MathWorks Math Modeling Challenge

Team: #15746

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Executive Summary Letter

Dear Mr. President,

We are writing to inform you of our stance upon remote working and how it is merely a fad not to be worked toward. Workplaces internationally have undergone a pivotal shift due to the Coronavirus pandemic. To protect employees, control the spread of the virus, and promote efficiency, workplaces have shifted to remote working. Video conferencing, and instant messaging services have replaced all meetings and conversations. The switch to online work is temporary according to our dual modeling methodology.

Our first model used proportions of different age groups and their education level in conjunction with the occupations they would likely have to estimate the maximum proportion of jobs that could realistically be done remotely. This model could also be used to predict the future as we did for the years 2024 and 2027. What we found was that the total number of remote jobs did not increase by a significant degree and therefore the post-COVID future would see a return to the workplace.

We analyzed data through graphs by locating needed units in each equation. Initially, we gathered data from the United States and United Kingdom Census' as well as the bureau of labor statistics to establish different demographics for each occupation whether it be remote or in-person. In addition to

Through our formulation and analysis of two models, we have concluded that remote work is not the way of the future. Populations are moving back to their workplaces and the increase in remote work as of late is a fad to be undone in the coming years.

Sincerely,
Team #15746

Q1: Ready or Not

Solution Summary:

Estimating the percentage of workers whose jobs are currently remote ready requires the determination of a myriad of unknown variables. Using the 2015 U.S. Census and Statistics from the U.S. Bureau of Labor Statistics, we sorted the population into three categories defined as Young (individuals aged 16-24), Middle Aged (individuals aged 25-64), and Elderly (individuals aged 65+) then determined the proportion of education level within each category by dividing the number of persons within that education level by the total number of persons within the population.

Proportion of education level for each age group	Young (16-24)	Middle Aged (25-64)	Elderly (65+)
Less Than High School	.2987	.1048	.157
High School Diploma	.204	.2805	.346
Some College	.4226	.2737	.23
Bachelor's Degree	.0747	.219	.154
Post-Graduate	0	.122	.113

Following the determination of these proportions, assuming they would remain relatively constant, we derived the equation, $R = \frac{GJ(Prop\ G) + BJ(Prop\ B) + HJ(Prop\ H) + NJ(Prop\ N)}{P}$ and defined the variables below:

R	Estimated maximum percentage of

	workers whose jobs are currently remote-ready in a given city.
G_J	Estimated number of jobs held by individuals with a postgraduate degree as their highest form of education.
Prop G	The average percentage of jobs that can be done at home requires a postgraduate degree.
B_J	Estimated the number of jobs held by individuals with a bachelor's degree as their highest form of education.
Prop B	The average percentage of jobs that can be done at home requires a bachelor's degree.
H_J	Estimated the number of jobs held by individuals with a high school diploma as their highest form of education.
Prop H	The average percentage of jobs that can be done at home requires a high school diploma.
N_J	Estimated number of jobs held by individuals who haven't graduated high school.
Prop N	The average percentage of jobs that can be done at home does not require any education.
P	The total working population in a given city.

The variables G_J ,B_J ,H_J, and N_J are defined mathematically below (Pop is the total population of the desired city:

G_J	$pop[(p_m(p_{mg}) + p_e(p_{eg}))]$
B_J	$pop[(p_y(p_{yb}) + p_m(p_{mb}) + p_e(p_{eb}))]$

H_J	$pop[(p_y(p_{yh}) + p_m(p_{mh}) + p_e(p_{eh}))]$
N_J	$pop[(p_y(p_{yn}) + p_m(p_{mn}) + p_e(p_{en}))]$

The variables $p_y, p_m, p_e, p_{mg}, p_{eg}, p_{yb}, p_{mb}, p_{eb}, p_{yh}, p_{mh}, p_{eh}, p_{yn}, p_{mn}, p_{en}$ are defined below, all variables with two subscripts were defined via data from the 2015 U.S. Census and Statistics from the U.S. Bureau of Labor Statistics.

p_y	The proportion of young people out of the total population
p_m	The proportion of middle-aged people out of the total population.
p_e	The proportion of elderly people out of the total population.
p_{mg}	The proportion of middle-aged people with only a postgraduate degree, equal to .122.
p_{eg}	The proportion of elderly people with only a postgraduate degree, equal to .113.
p_{yb}	The proportion of young people with only a bachelor's degree, equal to .0747.
p_{mb}	The proportion of middle-aged people with only a bachelor's degree, equal to .219.
p_{eb}	The proportion of elderly people with only a bachelor's degree, equal to .154.
p_{yh}	The proportion of young people with only a high school diploma, equal to .204.
p_{mh}	The proportion of middle-aged people with only a high school diploma, equal to .2805.

p_{eh}	The proportion of elderly people with only a high school diploma, equal to .346.
p_{yn}	The proportion of young people who have not graduated high school, equal to .2987.
p_{mn}	The proportion of middle-aged people who have not graduated high school, equal to .1048.
p_{en}	The proportion of elderly people who have not graduated high school, equal to .157.

Limitations:

Our equation relies mainly on data derived from the 2015 United States Census meaning that, while it is comparable to other industrialized nations of a similar culture, it will be unable to properly predict the maximum number of jobs that can be fulfilled online in nations which are not similar to the United States in that way (e.g. while it is well suited to estimate the percentage of remote workable jobs in the United Kingdom, it would be unable to estimate the percentage in a nation like Kazakhstan).

Projections:

Population Growth: 0.40%
Seattle:
Maximum remote today: 471,989 ≈ 27.59%
Maximum remote 2024: 475,921 ≈ 27.59%
Maximum remote 2027: 481,822 ≈27.6%

Omaha:
Maximum remote today: 128,387 ≈ 25.95%
Maximum remote 2024: 129,456 ≈ 25.96%
Maximum remote 2027: 131,062 ≈ 25.97%

Scranton:
Maximum remote today: 66,589 ≈ 26.88%
Maximum remote 2024: 67,144 ≈ 26.89%
Maximum remote 2027: 67,977 ≈ 26.9%

UK Population Growth: 0.53%
Liverpool:
Maximum remote today: 197,102 ≈ 26.82%
Maximum remote 2024: 198,744 ≈ 27.04%
Maximum remote 2027: 201,208 ≈ 27.38%

Barry Whales:
Maximum remote today: 14,929 ≈ 27.04%
Maximum remote 2024: 15,055 ≈ 28.08%
Maximum remote 2027: 15,240 ≈ 28.08%

Q2: Remote Control

Python Script: Src Code

Solution Summary:

When approaching the movement towards remote work we utilized a python script to arrange an array associating all vocabulary terms to a number. We then used one-hot encoding to convert text listings into numerical values that our model could understand. Once organized we began to plot correlation models that would compare the number of postings between remote and non-remote work for a given city. We compared major cities in the United States and the United Kingdom to create a more globalized comparison and attain results from a broader data set. After creating the data set within a python model we began to plot points on a correlation model. We compared United States cities amongst themselves and against each other in remote and virtual positions. Our data set had been focused on job postings posted within 24 hours, 5 miles from the center of the city, Full-Time, and any job type. These listings were gathered from sites such as Monster, and Total Jobs. Although we searched LinkedIn, Glassdoor, Indeed, and Reed.UK. These sites were limited in providing an adequate sample of both in-person and remote job listings. The All charts provided confirmation that virtual work offerings and in-person offerings were the same across the United States and abroad. The distributions on all correlation models draw the conclusion that there is a consistent uptrend in remote job listings across the board. Finally, our Markov probability can predict the exact percentage of workers who will be prepared and are willing to transition to remote work from polling statistics from companies such as PWC and Stack Overflow. On metrics such as percentages of executives preferred remote work to in-person work. As well as taking into account other factors like the rate at which workers quit and accepted job offers. These two models combined tackle the issue of approximating the number of workers who will join the workforce from home in the coming years.

Limitations:

While we are confident that our model demonstrates a possible scenario, there are some flaws in our study. Using only four cities, our model demonstrates a correlation between the cities and job postings with remote work. We also only obtained data from a single website, although this was altered for different countries. By analyzing an API, we could create cleaner data, and collect more than we could by hand. Our data could also be more accurate by collecting data for our Markov model.

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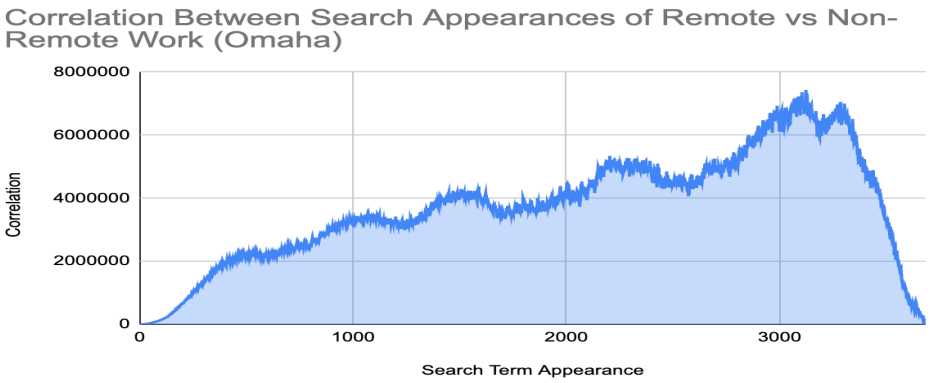
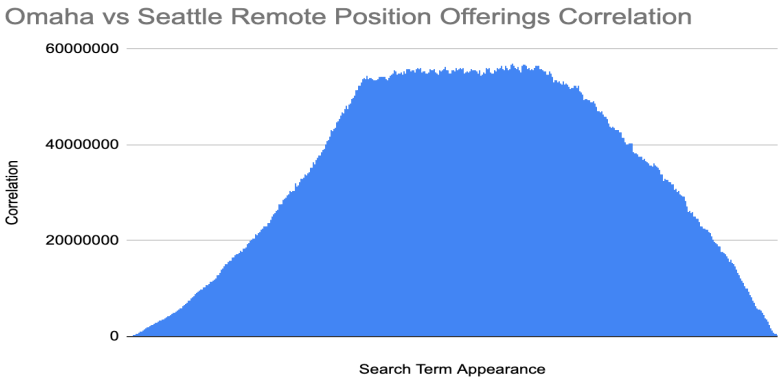
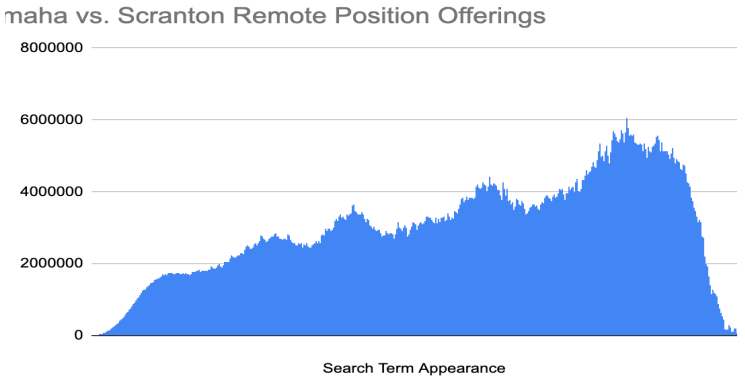
Statistics:

Keyword percentage appearance 15% of 1,021 random sample size by terms “Virtual”, “Home”, and “Remote” in Omaha area.



Correlation between Remote vs. Non-Remote Job Listings (Omaha)





Omaha Correlation Compared Against Other Cities

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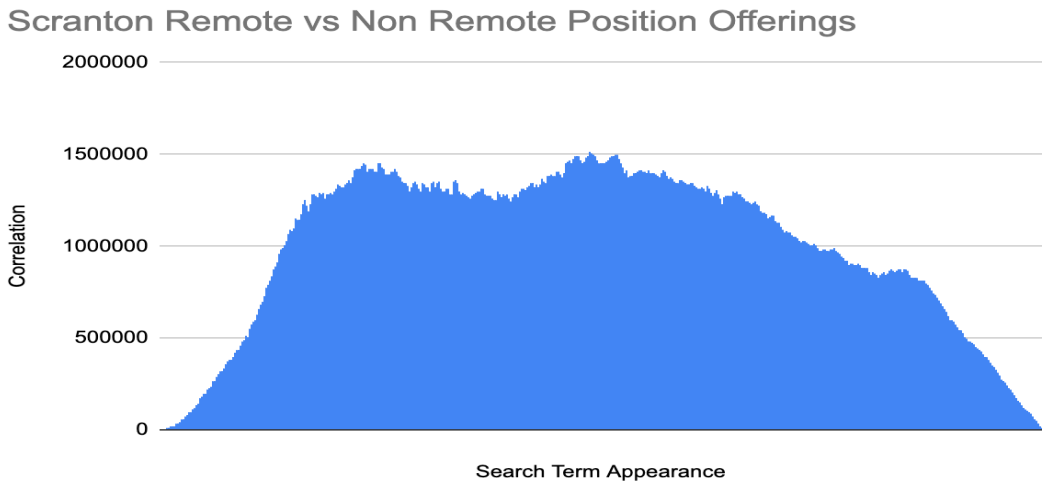
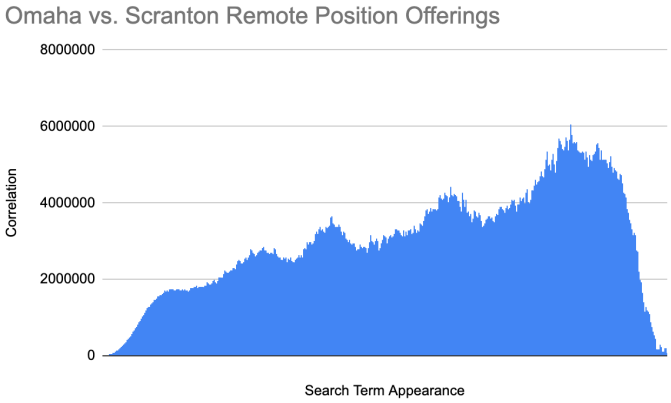
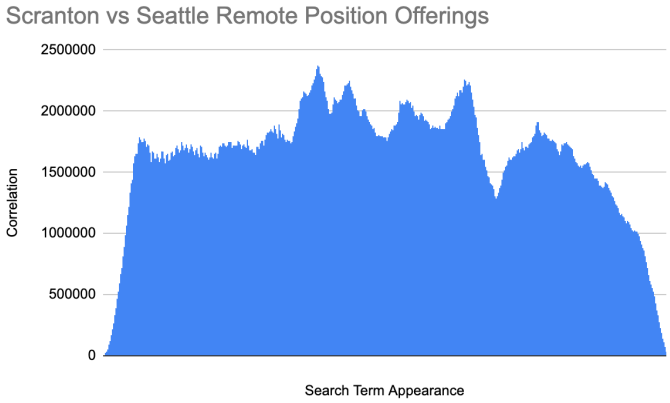
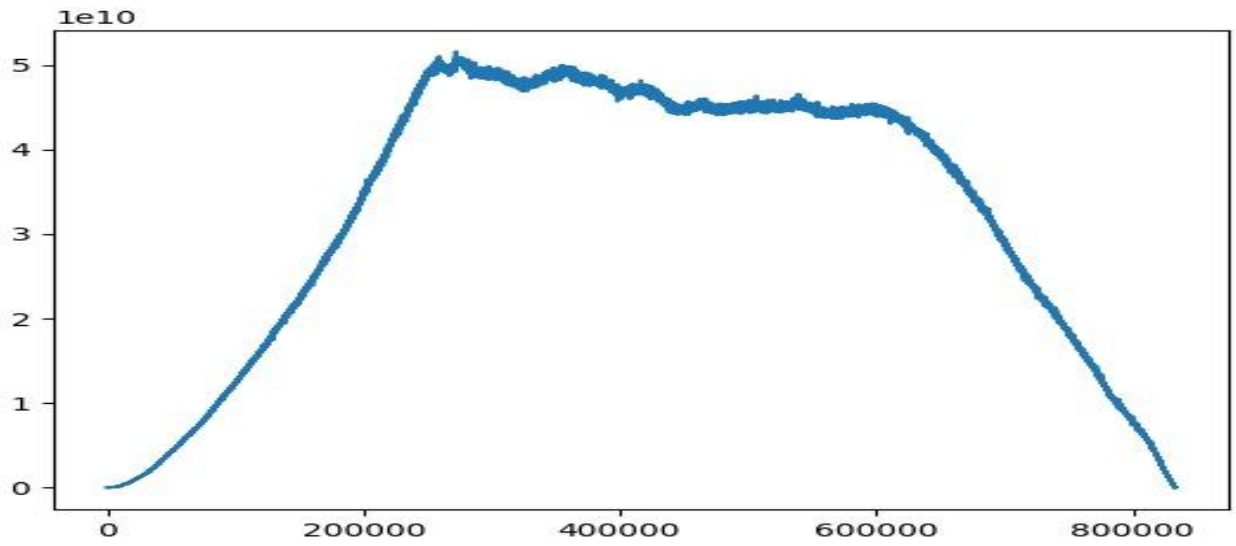


Scranton Position Comparison Remote vs. Non-Remote

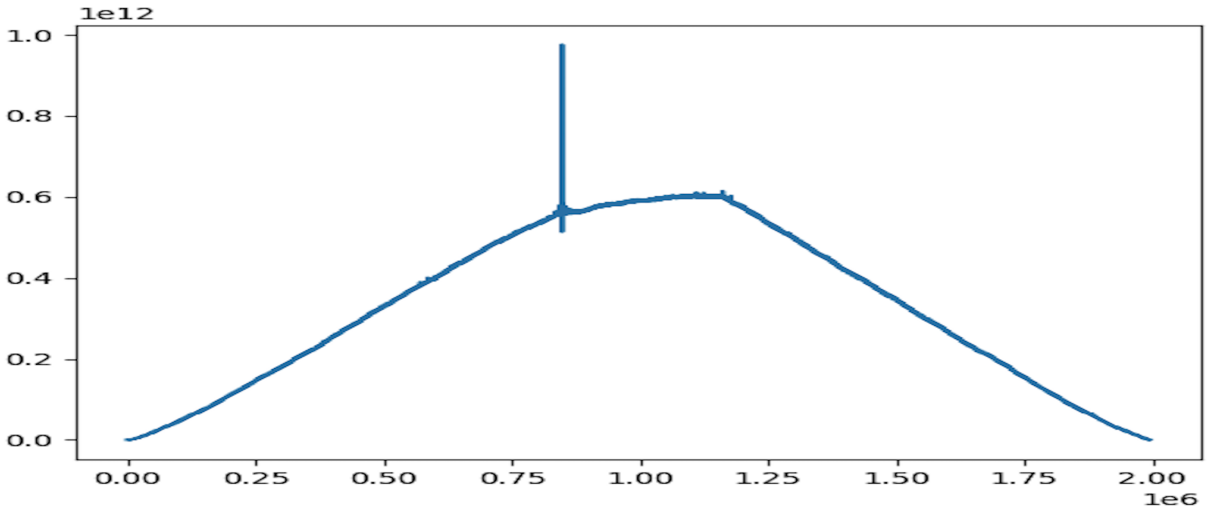




Scranton vs Other Cities Remote Work



The United Kingdom Regional Comparison



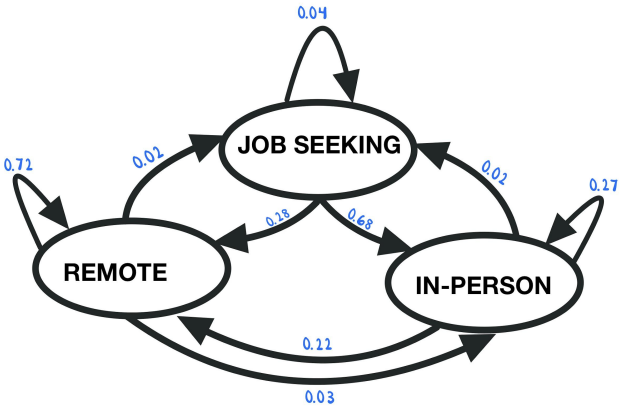
The United Kingdom vs. The United States

Q3: Just a Little Home-Work

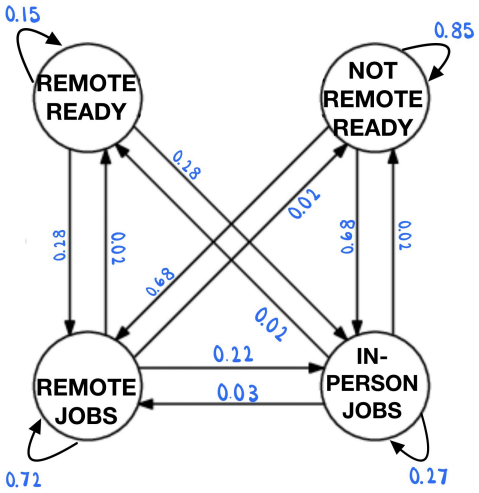
Solution Summary: Displayed below is a Markov model, which essentially is a stochastic method to represent the changing systems where an assumption is made that current states do not depend on past states. This model represents the occupations that are ready to transition to a remote work environment. When deciphering the predictions for the percentage of the workforce that will work remotely in 2024 and 2027 we can rank the magnitude of impact on a city by city basis. As the United States has 10 cities that exceed a population of 1 million people. But a total of about 300 incorporated United States cities. We can apply an expected growth rate of jobs that will become remote will be 22% according to Apollo technicals. We can follow this line of reasoning by dividing it by all major cities by this rate and multiplying the current population of those that work in these cities. This will in turn give us the annual yield of growth of the population of workers in remote jobs. We can then connect these predictions to get a more accurate representation of those who will actually accept remote offers or prefer this work environment utilizing a second Markov model. The 4 point Markov model leads to the percentage of those jobs that are currently ready to transition to remote employment as well as those that will accept the offers from these jobs giving us the most accurate projection for the magnitude of impact remote work will have on cities in the United States as well as the United Kingdom.

Statistics of Markov Model:

4% of the population is unemployed
2% the number of people who quit their job or got fired
28% Accepted remote jobs
68% Accepted in-person jobs
27% Prefer in person
72% Prefer remote jobs
22% Prefer to switch to remote jobs
3% Prefer to switch to in-person jobs



3 Point Markov Model (Percentile Based on 100)



4 Point Markov Model (Percentile Based on 100)

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