ACTIVITY 5: MODELING THE COST OF WATER

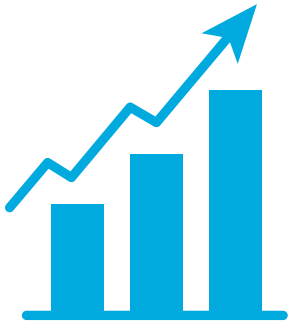


Image Credit: Gary Abud, Jr.

If the cost of water has been increasing over the years, will it continue to increase into the future? What kind of utility costs can students in classrooms today expect when they get to be adults with their own households in the future? By engaging students in mathematical modeling, this activity aims to provide students further understanding of the costs of water and how to estimate the impact of cost increases for water on citizens, like themselves as future adults.

Students will be given historical data for the cost of water utility bills for several major cities. They will proceed to mathematically model* the data in order to determine trends over time and analyze the data* to make forecasts into the future. (*Note: use handout **Mathematical Modeling the Cost of Water**)

Procedure

First, assemble students into groups and explain to them that they are going to be analyzing water utility bill data from some major cities and trying to determine how much it would their utility bills might cost if they lived in that city as an adult in the future. Allow students to choose which city's data they will work for the activity, or you can assign each group a different city. All groups can, alternatively, use data for the same city.

Then, review with the whole group what a linear model is and how to generate one by graphing data points, finding a line of best fit, determining the slope and y-intercept for that line, and writing a slope-intercept equation for that line, e.g., y=mx+b.

You may want to also review the skills of **extrapolation** (finding a data point outside of your range based on the mathematical model for your data) and **interpolation** (finding a data point within your range based on the mathematical model for your data).

Next, provide students with their data set (available in the handout at the end of this lesson) and give them time to graph their data and develop their linear models. This could be done on large dry erase boards or chart paper so that it can be displayed and presented to everyone. Ask students to determine, based on their models using evidence and reasoning, what would be the expected cost of water when they are adults at age 25, 35, 45, and 55. Regardless of their ages, each of these points in the future will require them to extrapolate a number of years into the future for their water data.

Last, have students present their findings in a poster presentation format where they can show their graph, mathematical model, and predictions of water utility bills at various points into the future. Facilitate a group discussion to help the group compare various costs in different cities and make connections between the methods by which they made their estimations of future water utility costs. Ask students to point to the city where they would want to live in the future, based on what they learned with this data, and invite a couple of volunteers to explain their rationale for why they chose to live in that certain city in the future.

***Teacher Notes:**

- All data is from the **IPUMS USA database**
- Not all years have data for each city
- 2020 data was not reliably available for any cities due to the COVID-19 pandemic.
- Use the Consumer Price Index (CPI) to adjust water/sewer costs for inflation
- To do so, the students should multiply the cost of water for a given year by the CPI for that year, then divide the result by the CPI for the year you want to adjust to.

Annual Water and Sewer Bill by City [Michigan]

Source: IPUMS USA Database—*Courtesy: Noah Attal, University of Michigan Earth and Environmental Studies Program in the Environment (PITE)*

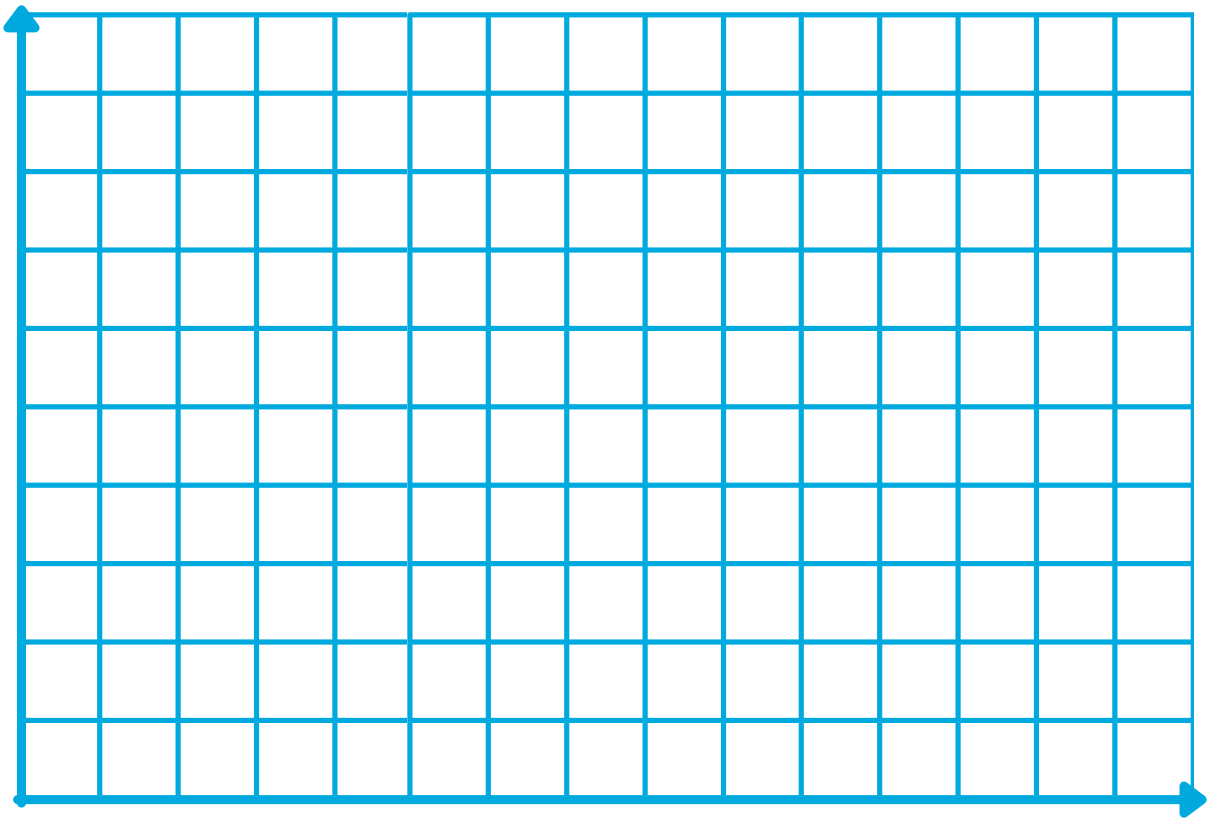
Year	Consumer Price Index (CPI)	Michigan (State Average)	Ann Arbor, MI	Detroit, MI	Flint, MI	Grand Rapids, MI	Sterling Heights, MI	Warren, MI	Lansing, MI	Livonia, MI
1960	29.6	$48		$46	$74	$34		$41		
1970	39	$50								
1980	82	$113	$120	$100	$112	$106	$126		$97	$120
1990	130.7	$263	$270	$293	$369	$247	$232	$189	$263	$249
2000	172.2	$343								
2001	177.1	$352								
2002	179.9	$371								
2003	184	$384								
2004	188.9	$401								
2005	195.3	$425	$336	$566	$532	$441	$320	$303	$470	$454
2006	201.6	$455	$399	$644	$560	$475	$342	$305	$507	$414
2007	207.3	$466	$444	$642	$535	$466	$371	$311	$537	$423
2008	215.33	$487	$491	$680	$537	$541	$364	$316	$501	$435
2009	214.53	$501	$514	$666	$547	$585	$360	$327	$562	$461
2010	218.05	$511	$452	$679	$550	$562	$403	$391	$550	$458
2011	224.93	$542	$481	$751	$706	$585	$415	$380	$551	$419
2012	229.59	$561	$517	$744	$896	$599	$457	$427		
2013	232.95	$588	$491	$790	$1,113	$606	$486	$419		
2014	236.73	$587	$482	$786	$1,147	$566	$419	$451		
2015	237.01	$602	$507	$863	$1,345	$566	$505	$448		
2016	240	$617	$483	$871	$1,177	$582	$519	$432		
2017	245.12	$642	$558	$905	$1,017	$579	$602	$472		
2018	251.1	$651	$567	$875	$1,091	$614	$625	$509		
2019	255.65	$646	$627	$837	$1,135	$591	$627	$528		

NOTE:

- Not all years have data for each city, and no city data was available for 2020
- Use the Consumer Price Index (CPI) to adjust water/sewer costs for inflation by multiplying the cost of water for a given year by the CPI for that year. then, divide that result by the CPI for the year you want to adjust to (example: adjust 1960 costs to 2018 standard.

NAME: _____ DATE: _____

Mathematical Modeling of the Cost of Water



Directions:

1. Label each axis of the graph with a quantity and unit, e.g., time (years) or cost ($).
2. Scale each of your axes according to the range of data that is contained in the data table.
3. Plot the data from the table for your given city's water utility bill costs over time.
4. Find and draw a line of best fit over your data points once you have graphed them.
5. Calculate the slope of the best fit line.
6. Determine the y-intercept value of the best fit line.
7. Write an equation in point-slope form (y=mx+b) for your best fit line
8. Give your graph a title