Shopping Center Planning

Looking at Exponential and Linear Models

"When am I ever going to use this?"

Using the concepts in this worksheet, you will be able to create and use linear and exponential models to forecast growth.

Queen Creek Marketplace is a 1.1 million square foot commercial center built in Queen Creek, Arizona. It is anchored by stores such as Kohls, Lowes, Super Target, and others. In its report for the city of Queen Creek, Vestar Development projected the following for its marketing area.

	2006	2008	2010
population	100,945	148,138	194,207
households	30,776	45,441	49,756
average income	$65,136	$69,775	$74,024

1. Which of the above demographic factors (population, households, average income) is closest to being an exponential function of time? Explain.

2. For the factor identified in (1), what is the growth factor and what does it represent it this context?

3. For the factor identified in (1), find an exponential model and forecast the value of the factor in 2012.

4. Which of the demographic factors (population, households, average income) is closest to being a linear function of time? Explain.

5. Use regression to find a linear function model for the factor identified in (4) and predict the value of the factor in 2012.

6. Referring to the model in (5), what is the real world meaning of the slope of the model?

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1. Which of the above demographic factors (population, households, average income) is closest to being an exponential function of time? Explain.

We calculate the ratio of consecutive output values. We looking to see which factor has a near-constant ratio.

$$\textit{Population:}\quad \frac{148,138}{100,945}\approx 1.468 \qquad \frac{194,207}{148,138}\approx 1.311$$

$$\textit{Households:}\quad \frac{45,441}{30,776}\approx 1.477 \qquad \frac{49,756}{45,441}\approx 1.095$$

$$\textit{Income:}\quad \frac{69,775}{65,136}\approx 1.071 \qquad \frac{74,024}{69,775}\approx 1.061$$

Of the three factors, the ratios for income are closest to being constant. Therefore, average income is closest to being an exponential function of time.

2. For the factor identified in (1), what is the growth factor and what does it represent it this context?

$$b=\left(\frac{74,024}{65,136}\right)^{\frac{1}{4-0}}\approx 1.032$$

Each year, the average household income increases by about 3.2%.

3. For the factor identified in (1), find an exponential model and forecast the value of the factor in 2012.

$$I(t)=65,136(1.032)^t$$

$$I(6)=65,136(1.032)^6$$

$$\approx 78,686$$

In 2012, the average household income is projected to be $78,686.

4. Which of the demographic factors (population, households, average income) is closest to being a linear function of time? Explain.

We calculate the difference of consecutive output values. We are looking to see which factor has a near-constant difference.

Population:	$148,138 - 100,945 = 47,193$	$194,207 - 148,138 = 46,069$
Households:	$45,441 - 30,776 = 14,665$	$49,756 - 45,441 = 4315$
Income:	$69,775 - 65,136 = 4639$	$74,024 - 69,775 = 4249$

The differences for population and for income are close to being constant. By calculating the ratios of the differences, we can further quantify how close the values are to being constant.

$$\frac{47,193}{46,069} \approx 1.024$$

The population differences are within 2.4% of being constant.

$$\frac{4639}{4249} \approx 1.092$$

The income differences are within 9.2% of being constant. Therefore, population is the demographic factor closest to being a linear function of time.

5. Use regression to find a linear function model for the factor identified in (4) and predict the value of the factor in 2012.

$$p(t) = 23,316t + 101,132 \; people$$
$$p(6) = 23,316(6) + 101,132 \; people$$
$$= 241,028 \; people$$

We predict there will be 241,028 people in the market area in 2012.

6. Referring to the model in (5), what is the real world meaning of the slope of the model?

The slope represents the annual rate of change in the population. In this case, the population is increasing at a rate of 23,316 people per year.

Worksheet Title	Shopping Center Planning: Looking at Exponential and Linear Models				*Filename:*	m3045
Keywords	Exponential, linear, growth factor, slope, modeling, regression, Vestar, shopping					
NCTM Standard		Content Standards			Process Standards	
		Number and Operations			Problem Solving	
	X	Algebra		X	Reasoning and Proof	
		Geometry		X	Communication	
		Measurement		X	Connections	
	X	Data Analysis and Probability		X	Representations	
Grade Band		PreK – 2				
		3 – 5				
		6 – 8				
	X	9 – 12				
Data Type	Table					

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