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Canadian Jobs amid a Pandemic: Examining the Relationship between Professional Industry and Salary to Regional Key Performance Indicators

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***Abstract*—The COVID-19 pandemic has contributed to unprecedented rates of unemployment and greater uncertainty in the job market. There is a growing need for data-driven tools and analyses to better inform the public on trends within the job market. In particular, obtaining a "snapshot" of available employment opportunities mid-pandemic promises insights to inform policy and support retraining programs. In this work, we combine data scraped from the Canadian Job Bank and Numbeo globally crowd-sourced repository to explore the relationship between job postings during a global pandemic and Key Performance Indicators (*e.g.* quality of life [QOL] index, cost of living) for major cities across Canada. This analysis aims to help Canadians make informed career decisions, collect a "snapshot" of the Canadian employment opportunities amid a pandemic, and inform job seekers in identifying the correct fit between the desired lifestyle of a city and their career. We collected a new high-quality dataset of job postings from jobbank.gc.ca obtained with the use of ethical web scraping and performed exploratory data analysis on this dataset to identify job opportunity trends. When optimizing for average salary of job openings with QOL, affordability, cost of living, and traffic indices, it was found that Edmonton, AB consistently scores higher than the mean, and is therefore an attractive place to move. Furthermore, we identified optimal provinces to relocate to with respect to individual skill levels. It was determined that Ajax, Marathon, and Chapleau, ON are each attractive cities for IT professionals, construction workers, and healthcare workers respectively when maximizing average salary. Finally, we publicly release our scraped dataset as a mid-pandemic snapshot of Canadian employment opportunities and present a public web application that provides an interactive visual interface that summarizes our findings for the general public and the broader research community.**

***K*eywords** Job Market · COVID-19 · Key Performance Indicators · Employment · Geolocation

I. Introduction

The COVID-19 pandemic has disrupted personal lives and economies worldwide. Studies on Canadian businesses have reported that the initial impacts of the pandemic resulted in a 15% decline in employment [1], [2]. A study by Akkermans *et al.* demonstrated that both positive and negative career shocks will trigger individual job search processes [3]. In the context of the COVID-19 pandemic, the career shock of unexpected layoffs has impacted many individuals, leading to uncertainty. In lieu of these uncertainties, data-driven tools can be used to help identify new opportunities, making the job search a more informed process. In this paper, we present a mid-pandemic "snapshot" of available employment opportunities and produce data-driven tools and analyses on the Canadian job market during to the COVID-19 pandemic. We incorporate Key Performance Indicators (KPIs) such as the quality of life (QOL) Index as additional features to enrich our analyses.

A. Related Literature

Web scraping applied to job postings has been used as a data collection mechanism in various studies. For example, it has been used to determine skill set requirements for medical and white collar occupations [4], [5], and to inform curriculum decisions for computer science courses [6]. Amid the ongoing pandemic, web scraping approaches have been applied to job market postings of various countries to study the impacts of COVID-19 in the US, Sweden and Mexico [1], [7]–[10].

Dias *et al.* acquired historical and live job postings from Find A Job (an American public website operated by the Department for Work and Pensions) through a combination of web scraping and Freedom of Information requests. They noted an overall 70% drop in new vacancies from 2019 to 2020 across industries [1]. Forsythe *et al.* analyzed job posting data from Burning Glass Technologies as well as unemployment statistics from the US Bureau of Labor Statistics during the beginning of the COVID-19 pandemic. They found a sharp decline in job postings during the initial wave of the pandemic (44% decrease across the first 1.5 months of the pandemic) [7].

This finding was mirrored in Sweden where Hensvik *et al.* found a 40% decrease in job postings across four months during the early COVID-19 outbreaks [8]. They analyzed data on a job board called platsbanken.se which is maintained by the Swedish Public Employment Service. However, the authors augmented their analysis with click-through data which was inaccessible by data scraping, finding that the average clicks per user had also decreased during this period.

Finally, Campos-Vazquez *et al.* scraped data from an undisclosed top-five job board in Mexico to analyze the posting trends in Mexico during the early stages of the COVID-19 pandemic. They provided a comprehensive analysis on the

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job market trends, detailing an increased demand for low-skill workers [9]. Similar analyses on the impacts of the Great Lockdown on the Mexican Job Market was conducted by Hoehn-Velasco *et al.* where it was reported that the overall job market in Mexico contracted by 5% during the first 9 months of the Great Lockdown [10].

Our work differs from these works in three respects: (1) our work considers the job market trends in the Canadian economy; (2) our work considers the trends *mid-pandemic* in complimentary to the early-pandemic analyses of the three previously cited works; and (3), we consider KPIs in our work to motivate actionable analyses by job-seekers, policy-makers, and the broader research community.

B. Key Performance Indicators

Important to this work are KPIs, values that represent a performance metric that might be of interest to prospective job seekers [11]. We collected KPI data from Numbeo, a crowd-sourced website which gathers, aggregates, and publishes statistics from cities around the world [12]. In this work, the KPIs considered are the *QOL index*, the *traffic index*, the *affordability index*, and the *cost of living with rent index*.

The *QOL index* (KPI_q) is a composite of several other KPIs. Equation 1 defines the calculation used for determining the QOL index [13]:

$$\text{KPI}_q = max(0, \frac{p}{2.5} - h - \frac{c}{10} + \frac{s}{2} + \frac{m}{2.5} - \frac{t}{2} - \frac{2n}{3} + \frac{l}{3} + 100) \quad (1)$$

where p is the purchasing power index, h is the average house price to income ratio, c is the cost of living index, s is the safety index, m is the health index, t is the traffic index, n is the pollution index and lastly, l is the climate index. The constants in Equation 1 were selected empirically by Numbeo and are subject to change over time [12].

The *traffic index* (KPI_t) is a measure of the impact of traffic of a given city. The larger the index value, the worse the impact of traffic is within the considered region [14]. The KPI_t of a given city is given as [14]:

$$\text{KPI}_t = t + \sqrt{t + (t - 25)^e} + \sqrt{c} + \sqrt{i} \quad (2)$$

where t is an index of the average time (in minutes) spent in compute per day, c is the CO_2 emission index, and i represents an index encompassing the inefficiencies of traffic. The value 25 in Equation 2 was selected empirically by Numbeo. This value represents an assumed 25 minute commute time before an individual begins to be dissatisfied with the commute [14].

The *affordability index* (KPI_a) refers to the "inverse of mortgage as percentage of income" [15]. The *cost of living plus rent index* (KPI_c) is an indicator of the consumer goods and rent prices. The index value is relative to the cost of living in New York City and replicated from the work in [16].

C. Problem Definition

As a result of the COVID-19 pandemic and the transition towards a remote workforce, there has been a migration of individuals moving away from city centers [17]. Consequently, this work introduces a web tool that helps individuals identify Canadian cities or provinces best suited to their needs with respect to their KPI of interest.

The current job market was analyzed by scraping job posting data from the Canadian Job Bank [18]. This is a service provided by Employment and Social Development Canada to help Canadians find employment opportunities across the country. Each job posting contained information such as the job title, compensation, location, and, importantly, the National Occupation Classification (NOC) number.

The NOC number is Canada's national system for describing occupations and identifying the skill levels of a given occupation [19]. A dataset containing all NOC numbers, related occupation class, skill levels, and description was collected from the Open Canada online database [19], [20]. We considered the Job Bank to be a representative sample of the hiring ecosystem of the mid-pandemic Canadian job market as it collaborates with provincial governments and external job boards to gather job postings.

II. Data & Methodology

The following section outlines all of the data sources considered — their means of acquisition, aggregation, transformation, and cleaning — and defines the ethical concerns and reproducibility of this work. A conceptual overview of this processing pipeline is illustrated in Fig. 1.

A. Approach

Our work explores employment-based trends that could be used to provide insights on provincial, territorial, and city characteristics that might inform individuals when relocating. This objective was realized by formulating and answering descriptive, exploratory and causal questions using the data we collected. Our aim was to combine the KPI data with the job posting data to form a high-quality dataset that can be used to answer these questions. Our analysis is unique as it considers the hiring salaries and therefore is future-facing, in contrast to other analyses that use historical salary information.

B. Data Collection

The steps for Data Collection and Data Cleaning are depicted in Fig. 1. The first step in the data collection process was to scrape the job details for each listing on the job board. We began by collecting 91,251 hyperlinks of Job Bank job posts and then extracted the relevant HTML for each of the collected hyperlinks. Finally, we extracted relevant values from the scrapped HTML components, such as job title, pay, and geolocation, and transformed it into a CSV format. Job posts were dropped if they were no longer available on the job board, leaving a total of 64,945 rows.

The second step was to obtain the NOC dataset from Open Canada online database [20]. This dataset was used to match the NOC numbers from each job posting to a job classification title. A Python script was written to map a NOC designation to its job skill level according to the National Occupational

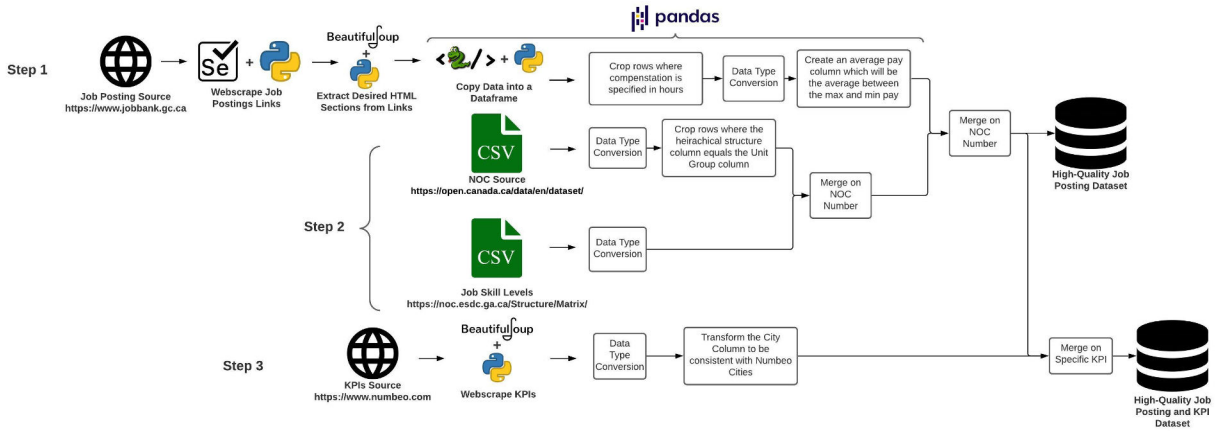

Fig. 1: **Overview of the data Acquisition, Cleaning and Transformation Pipeline.** Two datasets were created, one which merges data from job postings from the Canadian Job Bank with NOC-related fields and another which incorporates data from the first dataset and a specific KPI found sourced from Numbeo. The job postings and KPIs from Numbeo were web-scrapped using Beautifulsoup4 and/or Selenium. Python was used throughout the pipeline to scrape, clean, and transform the data into a high-quality dataset.

Classification Matrix [20]. The final step for the data collection process was to extract KPI values from Numbeo for Canadian cities. All scripts were written using the Python language with the Selenium and BeautifulSoup libraries.

C. Data Cleaning

The job posting, Numbeo, and NOC data were cleaned and joined to produce an aggregated dataset. An overview of the complete data processing pipeline is illustrated in Fig. 1. Each row of the job posting data that did not specify the job's compensation in hours was removed. Where a maximum and minimum hourly pay was specified, the average was used. For the NOC dataframe (step 2 in Fig. 1), all rows where the *Hierarchical Structure* did not equal the *NOC Unit group* were deleted. Each NOC number belongs to a specific hierarchical category. Each category generalizes what field of work is accomplished. There are four levels of NOC numbers and the Unit group is the most precise NOC number. Only the NOC numbers which represent a Unit group were kept because only the Unit group codes represented a full NOC code for an actual occupation title.

Finally, the job-level dataframe and NOC dataframe were merged with the job posting dataframe on the NOC column resulting in our finalized job posting dataset. The KPI data was joined by geolocation. Our code is open-sourced here: [21].

D. Ethical Concerns

Risks and ethical concerns associated with this paper involve the legality of scraping websites for information to generate the data set. Websites may implement a variety of solutions in order to safeguard and protect against potential web scraping and unauthorized data access [22]. Techniques such as defining a terms of service policy can restrict the actions that users perform on the platform [23]. For all websites scraped in this paper, the terms of service indicates non-commercial reproduction is allowed without charge or further permission if due diligence is ensured and the original source of the data is referenced [24] [25].

In accordance with ethical scraping practices [22], we ensured a sufficient sleep-time delay was set between requests to avoid overloading the web servers [26]. The remaining datasets were acquired through various open-source repositories.

One concern with the analysis was the potential bias in the job data collected. Jobs of certain skill levels may be over-represented or under-represented. For example, as a limitation to this work, if we assume a uniform distribution of jobs by skill-level, our data has an over-representation of NOC Level B jobs. This could potentially lead to incorrect recommendations to our readers. In addition to this skill level over-representation, some provinces have a proportionally higher number of jobs. As an example, there are very few job postings from the territories and East-coast provinces compared to those in populated provinces such as Ontario. A future improvement to this paper would be to reduce job level bias by collecting job postings from various Canadian job boards and using a frequency normalized evaluation.

III. Results & Discussion

At the mid-point of the COVID-19 pandemic, it is critical to explore the employment landscape to better inform governmental policy. We analyze a snapshot of Canadian employment opportunities from 2021-03-25 to 2021-04-04.

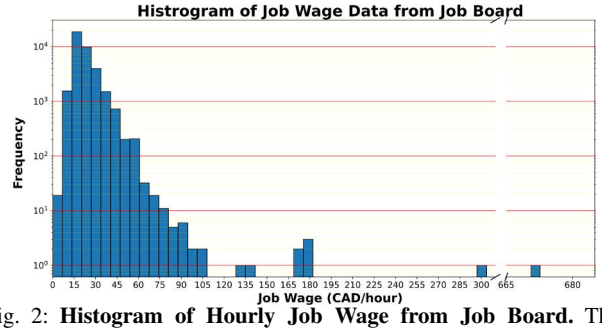

Fig. 2: **Histogram of Hourly Job Wage from Job Board.** The graph displays the distribution of the job wages proposed by the job postings collected. The job wages are measured in $CAD/hour. The modal wage is $20/h and most wages distribute around this wage.

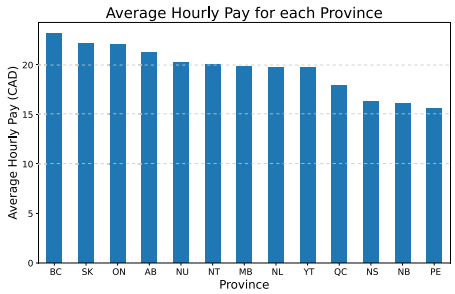

Fig. 3: **Distribution of all wages across all Canadian Provinces and Territories during the Pandemic months.** The data depicted was collected from job posting on the Canadian Job Bank.

In Fig. 2, we illustrate a histogram to visualize the distribution of all wages on the job board. A modal $20CAD/h wage is immediately apparent and it is important to note the logarithmic frequency axis indicative that the vast majority of wages are distributed proximal to the distribution mode (Fig. 2). Notably, the number of wages in the [0,10] range may suggest that our study under-represents minimum wage and/or tip-based employment.

Fig. 3 visualizes the distribution of hourly wages across the provinces and territories, ordered in decreasing average wage. British Columbia, Saskatchewan, and Ontario appeared to have the job postings with the highest average hourly pay, while Prince Edward Island had the lowest. This would make certain provinces appear more attractive than others if the only criteria considered is average pay, a regional proxy for economic prosperity [27].

Conceptualizing an "ideal" region or city of employment is subjective and depends on individual worker's priorities. We pose several questions to explore how certain KPI's may affect job seeker decisions. The metrics considered include job compensation, the QOL index, city emissions (pollution index), and the level of health services available (health index).

A. What is the distribution of the number of jobs with respect to their job levels across provinces?

To address this question, we visualize in Fig. 4 the total jobs in a province based on job level. Job levels refer to the skills required to perform a job. These job levels were obtained by mapping the National Occupation Classification (NOC) for each job on the Canada Open Job Bank with the NOC dataset retrieved from Statistics Canada Open Government. The NOC values group jobs into five skill levels shown in Table I.

TABLE I: NOC levels

Level	Description
0	Management jobs
A	Professional jobs requiring a university degree
B	Technical jobs and skill trades requiring a college diploma or apprentice training
C	Intermediate jobs requiring high school diploma or job-specific training
D	Labour jobs requiring on-the-job training

Fig. 4 shows that the number of total jobs posted is disproportionate based on province. Provinces such as British Columbia, Alberta, Ontario, and Quebec host many of the major metropolitan hubs within Canada and resulting in more postings from these regions. Additionally, British Columbia, Quebec, Ontario, and Alberta have more Technical and Intermediate jobs (levels B and C) than other job levels, while P.E.I. has more Labour jobs (level D) than any other province or territory. These results indicate that P.E.I. has a high demand for Labour jobs relative to its population size.

B. What is the distribution of the average salary of jobs with respect to their job levels across provinces?

Fig. 5 plots the distribution of the jobs by skill level for each province against the average starting salary. This distribution demonstrates that for jobs of skill levels B, C, and D the average pay is approximately consistent across the country. From this data it is evident that working in a higher skilled position pays more when working in Newfoundland and Labrador, the North West Territories, Nunavut, Prince Edward Island and Saskatchewan. These provinces may provide higher pay for these positions as they need to entice highly educated and trained individuals to move to more rural, northern, or lower-resource areas.

C. How is QOL index related to hiring salary?

To address this question, Fig. 6A depicts the average pay to QOL index for various cities in Canada. The plot has a slight positive (though negligible) correlation between the average hiring pay and the QOL index ($R^2 = 0.027$). This slight correlation is likely explained by the fact that the QOL index accounts for the cost of living in the city, which scales with average hiring pay. Mississauga, ON and Edmonton, AB are

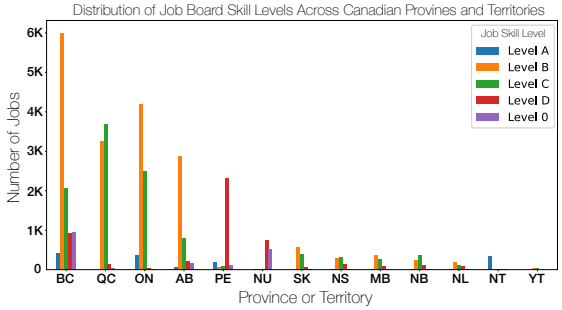

Fig. 4: **Distribution of Job Skill Levels on the Job Board across Canadian Provinces and Territories.** The provinces and territories are sorted by the number of jobs across job skill levels from highest to lowest for the month of March 2021.

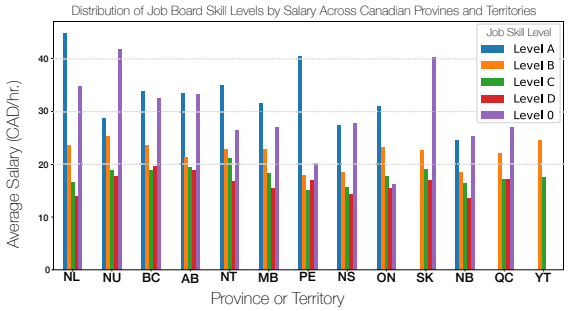

Fig. 5: **Distribution of Salary on Job Board by Job Skill Level across Canadian Provinces.** The provinces and territories are sorted by salary across job skill levels from highest to lowest for the month of March 2021 based on the Canadian Job board.

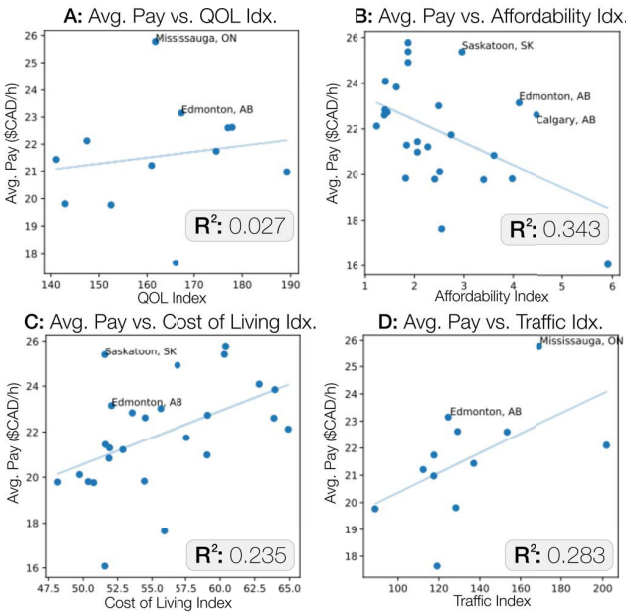

Fig. 6: **Correlation of Average Salary against KPIs for Canadian Cities.** (A) compares average pay & the QOL Index, (B) compared average pay & the Affordability Index, (C) compares average pay & the Cost of Living Index, (D) compares average pay & the Traffic Index.

outliers with abnormally high average hiring pay to QOL index value. Therefore, if one wants to maximize their average pay and QOL, it is recommended that one moves to Mississauga, ON or Edmonton, AB.

D. How is the affordability index related to the hiring salary?

An ideal location to move should have a housing market that is affordable given the average job compensation for a city. Based on 6B, there is a negative correlation between the average starting salary and affordability index ($R^2 = 0.343$). Saskatoon, SK, Edmonton and Calgary, AB are the ideal places to live because of their relatively high affordability index in relation to their average salary. This ultimately means one can financially afford a better lifestyle working in these cities more than any other city in Canada.

E. How is the cost of living index related to the hiring salary?

Fig. 6C displays average pay versus cost of living plus rent index. The data shows that there is a positive correlation between the average pay and the cost of living plus rent index ($R^2 = 0.235$). This correlation makes sense because as the cost of living increases, the average pay will also increase. From the data, Saskatoon, SK and Edmonton, AB appear to have higher than average pay, while having a low cost of living index plus rent index; these cities are ideal to live in if one wishes to have a high income while having low cost of living.

F. How is the traffic index related to the hiring salary?

To address this question, Fig. 6D displays the traffic index per city and the average pay. There is a positive correlation between the traffic index and the average pay ($R^2 = 0.283$).

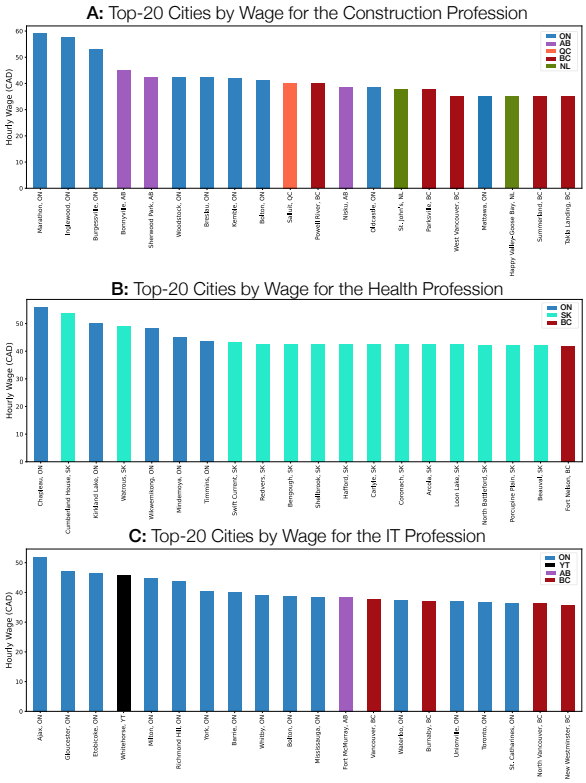

Fig. 7: **Highest Hourly Wage for Construction (A), Health (B), and IT (C) Professionals per Canadian City.** The data used to build each of these graphs was collected from the job postings web scrapped on the Canadian Job Bank during the pandemic. The title of each job posting was queried to determine if it contained industry specific keywords related to a given profession.

This is likely a result of potentially high correlations between commute time and wages against the increased number of workers in larger cities [28]. Cities that deviate from the mean in a beneficial way include Mississauga, ON and Edmonton, AB. This suggests that these cities are optimal if one's goal is to maximize average salary while minimizing commute time.

G. What cities are ideal with respect to the hourly wage for specific professions?

Cities generally attract certain industries. For instance, Silicon valley is famously known to have a developed, high-paying tech industry. For this reason, those looking to work in an industry may be drawn to particular provinces and/or cities. We provide a web application that allows for interested users to perform their own analysis. Fig. 7 shows some example graphs that users can generate for exploring various industries. We selected three professions of focus: the trades-focused construction profession, the pandemic-related healthcare profession, and the high-skilled IT profession. From this, we see that the highest mean hourly wages for the construction, healthcare and IT industries can be found in Marathon ON, Capleau ON, and Ajax ON respectively. Additionally, there seems to be a greater demand for health industry professionals in Saskatchewan. An important consideration when interpreting this graph is that

some cities might be biased by a lower number of job postings. In the future, a frequency-weighted wage averaging may be considered for better analysis.

IV. Interactive Web Platform

An interactive web platform was developed as a research tool using Dash Plotly. The tool was designed to allow users access to the processed data sets for further analysis and study with regards to a snapshot of the Canadian job market during the COVID-19 pandemic. The aim for the web platform is to provide an interactive data set of the Canadian Job market during a pandemic as a resource to the broader research community, policy makers, and ultimately, the general population. The web platform can be found here: Web Interface.

V. Conclusion

This paper provides Canadians and policy-makers with mid-pandemic job market insights needed to select a desirable work location when considering a number of factors such as QOL, traffic, cost of living, and affordability. When maximizing the average hiring salary while considering the KPIs analyzed, it was found that Edmonton, AB was a notable outlier among all categories considered and can thus be considered an ideal city of employment. For construction, healthcare, and IT professionals, when maximizing the average hiring salary, Marathon, Chapleau, and Ajax, ON are respectively the cities that rank highest. An interactive web platform was created to help researchers, policy makers, and the general population access the processed dataset of the Canadian industry during a pandemic. This promises to enable post-pandemic studies and highlight differences in the Canadian employment opportunity landscape.

This paper could be extended by gathering more job posting data from other external job boards. This would ensure that there is a larger sample of jobs to analyze and would help decrease the bias with regards to the type of industries posting jobs. In addition to existing interactive visualizations, more interaction features could be added to help better present the information. To support the replication of this work, all code and our dataset are available open-source: [21].

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