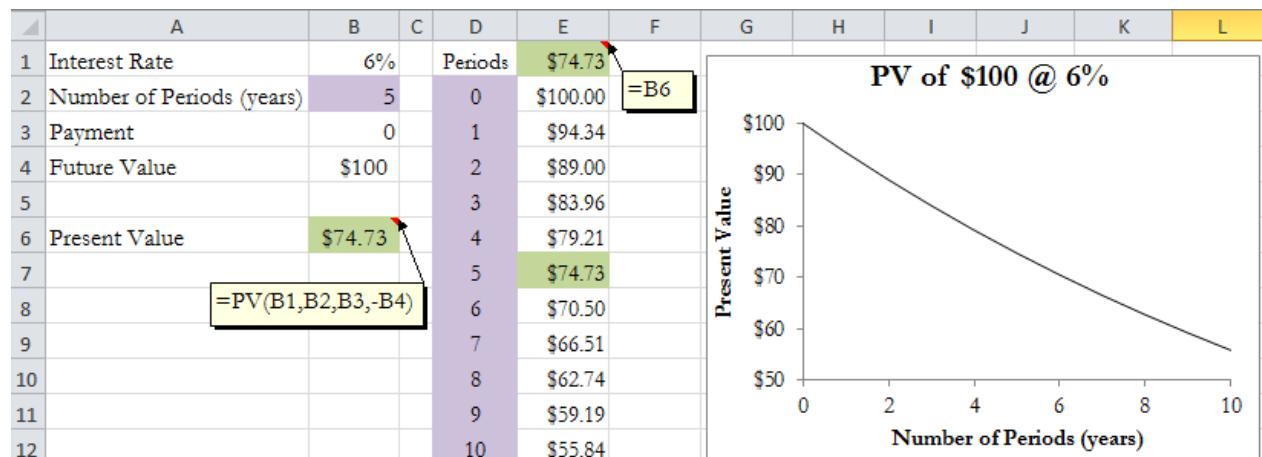
Example 1: Time Value of Money – Present Value
We first set up a spreadsheet to calculate the present value of $100 to be received at the end of year five for a nominal annual interest rate of 6%. We can either use Excel built-in function PV(rate, nper, pmt, fv) or PV-FV formula to find the present value. To make the spreadsheet more readable, flexible and user-friendly, we use cell references instead of actual numbers in Excel formulas and functions. This will minimize the amount of manual changes that need to be done when some inputs change. In Cell B6, we enter "=PV(B1,B2,B3,-B4)" and find that the present value of $100 to be received in year five at 6% is $74.73.

What if the number of periods is different from five years? Equivalently, we may ask how the present value changes when the number of periods increases or decreases? To answer this question, we can simply change the number of periods and Excel will recalculate the corresponding present value. However, it is more efficient to answer this type of questions by making use of Excel's sensitivity analysis tool - Data Table.

Suppose we want to examine the present values of $100 to be received at the end of year 0, 1, 2, 3, 4, …, 10. The first step in creating a data table is to organize the various number of periods in a column as shown in Figure 1 Column D (the input variable can be organized in a row as well). Next, we refer the cornerstone Cell E1 (the cell in the row above the first and one cell to the right of the column values) to Cell B6 that contains the initially calculated present value. We then highlight the cell range D1:E12, click "What-If Analysis" on the **Data** tab, and select "Data Table…", click in the "Column input cell" box (the number of periods are listed in a column) and select Cell B2, then click "OK". Excel replaces Cell B2 with each of the periods in column D and calculates the present value using the formula in Cell B6, and reports the result in the corresponding row of column E.

FIGURE 1
RELATIONSHIP BETWEEN PRESENT VALUE AND TIME PERIOD
FOR A GIVEN INTEREST RATE (ONE-VARIABLE DATA TABLE)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Interest Rate	6%		Periods	$74.73				PV of $100 @ 6%			
2	Number of Periods (years)	5		0	$100.00	=B6						
3	Payment	0		1	$94.34							
4	Future Value	$100		2	$89.00							
5				3	$83.96							
6	Present Value	$74.73		4	$79.21							
7				5	$74.73							
8		=PV(B1,B2,B3,-B4)		6	$70.50							
9				7	$66.51							
10				8	$62.74							
11				9	$59.19							
12				10	$55.84							

We can do a few quick checks here. When the number of periods is 0, the present value should be $100, as the present value of $100 to be received today is $100 (there is no time value). When the number of periods is 5 years, the corresponding present value should be $74.73 as we calculated earlier. We confirm that the data table is correctly generated. This is a one-variable data table since the only changing variable is the number of periods.

The table shows that when the interest rate is fixed at 6%, the longer the time period, the lower the present value, meaning that you will need to set aside less today to earn a specified amount in the future if you have more time. We can also show this relationship by graphing the data (time periods on the X-axis and the present values on the Y-axis) in a "scatter with smooth lines" chart.

We can also create a two-variable data table to examine the sensitivity of the present value to interest rates and number of periods at the same time. In addition to listing the various periods in a column as in the one-variable data table, we organize the interest rates of 0% to 12% with an increment of 2% in a row. The intersection Cell E2 of "periods" column and "interest rates" row is now the cornerstone cell and we refer it to the initial present value Cell B6. Following the previous procedure to use Data Table tool and specify B1 as the "Row input cell" and B2 as the "Column input cell". The resultant data table is shown in Figure 2.

FIGURE 2
RELATIONSHIP BETWEEN PRESENT VALUE AND TIME PERIOD & INTEREST RATE
(TWO-VARIABLE DATA TABLE)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Interest Rate	6%	=B6					Interest Rate				
2	Number of Periods (years)	5			$74.73	0%	2%	4%	6%	8%	10%	12%
3	Payment	0			0	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100
4	Future Value	$100			1	$ 100	$98.04	$96.15	$94.34	$92.59	$90.91	$89.29
5					2	$ 100	$96.12	$92.46	$89.00	$85.73	$82.64	$79.72
6	Present Value	$74.73			3	$ 100	$94.23	$88.90	$83.96	$79.38	$75.13	$71.18
7		=PV(B1,B2,B3,-B4)			4	$ 100	$92.38	$85.48	$79.21	$73.50	$68.30	$63.55
8					5	$ 100	$90.57	$82.19	$74.73	$68.06	$62.09	$56.74
9					6	$ 100	$88.80	$79.03	$70.50	$63.02	$56.45	$50.66
10					7	$ 100	$87.06	$75.99	$66.51	$58.35	$51.32	$45.23
11					8	$ 100	$85.35	$73.07	$62.74	$54.03	$46.65	$40.39
12					9	$ 100	$83.68	$70.26	$59.19	$50.02	$42.41	$36.06
13					10	$ 100	$82.03	$67.56	$55.84	$46.32	$38.55	$32.20

(Number of Periods (years) labels column D/E vertically)

Again, we plot the data in a scatter chart as in Figure 3. Each individual curve in Figure 3 shows the relationship between present value and number of periods for a given interest rate. If we draw a vertical line across a specific period, we can help students see another important relationship. For a given time period, the higher the interest rate, the smaller the present value. This means you would need set aside less today to earn a specified amount in the future if you can earn a higher interest rate.

FIGURE 3
PRESENT VALUE OF $100 TO BE RECEIVED IN A FUTURE YEAR

PV of $100
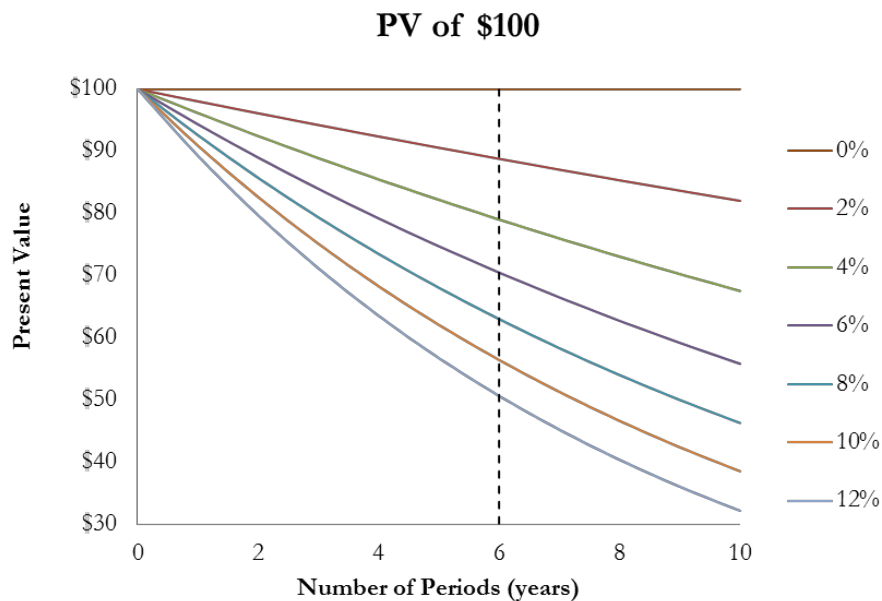
Example 2: Bond Valuations and Features

Bond valuation is another essential topic in introductory finance courses. Students often feel overwhelmed over the amount of information on this subject. Creating a two-variable data table for bond value sensitivity can help students tremendously in learning bonds and bond features.

We start with a spreadsheet to calculate the price of a 20-year semi-annual bond with a face value of $1,000, a 6% coupon rate, and a yield to maturity of 5%. To make the spreadsheet more flexible, we should include a coupon frequency cell, so that this workbook can be used for analyzing annual bonds as well[3]. To calculate the bond value, we need to adjust the interest rate, number of periods, and payment using the coupon frequency. Figure 4 shows what the initial setup of the spreadsheet looks like. Using cell references for the input variables, we enter "=-PV(B5/B6,B3*B6,B2*B4/B6,B4)" in Cell B8 and find the bond price to be $1,125.51.

FIGURE 4
SPREADSHEET SETUP TO CALCULATE THE PRICE OF A BOND

Now we set up a two-variable data table to examine the bond price sensitivity to changes in interest rates and time to maturity. First, refer Cell F2 to the bond price cell, B8. Below F2, type a list of interest rates from 2% to 10% with an increment of 1% in the same column. To the right of F2, enter a list of time to maturity from 20 years (now) to 0 (when the bond matures) with an increment of 2. Next, select cell range F2:Q12 of cells that contains both time to maturity and interest rate values. On the Data tab, in the Data Tools group, click What-If Analysis, and then click Data Table. Since the time to maturity values are in a row, we enter the reference to the initial maturity Cell B3 in the Row input cell box. In the Column input cell box, enter the reference to the initial interest rate Cell B5 as the rate values are listed in a column. Then click OK. Excel calculates bond prices for all combinations of row and column input values as shown in Figure 5.

This two-variable data table allows us to conveniently learn a lot about bonds and their features.

I. The first four rows of data show that, when the interest rate is lower than the coupon rate, the bond price is higher than the par value (a premium bond); When the interest rate is equal to the coupon rate, the bond price is the same as the par value (a par bond). When the interest rate is higher than the coupon rate, the bond price is lower than the par value (a discount bond) as shown in the last four rows.

II. At maturity, the price of any bond equals to its par value no matter what the interest rate is. This is not surprising because, at maturity, the expected cash flow from the bond is just its face value repayment on the same day.

FIGURE 5
BOND PRICE SENSITIVITY TO INTEREST RATE AND TIME TO MATURITY

|		Bond Price Sensitivity to Interest Rate and Time to Maturity										
		Time to Maturity										
	$1,125.51	20	18	16	14	12	10	8	6	4	2	0
	2%	$1,656.69	$1,602.15	$1,545.39	$1,486.33	$1,424.87	$1,360.91	$1,294.36	$1,225.10	$1,153.03	$1,078.04	$ 1,000
	3%	$1,448.74	$1,414.91	$1,379.01	$1,340.90	$1,300.46	$1,257.53	$1,211.97	$1,163.61	$1,112.29	$1,057.82	$ 1,000
	4%	$1,273.55	$1,254.89	$1,234.68	$1,212.81	$1,189.14	$1,163.51	$1,135.78	$1,105.75	$1,073.25	$1,038.08	$ 1,000
Interest rate	5%	$1,125.51	$1,117.78	$1,109.25	$1,099.82	$1,089.42	$1,077.95	$1,065.28	$1,051.29	$1,035.85	$1,018.81	$ 1,000
	6%	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
	7%	$ 893.22	$ 898.55	$ 904.66	$ 911.66	$ 919.71	$ 928.94	$ 939.53	$ 951.68	$ 965.63	$ 981.63	$ 1,000
	8%	$ 802.07	$ 810.92	$ 821.26	$ 833.37	$ 847.53	$ 864.10	$ 883.48	$ 906.15	$ 932.67	$ 963.70	$ 1,000
	9%	$ 723.98	$ 735.01	$ 748.17	$ 763.86	$ 782.57	$ 804.88	$ 831.49	$ 863.22	$ 901.06	$ 946.19	$ 1,000
	10%	$ 656.82	$ 669.06	$ 683.95	$ 702.04	$ 724.03	$ 750.76	$ 783.24	$ 822.73	$ 870.74	$ 929.08	$ 1,000

III. For a given time to maturity, there is an inverse relationship between bond price and interest rate (yield to maturity) as shown in each column. That is, as the interest rate increases, the price of a bond decreases. This relationship can be better visualized by plotting column F (or other given time to maturity) against column E in the data table. Figure 6 shows a clear inverse relationship between the value of a bond and the interest rate.

FIGURE 6
RELATIONSHIP BETWEEN BOND PRICE AND INTEREST RATE
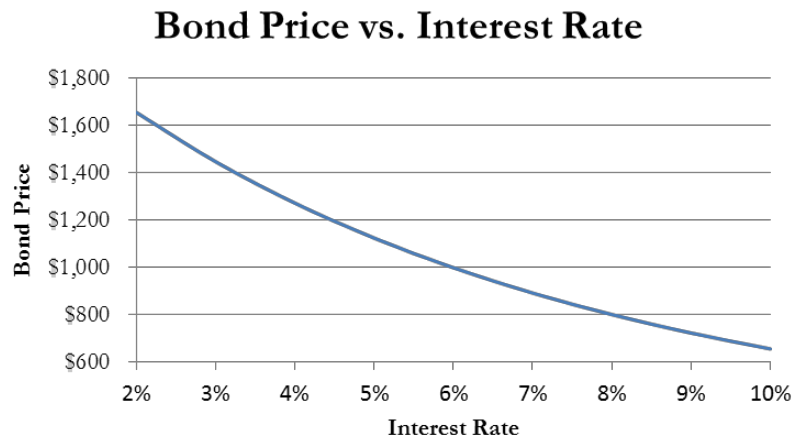
IV. The value of a call option increases as the underlying stock price increases. For a deep in-the-money call, the call value moves one for one with the underlying stock price. If the interest rate (yield to maturity) remains constant, the price of a premium bond declines over time and equals to its par value at maturity; the price of a par bond stays the same over time; and the price of a discount bond increases over time and equals to its par value at maturity. To help visualize this pattern, we plot the values of a premium bond, a par bond, and a discount bond over time in Excel as displayed in Figure 7.

FIGURE 7
RELATIONSHIP BETWEEN BOND PRICE AND TIME TO MATURE
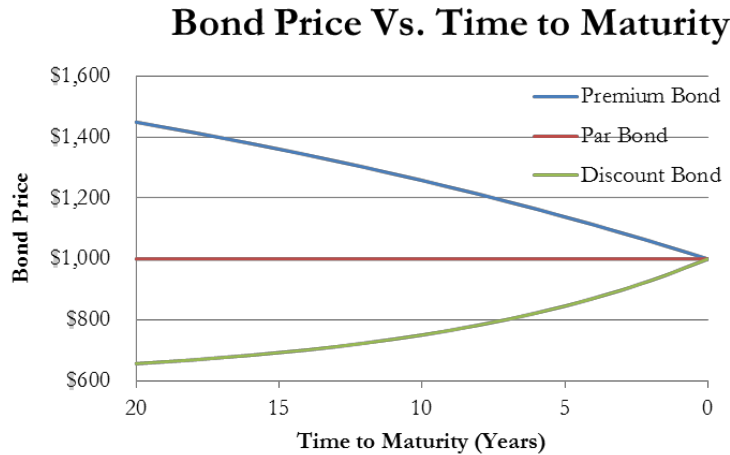
There are some other places in Introduction to Financial Management or Corporate Finance courses where we can use Data Table tool as an effective teaching and learning tool. They include:

1. Financial statement sensitivity analysis;
2. Future value versus interest rate and/or compounding periods;
3. Stock price versus required rate of return and/or dividend growth rate;
4. The relationship between expected return and risk (standard deviation for Capital Market Line (CML) or beta for Security Market Line (SML)); and
5. NPV profile of a proposed project (NPV vs. discount rate).

Investments / Portfolio Analysis and Management / Risk Management Course

Data Table can be a powerful tool in Investments, Portfolio Analysis and Management, and Risk Management courses as well. One application of this tool would be to find the return and standard deviation of a two-asset portfolio with the portfolio weight of the first asset as the input variable. The data table will allow us to see the tradeoff between risk and return.

Example 1: Constructing Efficient Frontier

A more advanced application of Data Table tool in these courses is to construct the efficient frontier of a set of risky assets. The efficient frontier is a key concept in modern portfolio theory introduced by Markowitz (1952). It represents the set of "efficient" portfolios that have the highest expected return for a given level of risk, or the lowest risk for a given rate of return.

Suppose we find the minimum variance portfolio (MVP), the optimal risky portfolio (ORP), and the covariance between the MVP and ORP already[4]. Merton (1972) shows that every point on the efficient frontier can be formed as a combination of any two efficient portfolios. Since both the MVP and ORP are efficient, we can construct the whole efficient frontier of the risky assets using the MVP and ORP. We assume a portfolio weight for the MVP. The weight for the ORP is then one minus the MVP weight. Therefore, we can calculate the return and standard deviation of the new portfolio consisted of the MVP and ORP.

Now we enter a set of possible MVP weights in the range of F4:F21. Let Cell G3 be "=B9" and Cell H3 be "=B10", and select the range of F3:H21. Follow the same procedure as outlined before to activate the Data Table dialog box. Leave the row input cell blank and the column input cell should be the portfolio weight in the MVP cell, B8. Click OK. Figure 8 shows the completed data table detailing the risk-return profile for portfolios consisted of the MVP and ORP with different weights.

FIGURE 8
SPREADSHEET SETUP TO CALCULATE ENVELOPE PORTFOLIOS

	A	B	C	D	E	F	G	H
1	Constructing Efficient Frontier						Portfolio Envelope	
2		Minimum Variance Portfolio (MVP)	Optimal Risky Portfolio (ORP)				Return	Standard Deviation
3	Expected Return	3.50%	16.03%				13.53%	20.26%
4	Standard Deviation	4.92%	25.06%			-20%	18.54%	29.89%
5	Covariance	0.0024				-10%	17.29%	27.47%
6						0%	16.03%	25.06%
7	Portfolio Consisted of MVP & ORP					10%	14.78%	22.65%
8	Weight in the MVP	20%	=B8*B3+(1-B8)*C3			20%	13.53%	20.26%
9	Return	13.53%				30%	12.27%	17.89%
10	Standard Deviation	20.26%				40%	11.02%	15.54%
11		=SQRT(B8^2*B4^2+2*B8*(1-B8)*B5+(1-B8)^2*C4^2)				50%	9.77%	13.23%
12						60%	8.52%	10.99%
13						70%	7.26%	8.86%
14						80%	6.01%	6.95%
15						90%	4.76%	5.50%
16						100%	3.50%	4.92%
17						110%	2.25%	5.50%
18						120%	1.00%	6.95%
19						130%	-0.26%	8.86%
20						140%	-1.51%	10.99%
21						150%	-2.76%	13.23%

(Weight in the MVP — label along column F)

The return and standard deviation of these portfolios can be plotted on a XY scatter graph with standard deviation on the X-axis and return on the Y-axis. Connecting these portfolios with a smooth line, we get the portfolio envelope as shown in Figure 9. Note that the MVP defines the upper and the lower portion of the portfolio envelope. Only the upper part of the envelope is the efficient frontier, which is represented by the black solid line. The lower portion, indicated by the read dashed line, is not part of the efficient frontier.

FIGURE 9
EFFICIENT FRONTIER

Efficient Frontier

■ MVP
♦ ORP
— Efficient Frontier
- - - Not Efficient

(Y-axis: Return; X-axis: Standard Deviation)
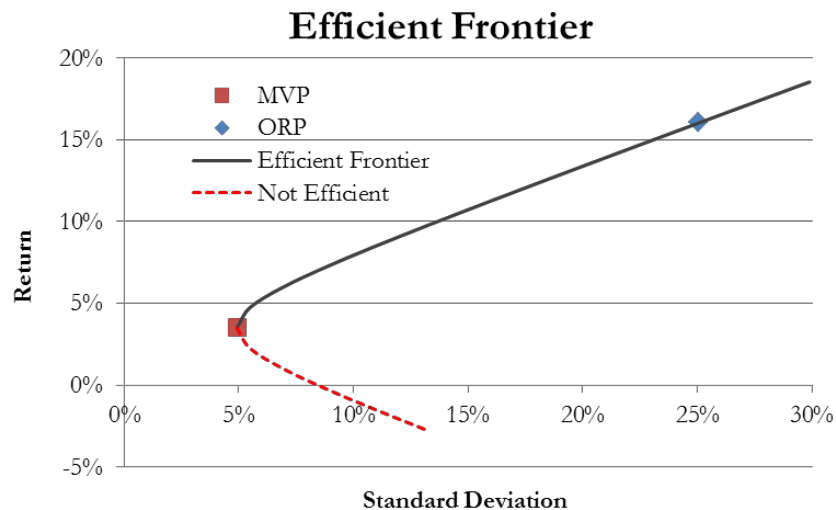
Example 2: Calculating Value at Risk (VaR)

Value at Risk, or VaR, is a very important and popular portfolio risk measure in investments and risk management, but it is not an easy concept for professors to teach, let alone for students to grasp. VaR is the potential loss in a portfolio at a certain confidence interval over a given time horizon under normal market conditions. The confidence interval is typically 95% or 99%. The exact time horizon depends on the institution and the nature of the portfolio. It could be one day, a month, or a year.

There are three methods of calculating VaR: Mento Carlo simulation, historical simulation, and analytical or parametric VaR[5]. The analytical method is simpler than the two simulation methods since it does not involve simulations and complicate statistical inference. In the following, I will demonstrate how we can calculate analytical VaR in Excel, and how Data Table tool and Chart may help students understand the concept of Value at Risk.

Consider a $100 million portfolio with an expected annual return of 11% and a standard deviation of 20%. We want to find the VaR of the portfolio at the 95% confidence interval over one year. Value at risk at the 95% confidence level means that we are 95% confident that the total loss on the portfolio will not exceed the VaR, or in other words, there is a 5% chance that the ending portfolio value will be ($100 million – VaR) or less. Assuming returns are normally distributed with a mean of μ and a standard deviation of σ, we can find a return such that, with a probability of p, the portfolio return will be less than or equal to this rate of return. This return can be found using Excel's $NormINV(p, \mu, \sigma)$ function. The total portfolio gain or loss would be the initial portfolio value times this return.

For a 95% confidence interval, the probability $p = 1 - 95\% = 5\%$. $NormINV(5\%, 11\%, 20\%) = -21.90\%$. This means that, with a probability of 5%, the portfolio return for the next year will be -21.90% or less. Or we are 95% confident that the portfolio return will be higher than -21.90%. The VaR at 95% confidence level is then $100\ million * (-21.90\%) = -\$21.90\ million$. The calculation is shown in Figure 10.
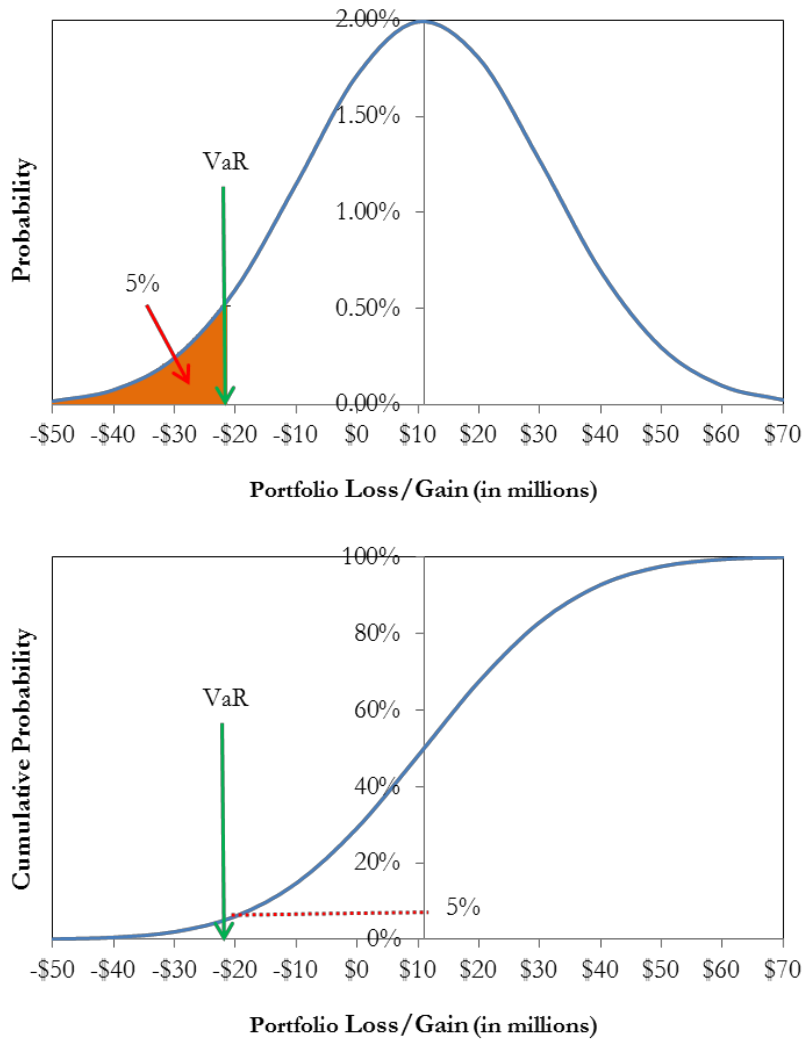
FIGURE 10
CALCULATING VALUE AT RISK (VAR)

	A	B	C	D	E	F
				Portfolio	Probability	Cumulative
1	Calculating VaR			Loss/Gain	Distribution	Distribution
2					0.52%	5.00%
3	Portfolio Value (in millions)	$100		-$50	0.02%	0.11%
4	Expected Return	11%		-$40	0.08%	0.54%
5	Standard Deviation	20%		-$30	0.24%	2.02%
6	Confidence Level	95%		-$20	0.60%	6.06%
7	=NORM.DIST(B9,B4*B3,B5*B3,0)			-$10	1.15%	14.69%
8				$0	1.71%	29.12%
9	Value at Risk (VaR, in millions)	-$21.90		$10	1.99%	48.01%
10	=NORM.DIST(B9,B4*B3,B5*B3,0)			$20	1.80%	67.36%
11				$30	1.27%	82.89%
12	Probability Distribution	0.52%		$40	0.70%	92.65%
13	Cumulative Distribution	5.00%		$50	0.30%	97.44%
14				$60	0.10%	99.29%
15	=NORM.DIST(B9,B4*B3,B5*B3,1)			$70	0.03%	99.84%

We can treat portfolio gain/loss as a random variable. If returns are assumed to be normally distributed with a mean of μ and a standard deviation of σ, then the gain/loss of a portfolio with a balance of b is normally distributed with a mean of $b\mu$ and a standard deviation of $b\sigma$. Excel's

$NormDist(x, b\mu, b\sigma, c)$ function can be used to find the probability that a particular portfolio gain or loss x will occur when the parameter c is set to 0, or the cumulative probability that portfolio gain or loss is less than or equal to x when c is set to 1. We calculate the probability and cumulative probability at the VaR of the portfolio at the 95% confidence interval in cells B12 and B13. Then we create a data table to show the probabilities and cumulative probabilities for a set of possible portfolio gains/losses. The data table allows us to plot the normal probability distribution and the cumulative distribution curves as represented in Figure 11.

FIGURE 11
VALUE AT RISK (VAR) ILLUSTRATED

The plots in Figure 11 allow us to visualize the concept of VaR. If the total area under the normal distribution curve is equal to 1.00 or 100%, the area under the normal curve to the left of the VaR (-$21.90 million) at the 95% confidence level is then 5% as illustrated in the top graph. That is, the cumulative probability that the portfolio loss will be greater than or equal to $21.90 million is 5%, which corresponds to the Y-axis value when the X-axis value is -$21.90 million in the bottom graph.

Financial Derivatives Course

Data Table tool can be extremely useful in Financial Derivatives course when analyzing

1. Payoffs from forward or futures contracts;
2. Payoff or profit pattern of a simple call or put option[6];
3. The profit patterns of option combination strategies, such as covered calls, protective puts, straddles, bull spreads, bear spreads, and butterfly spreads;
4. Option price sensitivity to underlying asset price (Delta), strike price, time to expiration (Theta), risk-free rate (Rho), and the volatility (standard deviation) of the underlying asset (Vega);
5. Sensitivity of Delta to underlying asset price (Gamma).

The next two examples demonstrate how to use Data Table and Chart tools to help students understand call option and bull spread strategy.

Example 1: Price and Intrinsic Value of a European Call Option

Hull's *Options, Futures, and Other Derivatives* (2014) is a widely used textbook on financial derivatives. In this book, Hull uses a lot of diagrams to illustrate option price sensitivity to the five factors mentioned above, as well as payoff or profit patterns of various combination strategies. Actually, we can use Data Table tool to generate the data needed to plot all these diagrams. Such a process will undoubtedly help students gain a deeper understanding of these topics.

Our first example examines the price sensitivity of a European call on a non-dividend paying stock. After we enter the strike price, risk-free rate, time to expiration, volatility, and a hypothetical underlying stock price in a spreadsheet, we can calculate the intrinsic value of the call option, as well as the call price (or call premium) using the Black-Scholes (1973) model. To have a basic understanding of options, students need to be able to answer questions like: How does a change in the underlying stock price affect the call price and its intrinsic value? Data Table is an ideal tool to solve this type of sensitivity analysis problems. Following similar steps as in the previous example, we can generate the table with calculated call prices and intrinsic values. For brevity, we skip the details. The screenshot of this spreadsheet is presented in Figure 12.

FIGURE 12
CALCULATING THE PRICE AND INTRINSIC VALUE OF A EUROPEAN CALL ON A NON-DIVIDEND PAYING STOCK

	A	B	C	D	E	F
				Underlying	Call	Call Intrinsic
1	Calculating Call Price			Stock Price	Price	Value
2	Underlying Stock Price S	$23			$3.42	$3.00
3	Strike Price X	$20		$10	$0.00	$0.00
4	Risk-free Rate R	2.00%		$11	$0.00	$0.00
5	Time to Expiration T (years)	0.50		$12	$0.00	$0.00
6	Volatility	20%		$13	$0.00	$0.00
7	=(LN(B2/B3)+(B4+B6^2/2)*B5)/(B6*SQRT(B5))			$14	$0.01	$0.00
8				$15	$0.02	$0.00
9	d₁	1.1297		$16	$0.07	$0.00
10	d₂ =B9-B6*SQRT(B5)	0.9883		$17	$0.19	$0.00
11	=NORMSDIST(B9)			$18	$0.40	$0.00
12				$19	$0.74	$0.00
13	N(d₁) =NORMSDIST(B10)	0.8707		$20	$1.22	$0.00
14	N(d₂)	0.8385		$21	$1.85	$1.00
15	=B2*B13-B3*EXP(-B4*B5)*B14			$22	$2.59	$2.00
16				$23	$3.42	$3.00
17	Call price (Black-Scholes Model)	$3.42		$24	$4.32	$4.00
18	Call intrinsic value	3.00		$25	$5.26	$5.00
19	=MAX(B2-B3,0)					

Figure 13 plots the call prices and intrinsic values in columns E and F. This plot allows us to see some important features of call options.

I.   The value of a call option increases as the underlying stock price increases. For deep in-the-money calls, the call value moves one for one with the underlying stock price.

II.   The difference between a call price and its intrinsic value is the time value. The time value is greater when the underlying stock price is close to the exercise price, and is smaller for deep in-the-money and deep out-of-money calls. This is also true to put options.

III. The slope of the call price curve is called Delta. It measures the rate of price change in an option with respect to changes in its underlying stock price. From the graph, we learn that for deep out-of-money calls, the delta is 0. For deep in-the-money calls, the delta is 1. The Delta of a call option increases as the underlying stock price increases.

IV. Gamma measures the rate of change of delta as the underlying stock price changes. For deep in- or deep out-of-the-money calls, gamma approaches zero because changes in the underlying stock price do not have a significant effect on delta as seen in Figure 13. Delta is very sensitive to changes in the underlying stock price when a call option is at-the-money. That is, Gamma is largest when a call is at-the-money.

V.   When we change the time to expiration in Cell B5 to a smaller number, say 0.25, the call price curve would move towards the intrinsic value curve. This indicates that as a call gets closer to expiration, its value declines due to diminishing time value.

FIGURE 13
PRICE AND INTRINSIC VALUE OF A EUROPEAN CALL OPTION
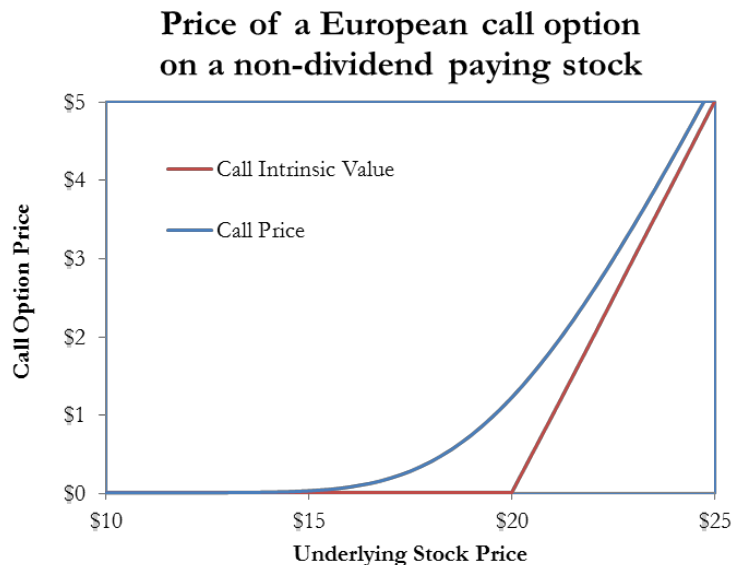
Similarly, we can use Data Table and Chart tools to illustrate call or put price sensitivity to time to expiration (Theta), risk-free rate (Rho), volatility (Vega), and Delta sensitivity to underlying stock price (Gamma).

Example 2: Profit/Loss Pattern of a Bull Spread Strategy

A bull spread is a bullish option strategy that is designed to profit from a moderate rise in the price of the underlying stock. A bull call spread can be constructed by simultaneously buying a call option with a lower strike price and selling another call with a higher exercise price of the same underlying stock. A

bull put spread involves simultaneously buying a put option with a higher strike price and selling another put with a lower strike price. Both options in a bull spread have the same expiration.

For a bull call spread, at expiration, the profit/loss for the long call is

$$\max(S_T - X_1, 0) - c_1 \tag{1}$$

and the profit/loss for the short call is

$$-\max(S_T - X_2, 0) + c_2 \tag{2}$$

where S_T is the underlying stock price on the option expiration date; X_1 and X_2 are the exercise or strike prices; c_1 and c_2 are the call prices or call premiums of these two call options, respectively.

The total profit/loss for the bull call spread is then the sum of (1) and (2),

$$\max(S_T - X_1, 0) - c_1 - \max(S_T - X_2, 0) + c_2 = \begin{cases} c_2 - c_1 & if\ S_T \leq X_1 \\ S_T - X_1 - c_1 + c_2 & if\ X_1 < S_T < X_2 \\ X_2 - X_1 - c_1 + c_2 & if\ S_T \geq X_2 \end{cases} \tag{3}$$

Suppose we buy a call option with a strike price of $30 for $7, and sell a call option on the same underlying stock with a strike price of $35 for $4 at the same time. For a given underlying stock price, we can find the profit/loss from these two calls in Excel. The total profit/loss from this combination would be the profit/loss for the bull call spread strategy.

As illustrated in the screen shot of Figure 14, the underlying stock price on the option expiration date is the input variable. We first fill D4:D13 with stock prices ranging from $5 to $50, with an increment of $5. Refer cells E3, F3, and G3 to the profit/loss cells B11, B12, and B13, respectively. Then select the range of D3:G13, and run Data Table. Type the cell reference (B2) for the input variable (underlying stock price) in the "Column input cell" box. Click OK and Excel fills the table.

FIGURE 14
BULL CALL SPREAD STRATEGY

	A	B	C	D	E	F	G
1		Bull Call Spread Profit / Loss					
2	Underlying Stock price	$20		Underlying Stock Price	Call 1 (Long)	Call 2 (Short)	Bull Call Spread
3	Call 1				-$7	$4	-$3
4	Exercise (Strike) price	$30		$5	-$7	$4	-$3
5	Call price (premium)	$7		$10	-$7	$4	-$3
6	Call 2			$15	-$7	$4	-$3
7	Exercise (Strike) price	$35		$20	-$7	$4	-$3
8	Call price (premium)	$4		$25	-$7	$4	-$3
9				$30	-$7	$4	-$3
10	Profit / Loss		=MAX(B2-B4,0)-B5	$35	-$2	$4	$2
11	Call 1 (long)	-$7	=-MAX(B2-B7,0)+B8	$40	$3	-$1	$2
12	Call 2 (short)	$4	=B11+B12	$45	$8	-$6	$2
13	Bull Call Spread	-$3		$50	$13	-$11	$2

To visualize the data, we plot the profit/loss of the bull call spread, as well as that of the two call options in Figure 15. The profit/loss pattern of the bull spread indicates that if we are moderately bullish on a stock and the stock price does move in direction as we expect, we will have a gain. That is why this strategy is called bull spread. Conversely, we can construct a bear spread and make a profit if we are bearish on a stock. We can also see that both profit and loss from a bull spread are capped. So a bull spread is a limited profit, limited risk options trading strategy. The graph also gives us some idea on where the break-even point is located for the bull spread strategy. We can find the exact break-even underlying stock price using Excel's Goal Seek tool or Solver.

FIGURE 15
BULL CALL SPREAD PROFIT/LOSS PATTERN

Bull Call Spread Profit/Loss
($X_1 = \$30, c_1 = \$7, X_2 = \$35, c_2 = \$4$)
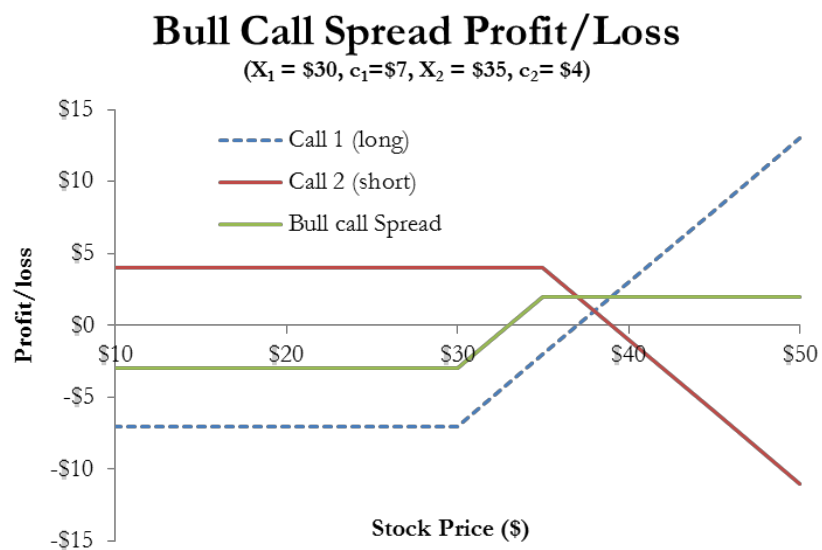
In like manner, we can plot the profit/loss curve for a more complicated strategy. No matter how many calls and/or puts are in a strategy, we just need to find the profit/loss for each call or put first, then add them up to find the profit/loss for the combination strategy.

CONCLUSION

Data Table, coupled with Chart feature in Excel, can be a very powerful teaching and learning tool in finance courses. This paper uses detailed examples to demonstrate how Data Table tool can effectively help professors teach and students learn in finance courses, including Introduction to Financial Management, Corporate Finance, Portfolio Management, Investments, Risk Management, and Financial Derivatives.

The benefit of integrating Data Table and Chart into finance courses is multifold. Most importantly, this method provides data visualization, which helps students understand finance concepts intuitively and more efficiently. Furthermore, revisiting these useful Excel tools in different finance courses improves students' Excel skills and, in turn, makes students more marketable. Incorporating Data Table and Chart in the classroom also makes students more engaged in learning as it provides some hands-on experience.

Professors in other business disciplines should consider integrating Excel's Data Table and Chart tools into other business courses as needed. This will not only help students gain a deeper understanding of what they learn, but also sharpen students' Excel skills and help them excel in the competitive business world.

ENDNOTES

1. See http://www.aacsb.edu/accreditation/business/standards/2013/learning-and-teaching/standard9.asp.
2. One-input data table is also called one-variable or one -dimensional data table. Two-input data table has similar names as well.
3. To analyze an annual bond, we can simply change the coupon frequency cell to 1. We don't need to change anything in the bond price calculation.
4. We can use Excel's Solver tool to find the Minimum Variance Portfolio (MVP) and the optimal risky portfolio (ORP). Zhang (2014) details how to use Solver to find the MVP.
5. Analytical VaR is also referred to as Variance-Covariance VaR**.**
6. From a buyer's perspective, payoff refers to the value of an option at expiration. Profit refers to the total gain (or loss) from the option. Profit is the difference between the payoff and the option premium (the initial cost to purchase the option).

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