

CHAPTER 1

INTRODUCTION

Review Questions

- 1.1–1 The rapid development of the discipline began in the 1940's and 1950's.
- 1.1–2 The traditional name given to the discipline is operations research.
- 1.1–3 A management science study provides an analysis and recommendations, based on the quantitative factors involved in the problem, as input to the managers.
- 1.1–4 Management science is based strongly on some scientific fields, including mathematics and computer science. It also draws upon the social sciences, especially economics.
- 1.1–5 Many managerial problems revolve around such quantitative factors as production quantities, revenues, costs, the amounts available of needed resources, etc.
- 1.2–1 Business analytics has drawn on various other quantitative decision sciences, including management science, mathematics, statistics, computer science, information technology, industrial engineering, etc.
- 1.2–2 The era of big data is where massive amounts of data (accompanied by massive amounts of computational power) are now commonly available to many businesses to help guide managerial decision making. A primary focus of business analytics is on how to make the most effective use of all these data.
- 1.2–3 Descriptive analytics uses innovative techniques (including algorithms) to explore the data, locate and extract the data that are relevant, and then identify the interesting patterns and summary data.
- 1.2–4 Predictive analytics often involves applying statistical models to predict future events or trends.
- 1.2–5 Prescriptive analytics uses powerful techniques drawn mainly from management science to prescribe what should be done in the future.
- 1.2–6 Data science tends to be more interdisciplinary, more based on scientific methods, more applicable to various areas in addition to business, and more concerned with how to deal with even massive amounts of data in various forms.
- 1.2–7 The goal of machine learning is to allow computers to learn automatically from historical relationships and trends in the data in order to do such things as making data-driven predictions. Machine learning is a popular method for applying predictive analytics by performing pattern recognition.

- 1.2–8 Machine learning is just one important part of artificial intelligence. Because its focus is on automatically learning from historical relationships and trends in the data, machine learning provides an ideal platform for performing artificial intelligence. The difficult part then is taking the next step to use this platform to truly simulate human thinking capability and behavior.
- 1.3–1 Business analytics provides a larger toolkit when dealing with descriptive analytics, data preparation, and predictive analytics. Management science techniques normally take the lead when performing prescriptive analytics.
- 1.3–2 Analytics have been making important contributions in such areas as sports, political campaigns, healthcare, combating crime, personal financial analysis, etc.
- 1.3–3 Top management now understands very well the impact that business analytics and management science can have on the bottom line. This will continue to require many more people who are very well trained in business analytics and management science
- 1.3–4 Operations research has been the usual name given to management science outside of business schools.
- 1.3–5 INFORMS (the Institute of Operations Research and the Management Sciences) is the largest professional society of management science and business analytics professionals or students in the world.
- 1.4–1 Variable costs include all of the costs that are proportional with the number of units produced.
- 1.4–2 Fixed costs include the costs that are incurred regardless of how many units are produced. These might include a prorated share of the salaries for upper management, capital equipment, property taxes, and more.
- 1.4–3 There are often diminishing returns from advertising that are not captured by linear regression.
- 1.4–4 If a polynomial equation is used to try to predict what sales will be for advertising budgets, it will eventually start sloping downward. While we intuitively would expect diminishing returns as advertising is increased, we wouldn't expect sales to actually decrease.
- 1.4–5 Sales do not increase proportionally with the level of advertising, but rather increase proportionally with the *square root* of advertising.
- 1.4–6 Solver will find the value of decision variable cells that will optimize the value of an objective cell.

Problems

- 1.1 The three modules are the Incident Ticket Classification Module (which lists and classifies the undesirable incidents for the various servers), the Server Classification Module (which links the server unavailable incidents to the servers involved and then develops metrics for the individual servers), and the Remediation Recommendation Module (which develops recommendations of the appropriate modernization actions that should be taken for problematic servers).
- 1.2 The techniques of management science and business analytics used include simulation, mixed-integer programming, genetic algorithms, linear programming, Dantzig-Wolfe decomposition, parallel processing, artificial intelligence, machine learning, etc. Pages 22-23 describe the financial benefits for both product architecture design and supply chain planning, and then combine them as given in the application vignette. Page 23 describes organizational benefits (much greater efficiency plus new insights and controls) and environmental benefits (reducing water usage and wastewater).
- 1.3 An answer for the selected application can be found by referring to the corresponding question in the chapter indicated in Table 1.1 and then reading its answer in this Solutions Manual.
- 1.4 Find the answers as described above for Problem 1.3.
- 1.5
 - a. True.
 - b. False. Management science doesn't make managerial decisions. Managers do. Management science *aids* managerial decision making.
 - c. False. Becomes true when you replace the word *qualitative* by *quantitative*.
- 1.6
 - a. True.
 - b. False. Business analytics focuses on transforming data into insight for making better business decisions.
 - c. True.
- 1.7
 - a. False. Management science became an established discipline in the middle of the 20th century whereas business analytics only began becoming well established after the beginning of the 21st century.
 - b. True.
 - c. False. This expansion already is well under way, especially with new programs in business analytics.
- 1.8
 - a. Answers will vary. See answer to part *d* for some possible intuition for a hypothesis.

- b. At the higher variable cost of \$315, the best level of advertising decreases to \$88,726.

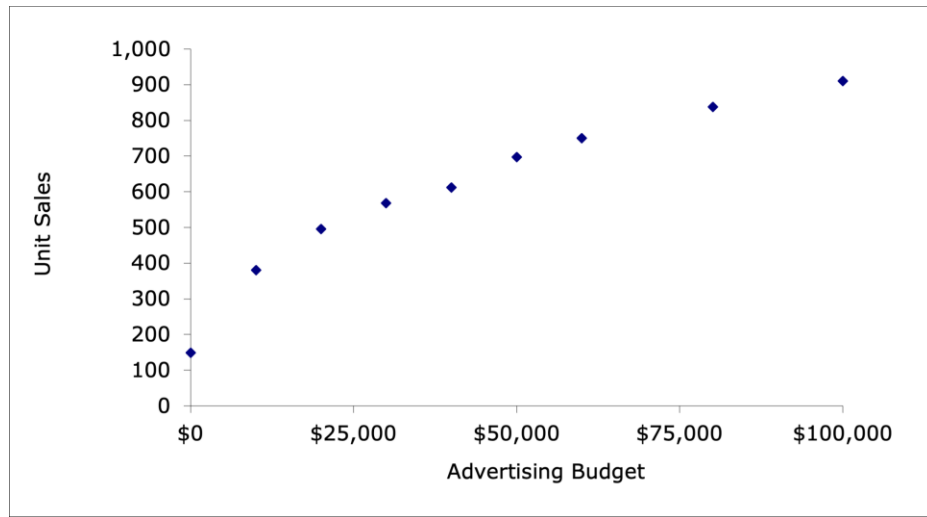
	A	B	C
1	VRX2000 Optimization Model		
2			
3	Parameters:		
4	Unit Variable Cost		\$315
5	Unit Revenue		\$400
6	Fixed Cost		\$100,000
7			
8	Decision Variable:		
9	Advertising Budget		\$88,726
10			
11	Prediction Formula: Sales $\approx a \sqrt{x} + b$		
12		a	7.01
13		b	400
14			
15	Expected Units Sold		2,488
16			
17	Total Revenue		\$995,196
18	Total Variable Cost		\$783,717
19	Fixed Cost		\$100,000
20	Advertising Cost		\$88,726
21			
22	Total Profit		\$22,753

- c. At the lower variable cost of \$275, the best level of advertising increases to \$191,882.

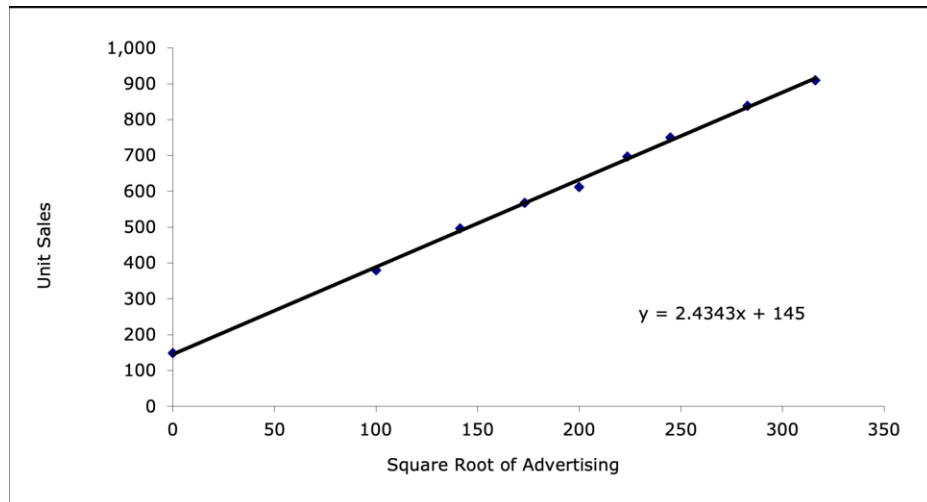
	A	B	C
1	VRX2000 Optimization Model		
2			
3	Parameters:		
4	Unit Variable Cost		\$275
5	Unit Revenue		\$400
6	Fixed Cost		\$100,000
7			
8	Decision Variable:		
9	Advertising Budget		\$191,882
10			
11	Prediction Formula: Sales $\approx a \sqrt{x} + b$		
12		a	7.01
13		b	400
14			
15	Expected Units Sold		3,470
16			
17	Total Revenue		\$1,388,171
18	Total Variable Cost		\$954,367
19	Fixed Cost		\$100,000
20	Advertising Cost		\$191,882
21			
22	Total Profit		\$141,921

- d. It appears that the best level of advertising goes down as the unit variable cost increases. With increased variable cost, the net profit per unit goes down. This means each additional sale produces less profit, and you get less “bang for the buck” from advertising. As you increase the advertising budget, this means you more quickly reach the point where the diminishing returns from advertising make it not profitable to advertise more.

1.9 a.



b. $a \approx 2.434$, $b \approx 145$ provide the best fit.



- c. The best level of advertising is \$78,350, leading to a total profit of \$31,700.

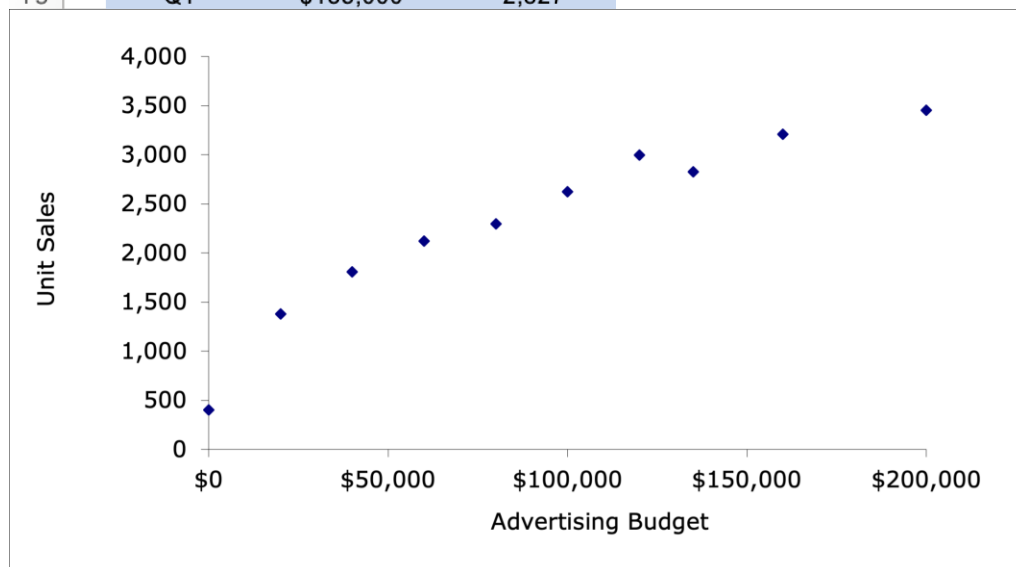
	A	B	C
1	VRX3000 Optimization Model		
2			
3		Parameters:	
4		Unit Variable Cost	\$495
5		Unit Revenue	\$725
6		Fixed Cost	\$80,000
7			
8		Decision Variable:	
9		Advertising Budget	\$78,350
10			
11		Prediction Formula:	Sales $\approx a\sqrt{x} + b$
12		a	2.43
13		b	145
14			
15		Expected Units Sold	826
16			
17		Total Revenue	\$599,068
18		Total Variable Cost	\$409,019
19		Fixed Cost	\$80,000
20		Advertising Cost	\$78,350
21			
22		Total Profit	\$31,700

Case

- 1-1 a. If there is reason to believe that there are extenuating circumstances that might make Q1 an outlier (e.g., unusual market conditions), then it might make sense to ignore the new data value and re-use the model as is for Q2. Otherwise, the new data provides more information about the relationship between sales and advertising for the VRX2000. It should be incorporated into the regression analysis, along with the other historical data, and the prediction formula updated to account for the new information.

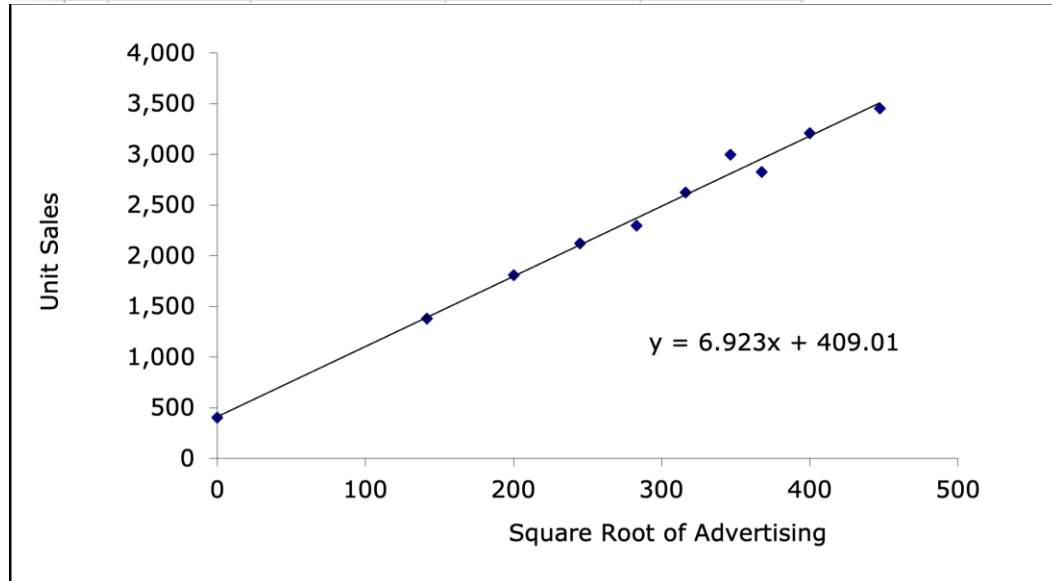
- b. While the new data point appears to have lower sales than might be expected based on the other nearby data points, it does not appear to alter the main takeaway from the original historical data—it still appears that sales are largely increasing with advertising, but at a decreasing rate. The square-root prediction formula still seems like it will be a good fit (as verified in part c).

	A	B	C	D
1	VRX 2000 Sales vs. Advertising			
2				
3		Quarter	Advertising	Sales
4		Q4	\$60,000	2,118
5		Q1	\$120,000	2,998
6		Q2	\$20,000	1,376
7		Q3	\$80,000	2,296
8		Q4	\$200,000	3,454
9		Q1	\$100,000	2,622
10		Q2	\$0	399
11		Q3	\$40,000	1,808
12		Q4	\$160,000	3,206
13		Q1	\$135,000	2,827



- c. $a \approx 6.923$, $b \approx 409.01$ provide the best fit. The straight line appears to be a good fit to the data suggesting that the square-root prediction formula is still appropriate to use.

	A	B	C	D	E
1	VRX 2000 Sales vs. Advertising				
2					
3				Square Root	
4		Quarter	Advertising	of Advertising	Sales
5		Q4	\$60,000	245	2,118
6		Q1	\$120,000	346	2,998
7		Q2	\$20,000	141	1,376
8		Q3	\$80,000	283	2,296
9		Q4	\$200,000	447	3,454
10		Q1	\$100,000	316	2,622
11		Q2	\$0	0	399
12		Q3	\$40,000	200	1,808
13		Q4	\$160,000	400	3,206
14		Q1	\$135,000	367	2,827

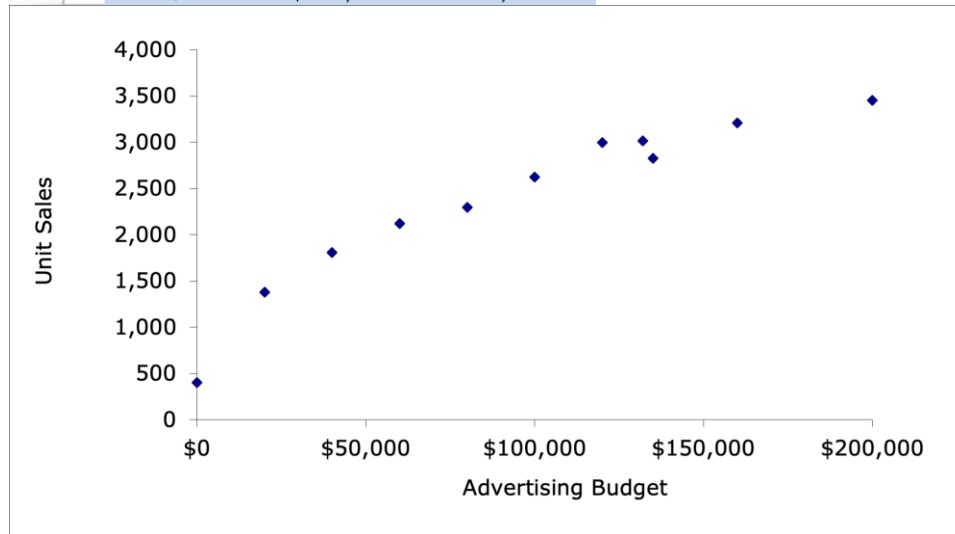


- d. Using the updated prediction formula from part c, the best level of advertising for Q2 is \$132,101, leading to a predicted total profit of \$75,047.

	A	B	C
1	VRX2000 Optimization Model		
2			
3		Parameters:	
4		Unit Variable Cost	\$295
5		Unit Revenue	\$400
6		Fixed Cost	\$100,000
7			
8		Decision Variable:	
9		Advertising Budget	\$132,101
10			
11		Prediction Formula:	Sales $\approx a\sqrt{x} + b$
12		a	6.92
13		b	409
14			
15		Expected Units Sold	2,925
16			
17		Total Revenue	\$1,170,091
18		Total Variable Cost	\$862,942
19		Fixed Cost	\$100,000
20		Advertising Cost	\$132,101
21			
22		Total Profit	\$75,047

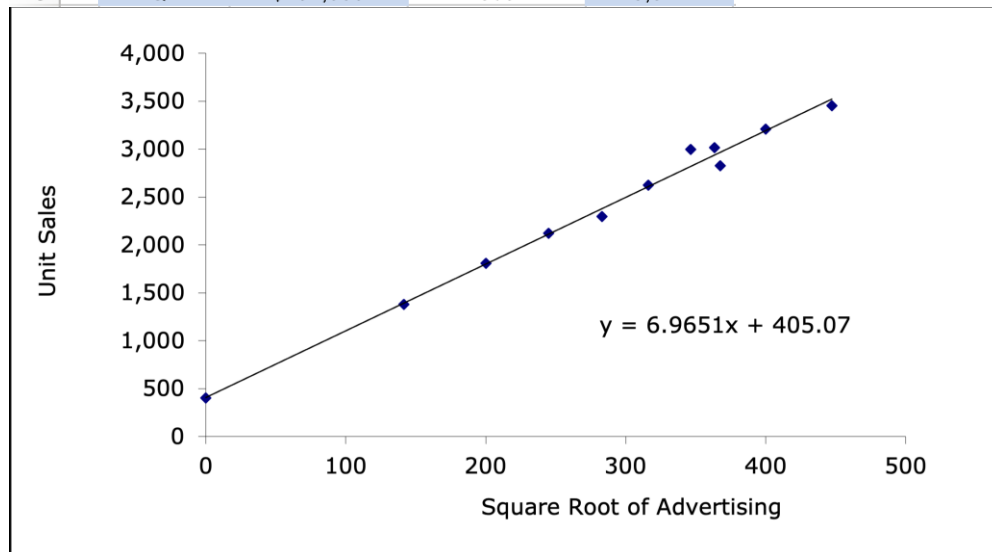
e(b). It still appears that sales are largely increasing with advertising, but at a decreasing rate. The square-root prediction formula still seems like it will be a good fit.

	A	B	C	D
1	VRX 2000 Sales vs. Advertising			
2				
3		Quarter	Advertising	Sales
4		Q4	\$60,000	2,118
5		Q1	\$120,000	2,998
6		Q2	\$20,000	1,376
7		Q3	\$80,000	2,296
8		Q4	\$200,000	3,454
9		Q1	\$100,000	2,622
10		Q2	\$0	399
11		Q3	\$40,000	1,808
12		Q4	\$160,000	3,206
13		Q1	\$135,000	2,827
14		Q2	\$132,000	3,012



e(c). $a \approx 6.965$, $b \approx 405.07$ provide the best fit. The straight line appears to be a good fit to the data suggesting that the square-root prediction formula is still appropriate to use.

	A	B	C	D	E
1	VRX 2000 Sales vs. Advertising				
2					
3				Square Root	
4		Quarter	Advertising	of Advertising	Sales
5		Q4	\$60,000	245	2,118
6		Q1	\$120,000	346	2,998
7		Q2	\$20,000	141	1,376
8		Q3	\$80,000	283	2,296
9		Q4	\$200,000	447	3,454
10		Q1	\$100,000	316	2,622
11		Q2	\$0	0	399
12		Q3	\$40,000	200	1,808
13		Q4	\$160,000	400	3,206
14		Q1	\$135,000	367	2,827
15		Q2	\$132,000	363	3,012

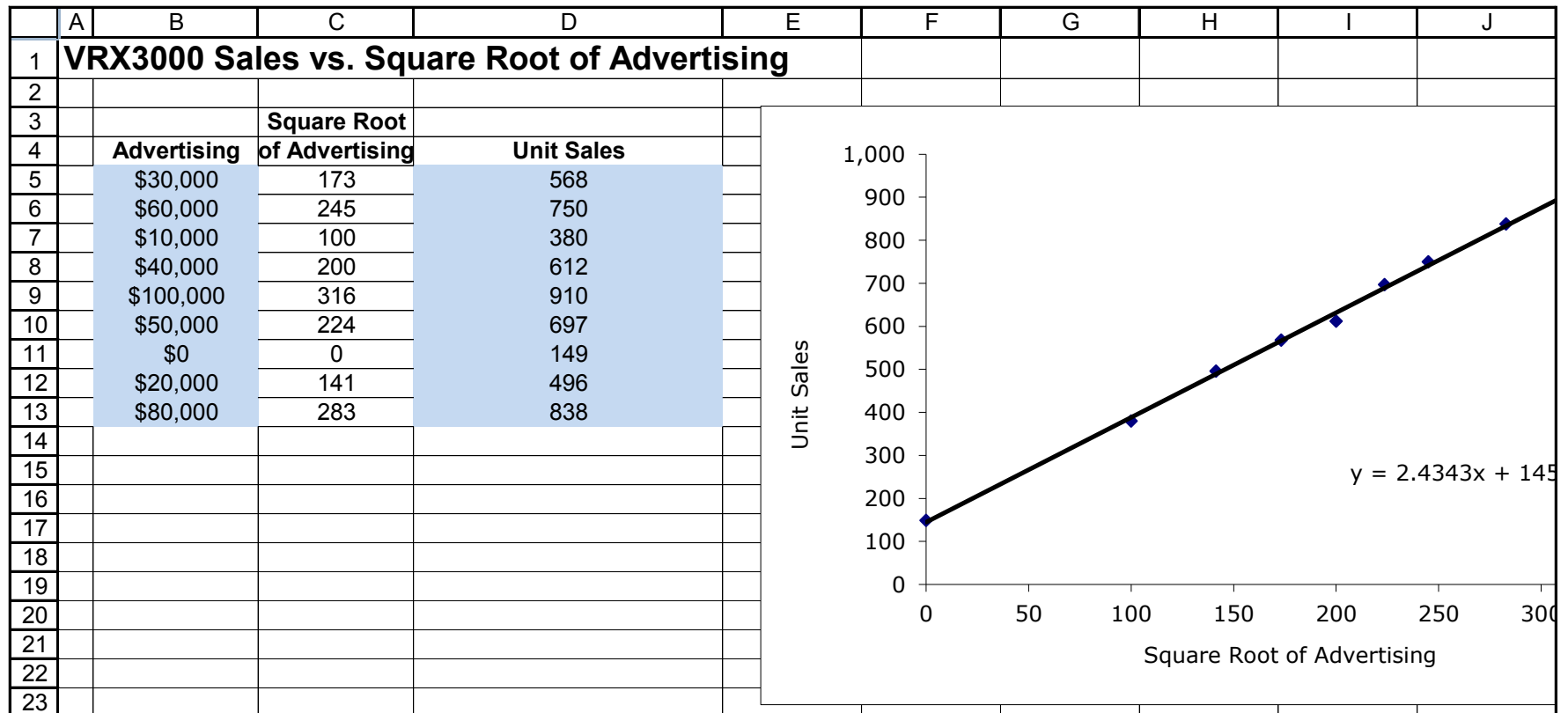


e(d). Using the updated prediction formula from part c, the best level of advertising for Q3 is \$133,713, leading to a predicted total profit of \$76,245.

	A	B	C
1	VRX2000 Optimization Model		
2			
3		Parameters:	
4		Unit Variable Cost	\$295
5		Unit Revenue	\$400
6		Fixed Cost	\$100,000
7			
8		Decision Variable:	
9		Advertising Budget	\$133,713
10			
11		Prediction Formula:	Sales $\approx a\sqrt{x} + b$
12		a	6.97
13		b	405
14			
15		Expected Units Sold	2,952
16			
17		Total Revenue	\$1,180,793
18		Total Variable Cost	\$870,835
19		Fixed Cost	\$100,000
20		Advertising Cost	\$133,713
21			
22		Total Profit	\$76,245

	A	B	C	D	E	F
1	VRX2000 Optimization Model					
2						
3		Parameters:				
4		Unit Variable Cost	\$315		Range Name	Cell
5		Unit Revenue	\$400		a	C12
6		Fixed Cost	\$100,000		AdvertisingBudget	C9
7					b	C13
8		Decision Variable:			ExpectedUnitsSold	C15
9		Advertising Budget	\$88,726		FixedCost	C6
10					TotalProfit	C22
11		Prediction Formula	Sales $\approx a\sqrt{x} + b$		TotalRevenue	C17
12		a	7.01		TotalVariableCost	C18
13		b	400		UnitRevenue	C5
14					UnitVariableCost	C4
15		Expected Units Sold	2,488			
16						
17		Total Revenue	\$995,196			
18		Total Variable Cost	\$783,717			
19		Fixed Cost	\$100,000			
20		Advertising Cost	\$88,726			
21						
22		Total Profit	\$22,753			

	A	B	C	D	E	F
1	VRX2000 Optimization Model					
2						
3		Parameters:				
4		Unit Variable Cost	\$275		Range Name	Cell
5		Unit Revenue	\$400		a	C12
6		Fixed Cost	\$100,000		AdvertisingBudget	C9
7					b	C13
8		Decision Variable:			ExpectedUnitsSold	C15
9		Advertising Budget	\$191,882		FixedCost	C6
10					TotalProfit	C22
11		Prediction Formula	Sales $\approx a \sqrt{x} + b$		TotalRevenue	C17
12		a	7.01		TotalVariableCost	C18
13		b	400		UnitRevenue	C5
14					UnitVariableCost	C4
15		Expected Units Sold	3,470			
16						
17		Total Revenue	\$1,388,171			
18		Total Variable Cost	\$954,367			
19		Fixed Cost	\$100,000			
20		Advertising Cost	\$191,882			
21						
22		Total Profit	\$141,921			



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	A	B	C	D	E	F
1	VRX3000 Optimization Model					
2						
3	Parameters:					
4	Unit Variable Cost	\$495		Range Name	Cell	
5	Unit Revenue	\$725		a	C12	
6	Fixed Cost	\$80,000		AdvertisingBudget	C9	
7				b	C13	
8	Decision Variable:			ExpectedUnitsSold	C15	
9	Advertising Budget	\$78,350		FixedCost	C6	
10				TotalProfit	C22	
11	Prediction Formula	Sales $\approx a\sqrt{x} + b$		TotalRevenue	C17	
12	a	2.43		TotalVariableCost	C18	
13	b	145		UnitRevenue	C5	
14				UnitVariableCost	C4	
15	Expected Units Sold	826				
16						
17	Total Revenue	\$599,068				
18	Total Variable Cost	\$409,019				
19	Fixed Cost	\$80,000				
20	Advertising Cost	\$78,350				
21						
22	Total Profit	\$31,700				