

Impact of COVID-19 on Industries in the Canadian Labour Market

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Abstract—Under the influence of the pandemic environment, many people have lost their jobs or are on the verge of being laid off, while there are many new job seekers. Therefore, the status of new jobs under the pandemic and how various industries are affected by the pandemic, including the prediction of future work trends, have become the focus of attention. Through the frequent pattern mining of recruitment information and the statistical analysis of labor market data in different types of industries, it can be concluded that the market has a great demand for medical workers and surprisingly there are still relatively large retail jobs. Besides, by analyzing the labor market manpower changes in different industries and comparing with 2018 and 2019 data, it is known that the types of jobs that have been most affected by the pandemic are (1) Accommodation and foodservice, (2) Information, culture and recreation, and (3) Construction. Finally, by combining the recruitment data of the industry's most severely affected by the pandemic in December and the changes in the labor market from 2019 to predict the future direction of these industries. Optimistically, these jobs will gradually return to normal.

I. INTRODUCTION

The outbreak of COVID-19 has become a Public Health Emergency of International Concern (PHEIC) since January 2020. There is no doubt this outbreak has a huge negative impact on the lives of people all over the world. In order to ensure the health and safety of everyone under such circumstances, people need to strictly maintain social distancing, so all walks of life have suffered different degrees of economic losses. To ensure a balance of income and expenditure, many companies are unable to provide new positions and need to reduce the working hours of their employees or even have to fire employees. With the decrease in the employment rate and the increase in the number of job seekers, we would like to focus on the impact of COVID-19 on occupations in the Canadian labour market to explore how the number of occupations changes during the COVID-19.

In this article, through capturing and analyzing big data using frequent pattern mining techniques to mine the frequency of jobs provided by companies under the COVID-19 pandemic. Additionally, we will represent how COVID-19 affects some special industries with reasonable

explanations through statistical analyzing, and predict the future development of these industries. To find out what industries have been most negatively affected and which industries are less affected by COVID-19 in Canada, through analyzing the changes of the Canadian labour market before and after the outbreak of COVID-19 [1]. Due to each occupation having its special characteristics, we use a heuristic algorithm to screen among many different industrial categories, in order to get which industries are most seriously affected by COVID-19 in order to analyze them in greater detail. Moreover, it is reported that the vaccines will start to roll out in Canada in December 2020, so we will perform a further prediction regarding those industries that have been affected by this virus based on the data we processed at the period before the COVID-19 outbreak, to see when those trends will return to normal standards.

The rest of this article is arranged as follows. The background and related works are provided in the next section. In section three, we describe how we get the result and our data science solution. We separately show our evaluations and conclusion in sections four and five.

II. BACKGROUND AND RELATED WORK

The COVID-19 pandemic has caused a global health crisis, and what is even more frustrating is the impact of the pandemic on people's normal life, entertainment, and work. It is also for the above reasons that this crisis quickly transformed into an impact on the economy and labor market, which led to an unprecedented global employment crisis [2]. Just at the beginning of the outbreak, from February to March 2020, the number of unemployed persons in Canada increased rapidly by 413,000. In just seven days (March 15-21), 1,300,000 people were suspended from work but retained positions and 800,000 had their working hours reduced [6]. These data can clearly illustrate the huge negative impact of the epidemic on the job market. Because of this, many analyses of the labour market and the impact of the pandemic on different industries have emerged.

Many people have analyzed the impact of the pandemic on the labour market and different industries through statistical data analysis. For example, Leonard and Lemelin-Bellerose [3] determines which industries are more likely to be affected by the pandemic and difficult to return to normal levels in short term through risk factors such as the

nature of the production process, the demand for products and services, the distance to others when providing goods or services, the accessibility of workers, and the vulnerability of companies in the industry and provide data analysis to prove it. Also, some people prefer to focus on research and analysis in one direction like Ellen [4] only concentrated on the impact of the epidemic on food retail and food services and its development under the epidemic. By analyzing the likely impact of lower disposable income on food expenditure and the share of food expenditure spent on food outside and at home, she illustrates how the old brick-and-mortar retail industry has been changed and what has to happen to these food retailing and services. At the same time, some people did an analysis related to the labor market. Lemieux et al. [5] mainly through the analysis of the labor force survey to record and explain this initial pattern of labor market decline which is the impact of the crisis on the labor market on the macro gross domestic product (GDP) and Canadian household income changes.

In these related works, most researchers mainly analyze the statistical data to sort out the impact on a single industry, or horizontally compare some more seriously influenced industries that are affected by similar factors. At the same time, some analysis of changes in labor market data can also confirm the impact of the epidemic on the work environment. Most of the existing work about the impact of the epidemic on the industry and the labor market is based on statistical methods instead of data mining and is separated. Data mining is a good technique for mining knowledge from data, so this is a good place to use it to help analyze the impact of the pandemic on the industry and the labor market. Another difference from them is that we not only use integrated standard data but also try to crawl fresh recruitment data information from job search websites. These data can better reflect the needs of employees in different companies, industries, and regions under the epidemic. Instead of only providing the change in a different sector, we implement frequent pattern mining to find which category of jobs, which positions and companies will offer more opportunities to job hunters. Also, trying to use association rules to find if there is any potential relationship between them. Moreover, we try to analyze the changes in the labor market under various types of jobs and compare them with the data changes in 2018 and 2019 to find out which industry is less stable under the epidemic. That means those industries are more severely affected by the epidemic.

III. MAIN BODY

In this section, we describe our data mining on job-related data from a Canadian job search website, Jobs.ca, statistical analysis on employment data from a Canadian national statistical website, Statistics Canada, and predictions of future trends in the Canadian labour market based on these data. Our goal is to analyze the current situations of the occupations offered in various industries during the COVID-19 era, determine the impact of COVID-19 in the Canadian labour market, as well as predict the overall

situation for 2021, and estimate when the labour market will return to normal. However, most of the job search websites do not provide job data in the past and expired job data will be periodically cleaned up. Therefore, the earlier time that job data are posted, the less the number of job data are kept on the websites. For example, the job search website Indeed mainly retains the job data for the most recent month. All data posted more than one month ago are displayed with the keyword of time as “30+ days ago”, making the website Indeed unsuitable to be chosen as the database source to study the impact of COVID-19. Similarly, the website Job Bank only keeps job data for the last few months as well. Although there exists the job data for the whole year of 2020 on the website Jobs.ca that we used, the number of data does decrease as time goes forward from now. Therefore, we need to preprocess and classify the job data, using relative values (percentage of data) instead of absolute values (number of data). On the other hand, we also need to reference the statistical job data on the website Statistics Canada to compare the job data during the pre-COVID-19 era and COVID-19 era, in order to analyze the changes in job data and obtain the impact of COVID-19 in the labour market in Canada. Based on the comparison, we identified the top four categories of occupations that are most affected by COVID-19. Then we performed data mining again on job data of only these four categories of occupations for further analysis. At last, we synthesized all data to make predictions for future trends of different job categories.

We divide our work into four parts. First, we analyze the job data of offered occupations in the year 2020 from the website Jobs.ca through data mining. Then we compare the statistical job data of employment during the pre-COVID-19 era and COVID-19 era from the website Statistics Canada through statistical analysis, identifying the top three categories of occupations that are most affected by COVID-19. Next, we further analyzed the job data of these three categories of occupations through data mining, exploring the details and situations of the most affected occupations during the current COVID-19 period. At last, we predicted the overall situation of the Canadian labour market for next year and estimated how long it would require for different industries to return to normal.

3.1. Data Mining on Job Data in 2020

3.1.1 Data Preprocessing

We designed a web scraper to collect data from the website Jobs.ca. This was done by requesting each page of data and parsing all the information on the cards, for every job category listed on their site. Note that each job is posted with much information, some of which is useful and should be kept as attributes while some are invalid and should be ignored during web scraping. In case there is some repetition in the dataset, we try to remove duplicates after parsing them from the website.

The information that is useful and kept:

- The information about “date”: the date that the job was posted, which helps to reveal relationships among

occupations and posted time, especially the month in 2020. It was kept as the attribute “date” in the database.

- The information about “job title”: the title of the job posted, which helps to identify the specific title or position of the job for detailed analysis. It was kept as the attribute “job title” in the database.
- The information about “company”: the company that offers the job, which helps to identify the specific company that provides the job, and can be combined with the corresponding attribute “job title” together to analyze the details of the job. It was kept as the attribute “company” in the database.
- The information about “location”: the location or workplace of the job, which helps to reveal relationships among occupations and work locations (in the form of city, province). It was kept as the attribute “location” in the database.
- The information about “category”: the category of the job, which helps to reveal relationships among occupations and categories to analyze the impact of COVID-19 on different categories of occupations during the COVID-19 era. It was kept as the attribute “category” in the database.

The website Jobs.ca provided job data divided into 17 different categories as follows: accounting, administrative, aeronautical, business analyst, call center, engineering, finance, healthcare, hospitality, human resources, information technology, legal, paralegal, pharmaceutical, project management, retail, and sales. We use this division directly in our database to obtain 17 different values in the attribute “category”.

- The information about “link”: the URL of the job, which helps to learn all information about the job by clicking the link. It was kept as the attribute “link” but was not used in data mining (frequent patterns mining).

The information that is invalid and ignored:

- The information about “responsibilities”: the responsibilities or work contents of the job. Specifically, what needs to be done for this job. This information is expressed in large pieces of text, which are difficult to transfer to representative keywords for an attribute. Besides, the information about responsibilities is presented in different forms and titles. For example, it is presented under the title of “description of the job”, “what you need to do”, “what your day to day will look like”, etc., which increases the difficulty of information collecting by web scraping. Since we are not intended to analyze the details of the responsibilities for each job, we can ignore this information
- The information about “qualifications”: the qualifications or requirements to do the job, for example, the degree of education, the work experience, the skills or characters, etc. Because of the same reasons as for “responsibilities”, we ignored this

information.

- The information about “salaries”: the salaries provided by the job. It is important information but only a small part of the posted jobs includes this information, so we ignored it.
- Other information: all other information except the information listed above, e.g., the company profile.

Through web scraping the job data in 2020 from the website Jobs.ca, we retrieved useful information and preprocess the data, capturing six attributes in total in the file to conduct data mining for occupation analytics: date, job title, company, location, category, and link.

3.1.2 Frequent Pattern Mining

Once the job data are preprocessed, we conduct data mining on the resulting preprocessed data with only five attributes except for the attribute “link”. Specifically, we perform frequent pattern mining to find implicit, previously unknown, and potentially useful information and knowledge in the form of sets or collections of frequently co-occurring attribute-values using the apriori algorithm shown in Algorithm 1 [7].

Algorithm 1. Generate *Frequent Itemsets*.

C_k: Candidate itemset of size k

L_k: Frequent itemset of size k

Join Step: Generate C_k by joining L_(k-1) with itself

Prune Step: Prune k-itemset if any of its (k-1)-itemset is infrequent

```

L1 ← {frequent items}
for (k = 1; Lk != null; k++) do begin C(k+1) ←
  candidates generate from Lk
  for each transaction t in dataset from Lk do {
    increment the count of all candidates in C(k+1) that
    are contained in t
    L(k+1) = candidates in C(k+1) with min_support
  }end
return ULk

```

Algorithm 1. Pseudocode for generating the *Frequent Itemsets* of the job data.

The singleton frequent patterns help reveal the frequently occurring values for each attribute related to occupations. For example, they help reveal information like:

- Which category of occupations was most offered/demanded during the COVID-19 era?
- Which company has the greatest demand for occupations during the COVID-19 era?
- Which location has the greatest demand for occupations during the COVID-19 era?

Moreover, non-singleton frequent patterns help reveal a combination of frequently co-occurring attribute-values related to occupations. For example, they help reveal information like:

- Which category of occupations was most demanded in

each location?

- Which category of occupations was most demanded by each company?
- Which combination of category, company, and/or location led to a high demand for occupations?

From all these discovered frequent patterns, we could get an insight into the demands and situations of the occupations in various categories during the COVID-19 era, which helps to analyze the impact of COVID-19 in the Canadian labour market. To a further extent, this revealed information also helps job hunters prepare better to seek jobs during the COVID-19 era.

3.2. Statistical Analysis on Employment Data

We conducted the statistical analysis on job data of employment during the pre-COVID-19 era and COVID-19 era from the website Statistics Canada. We collected the monthly statistical data of employment for various industries in 2018, 2019, and 2020. We aim to compare the employment data during the pre-COVID-19 era and COVID-19 era and analyze the fluctuations of data caused by COVID-19. However, the total number and fluctuations in employment data in various industries are inherently different. For example, according to the division of industries by Statistics Canada, the services-producing sector displayed much more employment and larger fluctuations than other industries. The results are reasonable since the services-producing sector is an economic concept that is essentially everything else except the goods-producing sector, which makes tangible products [8]. Services comprise a diverse range of activities, including high-tech and knowledge-intensive jobs, as well as low-skill, labour-intensive jobs—everything from software developer to fast food server [9]. The services-producing sector has always been developing rapidly with large size and seemingly continuous growth [10]. Moreover, the employment in agriculture shows periodic change because there are a few seasonal crops that yield only in a particular season, such as the Rabi or the winter crops, which is known as the concept of seasonal unemployment. Seasonal unemployment refers to the period when the demand for labor or workforce is lower than normal under certain conditions, however, such a situation is only temporary and employment reverts to normal thereafter. Seasonal unemployment is one type of natural unemployment (aka the natural rate of unemployment), which is the minimum unemployment rate resulting from real or voluntary economic forces, in other words, the rate of unemployment when the labour market is in equilibrium. Due to these inherent differences in the number and fluctuations of employment for diverse industries, we cannot use the number of employment itself or the absolute values of change in employment during a period of time to analyze the impact of COVID-19 on various industries in the Canadian labour market. Therefore, we introduced a new concept called “industrial stability” and defined some indicators and algorithms to support it.

Industrial Stability is a new concept that is introduced to describe the stability of the labor market. The labor market can be affected by multiple reasons, such as the oil/gas crisis,

booming infrastructure construction, epidemic contagious disease, and so on. As the Labor Market Indicator (LMI) shows the overall employment status by census metropolitan areas, the Industrial Stability aims more on the monthly changes within each year of the labor market, especially for each industrial category, in order to represent and analyze the stability.

Industrial Stability Indicator (ISI) is a measure that aims to show the changes in employment of an industry by comparing its employment data in between the current and the previous years. This parameter uses percentages to represent how stable industry is in a certain year, which is the degree of stability. With seasonally adjusted employment statistical data by industry and by month, the minimum, maximum, and average number of people employed in each industrial category in each year can be calculated. According to Algorithm 2, these values above are able to compute the fluctuation of employment. By using a fluctuation value of a current year minus that of the previous year, it gives the ISI value, which represents the industrial stability.

- Maximum Employment (M1): this parameter represents the maximum number of people employed in an industry in a month, from January to December of a certain year.
- Minimum Employment (M2): this parameter represents the minimum number of people employed in an industry in a month, from January to December of a certain year.
- Average Employment (A): this parameter represents the average number of people employed in an industry in a month, from January to December of a certain year.
- Fluctuation (F): this parameter results from using the Average Employment (A) divide the difference between Maximum Employment (M1) and Minimum Employment (M2). The difference between M1 and M2 shows the fluctuation of an industry by person, and using A to divide this difference will give a percentage that measures the fluctuation degree.

Algorithm 2. Find the *Industrial Stability Indicator (ISI)* of the labor market.

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F ← the fluctuation of employment in the industry.
ISI ← the indicator shows increment/decline of the
stability of the labor market.
for each industry C in the 12 months within a year
    M1 ← maximum number of people employed
    M2 ← minimum number of people employed
    A ← average number of people employed in
current year
    F ← (M1 – M2) / A
    ISI = F(current year) – F(previous year)
    if (ISI = 0), C maintains an ideally stable
employment
    if (ISI < 0), C has a more stable employment than
last year
    if (ISI > 0), C has a more unstable employment
than last year

```

Algorithm 2. Pseudocode for finding the *Industrial Stability Indicator (ISI)* of the labor market.

The three different sets of ISI values indicate three different situations for the employment status of an industry.

- If ISI equals 0, it means this industry has been affected neither positively or negatively (i.e. prosperity or recession). In other words, this industry kept its ratio of employees to the overall working-age population unchanged.
- If ISI is negative, it means this industry has become more stable than in the previous year. Usually, if there exists a rather large negative ISI for an industry, it means the very industry has been out of chaos for any sensible reasons such as a global economic crisis.
- If ISI is positive, it means this industry has become more unstable than in the previous year. A very large positive ISI value is a warning that shows this industry has been seriously affected that could result in lay off or turn over (i.e. full-time jobs become part-time jobs).

Note that the ISI cannot show whether an industry is booming or recessive. A large positive ISI value could mean either an industry is a brand new booming one to the business world, or it is going downhill. In the real world, multiple industries have rather large positive ISI values simultaneously illustrates that there are worldwide events happening, such as the economical crisis, popular infectious diseases, etc.

Based on the value of ISI, according to the employment database from Statistic Canada, we obtained the top four industries that were tremendously affected by COVID-19, which correspond to the four largest values of ISI. Then we delved into these four industries to explore the reasons behind the impact according to the nature and characteristics of the industries separately. Through analyzing the impact of COVID-19 on various industries in the labour market in Canada, job seekers could have a better understanding of

how to find a job during the COVID-19 era, and industries could also better adjust themselves to deal with the subsequent attack by COVID-19.

3.3. Data Mining on Most Affected Occupations

3.3.1 Data Preprocessing

We then conducted data mining again on the job data for the top four affected industries in 2020. Since the classification of categories or industries of occupations by Statistics Canada is different from that by the website Jobs.ca, we performed web scraping based on the “keyword” of the top four affected industries. In detail, one of the top four affected industries is construction, so we used “construction” as the keyword to search on the website Jobs.ca and then collected all job data relevant to this keyword. As for the other top four affected industries accommodation and food service, we use the keywords “accommodation” and “food” to search on the website respectively in order to retrieve more job data through keyword searching.

Through keyword searching and web scraping of the job data related to the top four affected industries in 2020 from the website Jobs.ca, we finally captured the following six attributes:

- Five attributes “date”, “job title”, “company”, “location”, “link”: same as the attributes in our data mining for the first time, which are explained in part 3.1.1.
- The attribute “keyword”: the keyword used in searching on the website to find related job data. This value represents the information similar to that of industry or category.

3.3.2 Frequent Pattern Mining

Similarly, we conducted data mining, namely, the frequent pattern mining, on the resulting preprocessed data with five attributes except the attribute “link” as well to retrieve useful information and knowledge in the form of sets or collections of frequently co-occurring attribute-values from both the singleton and non-singleton frequent patterns. For example:

- Which location has the greatest demand for the most affected occupations?
- Which month has the greatest demand for the most affected occupations?
- Which company and/or job title has the greatest demand for the most affected occupations?
- Which combination of job title, company, month and/or location led to high demand for the most affected occupations?

From all these discovered frequent patterns, we could further study the most affected occupations by COVID-19 to identify what specific situations these most affected occupations are going through and what specific characteristics they exhibit. We could also combine the data mining results with the previous results from the statistical analysis in part 3.2 to explore more interesting information, such as the consistency and inconsistency between data and

propose reasonable explanations. In a practical sense, the analysis of the impact of COVID-19 in the Canadian labour market (especially the most affected occupations) can help both employers and employees as well as job providers and job seekers better understand the current situations and face future challenges during the COVID-19 era.

3.4 Predictions of Future Trends and Industrial Recovery Time

According to the statistical job-related data, we also predicted the future trends in the Canadian labour market for next year, and estimated when various industries will get back to normal respectively.

In the data of seasonally adjusted employment by industry and month, statistical data for December 2020 was not given. To perform the predictions for 2021, we first need to estimate the employment data for December 2020 in order to get an overall estimation for the next year.

Once we obtained the estimation of the employment data for December 2020, we could predict the overall situation of the Canadian labour market next year. We also make predictions when the four industries that were seriously affected by COVID-19 will restore their normal employment as in 2019.

IV. ANALYSIS

4.1 Frequent Pattern Mining and Association Rules

We started by evaluating the job-related data from the job search website. In our evaluation, we mainly mine and analyze the (1) positions provided by employers from January 2020 to November 2020 to help job seekers understand the vocational skills they possess to find a job. Also, we will explore (2) the company offering the position to help job seekers determine whether their ideal place of employment will offer the position; (3) The job address helps the job seeker to determine whether the geographical location of the job is appropriate. Finally, dig (4) the job category and integrate the above three attributes to find out which type of work provides more jobs under the epidemic situation which means that people who study related majors are more likely to get jobs. Besides, this can also help infer which types of work are more needed or less affected during the epidemic. After finding frequent patterns, we apply association rules to them to obtain the correlation between the above four attributes and make some reasonable inferences.

Based on the work-related data from January to November 2020, we can get that engineering-related jobs are provided with the most among all positions offered which is not surprising since most engineering jobs can work in distance. As long as you own computers, you can still communicate with each other well online. However, we surprisingly find 3 of the top 8 positions offered are related to sales. Because of the pandemic, people need to maintain social distancing, which means that places like shopping malls that sell non-essential goods will be greatly affected. Additionally, through more detailed observation data, we also found that many companies that provide corresponding sales positions are related to daily retail rather than non-necessities such as

clothing and luxury goods which makes sense since people still need to purchase daily necessities and food. From Figure 1, we can see more briefly and clearly what related jobs employers provide.

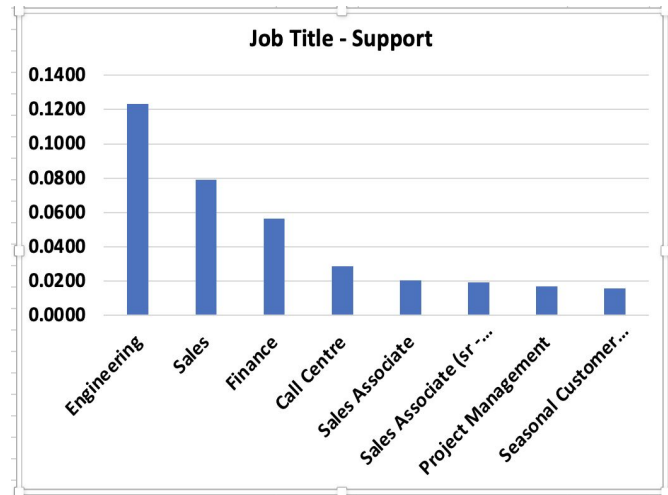


Figure 1. Top 8 provided jobs between Jan. and Nov. 2020

We have observed that more than half of the top 10 companies that provide jobs most frequently are healthcare-related companies and especially Healthcare, the first of them, has nearly 30% support. This shows that under the pandemic, we urgently need all kinds of medical talents. At the same time, we found that companies such as Deloitte Canada provide auditing, taxation, consulting, financial consulting and risk consulting services and banks such as Scotiabank provide relatively more positions. This makes sense because people still need to deal with these trivial matters in their daily lives. Figure 2 can help to see the big difference between the percentage of different companies.

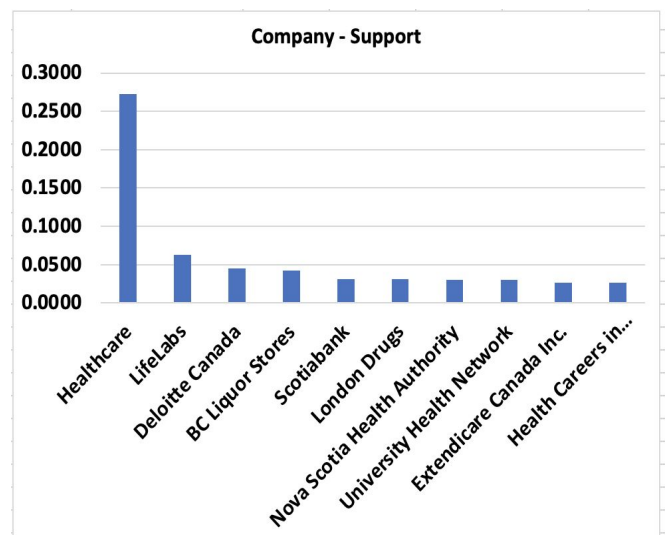


Figure 2. Top 10 companies with the most jobs

We also observed some results based on the location attribute. Although Ontario, B.C., and Quebec has a more serious epidemic situation as a whole, they still provide

relatively more jobs than they did before the epidemic. Especially in Toronto, the number of jobs provided significantly exceeds that of other cities. This also shows that Toronto is still the place that provides the most jobs as before the epidemic. According to Figure 3, the number of jobs provided by the remaining cities has not changed much, and has decreased in a relatively small range.

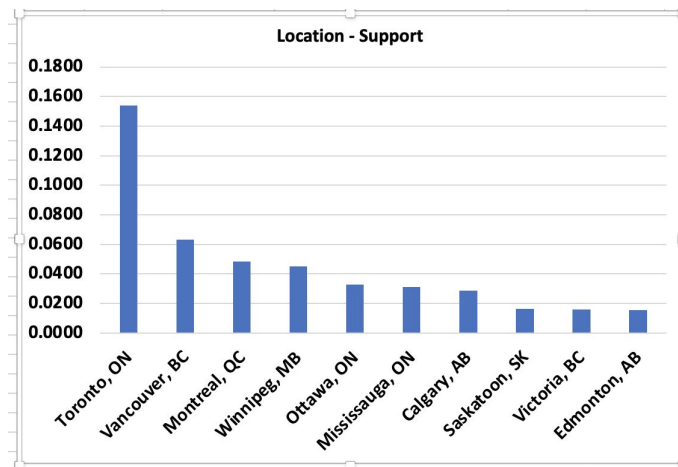


Figure 3. Top 10 cities with the most jobs

By observing the results of frequent patterns of category attributes, we were surprised to find that retail type jobs actually ranked first among them. This may be due to strict epidemic prevention requirements; many supermarkets or retail stores need more manpower to manage and provide services. Information technology and medical work ranked second and third respectively. The reason why information technology ranks second may be that it has a relatively large demand itself. Secondly, information technology jobs can be better divided and communicated well through the Internet, so it is less affected by the epidemic. The large demand for medical work is very normal. Due to the impact of the epidemic, medical teams everywhere are in relatively short supply. Figure 4 provides brief information about the rank of frequent pattern support of category attribute.

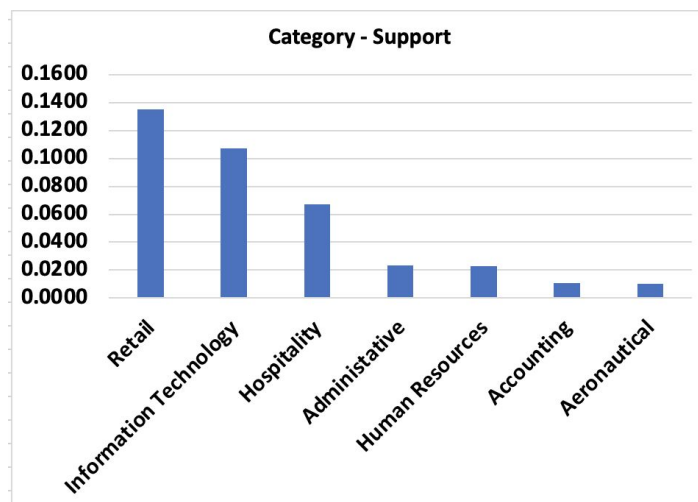


Figure 4. Top 7 categories of work with the most jobs

From the association rules we can observe that many cities such as Winnipeg, Toronto, and Saskatoon are all correlated with health science or health care which fully indicates that under the influence of the epidemic, there is a great demand for medical stuff in many places including the pharmaceutical industry. In addition, through association rules, we better know that companies like BC Liquor Stores or London Drugs provide relatively more retail-related jobs such as sales which helps us better understand why retail-related work is frequent.

4.2 Statistical Analysis

Based on the value of ISI, according to the employment database from Statistic Canada, the top 4 industries that were tremendously affected by COVID-19 are:

- (1) Accommodation and food service: ISI = 62.48%
- (2) Information, culture and recreation: ISI = 23.58%
- (3) Construction: ISI = 20.64%
- (4) Wholesale and Retail Trade: ISI = 19.89%

The calculation results actually show that the sector 81 - Other service (except public administration) has the 4th largest ISI value of 20.90%. However, by the definition of this sector, it includes sub-sectors that cannot be classified into any other industrial categories (i.e. maintenance, personal service, etc.). There is no proper method to distinguish then integrate them with other categories due to the weak interrelations and lack of data. Therefore, we are here discussing wholesale and retail trade instead.

Even though the first case that a Canadian was infected by COVID-19 appeared in January 2020, the LMI data shows the dramatic decline occurred in February 2020. According to the database of seasonally adjusted employment by industry and month from Statistic Canada, the number of the total employed population maintains a steady trend from 2017, until it started to become less than the average number in 2019 at March 2020. The overall number of employment has started to increase since April 2020. Therefore, for the chosen top 4 industries, we performed data mining to certain common job boards, with the data from April until November this year (due to lack of data for December 2020) in the employment statistics to estimate the labor market of December. By using the employment data in 2019, we will predict the labor market of 2021 and estimate when these industries will restore their average employment status as in 2019, which is before the first COVID-19 case was found in Canada.

1. Accommodation and food service

This industry is concerned with providing short term lodging and complementary services to travellers, as well as establishments that prepare and serve meals. Examples of careers that fall under this category are hotel workers, boarding house operators, waiters, and chefs.

The main reason this industry was affected is that due to the global pandemic, there has been a significant decrease in travel due to travel restrictions. This directly affects accommodation services because

their main source of income comes from travellers. In addition, a lot of restaurants have been forced to cease their dine-in services, to reduce spread, so that would also affect the stability.

2. Information, culture and recreation

This industry is concerned with providing entertainment to their clients, either by live performances or by recordings. Additionally, this category also deals with telecommunications and data hosting services. Examples of careers that fall under this category are recording studio operators, news anchors, web hosting, and publishers.

A primary reason this industry would be affected is that most live performances were cancelled to reduce spread. In a similar vein, in-person conventions had to be canceled, since large in-person gatherings were banned.

3. Construction

This industry deals with various aspects in the field of construction. Examples in this field include architects, engineers, trade contractors, and electricians.

A reason this industry was affected is that due to social distancing requirements, the number of workers on a building site had to decrease. Additionally, since a lot of construction workers tend to be of an older age [11], they may have stopped working under the concern of being at risk to COVID-19.

4. Wholesale and Retail Trade

This sector is made of establishments that wholesale merchandise to other businesses, as well as those that work in front-facing retail stores. Examples in this industry are warehouse workers, industrial machinery salespeople, cashiers, and non-store retailers.

A reason this industry was affected was because of the fluctuations in the levels of restrictions, if the restrictions were high, fewer customers were allowed in the store at once, which meant that fewer employees were needed to help address customers' needs. In addition, there has been a large push for businesses to implement remote working to encourage employees to work from home, which means that fewer supplies are needed in office spaces, like water coolers for instance. As such, there is a lower demand for wholesale services.

more about the jobs in demand to make sure whether the offered jobs meet their expectations as well as better prepare themselves to find jobs during the COVID-19 era. We analyzed the results of these three attributes separately, each combined with another attribute keyword, to explore the relationships among the particular affected industry or category and such attributes and support reasonable explanations.

First, according to the analysis of the attribute job title, we found that there are three job titles that occurred with high supports. The most frequent job title is "forklift operator", which occurs with the keyword "recording", so this type of job belongs to the third top affected category or industry—construction. This proves that although the category of construction is greatly negatively affected by COVID-19, the job of forklift operator in this category is still in demand. It is not surprising because: (1) industries always urgently need employees to do such job that required heavy physical work but not much in the degree of education or work experience, and (2) forklift operators are responsible for operating and managing industrial trucks to load and unload materials and deliveries and move them to and from storage areas, machines and loading docks, into railroad cars or trucks or storage facilities. This job is not limited by the requirement of maintaining social distance and thereby is lightly affected by COVID-19. In addition, we noticed that almost all forklift operator jobs are provided by the company Cosma International located in Milton, ON. Cosma is a company that provides a comprehensive range of body, chassis and engineering solutions to global customers. ON has always been the province with most large companies and most job opportunities. The second and third most frequent job titles are "nutrition aide (food delivery)" (with keyword food) and "producer" (with keyword recreation), which belongs to the first and second top affected industries "accommodation and food service" and "information, culture and recreation" respectively. The results can be explained by the fact that food is still in demand as a necessity of life. Especially during the COVID-19 era, when transportation is inconvenient, people prefer to order food online and select delivery rather than go out to eat in the restaurant, so the job of nutrition aide or food delivery is needed even under the impact of COVID-19. The producer is one type of work that can work in distance, so the job of producer showed high support in Figure 5 below.

4.3 Frequent Pattern Mining on Most Influenced Sector

Now we conducted data mining on the job-related data in the top four industries that were tremendously affected by COVID-19, namely, accommodation and food service, information, culture and recreation, construction, and wholesale and retail trade. This time we focused on three attributes: (1) job title, which offers the specific title or work position of occupations in the company or industry (2) company, which provides the information of the job provider of the occupations (3) location, which offers the workplace of the posted job. All these attributes help job seekers learn

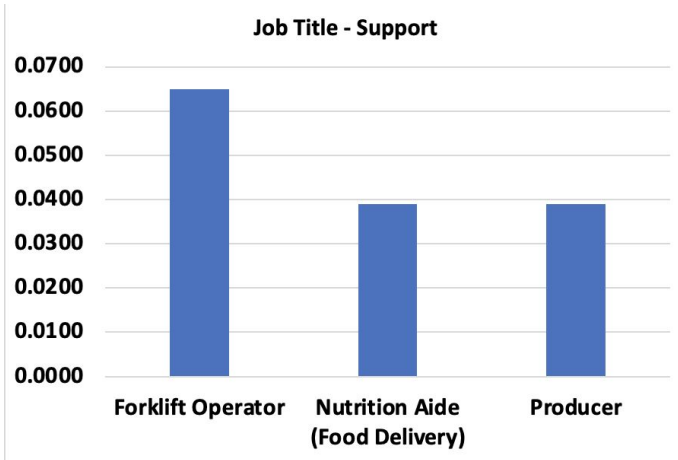


Figure 5. Top 3 jobs in the most affected industries

As for the attribute of the company, we observed that six of the eight top companies belong to the affected industry of information, culture and recreation. On the one hand, it shows that the information, culture and recreation industry are recovering to a certain extent. On the other hand, it reveals that most occupations in the information, culture and recreation industry are relatively concentrated and offered by several big companies. The results for the attribute of the company are shown in Figure 6 below.

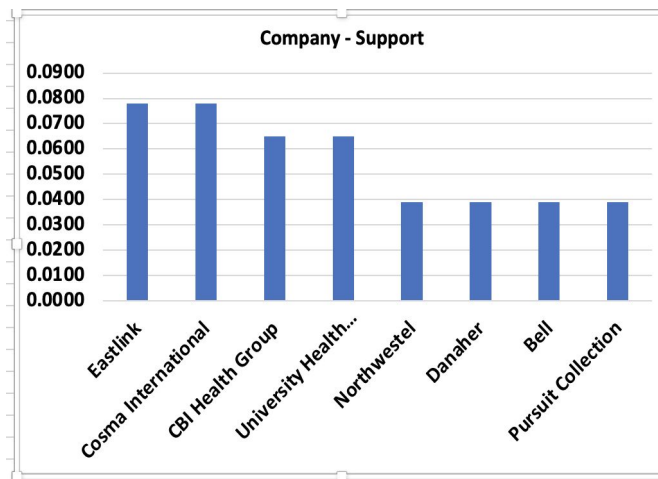


Figure 6. Top 8 companies in the most affected industries

We also analyzed the attribute of the location. Consistent with what we concluded in the previous part, although the provinces of ON and BC suffered from a severe COVID-19, they still offer the most job opportunities, mainly in two major cities in Canada, Toronto and Vancouver. It is worth noting that the province of NS provides relatively more jobs in these severely affected industries than in the overall data, which reflects that NS province is less affected by COVID-19 as a whole. Besides, the ranking of QC province is lower in these highly affected industries than in the overall industries. Considering the fact that Quebec suffers a serious epidemic situation, this result may prove that these industries are particularly affected by COVID-19 in QC and the impact is more severe than in other provinces. The results for the

attribute of the location are shown in Figure 7 below.

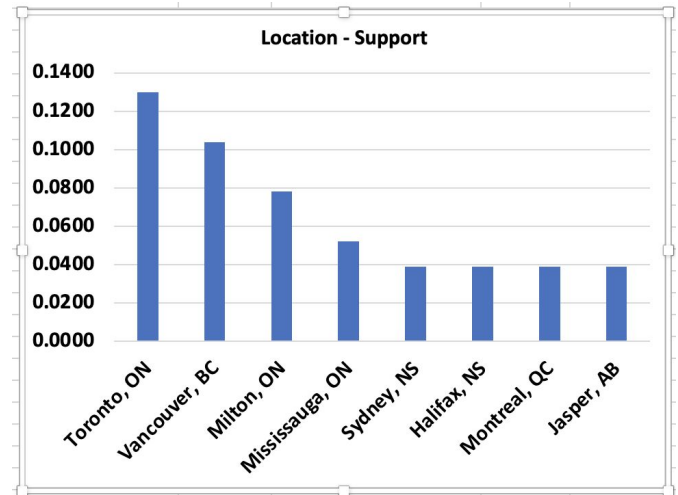


Figure 7. Top 8 cities in the most affected industries

4.4 Predictions

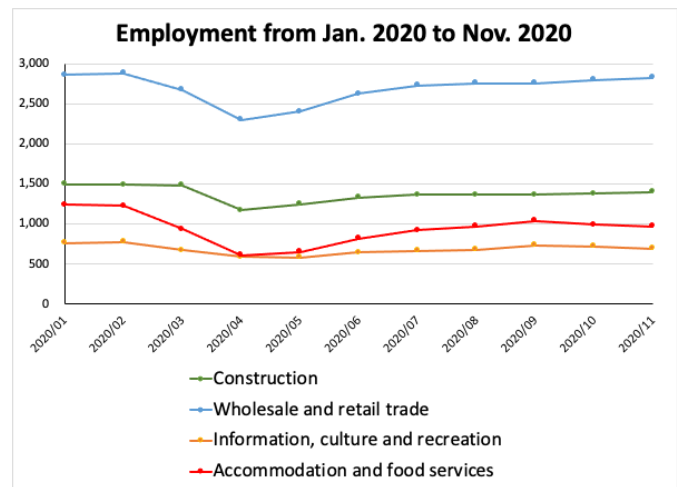


Figure 8. Employment from Jan. 2020 to Nov. 2020

From Figure 8 we can see there are clear declines in the first quarter this year, reaching a bottom in April 2020. According to the news, the first COVID-19 case was found in Toronto on January 25, 2020 [12], at which the labor market was not affected yet. However, due to the high infectivity of the COVID-19 and the lack of attention to its threat, the public was not in proper protection resulting in a rapid spread of the virus from several cases to a massive infection all over the whole country. Then, the Canadian Federal Government decided to launch a restricting entry order on March 18, 2020. With several lockdowns ordered by provincial governments, the economy has a slow increase after experiencing the bottom in April, but it still takes time to restore the situation as the employment was in 2019.

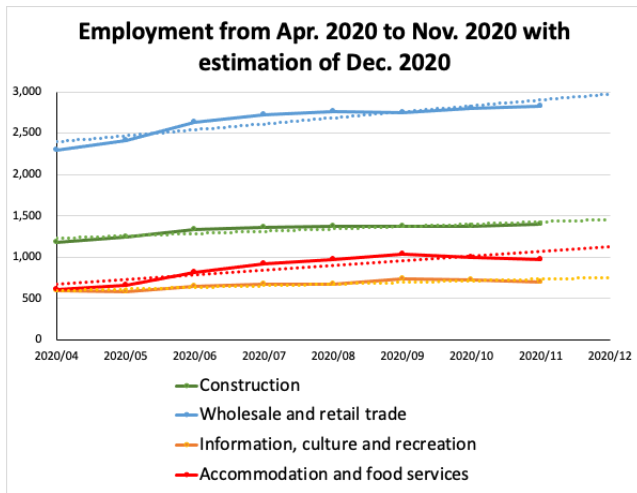


Figure 9. Employment estimation of December 2020

Due to the turning point existing at April 2020, and Figure 9 shows that the employment status has no dramatic rise or declines since April. Therefore, this part of data from April to November was used to perform the estimation of December 2020, which was labelled at the rightmost end of each dotted line.

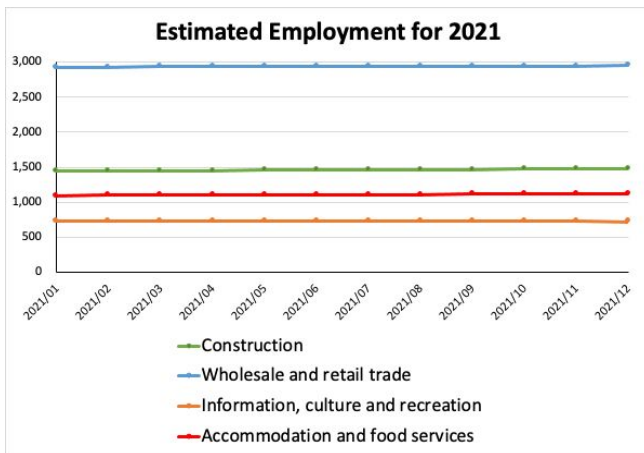


Figure 10. Estimated Employment for year 2021

In the prediction, we used employment data from 2019 as a reference to estimate the employment situation for the chosen four categories. As the COVID-19 was not found in the whole of 2019, plus the first thing for affected industries is to restore their employment back to what they were in 2019, Figure 10 shows that this prediction is performed by using trendlines from data in 2019 based on the estimation of December 2020 to generate an overview of next year.

With the statistical data of employment in 2019, we also have the average number of employment for the chosen four categories. As mentioned above, the prediction section also includes an estimation of when the four industries that were seriously affected by COVID-19 will restore their normal employment as in 2019.

Assume that the COVID-19 will be properly controlled in 2021, according to the news this December that Health Canada approves Pfizer-BioNTech COVID-19 vaccine [13],

the labor market will return to normal. For the chosen four industrial categories, here are the calculation results show that when they will restore their average employment status as in 2019:

- (1) Accommodation and food service: July 2024.
- (2) Information, culture and recreation: unknown, since the trendline of estimation keeps decline slightly.
- (3) Construction: April 2021.
- (4) Wholesale and Retail Trade: December 2020.

The above results tell us that Wholesale and Retail Trade is the first industry that became as normal as before the COVID-19 outbreak. The reason could be it is highly essentially demanded by the public. A good example is even though many restricted requirements are applied, such as must wearing a facial mask, sterilize hands before accessing stores, etc., grocery stores have never been completely closed during the period of lockdown. Accommodation and food service may require a rather long period to be back to normal, since they are involved with social contacting (i.e. spend a night in a hotel, or dining in a restaurant). This could contain many potential dangers that may cause infection being spread since there may exist trust issues to the local hygiene situations and the risk of crowding with strangers.

The estimated restoring times actually correspond to the ISI values for the four industrial categories above. Besides Information, culture and recreation lack predictable support, since they are the least related to basic demands of mankind, Wholesale and Retail Trade has the lowest ISI value among the four hence it is calculated and estimated to be the first COVID-19 impacted industry to restore its employment situation.

V. CONCLUSIONS, LIMITATIONS, AND FUTURE WORK

In this article, we first conduct frequent pattern mining on recruitment information from job search websites. By mining and analyzing the attributes of 4 types of jobs: job position, company providing the job, job location, and job type, we can know which companies provide more work related to what type, what location, and what main content under the epidemic. It can provide job seekers with more comprehensive and macro job information. In addition, we can also use these frequent patterns and association rules to gain an understanding of the overall state of the current work under the epidemic. The Industrial Stability Indicator (ISI) is a new introduced concept that measures the stability of an industry which can be expanded to the entire labor market. To give a proper description of how COVID-19 impacts on the labor market, ISI value for each industry will numerically show the degree of influence. Through the calculation of industrial stability, we found that the more an industry is related to the basic demand of mankind (i.e. surviving and living), the quicker this industry will be back to normal once the world event that affects it (i.e. COVID-19) starts to be controlled. In other words, the speed of an industry returning to its pre-COVID level of employment is positively proportional to its correlation to the survival needs of human

beings.

There exists some limitations in our analysis. First, due to the lack of complete data for the numbers of all industrial categories each month, we are unable to make a precise prediction from the past. There is only one data source that provides limited records of past job opportunities, and most of the majority of job boards such as Job Bank, Indeed, Glassdoor, etc. do not have any archives that keep the posted job records longer than a year. Moreover, any records that were posted before 30 days will not show their real post dates. These brought difficulties to our research hence we had to perform based on what we have.

With the volatility of the COVID-19 situation, there exist many ways this work can be further extended. As the progress of months, it can be determined how accurate the prediction is for the specific industry in terms of how long the trend takes to return to pre-COVID levels. Additionally, the methods of analysis can be extended to apply in other countries, to determine if the location has an effect on the findings.

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