Remote Work: Fad, or Future?

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February 27, 2022

0 Executive Summary

In our modern reality, work-from-home has become a norm, especially for those that live in areas with more technological development. In the hundred years before our modern era, the economies of the US and UK have shifted drastically from the manufacturing-based capitalist economies of the late 19th century to a modern economy focused on service and consumerism, with the development of ideas and the monetization of revolutionary ways of thinking. In our modern world, people can sit in front of a computer and make hundreds of thousands of dollars every single day, pressing buttons on a computer. While people used to do this in the office, with the advent of a global pandemic and quarantine lockdown procedures, an unprecedented surge of remote-work has ensued, resulting in rapid and unpredictable change to the proportion of remote-work in all industries.

Remote work has become the norm now, but the question that faces us now is whether or not it will continue to significantly influence the workforce in the next decade from now. Remote work has been on the rise in the last ten years, and using labor statistics from the last twenty years, our team has developed a rational function model to predict the prevalence of remote work in our industries in the next ten years. Specifically, our model is applied to a specific city and outputs the estimated percentage of workers with remote-ready jobs as a function of years after 2020. The percentage of workers with remote ready jobs in a particular year is the total number of workers with remote-ready jobs in a city divided by the employed population in that year. The number of workers with remote-ready jobs will be influenced by the growth rate of each individual industry in the city, which we account for in our model. The employed population of will also change with time, which we estimate with a linear model. Testing our model on several cities of various sizes has yielded surprising, yet reasonable results. Using data found off of the internet from the U.S. Bureau of Labor Statistics and local city statistics, we have found that the remote-readiness percentage of all jobs is usually around 30-40 percent within the next ten years. However, what's even more surprising is that this percentage decreases over time, suggesting that remote-readiness will continue to impact our workforce but diminishingly.

Contents

1 Part 1: Ready Or Not

1.1 Restatement of the Problem

We are asked to do the following:

1. Develop a general model that takes an input of a city and outputs the percentage of remote-ready jobs
2. Apply this model to several cities to test the model's efficacy

Our model uses a formula inputting the percentage of jobs per industry in a city. We multiply the percentage of industries in each city by an individual coefficient for each industry, taking into account that some industries are more remote-ready than others. Taking into account the growth rate of each individual industry in the next ten years, we

1.2 Assumptions

1. Remote ready jobs can be defined as jobs that can be done with telecommunication and performed at similar efficiencies
2. All jobs that can be fully done online will be defined as remote-ready regardless of whether that job is more practical in-person, hybrid, or online.
3. Remote readiness depends on individual industry and each industry will have a different percentage of remote-ready jobs.
4. Not every industry can be done remotely at all. There are some industries that cannot be factored in because they cannot be done remotely.
5. The remote readiness percentage of each job industry will remain roughly the same over the next ten years. The percentage of jobs that are remote-ready in this industry will likely not change considerably.
6. The national average growth rate of each individual job industry can be applied to the job industries of each individual city. There are too many factors too account for when looking at a city on an individual basis, and labor statistics per city may be sparse or dissimilar to other cities' statistics.
7. National year-on-year job growth will likely remain the same over the next ten years for both the U.S. and U.K. and follows a roughly linear trend.
8. The percentage of jobs in total that can be potentially done online in the UK is roughly 15 percent greater than than in the US [3]
9. The average growth rate of average metropolitan cities in the US per decade will remain close to 17.9 percent [8] and 8 percent in the UK [9]
10. All industry types can be categorized into a respective major industry sector
11. Because of the use of many national average estimations of various statistics, the model will be most accurate when applied to a city with non-abnormal economic statistics.
12. Population growth of cities and industries are typically linear

1.3 Model Development

1.3.1 Variables

- t - years after 2020
- $p(t)$ - the percentage of jobs that are remote-ready in year t after 2020
- r_i - the percentage of jobs in an industry that can be remote-ready
- c_i - number of workers per industry for each city
- $c(t)$ - total occupational population for each city in the year t after 2020
- g_i - the national average growth rate of an industry from 2020 to 2030
- P - population of city in 2020
- G - year-on-year growth rate of the city
- i - the set of industry sectors accounted for

1.3.2 Model Derivation

Because we are asked to find the percentage of remote-ready workers per city in the years 2024 and 2027, we will be looking at the time range of roughly 2020 to 2030 given the projected growth rates of each industry sector by the Bureau of Labor Statistics [15]. We will accordingly define a variable t to represent the number of years after 2020.

Given the wide variety of industries to account for, every single industry has a different percentage of jobs that are remote ready. For each industry, there is a percentage of jobs in that industry r_i which can be done remotely and by assumption 4, this value for each industry will remain roughly the same for the next ten years. For each city, we account for the total workers in each industry c_i and multiply them by the proportion of workers in the industry that are remote-ready r_i. We find the number of workers in each industry that are remote ready as $r_i \cdot c_i$ and can then multiply this value by $(1 + \frac{g_i \cdot t}{10})$ to find the number of remote ready workers for each industry for every year after 2020. Summing all the number of remote-ready workers for each industry will yield the total number of remote ready workers in each year t after 2020. Dividing this result by the total number of workers in the city c in year t will yield the percentage of workers who's jobs are remote-ready as a function of time. The resulting formula will be:

$$p(t) = \frac{\sum_{k \in i} r_i \cdot c_i \cdot (1 + \frac{g_i \cdot t}{10})}{c(t)} \tag{1}$$

$c(t)$ can be estimated on a local basis as the total employment of the local city population. Given that the national employment-to-population ratio is typically anywhere from 57 to 63 percent in the US [6] and 57 to 60 percent in the UK in the last twenty years [7], we can have an estimate of around 59 percent for both. The population of the city in the year 2020 P can be multiplied by $(1 + G \cdot t)$ to model the growth of the population of the city. Multiplying the estimated average employment-to-population ratio, we can estimate the total employment of the local city population with the expression:

$$c(t) = 0.59P(1 + Gt) \tag{2}$$

yielding the final model:

$$p(t) = \frac{\sum_{k \in i} r_i \cdot c_i \cdot (1 + \frac{g_i \cdot t}{10})}{0.59P(1 + Gt)} \tag{3}$$

1.4 Results (Example cities)

Given that our formula requires some universal national data on the majority of major industries in the U.S., the only data that depends on the city is the employment population of the city $c(t)$ and the c_i of each industry in each city. All the data used in this model was found through independent research. The following tables give universal data applied to all cases, particularly data on r_i and g_i values

Industry Sector	Remote-readiness proportion
Finance and Insurance	0.86
Management	0.78
Professional, scientific, and technical services	0.75
IT and telecommunications	0.69
Education	0.69
Wholesale Trade	0.52
Real Estate	0.44
Government and administrative support	0.42
Utilities	0.37
Arts, entertainment, and recreation	0.32
Healthcare and social assistance	0.29
Retail Trade	0.28
Mining	0.25
Manufacturing	0.23
Transportation and warehousing	0.22
Construction	0.20
Acommodation and food services	0.09
Agriculture	0.08

Table 1: Remote-Readiness Proportion of each Industry

The above table represents all the r_i values for each industry in the US. The proportions for UK are around 15 percent greater for each industry [3].

Industry Sector	Growth Rate (2020-2030)
Business and Financial	0.08
Management	0.09
Professional, scientific, and technical services	0.08
IT and telecommunications	0.13
Education	0.15
Wholesale Trade	0.02
Real Estate	0.03
Government and administrative support	0.17
Utilities	0.13
Arts, entertainment, and recreation	0.04
Healthcare and social assistance	0.17
Retail Trade	-0.04
Mining	0.17
Manufacturing	0.01
Transportation and warehousing	0.11
Construction	0.04
Acommodation and food services	0.20
Agriculture	0.02

Table 2: Growth Rate of each Industry

The above table represents all the g_i values for each major industry sector in the US. All of the values were obtained from the projected growths of industry sectors from BLS [15] by adding one to the Compound Annual Growth Rate of each sector, raising the result to the tenth power and subtracting one from the final result to obtain the projected growth rate for each sector above. For the sectors above that were not represented in the BLS report, growth rate values are obtained from the BLS Occupational Outlook Handbook. [16]

1.4.1 Seattle, WA

Take Seattle, WA, for example, a city that has over 724,305 people [19] in 2019 and an employed population of around 470,782 [5] in 2020. The city is reported to have a significant 21% population increase from 2010 to 2020 which equates to an average of 2.1% increase per year [20]. Assuming the employment rate of Seattle is near the national average of 59%, function c(t) can be defined as

$$c(t) = 0.59 \cdot (724,305) \cdot (1 + 0.021(t)) \tag{4}$$

Using labor statistics from the 2020 Census, provided by the U.S. Census Bureau and U.S. Bureau of Labor Statistics, we are able to derive a table accounting for the employment distribution of workers for each industry and a theoretical prediction of the number of workers that are remote-ready. Below is a table with each industrial sector and the predicted number of workers that are able to work remotely in each industry in 2024. Because the number workers by industry were not equivalent to the number of workers per sector, comparing different sources, we had to group certain industries by similar sectors, thus accounting for marginal error.

Seattle, WA Employment Distribution	
Total employed population: 470,782	
Industry type	Number of Employees who can work remotely
Management	21,684
Business and financial operations	37,187
Computer and mathematical	30,414
Architecture and engineering	9,401
Community and social service	4,373
Legal	1,132
Education instruction and library	16,216
Arts, design, entertainment, sports, and media	2,755
Healthcare practitioners and technical	7,554
Healthcare support	5,520
Protective service	3,236
Food preparation and serving related	3,386
Building and grounds cleaning and maintenance	4,119
Personal care and service	2,971
Sales and related	11,816
Office and administrative support	21,880
Farming, fishing, and forestry	43
Construction and extraction	4,532
Installation, maintenance, and repair	6,446
Production	5,392
Transportation and material moving	7,833

Table 3: Seattle, WA (2024)

From the data above, we may use the model to divide the summation of all the values by the population as a function of t, giving us the concluding proportion of the percentage of remote-ready workers in Seattle, given as

$$207,890/463,237 = 0.449 = 44.9\% \tag{5}$$

The same can be done with finding the proportion for 2027, by using the function p(7), creating the table as shown

Seattle, WA Employment Distribution	
Total employed population: 470,782	
Industry type	Number of Employees who can work remotely
Management	22,250
Business and financial operations	38,052
Computer and mathematical	31,542
Architecture and engineering	9,566
Community and social service	4,474
Legal	1,161
Education instruction and library	16,684
Arts, design, entertainment, sports, and media	2,788
Healthcare practitioners and technical	7,895
Healthcare support	5,769
Protective service	3,311
Food preparation and serving related	3,574
Building and grounds cleaning and maintenance	4,203
Personal care and service	3,151
Sales and related	11,781
Office and administrative support	21,681
Farming, fishing, and forestry	43
Construction and extraction	4,611
Installation, maintenance, and repair	6,578
Production	5,414
Transportation and material moving	8,037

Table 4: Seattle, WA (2027)

Total proportion:

$$212,565/463,237 = 0.459 = 45.9\% \tag{6}$$

Given the values p(4) = 44.9% and p(7) = 45.9%, the average increase of the amount of remote-ready workers increases around 1% every 3 years, or roughly 0.33% according to these calculations.

1.4.2 Omaha, NE

For Omaha, the employment rate in the future follows a roughly linear path. With a population in 2020 of about 486,051 and a population in 2010 of 408,958, the growth rate for the past ten years has been 18.8 percent and a year-on-year linear growth rate of around 1.88 percent of the original 2010 population, validating assumption 9. Assuming this growth rate continues for the next ten years [8], $c(t)$ can be modelled as

$$c(t) = 4536 \cdot t + 241285$$

Given the employment population in May of 2020 as 461,610 [14] and the economic distribution of workers in Omaha in May 2020 [13], the following table can be derived from which the total number of workers in each industry can be found.

Omaha Employment Distribution	
Total employed population: 461610	
Industry type	Number of Employees
Management	27,235
Business and financial operations	28,158
Computer and mathematical	19,849
Architecture and engineering	5,539
Life, physical, and social science	3,693
Community and social service	6,001
Legal	2,770
Education instruction and library	28,620
Arts, design, entertainment, sports, and media	5,078
Healthcare practitioners and technical	32,774
Healthcare support	16,618
Protective service	7,386
Food preparation and serving related	37,852
Building and grounds cleaning and maintenance	12,925
Personal care and service	11,079
Sales and related	46,161
Office and administrative support	63,702
Farming, fishing, and forestry	462
Construction and extraction	19,849
Installation, maintenance, and repair	18,003
Production	24,004
Transportation and material moving	39,698

Table 5: Occupational Employment and Wages in Omaha-Council Bluffs [13]

With this table, and the set of r_i and g_i given by the first tables in the results section, we can calculate the results of p(4) and p(7) for the years of 2024 and 2027 respectively. We have to be careful calculating the results, however, because the tables at the beginning of the results section have data on industry sectors, not individual industries, so the industry types may not line up. To resolve this issue, we have decided to instead choose the r_i and g_i values that represent industry sectors from the beginning tables closest to the industry types in the table above because all of the industry types above can be categorized into an industry sector. For p(4), t=4, so we use a python script to calculate the formula result $p(4) = 0.397$. The percentage of remote-ready jobs in 2024 will be 39.7 percent. Repeating the same for t=7, the percentage of remote-ready jobs in 2027 will be 31.0 percent.

1.4.3 Scranton, PA

Repeating the same processes for the previous examples and finding the total population and total population growth rate of Scranton, we find a population of 76328 in 2020 and 76089 in 2010 [21]. The growth rate for the past ten years has been 0.3 percent with an average linear year-on-year growth rate of 0.03 percent, far from the average assumed by assumption 9. The growth rate already places Scranton far from the average urban metropolitan area that this model applies to. Because the model uses national averages for the growth rates of individual industries with the assumption that they will be applied to an average city, it is reasonable to assume that because Scranton grows insignificantly, the growth of its industries will also be negligible. It follows that the percentage of workers with remote-ready jobs in each industry will remain roughly the same as 2020 percentage, given assumption 5.

Scranton Employment Distribution	
Total employed population: 34,786	
Industry type	Number of Employees
Management	1,252
Business and financial operations	1,287
Computer and mathematical	521
Architecture and engineering	452
Life, physical, and social science	208
Community and social service	660
Legal	173
Education instruction and library	1,843
Arts, design, entertainment, sports, and media	313
Healthcare practitioners and technical	2,435
Healthcare support	2,017
Protective service	765
Food preparation and serving related	2,539
Building and grounds cleaning and maintenance	974
Personal care and service	591
Sales and related	2,991
Office and administrative support	5,113
Farming, fishing, and forestry	34
Construction and extraction	1,182
Installation, maintenance, and repair	1,530
Production	2,887
Transportation and material moving	4,974

Table 6: Occupational Employment and Wages in Scranton [22]

Calculating the results of an adapted function:

$$p(t) = \frac{\sum_{k=i} r_i \cdot c_i}{34786} \tag{7}$$

with t=4 and t=7 yields the same result of 34.6 percent of the total Scranton population with jobs that are remote-ready.

1.4.4 Liverpool, England

For the city of Liverpool, England, the increase in employment can be shown with a linear increase of 0.2 percent. In 2021, the employed population of Liverpool was at 238,200, while the total population was at 500,500. The overall growth rate for the population of England is around 8 percent, so we can model the overall employment of a certain year as

$$c(t) = 0.59 \cdot (500500) \cdot (1 + 0.08(t))$$

With these information, we can find the denominator of our function by plugging in 3 or 6 to indicate years after 2021. We are using 3 and 6 because the data is from 2021, not 2020 where the year inputs would be 4 and 7. It is important to note that the differences in the data available for each cities affects the variable values for the equation. Given the employed population of Liverpool and the percent of employed population per industry [16], the following table represents the employment distribution of the city. We did not round the values for the table, but the results will be very similar either way.

Liverpool Employment Distribution	
Total employed population: 238,200	
Industry Type	Number of Employees
Agriculture	1667.4
Manufacturing	9051.6
Construction	6431.4
Retail	32395.2
Transport	12624.6
Food service	20723.4
Information	7146
Finance	8098.8
Scientific/Technical Services	23581.8
Business/Administrative Services	18103.2
Education	23343.6
Health	42399.6
Art	14530.2
Public Admin	17150.4

Table 7: Occupational Employment per Industry in Liverpool, England

The data in the table for Liverpool differs from that of the cities in the United States due to the different availability of datasets. The data set for Liverpool only contained 14 industries. Using the data from the table, calculating the r_i for the UK by multiplying the values in Table 1 by 1.15 to account for the UK's approximate 15 percent greater remote readiness, and using the growth rate of each industry g_i [17], we can create a program to plug in the values and calculate the results of p(3) and p(6) for the years 2024 and 2027 respectively. The program calculates the final model and outputs by determining the numerator first with the summation of different industries and dividing it by the total occupational population.

p(3)=0.28 or 28 percent for 7 years
p(6)=0.32 or 32 percent for 4 years

The estimates presented is subject to change as more specified information is revealed closer to the years of 2024 and 2027. Inputs to the model will change based on trends in society (like COVID-19) that alter the rates of industrial and population growth.

1.4.5 Barry, Wales

The largest town in Wales, Barry has a recorded population of 58,486 as of 2020 [25]. It's employed population is estimated to be around 42,800 with a national employment rate of around 74.6% and an average population growth of 0.73%. Using data from a European statistics and demographics database, we are able to create a table of the number of workers in each industry in Barry.

Scranton Employment Distribution	
Total employed population: 34,786	
Industry type	Number of Employees
Agriculture, Foresting, Fishing	700
Manufacturing	4,000
Construction	3,200
Wholesale, Retail, Transport, Hotels, and Food	10,800
Information/Communication	800
Finance and Insurance	500
Real Estate	600
Professional, Scientific, Technical	5,400
Public administration, Education, Health, Defense	13,900
Other	2,800

Table 8: Number of Employees per Industry - Barry, Wales (2024)

With the data above, we may use our model p(t) to divide the summation of all the values by the population as a function of t, giving us the concluding proportion of the percentage of remote-ready workers in Barry, given as

$$430,810/463,237 = 0.93 = 93\% \tag{8}$$

The percentage of remote-ready workers in Barry does not change drastically over the years, so the 93% corresponds to 2024 and 2027. The inputs for this town may have slight miscalculations as the location does not have specific data on employment, leaving room for interpretation.

References

[1] Bureau of Labor Statistics, *Occupations with the most job growth*, https://www.bls.gov/emp/tables/occupations-most-job-growth.htm#top

[2] United States Census Bureau, https://data.census.gov/cedsci/table?q=American%20Community%20Survey%20Means%20%20of%20Transportation%20to%20Work

[3] Mckinsley,https://www.mckinsey.com/featured-insights/future-of-work/whats-next-for-remote-work-an-analysis-of-2000-tasks-800-jobs-and-nine-countries

[4] Census Bureau, https://data.census.gov/cedsci/table?q=American%20Community%20Survey%20Means%20%20of%20Transportation%20to%20Work

[5] DataUSA, https://datausa.io/profile/geo/seattle-wa/#:~:text=Employment%20by%20Occupations&text=From%202018%20to%202019%2C%20employment,452k%20employees%20to%20471k%20employees.

[6] Bureau of Labor Statistics, *Employment-population ratio*, https://www.bls.gov/charts/employment-situation/employment-population-ratio.htm

[7] Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/SLEMPTOTLSPZSGBR

[8] Census Bureau, https://www.census.gov/quickfacts/omahacitynebraska

[9] University of Pennsylvania, https://www.oecd.org/economy/growth/Growth_of_cities_Duranton.pdf

[10] Statista, https://www.statista.com/statistics/380171/growth-of-cities-in-the-united-kingdom/

[11] Bureau of Labor Statistics, https://www.bls.gov/eag/eag.ne_omaha_msa.htm

[12] Bureau of Labor Statistics, https://www.bls.gov/regions/midwest/summary/blssummary_omaha.pdf

[13] Bureau of Labor Statistics, https://www.bls.gov/regions/midwest/news-release/occupationalemploymentandwages_omaha.htm

[14] Bureau of Labor Statistics, https://data.bls.gov/timeseries/LAUMT313654000000005?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true

[15] Bureau of Labor Statistics, https://www.bls.gov/opub/mlr/2021/article/pdf/projections-overview-and-highlights-2020-30.pdf

[16] Liverpool City Council, https://liverpool.gov.uk/council/key-statistics-and-data/headline-indicators/labour-market/

[17] UK Commission for Employment and Skills, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/543301/WF_Headline_Presentation_v3.pdf

[18] Bureau of Labor Statistics, https://www.bls.gov/ooh/

[19] U.S. Census Bureau, https://www.census.gov/data/developers/data-sets/acs-5year.html

[20] Seattle Times, https://www.seattletimes.com/seattle-news/data/seattle-ended-decade-with-faster-growth-than-suburbs-reversing-a-100-year-trend/#:~:text=From%202010%20to%202020%2C%20Seattle's,exceeded%20that%20of%20the%20city.

[21] Census Bureau https://www.census.gov/quickfacts/scrantoncitypennsylvania

[22] Bureau of Labor Statistics, https://www.bls.gov/regions/mid-atlantic/news-release/occupationalemploymentandwages_scranton.htm

[23] Union of Concerned Scientists, https://blog.ucsusa.org/doug-boucher/world-population-growth-exponential/

[24] Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina (2013) - "World Population Growth". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/world-population-growth' [Online Resource]

[25] Brinkhoff, Thomas, https://www.citypopulation.de/en/uk/wales/the_vale_of_glamorgan/W37000342__barry/

[26] StatsWales, https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/People-and-Work/Employment/Jobs/Whole-Workforce/workplaceemployment-by-welshlocalareas-industry

A Code Used

Python Code

The code below can be altered with the values for industry, mckinsey, growth, population, and popgrowth respective to the city, and year as either 3 and 6 or 4 and 7 to determine the remote working readiness for different cities in 2024 and 2027:

industry = [1287, 1252, 12002, 19849, 28620, 0, 0, 63702, 30928, 5078, 55393, 46161, 0, 24004, 39698, 19849, 69242, 462]
mckinsey = [0.86, 0.78, 0.75, 0.69, 0.69, 0.52, 0.44, 0.42, 0.37, 0.32, 0.29, 0.28, 0.25, 0.23, 0.22, 0.20, 0.09, 0.08]
growth = [0.08, 0.09, 0.08, 0.13, 0.15, 0.02, 0.03, 0.17, 0.13, 0.04, 0.17, -0.04, 0.17, 0.01, 0.11, 0.04, 0.20, 0.02]
year = 7
population = 461610
popgrowth = 0.188
sum = 0
for i in range(0,18):

P = (mckinsey[i]*industry[i]*((growth[i]*year/10)+1))

sum = P + sum

print(sum)
ans = sum/ (population*(popgrowth*year+1)*0.59)

print(ans)

```
industry = [1287, 1252, 12002, 19849, 28620, 0, 0, 63702, 30928, 5078, 55393, 46161, 0, 24004, 39698, 19849, 69242, 462]
mckinsey = [0.86, 0.78, 0.75, 0.69, 0.69, 0.52, 0.44, 0.42, 0.37, 0.32, 0.29, 0.28, 0.25, 0.23, 0.22, 0.20, 0.09, 0.08]
growth = [0.08, 0.09, 0.08, 0.13, 0.15, 0.02, 0.03, 0.17, 0.13, 0.04, 0.17, -0.04, 0.17, 0.01, 0.11, 0.04, 0.20, 0.02]
year = 7
population = 461610
popgrowth = 0.188
sum = 0
for i in range(0,18):

    P = (mckinsey[i]*industry[i]*((growth[i]*year/10)+1))

    sum = P + sum

print(sum)
ans = sum/ (population*(popgrowth*year+1)*0.59)

print(ans)
```

Figure 1: Python Code

B Mind Map

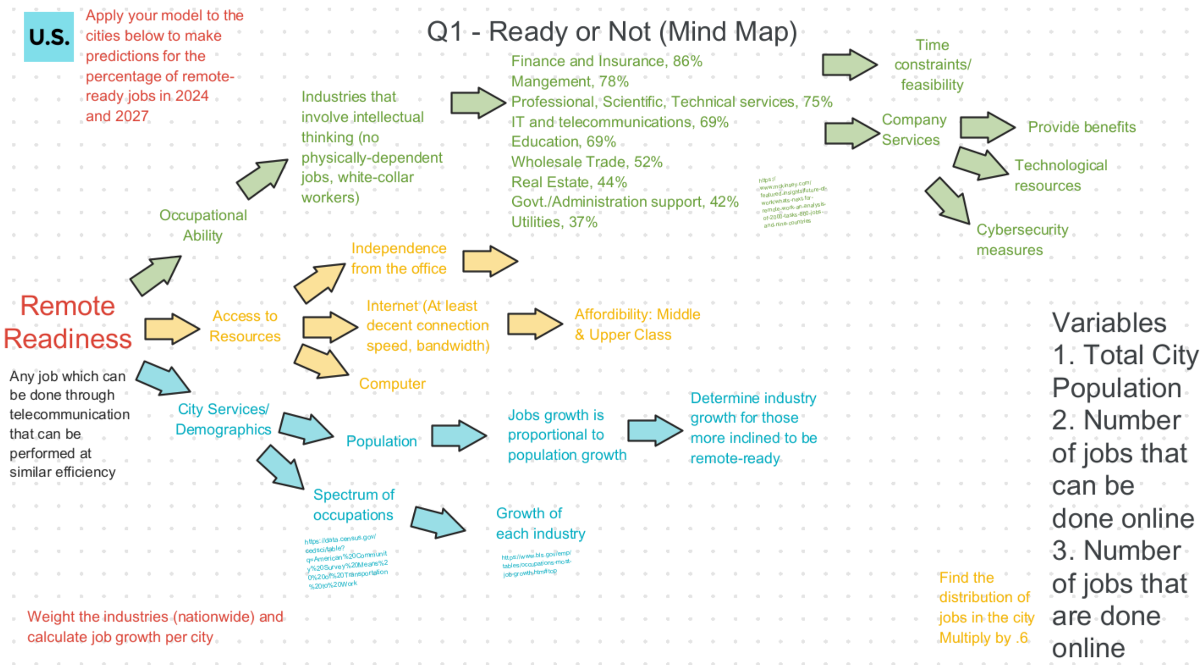

Figure 2: Mind Map