HiMCM 2020

*Team Control **#10663***

Problem A: The Best Summer Job *for You*

Contents

Summary

Our group created a mathematical model to determine the best summer job for a high school student, dependent on their personal needs. The model considers five main factors: personal reasons, qualifications the student has for the job, the opportunity the student may have in the market, the transportation limits that the student has, and the specific data for the job(s) the student prefers. We decided that the type of the region of residence of the student was very important for many of the factors, so we separated the types into four categories: major city, city, suburb, and rural area, using the most commonly accepted population. In our model, we predicted the trends for the summer of 2021 using lines of best fit for most of the data. These lines of best fit were either exponential to represent population growth or cyclical/sinusoidal to fit to aspects related to the economy. We used these trendlines to model much of the data. We created subdivisions for each of the five factors and calculated trendlines or found averages for the data. Three of the factors (personal reasons, the opportunity the student may have in the market, and the specific data for the job(s) the student prefers) were given a weight roughly 33% and were used to calculate the likelihood of a high schooler pursuing a job based on the input, while the transportation limits that the student has determine the likely cost of total commute depending on location, and qualifications the student has for the job determine certain outputs that are unique to those who would like to get an internship, such as whether they're old enough or which industry they would like to be an intern with.

The "Job Score" was one of the weighted factors. This considered the satisfaction of the student with the final output of the program compared to what they selected as job options. The solution asks the student for their top three choices of an industry to work in (out of small business, personal/internships, retail, food, and entertainment). Each industry has a weight, depending on their subjective importance (4, 3, 2, 1, 1 respectively). Then the Job Score is calculated by multiplying the weight by the total number of job openings in the preferred location(s).

The "Personal" factor was also weighted. The solution allows for the student to choose how sedentary the job is and the level of stress they can handle (subjective based on each industry), the purpose of their job (monetary gain or creating more opportunities in the future), and the qualifications of the student for the job (for industries that require age or experience). Each job would be assigned a value for each the user's inputs and adding each of these up would give the second part in establishing percent matches.

"Qualifications" was an unweighted factor. The purpose of this factor was only for those who put an internship as one of their preferred jobs. It was meant to establish the industry for the user to get an internship at and whether they're actually capable of being an intern.

"Opportunities" was the third and final weighted factor. It looked at the number of establishments per location type, the availability of jobs in a certain industry, and the economic health (the general employment rate). The competition demographics were calculated to be the chance of a high school student getting a job in an industry. The chance is equal to the percent of high school students who are projected to be employed in 2021 divided by the sum of the projected employment rate and the percent of high schoolers employed.

The final factor, "Transportation," was also unweighted. It dealt with finding the cost of transportation and the time of transportation of the student. The cost was split up into three possible options for different modes of transportation. The cost of travelling by car calculated using the projected gas price in 2021, the average miles per gallon of cars in the United States, and the average commute distance per region. The cost of public transport was the average cost of a metro card per month in the U.S. multiplied by two months in the summer. The cost of biking and walking were assumed to be free. On the other hand, the time of transportation was the average commute time for each region.

Once all of these factors were simplified into equations and algorithms, they could be inputted into a java program. First the weighted factors would be calculated, then scaled to ratios of about 33, all 3 of them roughly adding up to 100 to represent percentages. Qualifications used multiple condition statements and Transportation had a couple equations, and all of those combined would get the user our intended output, showing percent matches, internship information (if applicable), and total commute costs.

This model was able to accurately extrapolate data with an estimated 20 percent change between the observed and the expected data. This was because we took advantage of the exponential trends in population and cyclical trends in the economy. However, many of the data points used were at best – predictions – so there is no telling what will occur with the data in the summer of 2021. This model also accounted for five main factors of the variations of the preferences and situations of high school students across the United States. There was no way to include some factors, such as a worker having less competition due to personal connections. This model separated students by the type of region that they live in, which adds a benefit in separating students into groups with data that make sense (rather than taking the national average); however, these do not consider sources who have a different definition for the four region types. Finally, there are a few subjective weights in the Personal factor, meaning that different people may have different opinions of what the weights should be.

Our group's mathematical model about the best fit for a summer job for a high schooler accounts for several factors which would be important for a student to consider while searching for a job.

Problem Statement

It is time to begin planning for a summer job. This involves determining the transportation options available, what levels of physical activities are acceptable for a high school student, and a variety of numerous factors. This individual will have the goals to make some money while enjoying the summer.

1. What are some factors that the individual should consider when searching for a summer job?
2. Develop a model or algorithm for an individual to use to determine what their summer job should be based off the factors determined above.
3. Test the model or algorithm on ten fictional students with variables for the factors determined above.
4. Describe and show how the model could be presented to students for usage.

Assumptions

For us to have a functioning model, we had to make some key assumptions while interpreting the problem. These assumptions were chosen to generally make computing easier (such as computing with average statistics) as well as to allow for more concentration on more critical factors.

We ran the possible places a High School student could be in America through a dichotomy that generalizes how urban the area in which the student lives. We did this to better calculate the opportunity that the student would have. After all, the data we gathered strongly reinforces the notion that the more urban the place the student lived, the more job opportunities would be available, even in different markets. In order to take the student's location into account, we decided to subdivide the division between city and country to feature four categories in order from most rural to most urban:

- Rural: defined by a population less than 10,000 people
- Suburban: defined by a population between 10,000 and 100,000 people (lower inclusive)
- City: defined by a population between 100,000 and 1,000,000 people (lower inclusive)
- Major City: defined by a population of at least 1,000,000 people

Another main factor we considered into our algorithm was the implementation of our curves of best fit (see pages 7-9). We decided to use exclusively exponential and cyclic functions to represent the nature of population growth and factors influenced by the health of the U.S. economy, respectively. This reason can be justified by examining the similarities between two pairs of graphs. First, we have a graph of the global human population since the beginning of time next to a model of an exponential graph we used. We used two types of exponential models: one in the form of $a * b^{cx+d} + e$ and one in the form of $a * e^{bx}$. Both serve essentially the same purpose of providing an increasing slope as x increases.

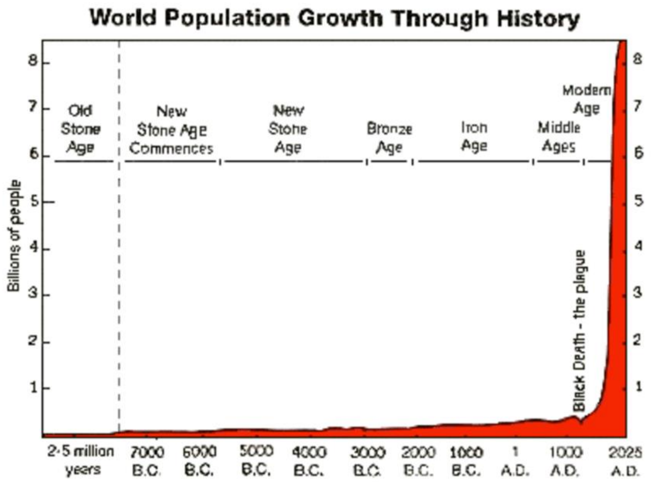


Figure *1*: Human Population Growth

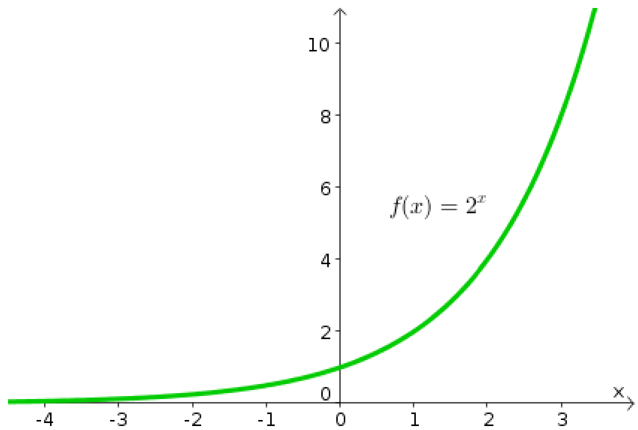


Figure 2: Exponential 2^x

Next, we can see that an overlay of the economic cycles that the markets experience bears resemblance to the classic Sine function from trigonometry if translated horizontally (c), vertically (e), or stretched horizontally (b), or vertically (a). In addition to these transformations, we also included a variable (d) to account for a slant within the prediction model. The general Sine equation we used to model our equations for curves of best fit was $a * Sin[bx + c] + dx + e$.

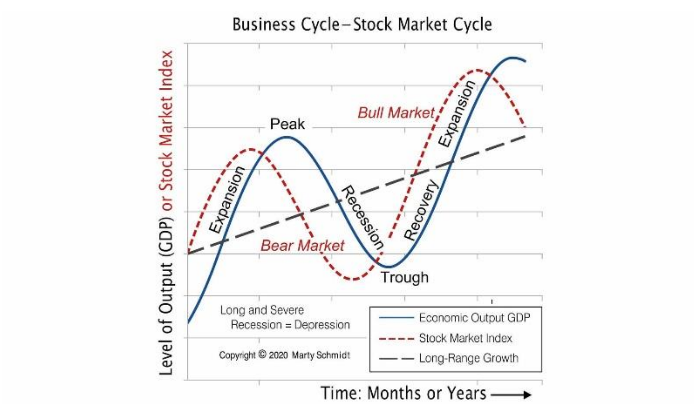


Figure 3: Oscillation of the Business Cycle

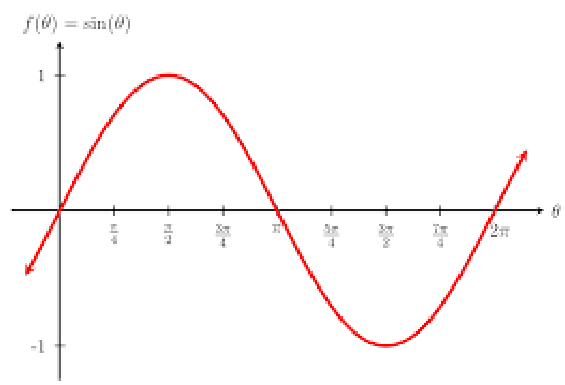


Figure 4: Sine Function

Process Overview

Methodology

We chose a *probabilistic* approach in which we. We considered five factors (to be further explained later): java data, personal reasons, market opportunity, qualifications, and transportation. Each of the first three factors were deduced into quantitative pieces of data, and once every maximum was calculated using algorithms we determined, they were all scaled up or down accordingly so those factors had an equal weight of 33.33, creating a total of 100 to output percentages. The last factor affects job location, based on prices and preferences. When a user would input the data we ask for into a java program containing all of our algorithms, those values would be substituted in, and the program would output each of the five job type's (retail, entertainment, food, small business, personal) percent matches and the best location for them to work. If they wished to have an internship, the "personal" output would make note of which industry the user has expertise in.

Factors

During our brainstorming session, we reasoned that we should focus our model on five types of factors:

- Job-Specific Data
    - *Justification:* It is important to count for different types of jobs because many industries are bigger than others and vice versa. Not to mention, many industries work in fundamentally different ways. Although we cannot count for each specific type of job, by categorizing them we are able to cover more ground and not overfit the model.
    - *Examples:* Different types of jobs have different demand, interest, and other factors. To illustrate this, look at the following table illustrating the differences between a few industries we analyzed.

Type	Rural	Suburban	City	Major City
Retail	12.46	92.79	1,630.22	8,406.20
Small Business	370.95	2,762.33	48,532.98	250,259.60
Entertainment	1.67	12.46	218.99	1,129.20
Food Franchise	8.50	63.31	1,112.39	5,736.00

Table 1: Industries and the Average Number of Establishments in Different Populations

- Personal Reasons
    - *Justification:* The model should consider the reason that the student is getting a summer job, which may include making some extra cash or staying busy during the vacation. If the individual is aware of how much money they would like to make and how many hours they would like to work, this helps to narrow down the options available to them.
    - *Examples:* Pay rate per hour, total hours worked
- Opportunity in the Market
    - *Justification:* A job needs to be available before it be an option. To find out whether a job is available, we need to look at the health of the economy, specific markets, and competitors. Our model focuses a great deal on competitors in this aspect because we end up calculating the populations of each demographic vying for the same jobs. The model also considers the varying ages for many High Schoolers and notes that there are many jobs that are difficult do if the student is not at least 16 or older.
    - *Examples:* Analyzing the number and/or percentages of High Schoolers with jobs

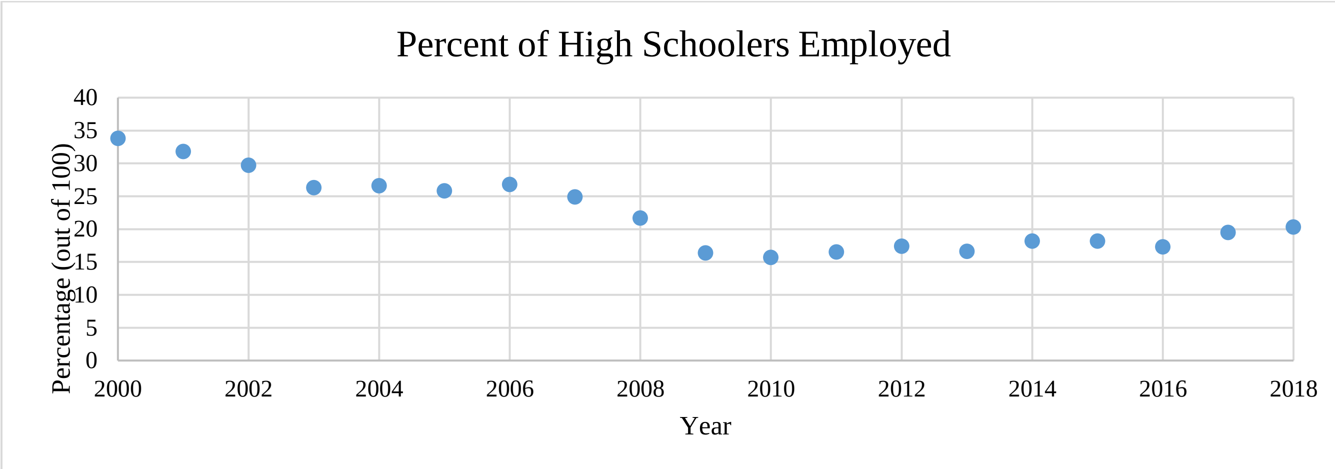


Figure 5: Percentage of Employed High School Students

- Qualifications that the student has for the job
    - *Justification:* This was included in the model to take the individual's qualifications into account and limit them from getting jobs that they would not be successful in. For example, a student who does not have any specified experience in any internship industries should most likely not plan to work as a intern (unless they have plans to acquire the skills necessary for one of those jobs). A student may also be limited by the money they expect to have over the summer. A student may be limited to certain types of transport and/or distances to work if they do not have adequate money.
    - *Examples:* Experience and education of the student in certain subject areas, the financial status of the student
- Transportation
    - *Justification:* The reason for including the transportation factor was to understand how variables such as the type of region (big city, city, suburban areas, and rural areas) and type of transport the user would like affect the monetary cost and the commute time. This is important for when an individual is considering a job; for example, one would not want to commute for a two hours each day if that time does not fit into their day or they do not have the money to travel that distance.
    - *Examples:* Monetary cost of traveling the distance from home to work, commute time

Solution

Figures

While crafting our solution, we needed to analyze the competition, health, and demand of the market. Thus, we decided to create lines of best fit to predict trends in data for the number of adults aged 15-64 in the United States, the total number of high school students in the U.S., the number of young adults 15-19 not in high school in the United States, the cumulative employment rate for adults over 20 in the U.S., the percentage of high school students employed in the U.S., and finally, the percentage of high schoolers unemployed in the U.S. These trendlines, which can be viewed below, were used to extrapolate for the year 2021 and may be able to be used in future years. This is justified in the section Sensitivity/Overfitting on page 12.

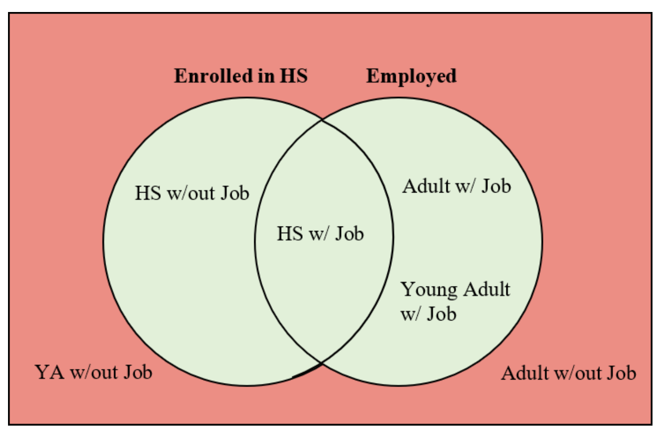


Figure 6: Possibilities for Different Demographics

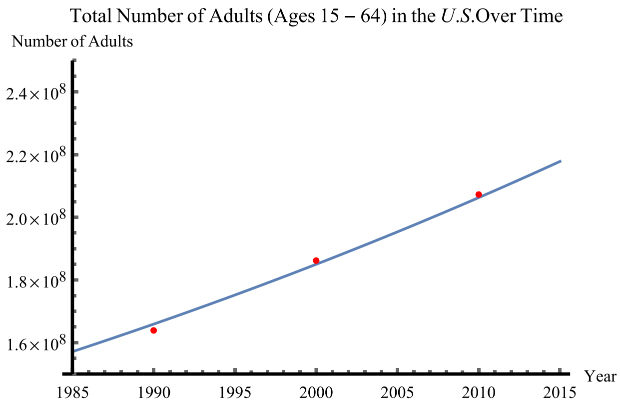


Figure 7: Number of Adults in U.S.

Calculating the number of Adults (including High School students) was important to get a general idea of just how many people are vying for the same jobs. This number combined with the percentages of employment (Figure 9) and other factors can help us get the numbers we need. This data acts as the foundation for many of our calculations.

2021: *219,331,985 Adults*

$$\text{Total Number of Adults} = 0.0709 \times 1.0102^{1.0697 \times Year - 8.5459} + 1.0019$$

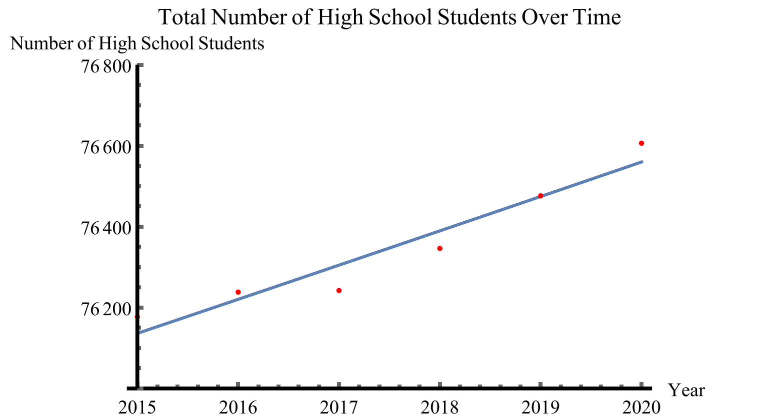


Figure 8: Total Number of High School Students Over Time (in Thousands)

A key part of our model was analyzing the competition that a student would face in the workplace. By extrapolating, we can find out the number of students expected to be in high school in 2021 to understand what the job competition may be like for the individual. We used an exponential model because it dealt with population growth over time.

2021: *28,414,900 High School Students*

$$\text{Number of HS Students} = 16.5668 * 1.00135^{2.28073 * Year + 909.589} + 48.754$$

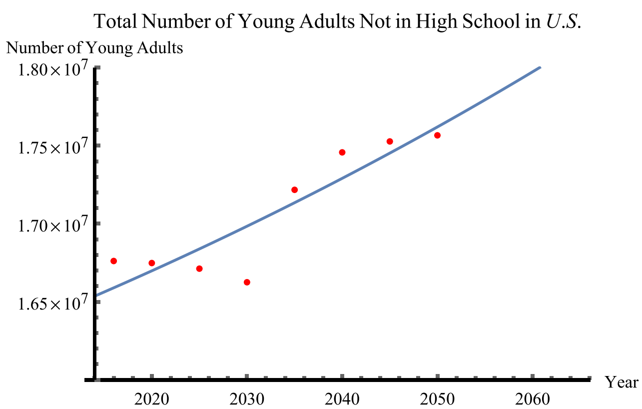


Figure 9: Young Adults Not in High School in U.S.

While it can be argued that the health of an economy determines the enrollment in High School, that would be a cyclical factor on an exponential factor. We generalize by using an exponential model for this data, but it is ultimately more representative of reality than a cyclical model due to population growth.

2021: *16,368,443 Young Adults*

$$\text{Total Number of YA not in HS Employed} = 2.7199 \times 1.0064^{1.0986 \times Year - 21.5010} + 1.3007 \times 10^7$$

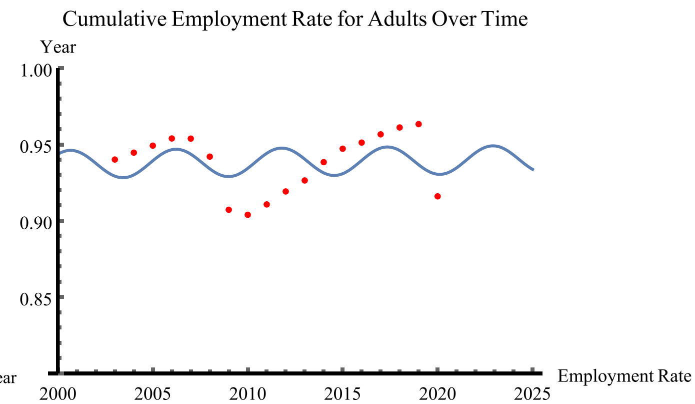


Figure 10: Cumulative Employment Rate for Over 20

This is one of the most important statistics that helps us read the health of the economy. We have used this figure when computing internship and personal job types as well as for finding out what proportion of the population is within the **Employed** section of the Venn Diagram

2021: *94.2455% of Workers*

$$\%\text{ of Adults Employed} = 0.0091 \times \text{Sin}[1.1297 \times Year - 261.076] + 0.0001x + 0.6704$$

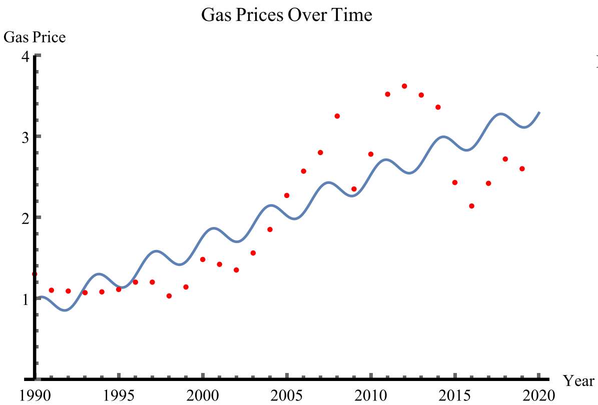


Figure 11: Gas Prices Over Time

To find out the cost of the transportation for cars, predicting the average gas price in the United States in 2021 is important. *

***2021:** $3.55*

$$Gas\ Price\ (\$) = -0.146925 * \mathrm{Sin}[1.83927 \times Year - 1676.68] + 0.0826709 * Year - 163.672$$

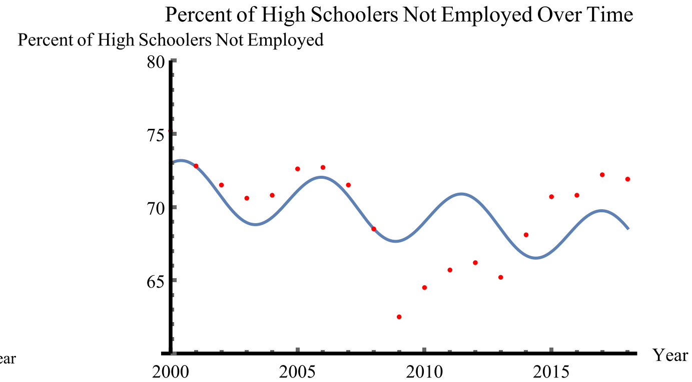


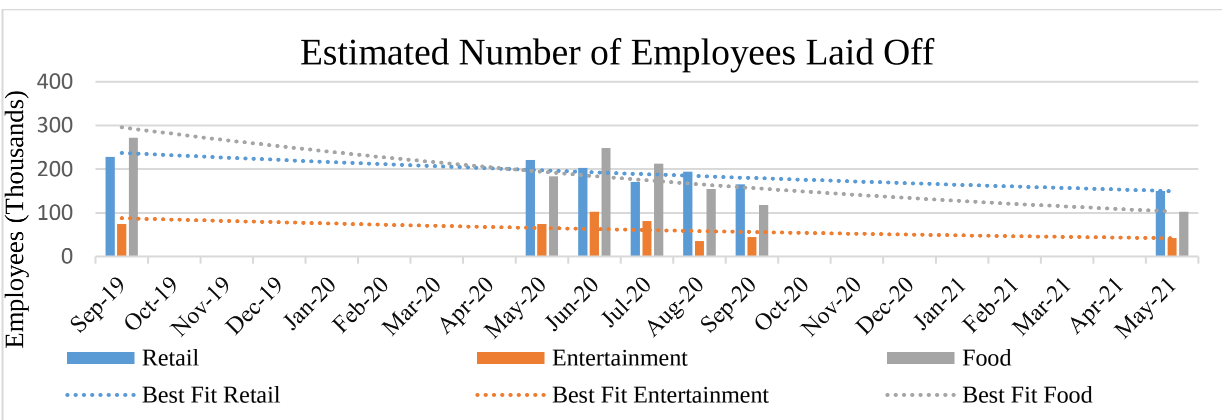
Figure 12: Percent of Unemployed High School Students

Like Figure 10, it is important to know what the percentage of high schoolers are expected to be unemployed in 2021 (so that the individual can understand competition for jobs). A cyclical model was used for the same reason as in Figure 10. *

***2021:** 66.60% of High Schoolers*

$$\%\ of\ HS\ not\ employed = 1.89364 * Sin[1.13785 * Year - 276.628] - 0.206808 * Year + 484.985$$

* Note: these functions used radians, not degrees.



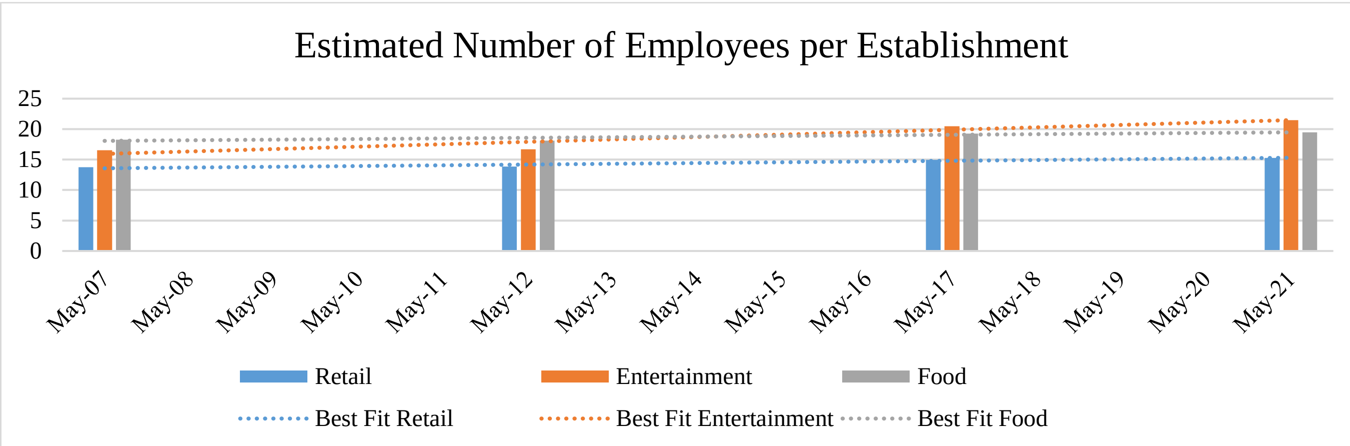
$Employees\ Laid\ Off\ in\ Retail = 7 * 10^{19} * e^{-8*10^{-4}*Month}$ May 2021: ~150,000

$Employees\ Laid\ Off\ in\ Entertainment = 4 * 10^{28} * e^{-1*10^{-3}*Month}$ May 2021: ~42,000

$Employees\ Laid\ Off\ in\ Food = 5 * 10^{19} * e^{-8*10^{-4}*Month}$ May 2021: ~103,000

Figure 13: Estimated Number of Employees Laid Off for Summer 2021

The data from September 2019 and May-September 2020 were used to create a curve (based of e^x to represent continuously changing slope) best fit for each job type, We chose e as the base as it most closely fit the data. A rough estimate of where those curves would cross May 2021 were determined and included.



$Employees\ Per\ Establishment\ in\ Retail = 0.0003 * Year + 0.4144$ 2021: ~15.30
$Employees\ Per\ Establishment\ in\ Entertainment = 0.0011 * Year - 26.434$ 2021: ~21.48
$Employees\ Per\ Establishment\ in\ Food = 0.0003 * Year + 7.3698$ 2021: ~19.47

Figure 14: Estimated Number of Employees Per Establishment for Summer 2021

The data from 2007, 2012, and 2017 were used to create a line best fit for each job type, and a rough estimate of where those lines would cross 2021 were determined and included. We decided to use linear lines of best fit for these data points because the data showed a strong linear correlation. This can also be seen in Figures 7 and 8 where even though the equation is exponential, the base is less than half a tenth away from 1. Therefore, we decided to use linear models for this section of the model.

Table 2: Number of Jobs Available Per Location in Each Industry

For columns 2-4, Figures 13-14 were used to first figure out the number of open positions in each individual establishment ($\frac{Employees\ Laid\ Off}{Total\ Establishments}$), then the number of open positions in each type of location using the data from Table 1 ($\frac{Employees\ Laid\ Off}{Total\ Establishments} * Average\ Establishments$). Since there was information provided about Summer 2020 for columns 5-7, the equation can be applied without having to predict what $\frac{Employees\ Laid\ Off}{Total\ Establishments}$

Average Openings	**Retail**	**Entertainment**	**Food**	**Small Business**	**Personal**
Per Rural Area	1.756	0.4907	1.206	30.46	24.85
Per Suburb	13.08	3.661	8.982	226.8	185.1
Per City	229.8	64.34	157.8	3,985	3,201
Per Major City	1,185	331.8	813.8	206,100	16,770

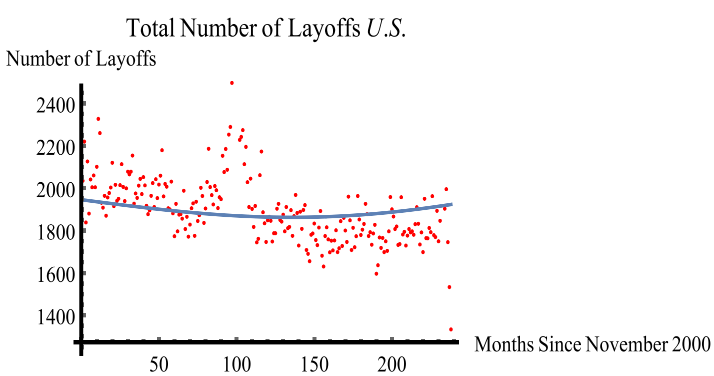


Figure 12B: Total Number of Layoffs (in Thousands)

To find the data for "Personal" in the table, we generalized it as much as possible since the category entails different types of jobs. Using the trendline shown on the right, we extrapolated the number of layoffs in 2021 to find the general number of job openings.

$$\text{Number of Layoffs} = -133.877 * \text{Sin}\left[\frac{161.557 * \text{Month} - 338.887}{156.878}\right] + 0.2283 * \text{Month} + 1942.93$$

Region	Average Commute Time	Average Commute Distance	Average Cost by Car
Major city	27.1 min.	7.5 mi.	$107.02
City	30.5 min.	19.2 mi.	$273.99
Suburban area	30.1 min.	29.7 mi.	$423.81
Rural area	22.6 min.	37.4 mi.	$533.69

Table 3: Transportation

Predicted average gas price in the United States (Figure 11): $3.55
Average miles per gallon in the United States: 24.9 mpg
Average public transport cost for one month in the United States: $127
Average cost by car: gas price/mpg * Commute Distance) * 2 times a day * 5 days a week * 10 weeks summer

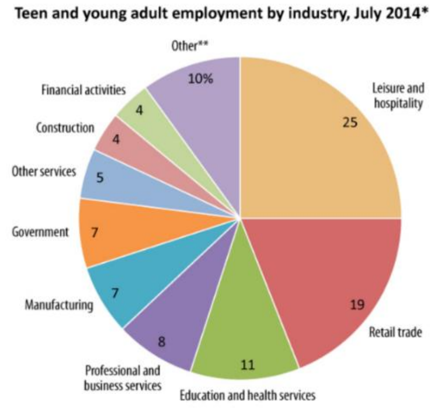


Figure 11B: Distribution of Teenage Employment Across Industries

Methodology Bullet-Point List Summary

Job Score (33.33%)

- Satisfaction ($10\ different\ possibilities\ for\ 3\ industries\ for\ 5\ options$)
  - Small Business (weight = 4)
  - Personal & Internships (weight = 3)
  - Retail (weight = 2)
  - Food (weight = 1)
  - Entertainment (weight = 1)
  - $Job\ Type\ Weight * \sum Job\ Openings\ in\ Prefered\ Locations = Job\ Type\ Score$
  - Max: $Retail: 4*(1.756+13.08+229.8+1185) = 5{,}718.54, Entertainment: 4*(0.4907+3.661+64.34+331.8) = 1{,}601.1668, Food: 4*(1.206+8.982+157.8+813.8) = 3{,}927.15, Small\ Business: 4*(30.46+226.8+3985+206100) = 841{,}369.04, Personal: 4*(24.85+185.1+3201+16770) = 684444.8$
  - Min: $Retail: 1.756, Entertainment: 0.4907, Food: 1.206, Small\ Business: 30.46, Personal: 24.85$

Personal (33.33%)

- Sedentary ($1\ least\ to\ 5\ most\ rating$)
  - Retail: 5
  - Entertainment: 1
  - Food: 4
  - Small Business: 2
  - Personal: 3
- Stress (5 is most 1 is least)
  - Retail: 3
  - Entertainment: 1
  - Food: 2
  - Small Business: 4
  - Personal: 5
- Purpose (money, future)? //reflected in job type
  - Money
    - INPUT 5 most 1 least
    - Retail: 1
    - Entertainment: 5
    - Food: 4
    - Small Business: 3
    - Personal: 2
- Experience (Number of internships)

Opportunities (33.33%)

- Establishments per Location Type ($\frac{Total\ Establishments * Percentage\ of\ Population\ in\ Area\ Type}{Number\ of\ Locations\ of\ Area\ Type}$)
- Availability ($\frac{Employees\ Laid\ Off}{Total\ Establishments} * Average\ Establishments$)
- Economic Health (General employment rate)
- Employment Rate ($\frac{Employees\ Laid\ Off}{Total\ Establishments} * Average\ Establishments$)
- Competition demographics (Figures 6-12)
  - $Chance\ of\ HS\ Getting\ Job = \frac{\%\ HS\ Employed}{\%\ HS\ Employed + Employment\ Rate}$

Qualifications (unweighted)

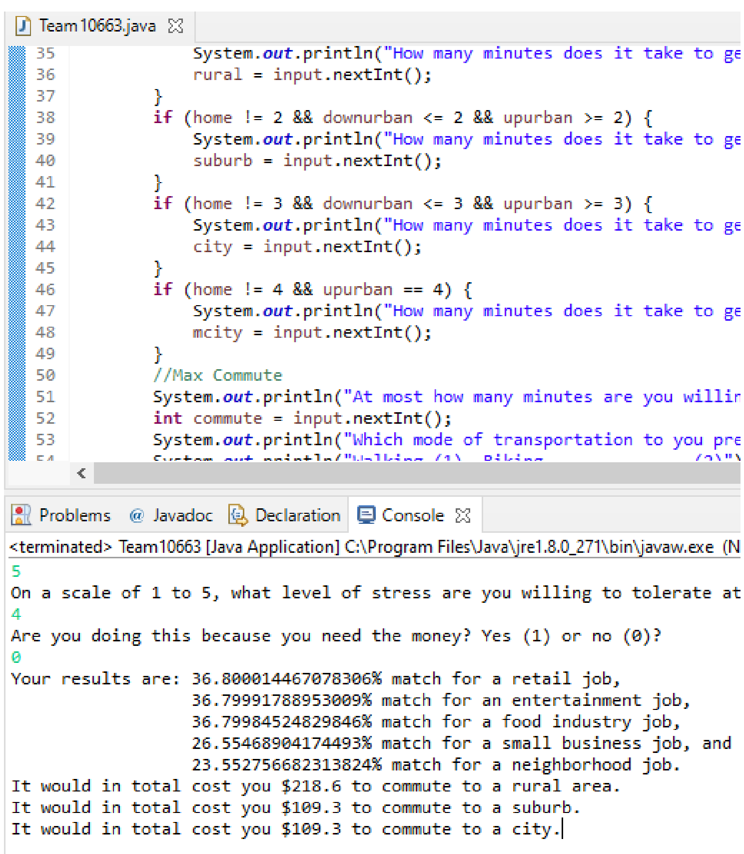
- Age (some jobs such as medical internships are only for 16 and older)
- Experience in field (if required)

Transportation (unweighted)

- Cost of transportation (either car or public transport in big city or city areas only)
  - $\$\ by\ Car = \frac{Gas\ Price * Commute\ Distance\ per\ Region}{Average\ mpg.} * 2\ times\ per\ day * 5\ days\ a\ week * 10\ weeks\ summer$
  - $\$\ by\ Public\ Transportation = Average\ cost\ per\ month * 2.5\ months\ of\ summer$
  - Bike, walk = $0.00
- Time of transportation
  - Average commute time in major city (27.1 min.), city (30.5 min.), suburban area (30.1 min.), rural area (22.6 min.)

Java Program

Because this is a very tedious method to carry out by hand, we decided to make a Java Program to calculate the probabilities for us. The full program is in the addendum and its sample results are referenced in the following section. There is a snippet of the program. Find the rest in the addendum.



Team10663.java

```
                System.out.println("How many minutes does it take to ge
                rural = input.nextInt();
            }
            if (home != 2 && downurban <= 2 && upurban >= 2) {
                System.out.println("How many minutes does it take to ge
                suburb = input.nextInt();
            }
            if (home != 3 && downurban <= 3 && upurban >= 3) {
                System.out.println("How many minutes does it take to ge
                city = input.nextInt();
            }
            if (home != 4 && upurban == 4) {
                System.out.println("How many minutes does it take to ge
                mcity = input.nextInt();
            }
            //Max Commute
            System.out.println("At most how many minutes are you willir
            int commute = input.nextInt();
            System.out.println("Which mode of transportation to you pre
```

Problems @ Javadoc Declaration Console

```
<terminated> Team10663 [Java Application] C:\Program Files\Java\jre1.8.0_271\bin\javaw.exe (N
5
On a scale of 1 to 5, what level of stress are you willing to tolerate at
4
Are you doing this because you need the money? Yes (1) or no (0)?
0
Your results are: 36.800014467078306% match for a retail job,
                  36.79991788953009% match for an entertainment job,
                  36.79984524829846% match for a food industry job,
                  26.55468904174493% match for a small business job, and
                  23.552756682313824% match for a neighborhood job.
It would in total cost you $218.6 to commute to a rural area.
It would in total cost you $109.3 to commute to a suburb.
It would in total cost you $109.3 to commute to a city.
```

Model Students

Table 4: Percent of High School Students Employed with initial unaccounted values

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Residence		R	S	C	M	R	S	C	M	S	C
Location Range		R-S	R-C	S-C	C-M	R-C	M	S-M	M	S-M	C
Drive Time from Nearest	Rural	0	20			0					
	Suburb	20	0	15		10		10		0	
	City		10	0	10	15		0		15	0
	Major				0		15	10	0	25	
Max Commute		60	30	45	30	75	75	30	30	45	15
Mode of Transport		B	D	D	P	D	D	P	W	B	W
Job Type Choices	First	E		PN	E	Re	PI	Re	PI	SB	SB
	Second	Re			PI	E		SB	F	PN	PN
	Third	F			Re	F		E	SB		
Intern Industry					En		A		VP		
Sedentary Level		4	5	2	5	3	4	1	2	3	2
Stress Level		5	2	3	1	1	4	2	3	2	3
Need for Money?		No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Future Purpose?					Yes		Yes		No		
Age					14		17		16		

R = Rural, S = Suburb, C = City, M = Major City
W = Walking, B = Biking, D = Driving, P = Public Transportation
Re = Retail, E = Entertainment, F = Food, SB = Small Business, PN = Neighborhood, PI = Internship
A = Accounting, En = Engineering, VP = Video Production

Justification

Rows 4-7 are based on driving times, while row 8 is based on the time it would take to use the transportation method defined in row 9. To convert row 9 into driving time, divide the data linked to biking by 3 and divide the data linked to walking by 9. This is based on rough comparisons we have experienced (it usually takes us on average 3 times as long to reach locations via biking and 9 times as long via walking).

Neighborhood and Internship are subcategories of Personal.
The model students were built from this data. For the most part, the choices were random, but sometimes certain pieces of data were limited in available outcomes to make each student make logical decisions. For example, students from less urban locations would be more likely willing to have longer commutes because they are more used to having to take longer rides to get to places more commonly found in more urban cities. It is also generally more likely for those who would rather bike or walk to prefer to take a shorter commute than those who would drive or take public transportation. The data in rows 10-18 was computer pseudorandom generated.

The purpose of rows 2-12 are solely to establish the job scores and possible locations to consider in future calculations. If a location type doesn't fall within the range specified in row 3, and/or the maximum commute (when scaled based on mode of transportation) is less than the time required to drive to that location type, it is disregarded in the rest of the calculations. For example, Student 9 preferers jobs in suburbs, cities, and major cities, and wants to spend at most 45 minutes biking (same as a 15-minute drive) to their job. This means only jobs in suburbs and cities will be accounted for, since they do not want to work in rural areas and the 25 minutes to drive to a major city is greater than the specified time. Locations that match up with where the user lives default to 0 because they will always be accounted for unless it is not within their preferred range. Job types specified in the table hold more weight than the others (internship is only accounted for if specified), and if someone chooses internship, only the subject specified is used. Rows 14-17 establish the personal reasons factor, and those 2 in conjunction with the constant deduced from opportunities determine the percent matches. Rows 13 and 17-18 establish the qualifications factor, and rows 4-7 are substituted into an equation based on current information to get the result of the transportation factor.

1	Your results are: 35.65% match for a retail job, 38.73% match for an entertainment job, 41.56% match for a food industry job, 29.4% match for a small business job, and 29.4% match for a neighborhood job.	**6**	Your results are: 33.23% match for a retail job, 42.23% match for an entertainment job, 42.23% match for a food industry job, 27.47% match for a small business job, and 45.2% match for an internship job in the Accounting industry. It would in total cost you $163.95 to commute to a major city.
2	Your results are: 30.8% match for a retail job, 30.8% match for an entertainment job, 30.8% match for a food industry job, 23.55% match for a small business job, and 23.55% match for a neighborhood job. It would in total cost you $218.60 to commute to a rural area. It would in total cost you $109.30 to commute to a suburb. It would in total cost you $109.30 to commute to a city.	**7**	Your results are: 50.35% match for a retail job, 51.87% match for an entertainment job, 31.63% match for a food industry job, 44.13% match for a small business job, and 18.36% match for a neighborhood job. It would in total cost you $317.50 to commute to a city or major city.
3	Your results are: 21.79% match for a retail job, 36.79% match for an entertainment job, 27.79% match for a food industry job, 22.55% match for a small business job, and 21.04% match for a neighborhood job. It would in total cost you $163.95 to commute to a suburb. It would in total cost you $109.30 to commute to a city.	**8**	Your results are: 33.23% match for a retail job, 42.23% match for an entertainment job, 49.9% match for a food industry job, 45.56% match for a small business job, and 27.2% match for an internship job in the Accounting industry.
4	Your results are: 39.72% match for a retail job, 59.05% match for an entertainment job, 31.55% match for a food industry job, 24.63% match for a small business job, and 45.35% match for a neighborhood job (You're too young to take on an internship. Please wait until you're at least 16). It would in total cost you $317.50 to commute to a city or major city.	**9**	Your results are: 18.79% match for a retail job, 30.79% match for an entertainment job, 27.79% match for a food industry job, 20.05% match for a small business job, and 23.88% match for a neighborhood job.
5	Your results are: 29.04% match for a retail job, 30.62% match for an entertainment job, 29.21% match for a food industry job, 26.55% match for a small business job, and 29.55% match for a neighborhood job. It would in total cost you $109.30 to commute to a rural area. It would in total cost you $109.30 to commute to a suburb. It would in total cost you $163.95 to commute to a city.	**10**	Your results are: 21.71% match for a retail job, 36.71% match for an entertainment job, 27.71% match for a food industry job, 23.01% match for a small business job, and 20.85% match for a neighborhood job.

Sensitivity/Overfitting

For our graphs used to predict trends in data over time, either a trigonometric or an exponential line of best fit was created. This allowed for us to create an expected value based on the patterns of the data points collected. While this method can help us gage an idea of what the future data may be, it is merely extrapolation and can be quite far off from the observed value. However, for our purposes, we are looking to see what certain aspects of our model will look like in 2021. Thus, we created trendlines for each of our graphs and concluded the expected value for next summer. These graphs are presented in the Solutions section.

To see how well our graphs would be at extrapolating, we took some of them and added in past or future data (shown in purple) that the computer did not factor in when creating the trendline (only the red points shown were factored in). For Figure 12, the past data helped to understand how the model handled predicting data outside the red data range. For Figure 13, the future data was added from a source predicting the population in the future. The |Observed – Expected| count helped us to understand how close our model was with their predictions.

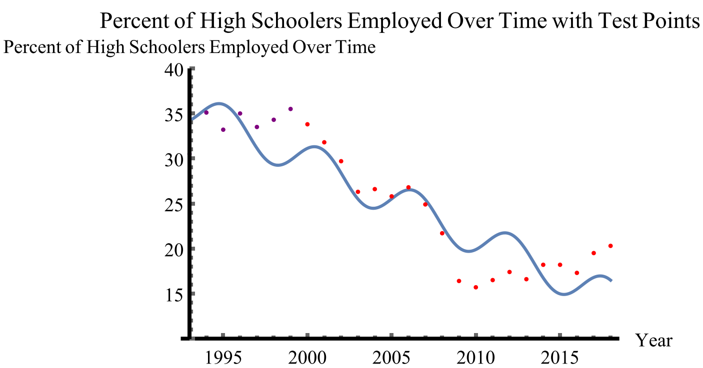


Figure 14: Percent of High School Students Employed with initial unaccounted values

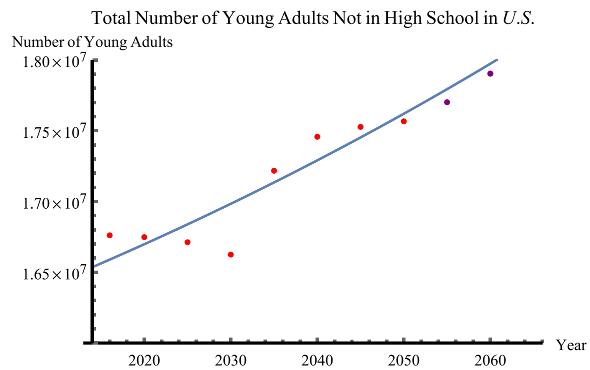


*Figure 15: Total Number of Young Adults not in High School Employed with initial unaccounted values**

$$\mathit{Figure}\ 14\!: \%\ \mathit{of\ HS\ employed} = 2.0826 * \mathrm{Sin}[1.1101 \times \mathit{Year} - 221.421] - 0.845 * \mathit{Year} + 1719.74$$
$$\mathit{Figure}\ 15\!: \mathit{Total\ \#\ of\ YA\ not\ in\ HS\ Employed} \ = \ 2.7199 \times 1.0064^{1.0986 \times \mathit{Year} - 21.5010} + 1.3007 \times 10^{7}$$

Figure #	Year	Observed	Expected	% Change = (Expected – Observed) / Expected
14	1993	30.5 %	35.2267 %	13.4179 %
14	1994	35.1 %	34.3422 %	-2.2066 %
14	1995	33.2 %	33.4578 %	0.7705 %
14	1996	35.0 %	32.5736 %	-6.8842 %
14	1997	33.5 %	31.6896 %	-5.7129 %
14	1998	34.3 %	30.8058 %	-11.3427 %
14	1999	35.5 %	29.9222 %	-18.641 %
15	2055	17,701,000 people	17,272,946 people	-2.4782 %
15	2060	17,903,000 people	17,425,089 people	-2.7427 %

Table 5: Table of Sensitivity Factors

As it can be seen, the percent change for Figure 14 remain under ± 20 %. By using this model for extrapolation, we can expect to see a similar accuracy for other data points. For Figure 15, the percent change was within -3 %. Please note that we used predicted values from another source, as the goal was to see how much our model matched up with theirs for predicting future trends.

Strengths & Weaknesses

Our model, like any other, has its strengths and its weaknesses. Being aware of these strengths and weaknesses can be helpful in exploring improvements to the current model as well as provide valuable insight to how the model functions. The strengths and weaknesses can be directly associated with certain outcomes of the model, as specified by the following table.

Strengths	**Weaknesses**
As shown in the **Sensitivity/Overfitting** section, the cyclical and exponential models can extrapolate data with a 20% change between the observed and expected data. Actively planning rather than using past data is helpful for using this in the future.	The extrapolation of data in general is not perfect, so it is impossible to know exactly what the trends for 2021 will look like.
In this model, both qualitative and quantitative data were used. This allows for the model to intake various types of data and become more accurate.	The data chosen for **Figure 15** were from a prediction from a source, rather than actual data. Therefore, this adds another source of possible errors in extrapolation for 2021.
The factors included in the model allowed for us to consider many different aspects that a high school student would question when searching for a summer job. These factors are justified and explained in the **Factors** section.	Some factors not included (for example, having an increased chance to be hired due to personal connections) could sway the results such as the competition.
Our model takes advantage of the trends (exponential for population growth and cyclical for economical) in the data we analyzed to create more accurate extrapolations.	Using averages for the wages of each industry does not accurately cover the scope of all available jobs for that industry. However, for high schooler, we can assume most of them would have the same pay.
The assumptions in the model make logical sense for the situation and help us to narrow down the options for methodology for creating a model.	Finding averages for the transportation data rather than calculating a trendline was not possible due to lack of data available was not as accurate as using trendlines to predict.
Considering the type of region (big city, city, suburbs, or rural) was very useful because it allowed for us to break up the data into groups with similar trends in data. For example, just looking at the national average would not be as useful since a user who lives in a big city or rural area would have to expect a large difference in data between what was observed and expected.	The population ranges used for the type of region (big city, city, suburbs, and rural area) was researched to be the main definition for these regions; however, there is some discrepancy. Therefore, some of the findings during research for "suburbs" may be implying a different population range.
COVID-19 Resistant	The weights assigned in the decision matrix were not based on mathematical calculations but rather by what we thought was most important when deciding a job. Therefore, the opinion of what the weights should be is debatable and differs amongst people.

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Addendum

The Java Program:

```
import java.util.Scanner;

public class HiMCM {

	@SuppressWarnings("resource")
	public static void main(String[] args) {

		//Job type scores
		Scanner input = new Scanner(System.in);
		System.out.println("Welcome to your job selector!");
		//Residence
		System.out.println("What type of city/town/village do you live in?");
		System.out.println("Rural......(1): Population is less than 10,000");
		System.out.println("Suburban...(2): Population is between 10,000 and 100,000");
		System.out.println("City.......(3): Population is between 100,000 and 1,000,000");
		System.out.println("Major City.(4): Population is greater than 1,000,000");
		int home = input.nextInt();
		//Preferred locations
		System.out.println("What is the most urban location you're willing to work in?");
		System.out.println("Rural.(1), Suburban...(2)");
		System.out.println("City..(3), Major City.(4)");
		int upurban = input.nextInt();
		System.out.println("What is the least urban location you're willing to work in?");
		System.out.println("Rural.(1), Suburban...(2)");
		System.out.println("City..(3), Major City.(4)");
		int downurban = input.nextInt();
		//Time to drive nearest location
		int rural = 0;
		int suburb = 0;
		int city = 0;
		int mcity = 0;
		if (home != 1 && downurban == 1) {
			System.out.println("How many minutes does it take to get to the nearest Rural Area?");
			rural = input.nextInt();
		}
		if (home != 2 && downurban <= 2 && upurban >= 2) {
			System.out.println("How many minutes does it take to get to the nearest Suburb?");
			suburb = input.nextInt();
		}
		if (home != 3 && downurban <= 3 && upurban >= 3) {
			System.out.println("How many minutes does it take to get to the nearest City?");
			city = input.nextInt();
		}
		if (home != 4 && upurban == 4) {
			System.out.println("How many minutes does it take to get to the nearest Major City?");
			mcity = input.nextInt();
		}
		//Max Commute
		System.out.println("At most how many minutes are you willing to make your commute?");
		int commute = input.nextInt();
		System.out.println("Which mode of transportation to you prefer?");
		System.out.println("Walking.(1), Biking..............(2)");
		System.out.println("Driving.(3), Public Transpotation.(4)");
		int mode = input.nextInt();
		int drivecommute = commute;
```

```
		if (mode == 1) {
			drivecommute = commute / 9;
		}
		if (mode == 2) {
			drivecommute = commute / 3;
		}
		//Locations to disregard
		if (downurban > 1 || drivecommute < rural)
			rural = -1;
		if (downurban > 2 || upurban < 2 || drivecommute < suburb)
			suburb = -1;
		if (downurban > 3 || upurban < 3 || drivecommute < city)
			city = -1;
		if (upurban < 4 || drivecommute < mcity)
			mcity = -1;
		//Job types
		System.out.println("Job Options:");
		System.out.println("Retail............(1), Entertainment.....(2)");
		System.out.println("Food..............(3), Small Business....(4)");
		System.out.println("Neighborhood Jobs.(5), Internship........(6)");
		System.out.println("Unsure............(0)");
		int first = 0;
		int second = 0;
		int third = 0;
		System.out.println("What would be your 1st choice for a job?");
		first = input.nextInt();
		if (first != 0) {
			System.out.println("What would be your 2nd choice for a job?");
			second = input.nextInt();
			if (second != 0) {
				System.out.println("What would be your 3rd choice for a job?");
				third = input.nextInt();
			}
		}
		//Intern
		int intern = 0;
		if (first == 6 || second == 6 || third == 6) {
			System.out.println("Which industry do you want to internship in?");
			System.out.println("Accounting...............(1), Advertising..........(2), 
Architecture............(3)");
			System.out.println("Art Gallery..............(4), Business Development.(5), 
Engineering.............(6)");
			System.out.println("Entrepredeurship.........(7), Event Planning.......(8), 
Fashion.................(9)");
			System.out.println("Finance.................(10), Graphic Design......(11), Green 
Technology.......(12)");
			System.out.println("Hospitality and Tourism.(13), Human Resources.....(14), Information 
Technology.(15)");
			System.out.println("Journalism..............(16), Legal...............(17), 
Logistics..............(18)");
			System.out.println("Marketing...............(19), Non-Profit..........(20), Public 
Relations.......(21)");
			System.out.println("Publishing..............(22), Pharmaceutical......(23), Real 
Estate............(24)");
			System.out.println("Sports Management.......(25), Video Productions...(26)");
			intern = input.nextInt();
		}
		//Score algorithms
		double retail = 0;
		double entertain = 0;
```

```
double food = 0;
double sbusiness = 0;
double personal = 0;
if (retail != -1) {
        retail = retail + 1.756;
        entertain = entertain + 0.4907;
        food = food + 1.206;
        sbusiness = sbusiness + 30.46;
        personal = personal + 24.85;
}
if (suburb != -1) {
        retail = retail + 13.08;
        entertain = entertain + 3.661;
        food = food + 8.982;
        sbusiness = sbusiness + 226.8;
        personal = personal + 185.1;
}
if (city != -1) {
        retail = retail + 229.8;
        entertain = entertain + 64.34;
        food = food + 157.8;
        sbusiness = sbusiness + 3985;
        personal = personal + 3201;
}
if (mcity != -1) {
        retail = retail + 1185;
        entertain = entertain + 331.8;
        food = food + 813.8;
        sbusiness = sbusiness + 206100;
        personal = personal + 16770;
}
switch (first) {
        case 1:
                retail = 4 * retail;
                break;
        case 2:
                entertain = 4 * entertain;
                break;
        case 3:
                food = 4 * food;
                break;
        case 4:
                sbusiness = 4 * sbusiness;
                break;
        case 5:
                personal = 4 * personal;
                break;
}
switch (second) {
        case 1:
                retail = 3 * retail;
                break;
        case 2:
                entertain = 3 * entertain;
                break;
        case 3:
                food = 3 * food;
                break;
        case 4:
                sbusiness = 3 * sbusiness;
```

```
                break;
            case 5:
                personal = 3 * personal;
                break;
        }
        switch (third) {
            case 1:
                retail = 2 * retail;
                break;
            case 2:
                entertain = 2 * entertain;
                break;
            case 3:
                food = 2 * food;
                break;
            case 4:
                sbusiness = 2 * sbusiness;
                break;
            case 5:
                personal = 2 * personal;
                break;
        }
        //Scale to 33
        retail = retail / 173.29;
        entertain = entertain / 48.52;
        food = food / 119.01;
        sbusiness = sbusiness / 25496.03;
        personal = personal / 20740.72;
        //Personal
        int retail1 = 1;
        int entertain1 = 1;
        int food1 = 1;
        int sbusiness1 = 1;
        int personal1 = 1;
        System.out.println("On a scale of 1 (least) to 5 (most), how sedentary (lack of activity) do
you want your summer job to be?");
        int sedentary = input.nextInt();
        switch (sedentary) {
            case 1:
                entertain1 = 3 * entertain1;
                sbusiness1 = 2 * sbusiness1;
                break;
            case 2:
                entertain1 = 2 * entertain1;
                sbusiness1 = 3 * sbusiness1;
                personal1 = 2 * personal1;
                break;
            case 3:
                sbusiness1 = 2 * sbusiness1;
                personal1 = 3 * personal1;
                food1 = 2 * food1;
                break;
            case 4:
                personal1 = 2 * personal1;
                food1 = 3 * food1;
                retail1 = 2 * retail1;
                break;
            case 5:
                food1 = 2 * food1;
                retail1 = 3 * retail1;
```

```
                        break;
        }
        System.out.println("On a scale of 1 to 5, what level of stress are you willing to tolerate at
your job?");
        int stress = input.nextInt();
        switch (stress) {
                case 1:
                        entertain1++;
                        break;
                case 2:
                        entertain1 = entertain1 + 2;
                        food1++;
                        break;
                case 3:
                        retail1++;
                        entertain1 = entertain1 + 3;
                        food1 = food1 + 2;
                        break;
                case 4:
                        retail1 = retail1 + 2;
                        entertain1 = entertain1 + 4;
                        food1 = food1 + 3;
                        sbusiness1++;
                        break;
                case 5:
                        retail1 = retail1 + 3;
                        entertain1 = entertain1 + 5;
                        food1 = food1 + 4;
                        sbusiness1 = sbusiness1 + 2;
                        personal1++;
                        break;
        }
        System.out.println("Are you doing this because you need the money? Yes (1) or no (0)?");
        int money = input.nextInt();
        if (money == 1) {
                retail1++;
                entertain1 = entertain1 + 3;
                food1 = food1 + 2;
                sbusiness = sbusiness + 2;
                personal1++;
        }
        else {
                retail1 = retail1 + 3;
                entertain1 = entertain1 + 3;
                food1 = food1 + 3;
                sbusiness1 = sbusiness1 + 3;
                personal1 = personal1 + 3;
        }
        if (intern != 0) {
                System.out.println("Are you taking this job for your future? Yes (1) or no (0)?");
                int future = input.nextInt();
                if (future == 1)
                        personal1 = 11;
        }
        retail1 = retail1 * 3;
        entertain1 = entertain1 * 3;
        food1 = food1 * 3;
        sbusiness1 = sbusiness1 * 3;
        personal1 = personal1 * 3;
        //Opportunities
```

```java
		double chance = 11.3883; //34.51% (chance of HS getting a job) of 33
		//Percent match
		retail = retail + retail1 + chance;
		entertain = entertain + entertain1 + chance;
		food = food + food1 + chance;
		sbusiness = sbusiness + sbusiness1 + chance;
		personal = personal + personal1 + chance;
		//Qualifications
		if (intern != 0) {
			System.out.println("How old are you?");
			int age = input.nextInt();
			if (age < 16) {
				intern = -1;
			}
		}
		//Transportation
		double rcost = 0;
		double scost = 0;
		double ccost = 0;
		double mcost = 0;
		if (mode == 3) {
			if (rural == 0) {
				rcost = 109.3;
			}
			else if (rural > 0) {
				rcost = 10.93 * rural;
			}
			if (suburb == 0) {
				scost = 109.3;
			}
			else if (suburb > 0) {
				scost = 10.93 * suburb;
			}
			if (city == 0) {
				ccost = 109.3;
			}
			else if (city > 0) {
				ccost = 10.93 * city;
			}
			if (mcity == 0) {
				mcost = 109.3;
			}
			else if (mcity > 0) {
				mcost = 10.93 * mcity;
			}

		}
		if (mode == 4) {
			ccost = 317.5;
			mcost = 317.5;
		}
		//Output
		System.out.println("Your results are: "+retail+"% match for a retail job,");
		System.out.println("                  "+entertain+"% match for an entertainment job,");
		System.out.println("                  "+food+"% match for a food industry job,");
		System.out.println("                  "+sbusiness+"% match for a small business job, and");
		if (intern == -1) {
			System.out.println("                  "+personal+"% match for a neighborhood job 
(You're too young to take on an internship. Please wait until you're at least 16).");
		}
```

```
else if (intern == 0) {
        System.out.println("                        "+personal+"% match for a neighborhood job.");
}
else {
        String industry = "Accounting";
        switch (intern) {
                case 2:
                        industry = "Advertising";
                        break;
                case 3:
                        industry = "Architecture";
                        break;
                case 4:
                        industry = "Art Gallery";
                        break;
                case 5:
                        industry = "Business Development";
                        break;
                case 6:
                        industry = "Engineering";
                        break;
                case 7:
                        industry = "Entrepreneurship";
                        break;
                case 8:
                        industry = "Event Planning";
                        break;
                case 9:
                        industry = "Fashion";
                        break;
                case 10:
                        industry = "Finance";
                        break;
                case 11:
                        industry = "Graphic Design";
                        break;
                case 12:
                        industry = "Green Technology";
                        break;
                case 13:
                        industry = "Hospitality and Tourism";
                        break;
                case 14:
                        industry = "Human Resources";
                        break;
                case 15:
                        industry = "Journalism";
                        break;
                case 16:
                        industry = "Legal";
                        break;
                case 17:
                        industry = "Logistics";
                        break;
                case 18:
                        industry = "Marketing";
                        break;
                case 19:
                        industry = "Non-Profit";
                        break;
```

```
                        case 20:
                            industry = "Public Relations";
                            break;
                        case 21:
                            industry = "Publishing";
                            break;
                        case 22:
                            industry = "Pharmaceutical";
                            break;
                        case 23:
                            industry = "Real Estate";
                            break;
                        case 24:
                            industry = "Sports Management";
                            break;
                        case 25:
                            industry = "Video Productions";
                            break;
                    }
                    System.out.println("                    "+personal+"% match for an internship job in the
"+industry+" industry.");
                }
                if (mode == 3) {
                    if (rural != -1) {
                        System.out.println("It would in total cost you $"+rcost+" to commute to a rural
area.");
                    }
                    if (suburb != -1) {
                        System.out.println("It would in total cost you $"+scost+" to commute to a
suburb.");
                    }
                    if (city != -1) {
                        System.out.println("It would in total cost you $"+ccost+" to commute to a
city.");
                    }
                    if (mcity != -1) {
                        System.out.println("It would in total cost you $"+mcost+" to commute to a major
city.");
                    }
                }
                if (mode == 4) {
                    System.out.println("It would in total cost you $317.50 to commute to a city or major
city.");
                }

        }

}
```