

PAPER 1 - AI/COVID-19/BUSINESS (PART I, II, III and IV)

Team Members: Eunryeong Sa, Kevin Wiersma, Paul Benoit, Hyunju Park, Pema Singye, and Muhammad Anis Jadoon

**Sentiment Analysis and Insight about the Increasing Use of Artificial Intelligence by
Businesses Amid the Coronavirus**

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Prepared by:

Pema Singye

Paul Benoit

Kevin Wiersma

EunRyoung Sa

Hyunju Park

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ABSTRACT

This research paper aims to gauge the public sentiment of the use of artificial intelligence (AI) by businesses during the COVID-19 pandemic to provide insights to decision makers in business and regulation of AI. Over 48,000 tweets were collected, from March 15 until November 15, 2020, using the search terms: “artificialIntelligence”, “coronavirus”, and “business”. Frequently used words included broad concept words (ie. economy, pandemic), technology related words (ie. automation, data), and affective words (ie. improve, help). Overall public sentiment was more negative (42%) than positive (31.8%) or neutral (26.1%). The eight most discussed topics were: AI, business, use of technology, technology, social aspect, COVID-19, big data, and global. When taking a closer look, public sentiment was mixed about AI and mostly negative about business and COVID-19. Business and big data were highly correlated, likely due to the significance of implementing big data on businesses during and after COVID-19. Business, global, and AI were the most closely clustered, indicating the importance of use of AI by global businesses, and another high correlation was detected among technology, use of technology, big data, and “COVID-19” implying great interest among the public and businesses to use big data and technologies to help handle the unique challenges of the current COVID-19 pandemic. Recommendations are presented on how to reduce the concerns of the public through investing in education and awareness around AI and by studying the implications of AI and big data within the context of the pandemic and its aftermath.

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I. INTRODUCTION

Since the first case of COVID-19 in Wuhan, China, in December 2019, as of November 2020, there are more than 61 million cases with over 1.4 million deaths around the world (“WHO Coronavirus Disease (COVID-19) Dashboard”, 2020). With such a speed and a magnitude of its spread, COVID-19 has caused an unprecedented social and economic disruption around the globe.

While the health care sectors were dealing with abrupt and overwhelming numbers of severe cases and deaths of COVID-19, governments had to opt for policies such as border closure, lockdown, and social distancing and most business sectors were affected drastically by those policies. The business sectors have been facing a major disruption in their business processes and models. The global and local supply chains have become unstable. Most employees are working and communicating remotely. With physical distancing, consumer behaviour has been changed which would impact the business strategies (Zhang D. et. al. 2020). The survival of business during and post COVID-19 pandemic depends on how quickly and efficiently they can adapt to this new business environment.

The use of artificial intelligence (AI) has been available in the business world in order to improve business efficiency and business decision making, however, the business challenges brought about by the COVID-19 pandemic accelerated the need for AI use in businesses. More companies are moving to cloud computing in order to accommodate employees working and communicating from home, and the centralization of corporate data and the rise of online shopping platforms and the subsequent data accumulation from all transactions will enable companies to develop a better AI capability (Kim T. 2020).

Another example of accelerated technology adoption during the COVID-19 pandemic is the dramatic increase in the use of social media platforms. With the lockdown and physical distancing, social media platforms have become an essential conduit for news, information, and

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connection, and the discussions and contents shared on social media platforms are a significant source to assess public sentiment (Zhang D. et. al. 2020). Twitter, in particular, is used by over 200 million users globally who share their opinions on the platform making it valuable for tracking and analyzing public sentiment (Tan et. al., 2014).

As the business environment and society are incorporating the use of AI more along with the COVID-19 pandemic, it is important to understand the public sentiment on AI usage in businesses to gain practical and valuable insights on the topic in order to improve on business decision making and practices during and after the COVID-19 pandemic. However, very little research has been done on this research topic.

The purpose of this study is to gain insights into public sentiments about the increased use of AI in businesses during the COVID-19 pandemic. This study aims to examine the public sentiment and discussion on the research topic using the Twitter social media platform and further to identify the main topics of discussion and their correlation. This study will help understand the overall public sentiment on the use of AI in businesses amid the COVID-19 pandemic, and contribute to the existing knowledge base on this topic. By providing insights into the public sentiment on the usage of AI by businesses, this study will help build better business strategies and decisions in order to improve business performance.

The followings are the research questions of this study:

Q1. What are the most frequent words used about AI usage by businesses during the COVID-19 pandemic?

Q2. What are the main topics and themes discussed about AI usage by businesses during the COVID-19 pandemic?

Q3. What are the public sentiments about AI usage by businesses during COVID-19?

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Q4. What is the relationship between the identified topics and themes on AI usage by businesses?

Q5. What are the correlations between the identified topics and themes on AI usage by businesses?

Q6. What are the trends in the topics and themes identified during the studies periods?

The literature review of this study includes a broader definition of AI and an overview of AI use in businesses. It also includes an overview of how AI is shaping the businesses during COVID-19 and on the use of social media to measure the public sentiment of AI use and the impact of COVID-19. The research methodology of this study described how data was collected, cleaned, and stored, and which digital media analytical tools were used. The data analysis of the study illustrated how the collected data was analyzed and explains which type of analyses were conducted. Finally, this study will discuss the interpretation of the study findings and their significance and limitations and will suggest future research considerations.

II. LITERATURE REVIEW

A. What is Artificial Intelligence?

Artificial intelligence can be categorized by its level of functionality: reactive machines, limited memory, the theory of mind, and self-awareness (Patel et al., 2020). Currently, only reactive machines and limited memory machines have been developed and these two types are used by business organizations.

Reactive machines make decisions based on information from the current situation (Patel et al., 2020). They possess no ability to learn from past experience because they do not evaluate past data to create predictions. Game-playing AI such as IBM's Deep Blue or Google's AlphaGo are examples of this type of AI (Chui et al., 2018).

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Limited memory machines are AI that incorporates memory storage and retrieval to augment their decision-making ability (Patel et al., 2020). These AI are capable of learning from historical data to form a model for future problem-solving. The majority of AI applications are of this variety, including image recognition programs (Savadjiev et. al 2018), autonomous vehicles (Gadam, 2018), and chatbots (Divya et al., 2018).

Both theories of mind machines and self-aware AI are theoretical concepts only and have not been developed for real-world applications (Patel et al., 2020). An AI with a theory of mind is able to form representations of entities, like individual humans, including the internal thoughts and feelings which motivate their behaviour (Çelikok et al. 2019). This is in contrast to limited memory machines which only use discrete data points for analysis. Self-aware AI would apply this holistic understanding to itself, achieving 'self-awareness' similar to a living person (Hintze, 2016).

B. What is the incumbent AI technology and tools available to businesses?

The utility of AI to businesses depends on both technology and the availability of data. Ransbotham et al. (2017) found that "No amount of algorithmic sophistication will overcome a lack of data" and many firms do not possess the data infrastructure on which to train artificial intelligence. For those firms that invest in AI, several training models and algorithms exist to hone an AI system using business data.

Machine learning is one paradigm for training AI. Put simply, machine learning is teaching a computer using examples rather than predefined formulas. These examples can be paired with their desired outputs as defined by a human trainer in a process known as supervised learning (Alzubi et al., 2018). If the objective is to design an AI that is able to find previously unidentified patterns, an unsupervised learning model is used instead (Alzubi et al.,

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2018). Multiple paradigms of unsupervised learning exist depending on the specifics of how the training occurs.

Deep learning is a particular type of machine learning that uses neural networks to train. A neural network is a way of organizing information into layers for analysis (Nguyen et al., 2019). By categorizing data using many layers of abstraction and discovering associations between data points, a deep learning algorithm doesn't require explicit examples to learn. This method requires massive amounts of data so these algorithms are developed by only the largest software companies (Nguyen et al., 2019).

C. How are businesses using AI?

A study conducted by MIT Sloan Management Review, in collaboration with The Boston Consulting Group, surveyed over 3,000 business executives, managers, and analysts on their expectations, understanding, and adoption of AI technology. The study found two main areas for AI adoption: processes and offerings (Ransbotham et al., 2017). Artificial Intelligence is increasingly being adopted by industries such as financial services, transportation and logistics, healthcare, and retail (Chui et al., 2018).

AI offers improved efficiency and lower costs within business processes. Usage of AI in supply chain management has grown dramatically in recent years. AI tools are assisting with addressing the major issues in the supply chain, which include coordination, collaborative demand planning, outsourcing relationships and business to business negotiations (Min, 2010). AI gives notification when a company has to re-order stock and helps in logistics, manufacturing, warehousing, and the accuracy of delivery of products to customers (Lingam, 2018). The financial service industry is implementing AI to reduce and prevent money laundering and fraudulent credit-underwriting by analyzing data available in their financial networks (Vedapradha & Ravi, 2019).

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AI offers improvements to customer service and product or service offerings. AI can assist physicians in making decisions about patient care. AI has the ability to improve via learning from large data sets and over time it will help to reduce human diagnostic and therapeutic errors (Sharma et al., 2019). In e-commerce, AI and algorithm tools handle customer data and predict the behaviour of consumers' purchases of products or usage of service (Lingam, 2018). Financial service companies are adopting AI-based chatbots to provide better customer service (Vedapradha & Ravi, 2019).

D. The Role of AI in Businesses during the COVID-19 Pandemic

One aspect of the COVID-19 pandemic is the unique effects it has on businesses all over the world. The current pandemic that our world is facing has caused one of the biggest disruptive events in history. This paper has discussed some of the uses and new technology that AI has created and how businesses have taken advantage of this. Now the discussion will be around the role of AI in businesses during COVID-19.

AI technology has played a helping role in the changes businesses have made since COVID-19 has entered countries' respective borders. "The SARS outbreak, often credited with giving rise to e-commerce giants, while companies such as American Express and Starbucks pivoted during the global financial crisis of 2008–2009 to digital operating models." (Candelon et al., 2020) Major changes in economies and businesses have come during major disruptive events, and as COVID-19 made its impact, economies have seen changes to businesses like never before. AI has played a major role in businesses' decision-making process. Many channels in economies are interconnected and when COVID-19 began, these relationships were broken. The closing of factories and limited workers have put a strain on supply chains all over the world. Effective supply chains are increasingly important to many businesses as it has now become difficult to judge supply and demand for many resources. "Extreme disruptions have devastating effects for business and supply chain performance" (Papadopoulos, Gunasekaran, Dubey, Altay, Childe, Fasso-Wamba, 2017). AI has played a major role in helping with the uncertainties in supply chain

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management. “On track to reach \$1.3 billion by 2024, the integration of [AI] and supply chain management applications helps automate decision making, improve efficiencies” (McCrea, 2019). Companies can benefit greatly by taking advantage of AI-powered applications to better judge how to adjust their needs for resources to ultimately save money and improve efficiency. This all contributes to major decisions businesses need to make in order to stay in operation.

Another major change that has come from the pandemic has been to the overall structure of businesses and how they operate. Needless to say, AI is at the root of some of these major changes. Many offices around the world have been shut down and businesses have become more digital than ever before. This means major changes to basic operations. AI has played a role in how companies operate, for example in the use of AI in basic standardized processes, “utilizing the benefits of available AI technologies, providing vast opportunities for both new products/services and immense productivity improvement” (Makridakis, 2017). Standardized tasks have been a major selling point to some of the advantages AI can offer. Examples such as data entry, phone calls, back-office functions, and human resource management can be improved through AI technology. Since many company environments have changed because of lockdowns, these simple tasks have been forced to be controlled by AI technology so that management can focus its resources on other areas and ensure operations of businesses can still be performed.

Limited human contact has caused major disruptions to company business plans. Many aspects of businesses rely on human-to-human contact and with the pandemic making this impossible, this means that some employee positions have become redundant. For example, “[i]n banking, 70% of front-office jobs will be dislocated by AI, and the researchers say 485,000 tellers, 219,000 customer service representatives, and 174,000 loan interviewers and clerks” (Crosman, 2018). Major cuts to employees have been made at many different businesses and AI technology has made the replacement. Though the pandemic has forced many of these changes upon businesses, these trends may become the norm in the post-pandemic environment.

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Another role AI has is in relation to business communication. Companies have had the luxury of having all resources under one roof; however, the lockdown has caused many to work from home. This is something no company has ever had to experience. As a result, this has given rise to online communication platforms like Zoom and one of the major ways platforms like this understand how its users interact with their platform is through AI. “Nowadays, [AI] has entered into the overall system of an organization” (Yawalkar, 2019). AI has brought the conference room to the laptop screen. These interactions remain very important for AI technology to understand to make them more efficient.

Lastly, COVID-19 has caused emerging opportunities for some companies and individuals and many of them have pivoted their focus to take advantage of these opportunities. One example of this is the emergence of online businesses in the current global pandemic. “The domain of online business has matured and broadened into distinct sub-domains, there has been a growing and distinct stream of studies that consider online home-based businesses” (Naveed Anwar & Daniel, 2017). Many have taken advantage of online store platforms like Shopify to remain safe at home and bring an idea they have to the market. In addition, many companies are doing the same, online store platforms are an easy and quick way to bring business online and with the sudden change that the pandemic has caused this has become a very popular option. AI is at the forefront of how the Shopify platform is designed, Shopify generates large amounts of data and relies on insights to judge metrics around performance and user interaction to give the business user a better way to understand their online business.

The COVID-19 pandemic has caused a lot of change for businesses and economies alike. The role of AI can be found in many different aspects of changes made to businesses today. There are many ways that AI is being used and deployed to help and enhance businesses during these uncertain times. However, with these changes, AI has played major roles in decision-making processes, business structures, business plans, communication, and even in the emergence of new business opportunities. As these drastic changes impact every consumer and business entity,

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it is vital to understand the public sentiment on how AI is being used by businesses as the global pandemic develops.

E. The Use of Social Media to Gauge Public Sentiment of AI and the Impact of COVID-19

1. The use of social media to conduct public sentiment analysis

There has recently been more effort to measure public sentiment through the mining and analysis of available “big data” and social media (Bing et. al., 2014). Twitter, “an online micro-blogging and social-networking platform which allows users to write short status updates of maximum length 140 characters” (Baqapuri, 2015), has become a popular way of expressing opinions and interacting with other people online (Barnaghi et. al, 2016). In fact, Twitter is used by over 200 million users globally who share their opinions on the platform making it valuable for tracking and analyzing public sentiment (Tan et. al., 2014). In aggregate, they can provide an accurate reflection of public sentiment. This has allowed for data scientists and experts to collect data from this platform and provide critical information for decision making in various domains. Coupled with additional validations, this data can be used to guide corporations to make informed business decisions, especially during uncertain times such as during the COVID-19 pandemic.

Public sentiment analysis of Twitter is conducted by classifying each tweet according to the sentiment that is expressed in them. For example, they could be categorized as positive, negative or neutral (three buckets) or positive or negative (two buckets). A trained-machine learning method of text categorization, such as the Bayesian Logistic Regression classification method, is used to categorize and label each tweet based on the sentiment expressed in them. This methodology allows for the accurate analysis and determination of widespread public sentiment for a particular topic or event.

The COVID-19 pandemic has created complex challenges and adverse circumstances causing the development of extreme feelings (Samuel et. al., 2020). Such feelings expressed on

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social media, in particular, Twitter, have been analyzed by data scientists and experts to understand and identify dominant public sentiments surrounding COVID-19.

2. Sentiment Analysis on AI Used by Organizations Prior to COVID-19

Public sentiment is known to play a major role in the shaping of emerging technologies, especially in the world of AI. AI has widespread implications that impact society in many different ways including but not limited to the economy, the labour market, transportation, health care and national security. Public trust in public and private institutions can help with the acceleration of regulation that promotes the development and use of these new technologies. Inevitably, the opposite is expected in the event that the public sentiment towards AI is negative. Prior to the COVID-19 pandemic, researchers from the Centre for the Governance of AI Future of Humanity Institute at the University of Oxford published a paper on, “U.S. Public Opinion on the Governance of Artificial Intelligence.” In this paper, they concluded that “while Americans perceive all of the AI governance issues to be important for tech companies and governments to manage, they have only low to moderate trust in these institutions to manage AI applications” (Zhang et. al, 2020). In fact, the public sentiment with respect to AI has been consistently more optimistic than pessimistic (Fast et. al., 2016). However, the concerns still remain with respect to “loss of control of AI, ethical concerns for AI, and the negative impact of AI” (Fast et. al, 2016).

As the COVID-19 pandemic develops and businesses are adopting the use of AI increasingly, it is even more critical to gauge public sentiment on businesses and their use of AI. This research paper aims to understand the public sentiment of AI used by businesses during the COVID-19 pandemic. Conducting public sentiment analysis using data extracted from social media will determine whether the increasing use of AI technologies by businesses is received positively, negatively or neutrally by the public. We can then infer whether the results of our analysis will promote or deter AI innovation used by businesses.

III. METHODOLOGY

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A. Overview

For this research project, qualitative analysis was conducted using tweets collected from the Twitter social media website. The tweets were collected electronically using Python and Jupyter Notebook. Python library, TWINT, an advanced Twitter scraping tool, was used to collect data. Search words used for collecting tweets were “artificialIntelligence”, “coronavirus”, and “business”. Only tweets written in the English language were collected for the purposes of this research paper. A total of 48,455 tweets were collected for the search period between March 15, 2020, and November 15, 2020. March 2020 was the start time of data collection, as it was when the COVID-19 pandemic lockdown measures were first implemented in Canada and the United States, two English speaking countries, where our data, English language tweets, are coming from.

The tweets were then cleaned, as outlined in the following section. Finally, the clean data set was stored in excel format on a local computer where the analysis was performed. The analysis of the results is thoroughly discussed in Part IV (Data Analysis) of this paper.

B. Data Collection

Twitter is a free microblogging social media platform with 152 million registered daily users and more than 500 million users per month who visit Twitter without logging into an account (Rufai & Bunce, 2020). Twitter serves as a significant data source to extract information on what people are thinking and feeling regarding various subjects because Twitter has a maximum character limit of 280 which covers information from simple activity updates to large news coverage (Xavier & Souza, 2018).

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During the COVID-19 pandemic, Twitter served as a powerful public health platform for world leaders to share information and updates directly to their citizens together with conventional other media such as television, newspapers, and radio. After the World Health Organization (WHO) declared the COVID-19 as a pandemic, government-made regulations were implemented to maintain social distancing and people were encouraged to stay home. As an inevitable byproduct, the number of people using social media increased by millions.

By the beginning of March 2020, the number of COVID-19 cases increased exponentially around the world and many countries started to implement full or partial restrictions on the movement of people. With the effect of lockdown, thousands of non-essential businesses were closed down leaving millions of people unemployed (Roberts, 2020). This resulted in millions of people taking to Twitter to express themselves about the pandemic and the lockdown and because of this 48,455 tweets were scraped between March 15, 2020, and November 15, 2020.

C. Data Cleaning

In order to create reliable datasets, the data cleaning is performed to identify and remove errors and duplicates. This will help us to get better data quality and it will assist us to enhance the overall quality of paper. Once the tweets were collected, the data set was processed by removing unnecessary contents such as stopwords, HTML tags, and special characters, outliers, missing data and punctuations. Several machine learning techniques were used to perform this process of data cleaning by the researchers.

1. Removing unnecessary contents

The original data set of tweets had numerous unnecessary contents, such as the information of the index, id, conversation id, timezone, hashtag, user_id, photos, video, thumbnails, and retweets. Using Python, all of those columns were eliminated and only the actual tweet and date information were included in the final data that was used for the analysis.

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2. Removing stopwords

A list of the most regularly used words was imported from tweets from the python natural language toolkit, Stopwords, and those words in tweet, include for example, 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', and "you're". These words may hold back the effort of the text analysis process to improve the identification of terms that pick out different texts and hence, these words were removed. The strip case method was also used to make all the words lower case so that words with or without caps can be treated the same but not as two separate words.

3. Tokenization process

The tokenization method was used to break sentences into words based on specified patterns using Regular Expressions, and those non-alphabets, pictures and special symbols such as @, were further removed from the actual tweets.

4. Removing HTML

Lambda functions were used by the researchers to remove HTML tags and fixed java scripts from HTML strings because the Lambda functions are used to create small anonymous functions.

IV. DATA ANALYSIS

1. Overview

This research paper aims to gauge the public sentiment on the increasing use of AI by businesses during the COVID-19 pandemic. Using the Python Twint package, 48,455 tweets were collected from March 15, 2020, until November 15, 2020. The keywords used for tweet data collection were “artificialIntelligence”, “coronavirus”, and “business”. All tweets were cleansed using various methods, and the final clean dataset was used to conduct the following analyses: word frequency, theme analysis, sentiment analysis, cluster analysis, clustered correlation

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analysis, and trend analysis. These analyses were conducted using various Python libraries and Jupyter Notebook.

2. Analysis and Results

A. Word Frequency

A word frequency analysis was conducted on the data to determine the most common words found within the tweets collected. Word frequency can be useful to identify patterns or trends in public sentiment by helping researchers identify topics of conversation or public interest over a given period (Mostafa, 2013). Since the internet is an open platform and represents a wider selection of society than strictly academic sources, the topics identified are more representative of society as a whole (Blair et al., 2002).

Research Question 1: What are the most frequent words used about AI usage by Businesses during COVID-19?

The search terms used were “business”, “artificialIntelligence” and “covid”, therefore at least one of these terms appears in every tweet, making them the most frequent words in our frequency analysis. However, these words do not provide any new insight so they were not used in the analysis.

Other most frequent words include broad terms such as “science”, “economy”, “outlook”, “marketing”, pandemic”, etc. They include technological words such as: “automation”, “data”, “AI”, “chatbot”, “transformation”, “IoT” (internet of things), etc. and affective words: “improve”, “help”, “important”, “sharing” etc. In the current COVID-19 pandemic environment, many people are looking to technological solutions to help prevent economic disaster so it is consistent that

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these keywords would be the most frequently mentioned in tweets about artificial intelligence, business, and COVID-19.

Words that refer to specific technologies were among the most frequently tweeted keywords, such as “ai”, “webinar”, “robot”, “ml” (machine learning), “chatbot”, “automation”, etc. The covid-19 pandemic has accelerated the adoption of these new technologies (Kane et al. 2020). Things like machine learning and AI were once thought of as niche technological solutions to niche problems. Now, these technologies have become essential as the economy adapts to a fully digital landscape (Taub, 2020). Companies are looking to these types of solutions to keep functioning during the lockdown. Technologies from supply chain management to AI-powered office assistants are being developed to meet acute needs created by the disruptions caused to the work world by COVID-19 (Gerner, 2020).

The word frequency of the data is presented below as a word cloud visualization.

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Figure 1: Word Cloud Representing Word Frequency Analysis

B. Sentiment and Polarity Analysis

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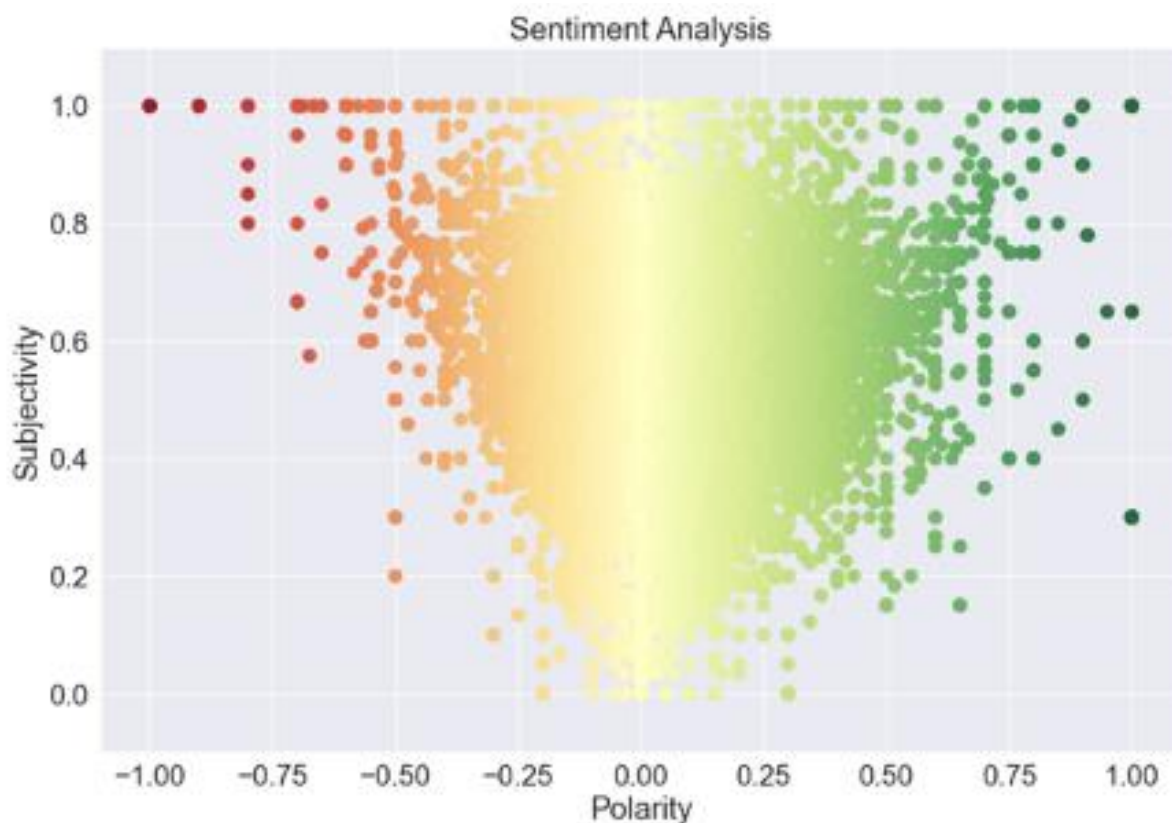


Figure 2: Polarity and Subjectivity Float

Research Question 3: What are the public sentiments about AI usage by Businesses during COVID-19?

Sentiment analysis was conducted to provide context to the word cloud representing the Word Frequency Analysis above. The Polarity and Subjectivity Float in Figure 2 shows the polarity and subjectivity of the tweets collected in a spectrum. The polarity of each tweet is between -1 and +1, with -1 being strongly negative and +1 being strongly positive. Tweets with polarity close to 0 are neutral in tone. The subjectivity of each tweet is between 0 and 1.0, with 0 being strongly objective and 1 being strongly subjective.

Taking a closer look at the tweets and the polarity of the tweets, it can be seen that the polarity of the tweets ranges from -1.0 to 1.0; however, most of the tweets are focused within

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the middle area of the chart (-0.50 and 0.50). This shows that the intensity of the sentiments for the keywords such as “business”, “AI” “intelligence”, “technology”, is not extraordinarily high. The intensity of feelings is gauged usually for complex challenges and adverse circumstances causing the development of extreme feelings (Samuel et. al, 2020). In this case, sentiment can still be analyzed to reflect whether it is positive or negative, but the intensity of whether the sentiment is positive or negative seems to be rather controlled. As reason would indicate, as the subjectivity of the tweet increases, the polarity of the sentiment is also increased.

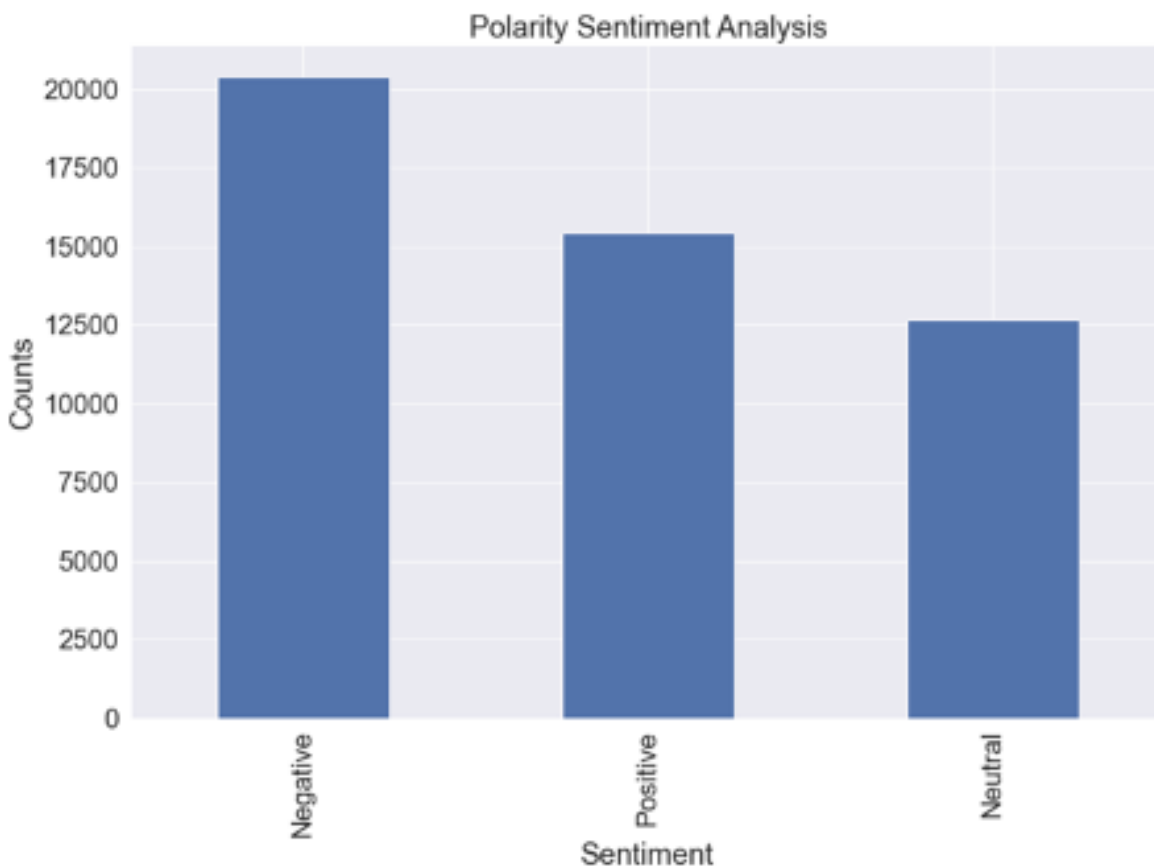


Figure 3: Results of the Polarity Sentiment Analysis in a Bar Graph

To display the results of the polarity of the sentiment analysis, a bar graph (Figure 3) was used. This allows for further scrutiny of the polarity of the tweets collected. The bar graph and the pie chart demonstrate the distribution of tweets into three buckets (e.g. Neutral, Positive,

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and Negative). Based on the information gathered, it shows that 42 percent of tweets are negative, around one-third (31.8%) is positive and the remainder (26.1%) is neutral.

We can derive from the results of the polarity sentiment analysis that AI usage by businesses during the COVID-19 pandemic is not necessarily warmly welcomed by the public. The sentiment analysis demonstrates that the tweets that are relevant to “COVID-19”, “AI” and “businesses” since March 2020 were mostly negative. However, this particular analysis does not show why many have been tweeting negatively about AI and its use by businesses or its connection with businesses during the pandemic. We can only generally infer that this finding can be due to the existing concerns that people have with the use of AI and the advancement of technology. AI drives concern for many issues, such as infringement of privacy rights, the accumulation and collection of data by businesses without knowledge of the individuals (or clients, customers, etc.) involved, and the manipulation of individual preferences based on information gathered through AI by businesses. Other concerns could also include automation of business processes that can include the loss of jobs for many people in the workforce.

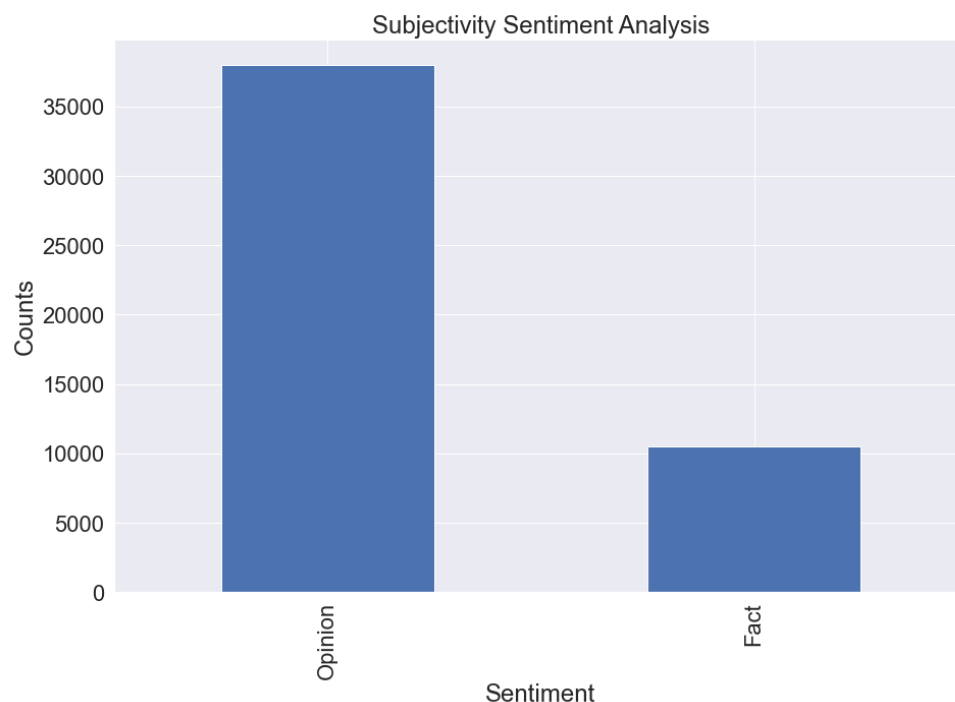


Figure 4: Subjectivity Sentiment Analysis in a Bar Graph

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As sentiment analysis requires the analysis of sentiment or feelings, distinguishing facts from feelings is an important step in cleaning the data collected. If tweets are based on facts, it is inaccurate nor precise to derive that the keywords in the tweet would reflect sentiment. Hence, a subjectivity sentiment analysis is conducted to determine the subjectivity of each tweet. Figure 4 details that the majority of tweets collected for the process of this analysis was based on opinion (> 35,000), whereas fact-based tweets were limited to slightly more than 10,000 tweets. This bar graph focuses on the quality of the data collected. As most of the tweets gathered and analyzed were based on personal opinion rather than facts, it can be inferred that the data collected for this research is reliable and we can move forward to the next step, which includes scrutinizing the content within the tweets collected.

C. Topic Modeling

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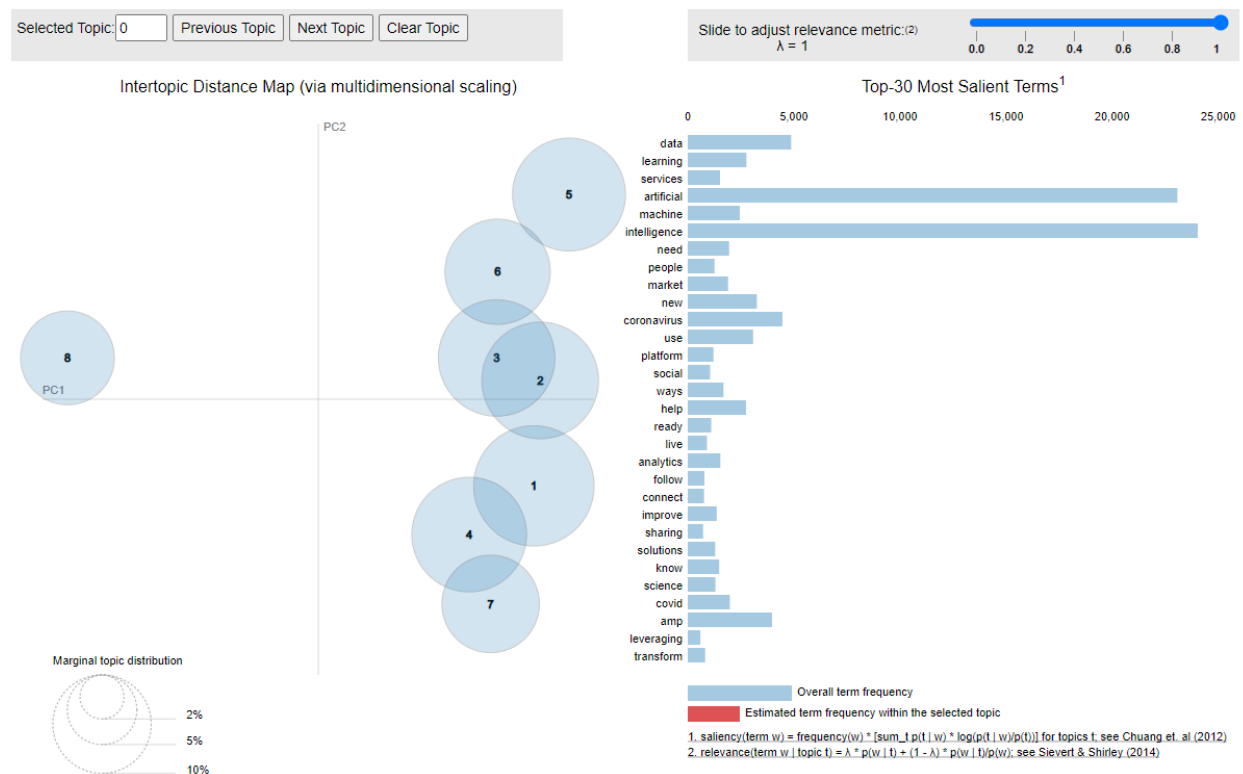


Figure 5: Topic Modeling by an Intertopic Distance Map and Top-30 Most Salient Terms

Research Question 2: What are the main topics discussed about AI usage by businesses during COVID-19?

The next phase of the analysis is topic modelling. In this section, the analysis focuses on specific topics of discussion. Utilizing the larger dataset collected, the goal with topic modelling analysis is to gain insight into certain patterns to help guide results related to our research questions. “Essentially all Twitter studies begin the sampling process by using search terms to identify relevant data. Investigators should give careful thought to their search terms to avoid under or overestimating the volume of discussion or obscuring patterns of interest.”(Kim et al., 2013) Avoiding this analysis will mean our results are too broad to understand the specifics of such a large dataset. From the literature review conducted eight topic words were chosen to

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begin the theme analysis. The eight topic words chosen were “AI”, “business”, “use of technology”, “technology”, “social aspect”, “COVID-19”, “big data”, and “global”.

Using the natural language processing technique (NLP) that is embedded within our analysis python code, we were able to then distinguish common terms that are within sentence structures in our dataset. Frequencies were then recorded for each term and ranked to give us the top thirty terms which are presented in Figure 5 under the title, “Topic Modeling by an Intertopic Distance Map and Top-30 Most Salient Terms.” As part of our analysis, we have included a breakdown of the top 30 words for each topic as shown in Figure 7. Looking at topic #6 which is related to “big data”, we can see that within the top 30 words found for this topic, there is already some overlapping context similar to other topic words. For example, within “big data”, popular words such as “artificial” and “intelligence” are present suggesting connections with other topics in the eight we had chosen, more specifically, “technology” and “AI”.

Once frequencies were generated, these terms were then grouped into smaller clusters based on the eight topics we had chosen. “Despite the research-led advances in natural language systems that have been deployed for real-world applications still cannot perform common-sense reasoning or draw on world knowledge in a general and robust manner.” (Bird et al., 2009) It must be noted that it is relatively difficult to get complete confidence when working with a large data set due to limitations associated with machine learning techniques, such as NLP, to understand the natural text through data. Tweets created with “slang” words and unconventional sentence structures limit NLP’s ability to extract exact results from a specific sentence found in Twitter data (Bird et al., 2009).

To combat these limitations, the topic modelling analysis groups the frequencies into smaller clusters to allow further understanding of the results given. The python code used creates interactive graphs in the form of an inter-topic distance map. In Figure 6, it is demonstrated that a majority of the topics chosen are interrelated with the exception of topic #8. The chosen topic

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#8 is “global”, which is shown on the far left of the inter-topic distance map. This result means that for estimated frequencies within the top 30 terms, the topic of “global” is represented in a majority of the 30 terms. This is not surprising based on how broad the topic of “global” can be in a mix of Twitter-related searches. It is therefore beneficial to step back from results and think about the common sense behind the results presented.

The seven other topics show a moderate-to-high relation with each other based on the distance between the topics on the map (in Figure 6) showing that six out of the seven remaining topics overlap with each other. Topic #5 which is “COVID-19” shows a close relation to the remaining six topics. However, it does not show any overlapping. The highest amount of overlap comes from topics #3 and #2 (i.e. use of technology, technology). Once again, stepping back from the results and using common sense would tell us that these two terms are inevitably closely related in context. Therefore, it is not surprising that the results showing the two terms are almost completely overlapping. However, it is beneficial to understand that although they are related in context, topics #2 and #3 are still showing relation to the other four topics excluding topic #8. Overall, the eight topics chosen for the analysis seem to be very interrelated giving confidence to the overall approach of the research, because it allows us to use further analysis to break down why these topics are interrelated. Having a close relationship between the chosen topics proves that the analysis is precise, and the results are reliable.

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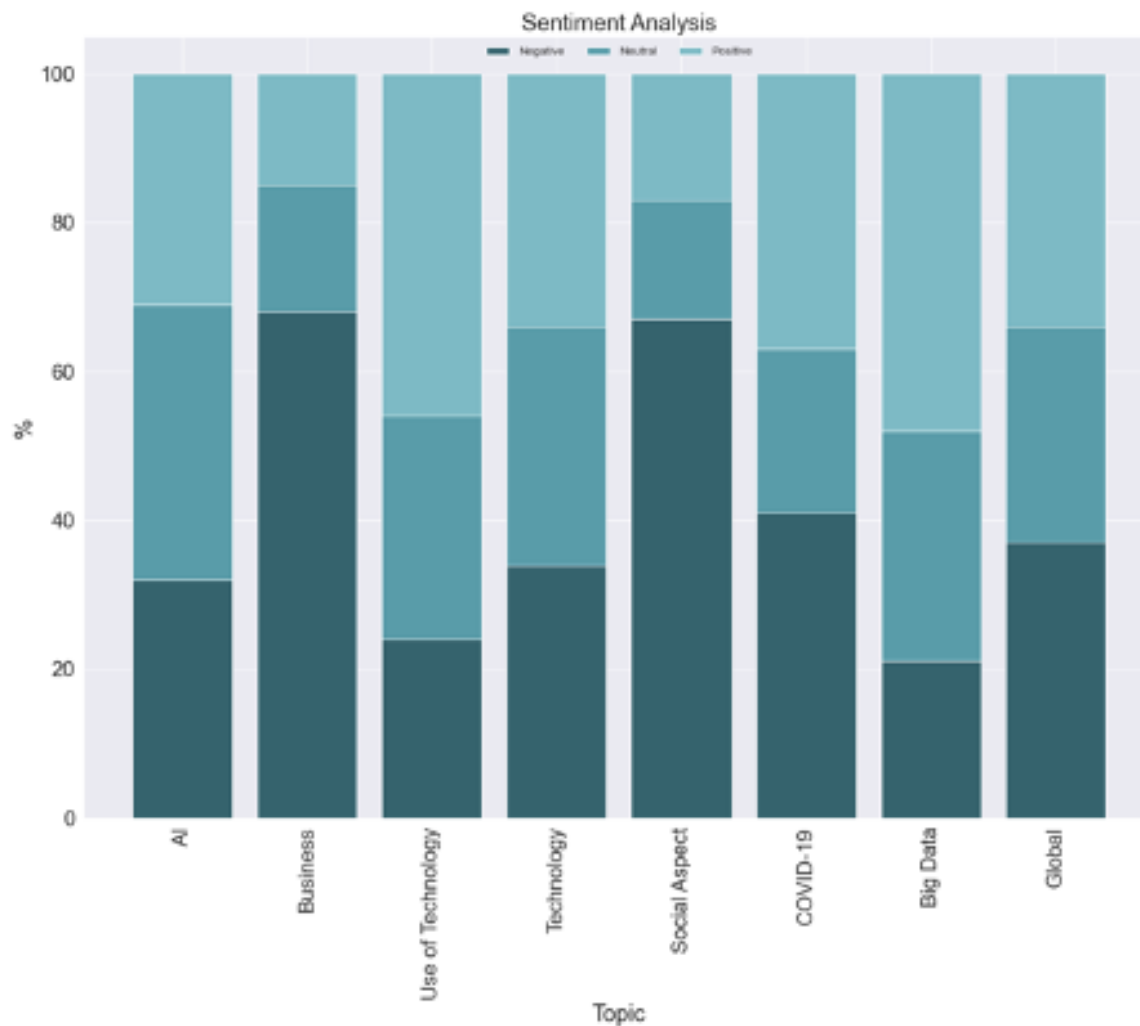


Figure 6: Topic Labelling for Sentiment Analysis

Topic labelling for sentiment analysis was conducted to broaden the understanding of which words or topics were most discussed about the keywords that we chose most suited our research objective. In addition to the identification of the keywords, it also exhibits the sentiment of each keyword. The keywords that were identified for topic labelling include “AI”, “business”, “use of technology”, “technology”, “social aspect”, “COVID-19”, “big data” and “global.”

1. AI (Mixed sentiment)

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The topic of AI had almost an even mix of positive, neutral, and negative sentiment. It had the most mixed sentiment of any of the eight topics identified. This is likely because AI has both positive and negative connotations depending on its use. Our initial literature review brought insight into the public's concern of the potential impact AI may have on job security and personal information privacy. Some people are concerned with the risks to jobs or privacy that AI may bring about and others are optimistic about the benefits to productivity and information discovery that AI offers. AI is a very broad tool, most tools are neither good nor evil but depend on their use by people, so it is not surprising that sentiment around the topic of AI would be a mix of positive, negative, and neutral.

2. Business (Negative sentiment)

Business is a very interesting topic that we have chosen and through our analysis have received results that were expected given the timeline we had chosen. Receiving a very strong negative sentiment result towards business was expected due to the very prominent negative perspective around businesses during the pandemic. Our initial research pointed out the struggle the COVID-19 Pandemic has caused and with many businesses continuing to face very negative outlooks as to their survival in current economic conditions. Negative public sentiment towards businesses using AI may also contribute to this result adding further negative results to our topic of business. The public has very limited knowledge of businesses using AI which may narrow the public's focus to only viewing businesses as negative because of little knowledge they are able to consume.

3. COVID-19 (Negative sentiment)

The sentiment around the topic of COVID-19 was unsurprisingly negative, though still only about 40%. The COVID-19 illness and the devastation it is causing to both global health and the global economy will have a lasting impact on the minds of everyone who is living through it. Whether it is people expressing sadness at the loss of loved ones, anger at the government's

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response to the pandemic, or frustration about putting lives on hold, people feel negatively towards the topic of COVID-19.

When looking at all eight topics, there is a wide variety of sentiments. Topics such as “use of technology” and “big data” were mostly positive, “technology”, “global”, and “AI” were mixed, and “business”, “COVID-19”, and “social aspect” were mostly negative. This reflects on the different nature of these topics. The topics with positive sentiment; “use of technology” and “big data” are often seen as solutions to business or social problems. It is not surprising then that these topics would be positive and this is explored further in **section G** - clustered correlation analysis. The topics that had a mixed sentiment are broad; “technology”, “global”, and “AI” are all so far-reaching that the sentiment towards them is likely a collection of a wide range of sub-topics. It is likely for this reason that the sentiments were mixed, there is no consensus about them. Finally, “business”, “COVID-19”, and “social aspect” were negative and this reflects the fact that the keywords, “business” and “social aspect”, are topics that relate to specific areas of life that have been negatively affected by COVID-19.

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D. Trend Analysis

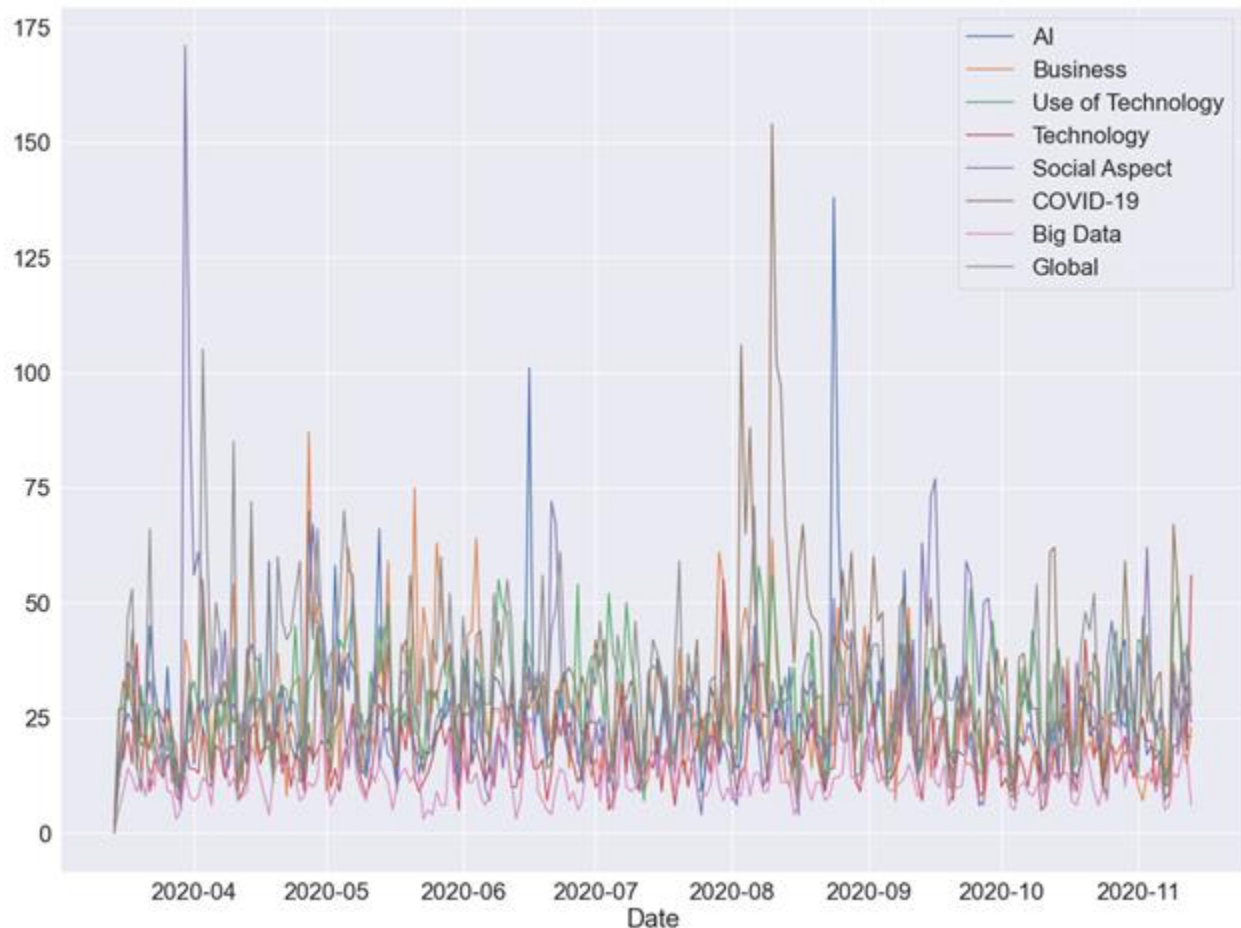


Figure 7: Trend Analysis for Topics

Research Question 6: What are the trends in topics identified during the studied period?

Trend analysis allows us to see changes in the frequency of these topics as they change over time (Hirsch et al., 1982). This is very important for our overall research and will help guide other areas of analysis. As shown above, in Figure 7, the results of the eight themes we have

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chosen are expressed for the dates of March 2020 to November 2020. The eight topics we chose were “AI”, “business”, “use of technology”, “technology”, “social aspect”, “COVID-19”, “big data”, and “global”. This eight-month time frame is a large enough window to see the clear trends within our data during the time COVID-19 made its impact around the globe. Looking at Figure 8, there are many large changes for all eight topics over the eight months. The trend shows that all topics tend to follow a congruent shape, however, this may be misleading in this graph due to a large range of results collected. Looking at April, August, and September there are large spikes in results from the keyword, “social aspect” during April, AI and COVID-19 were showing high results in August and September. This is important to note as these results show as outliers and in this case show that these were major topics during this time.

E. Cluster Analysis with Heatmap

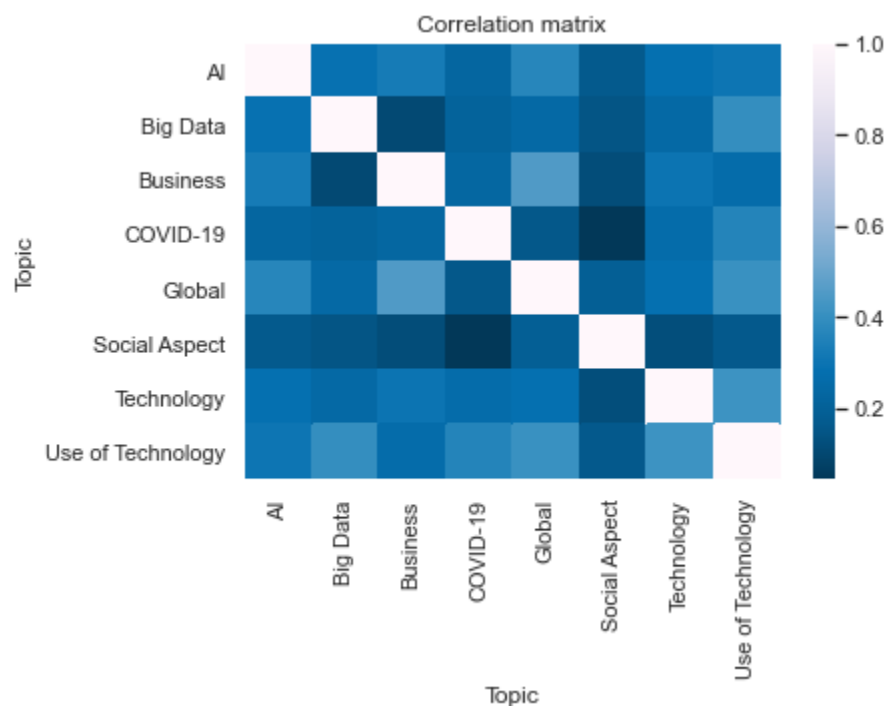


Figure 8: Cluster Analysis Heatmap

Research Question 5: What are the correlations between AI usage by business topics identified?

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Figure 8 exhibits a Cluster Analysis Heatmap for the keywords that we have used to conduct the public sentiment analysis for this research. Cluster heatmaps “visualize a data matrix by drawing a rectangular grid corresponding to rows and columns in the matrix and coloring the cells by their values in the data matrix” (Engle et. al, 2017). The advantages of using the cluster heatmap is for allowing to compact large amounts of information into a small space. (Engle et. al., 2017) As shown in Figure 8, the cluster heatmap, which adds the colour-coding of each cell, easily exhibits to the viewer the level of correlation between various variables. The correlation is presented on a spectrum and the spectrum is shown with the legend on the top left from 0.00 to 1.00. To interpret the spectrum into words, the darker of the cell, the deeper or higher the correlation of the variables.

The level of correlation was highest with keywords, such as “COVID-19” and “social aspect.” This is likely because the social aspect of COVID-19 has been a pressing concern and issue for the public (Bavel et. al, 2020). The social aspect includes job loss, difficulty finding work, the lack of affordable childcare for working parents, and the financial impact of forced closure of businesses during the “lockdown” measures (Bavel et. al, 2020, *see also* Van Lancker, 2020). The pandemic has affected many people in this regard and therefore, it can be reasonably inferred that there is a strong correlation between COVID-19 and the social aspect.

Furthermore, two keywords that are also strongly correlated are “business” and “big data.” With businesses from all sectors mandated to close down after declarations of emergency around the world, many businesses were forced to find creative and innovative ways to continue offering their products to the public. “Big data” is an important part of re-inventing and innovating businesses. Businesses use big data specifically to understand the preferences of their customers and to offer products that are tailored to them. Another way data is used to tailor advertising mechanisms to decrease the spending on advertising. For example, if advertising is not filtered or customized to a particular target group, businesses may be incurring more costs to display advertising to those who would never purchase their products or services. When

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advertising is more tailored and supported by data, it can be derived that businesses can also accumulate savings. Businesses are satisfied due to less money spent on each customer acquisition, and customers feel the same because the advertising is relevant to them. It becomes a win-win situation. This is one example of infinite ways for how businesses can leverage “big data.” With this said, big data plays a big role in how businesses are using technology to improve their offerings, and it is further explored in the next section.

Another group of keywords that showed a strong correlation (as shown in Figure 10) is “social aspect” and “technology.” It can be inferred that this is because technology can positively impact and better “social aspect” initiatives. During the COVID-19 pandemic, many aspects of peoples’ social life have been affected. As previously mentioned, the pandemic has created new burdens for people who were already vulnerable. But in these dire circumstances, technology has also paved the way for new opportunities. The social aspects of peoples’ lives were affected in many different ways, there have been numerous ways that technology has provided new services that helped reduce social burdens economically and emotionally. For example, the increased use of mobile applications to order food has not only allowed people at home to gain access to food more conveniently but also, safely. Many restaurants have been forced to close the doors and only provide take-out services. As people are discouraged from meeting or socializing indoors, mobile applications that specialize in food delivery have provided a safe alternative. Furthermore, these food delivery services have also provided a way to ease economic burdens for those whose work has been impacted due to the COVID-19 pandemic.

Other ways technology can be related to the social aspect includes the increase of digital tools and online platforms to ease the social burden of loneliness and lack of social connection. Technology has been used to improve the quality of peoples’ lives during these unprecedented times and therefore, it is not a surprise that the keywords, “technology” and “social aspect” were highly correlated in the tweets that were collected.

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The correlation between topics is further discussed based on their relatedness to each other in the next section in order to identify the relationships between topics identified about AI usage by businesses during the COVID-19 pandemic.

F. Clustered Correlation Analysis

Clustered correlation analysis sorts topics into a tree diagram based on their relatedness to each other. The closer topics are within the tree, the more closely they are related and they become more dissimilar moving up the branches of the tree diagram (Tullis & Albert, 2013). By looking at how our python code sorts the topics, we can interpret which topics are related to each other in the data and make inferences about the meaning of those relationships.

Research Question 4: What are the relationships between topics identified about AI usage by business?

A clustered correlation analysis was performed on our 8 topics: “social aspect”, “AI”, “business”, “global”, “COVID-19”, “big data”, “technology”, “use of technology”. This analysis allowed us to identify which topics were most closely related to the tweets collected.

The first relationship to explore is that between “business” and “global” and the relationship between these two and “AI”. Global businesses are defined as businesses that have operations in multiple different countries, rather than just selling products or services in multiple countries (“Global Business”, 2020). The economic shocks of COVID-19 have caused huge disruptions to almost all industries worldwide.

One global industry that has been impacted by the pandemic is the automotive industry. It is estimated that global car sales will decline between 20 and 30 percent in 2020 and may take up to four years to fully recover (Hofstätter et al., 2020). Manufacturers have had to re-examine

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their reliance on foreign manufacturing in a similar way to the pharmaceutical industry (“COVID-19 and the automotive sector”, 2020). The general shift from physical stores to online shopping will also affect the recovery of auto sales firms and they may be forced to adapt to an online selling model to recover (Hofsätter et al., 2020).

Another global industry that has suffered disruption during the pandemic is the banking and insurance sector (“COVID-19: Impact on the banking sector”, 2020) (“Covid-19: Considerations for the Insurance Industry”, 2020). The landscape for lending money and guaranteeing risk is changing as different countries react to COVID-19 with shutdowns, bailouts, and regulations. Will businesses that are forced to shut down by government order going to be covered by insurers? Can these businesses claim relief on their debts or expenses? There are many unknowns that are causing issues in the operations of both banking and insurance worldwide.

These are just a few examples of the wide variety of global businesses that are being impacted by the COVID-19 pandemic. The relationship between global business and AI, as found in our analysis, should also be addressed. Businesses of all types are adopting innovative technologies to survive the new business environment (“How six companies are using technology and data to transform themselves”, 2020).

AI-based solutions are touching virtually all industries to some degree, whether that is in the form of improved performance, data analysis, or provision of products or services (“How Artificial Intelligence Helps Businesses During the COVID-19 Pandemic”, 2020). AI is being used by financial service companies to provide robot-advisors to give their clients more personalized and cost-effective financial advice (Daley, 2020). Even traditional industries like oil drilling are using AI-based solutions to map out oil reservoirs (Ouahed et al., 2005).

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Many business publications are talking about a 'new normal', where the digitalization of business is accelerated even after the COVID-19 pandemic is over. In an interview with Fortune magazine, Wharton business school professor Kartik Hosanagar predicted that strategic use of AI will be the next competitive advantage sought out by companies in this 'new normal.' (Khan, 2020). Whether this is in the form of using AI to help predict sales opportunities, manage supply chains based on real-time demand, or some other innovation, there is little doubt that the AI revolution in business brought on by the COVID-19 pandemic is here to stay.

Another relationship identified between the topics in our data was between "technology" and "use of technology" together with "big data" and then all these together with "COVID-19". Big data is defined by Oracle as data sets too large and complex for traditional data processing software to handle ("Big Data Defined", 2020). The advantage of big data is that it is so large and complex that it can be used to solve business problems that used to be impossible for machines to answer. According to Oracle, big data can be used for a wide variety of business problems such as product development, predictive maintenance, customer experience, fraud detection, and many more ("Big Data Defined", 2020). It is not surprising then that the topic of technology and its use are closely related to big data. Furthermore, the topic of "COVID-19" was most closely related to these three as well. This indicates there is great interest among the public to use big data technologies to help handle the unique challenges of the current pandemic.

Big data applications for combating the COVID-19 pandemic come in many forms. It can be used to analyze the case and patient information to find useful patterns about those who recover from and those who perish from the disease (Haleem et. al, 2020). This data can be used to more effectively allocate resources in the treatment of COVID-19 and discover potentially useful treatment options.

It can also be used to prevent the spread of COVID-19 by analyzing travel data and contact tracing (Haleem et al., 2020). South Korea implemented a contact tracing system called the

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“COVID-19 Smart Management System” (COVID-19 SMS) which uses data from things as different as credit card transactions and security camera footage to track down people who have been in contact with infected individuals (Lin & Hou, 2020). This aggressive system allowed the government of South Korea to reduce the number of people that an infected person could come into contact with before they discovered they were sick by testing those who may have been exposed quickly.

The development of a vaccine is also a big data problem. Machine learning and AI are being used to model new drug formulations and analyze information from existing databases (Kent, 2020). Large big data companies like Google and Amazon are giving researchers free access to their COVID-19 data to accelerate the development of treatment (Kent, 2020). This has allowed pharmaceutical companies around the world to develop potential COVID-19 vaccines in a matter of months, rather than the years it took in the past.

The results of our clustered correlation analysis are presented below as a heatmap.

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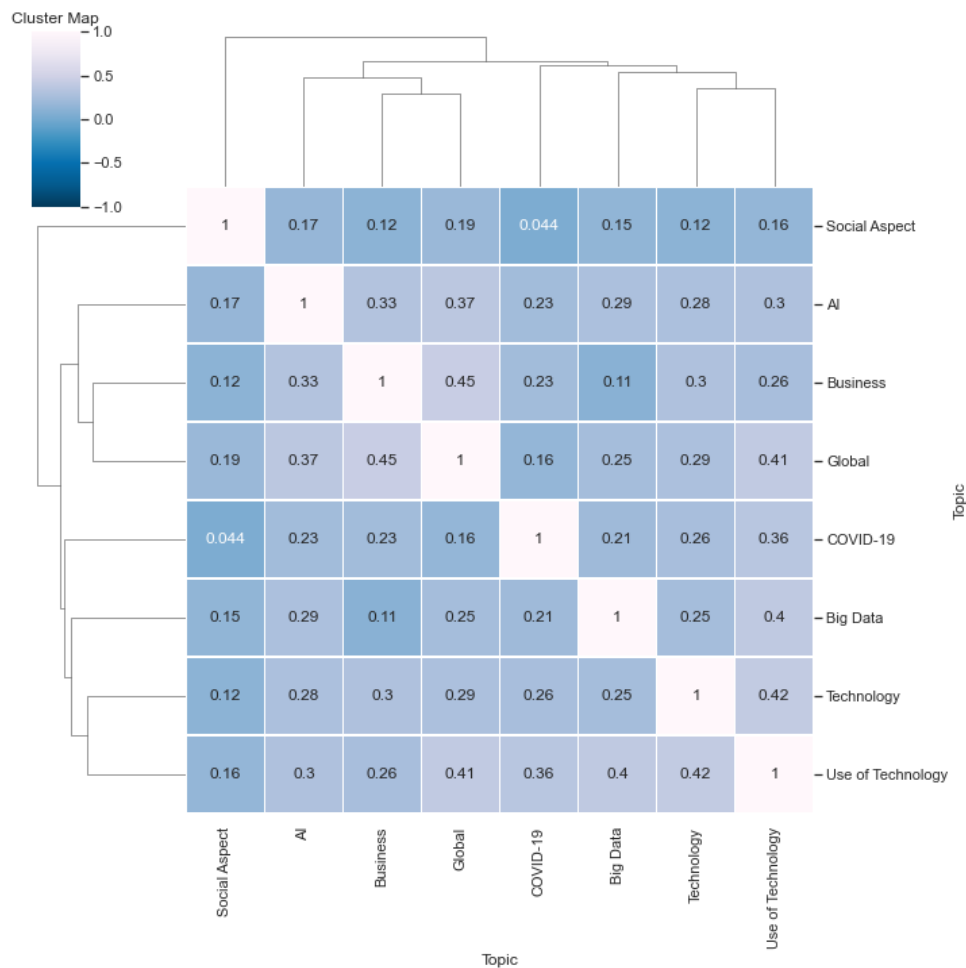


Figure 9: Clustered Correlation Analysis

The final section of this paper presents recommendations for business and regulatory decision-makers based on the results of our research.

VII. Practical, Theoretical and Research Implications

This section explores the practical and theoretical implications of the research that was conducted for this paper. Public sentiment analysis on the increasing use of AI by businesses was conducted and the data were analyzed in the previous section. However, there is a critical need to evaluate this information to make proper and appropriate recommendations for public and

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private regulators and decision-makers in this space. The results of the public sentiment analysis revealed that AI used by businesses was viewed with mixed sentiment (e.g. negative and positive) by the public. As outlined in our literature review, it is evident that AI is viewed positively to an extent that it can help transform business processes and increase the quality of service offerings to consumers. However, existing literature also emphasized the heightened level of concern about the increased use of AI by businesses. There are various reasons that can be inferred with respect to the public's negative sentiment towards AI. For example, negative sentiment can be rooted from the lack of awareness and certainty of the effects of businesses using AI, but it could also be related to concerns with the plausible violation of one's privacy rights (Solon, 2017). Practical and theoretical implications will be discussed on how to reduce or eradicate the concerns of the public through investing in educational and awareness initiatives related to AI and also, by studying and monitoring the implications of AI and big data initiatives, especially within the context of the COVID-19 pandemic and its aftermath.

A. Practical Implications

1. Getting Businesses to Invest Further in Big Data and AI Initiatives

Through our research, we found that there is still a gap in people's view of AI technology and more outreach is needed to gain a more accurate representation of sentiment. Bridging the gap between public sentiment and the use of AI and big data can be accomplished by increasing the public's awareness of how AI positively impacts their lives. Getting more businesses to invest in AI and big data solutions will bring many advantages to both businesses and the public. "In all, [the University of Toronto]'s AI programs attracted \$244 million in research funding between 2015 and 2019 – a period that saw substantial increases in funding for AI research from the federal government." (Kalvapelle, 2020) U of T's start-up AI technology companies are a local example of investment in the area of AI and big data. This is seen also in many Canadian industries and around the world. With investments, whether it be private or public brings positive residual

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effects such as increased jobs, more attraction to AI technology, and potentially increased quality of technology, products and services that are created from these AI initiatives (University of Toronto News, 2020).

2. Getting Businesses to Invest in Practical AI Technologies

A collective investment is not always an easy task to accomplish. There are many different businesses around the world that do not have the opportunity or finances to accomplish major AI technology and big data initiatives. Investing in simpler and more practical technology will give greater advantages to a wider range of businesses. A “moon shot project was created to diagnose and recommend treatment plans for certain forms of cancer using IBM’s Watson cognitive system. But in 2017, the project was put on hold after costs topped \$62 Million”(Davenport and Ronanki, 2018). The cost of such initiatives are so high that they will only adhere to a fraction of businesses in the economy. In addition, a business with no prior framework setup to implement big data and AI technology will have a long and potentially difficult path till they are using the technology efficiently. Looking into more practical and more attainable technology will mean an even greater offering to small and medium sized businesses and in turn the economy. Investing in more practical technology will mean a shorter learning curve and quicker adaptation.

3. Provide More Insight and Information to the Public about Big Data and AI

Throughout this study, there is a focus on public sentiment towards AI. Through the results, it is identified that there is a negative view of AI technology. Although more insight is needed into the specifics of this result it is still determined that this needs to be improved. Improving overall public knowledge will greatly advance AI technology and increase its outreach. “The Ontario COVID-19 Data Tool provides epidemiological information of COVID-19 activity in Ontario to-date. Users can explore the most recent COVID-19 data by the public health unit, age

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group, sex, and view trends over time.” (Public Health Ontario, 2020) The COVID-19 pandemic has brought some exposure to the world of big data and AI. The public has a general interest in the data that is being presented during the pandemic as it has a major impact on our current way of life, if more people understand how data affects our lives then more sentiment will be brought forward. More effort is needed to increase public awareness of big data initiatives and AI to bring more positive sentiment from society. With this recommendation comes more positive effects such as public approval, and more public input into the development of technologies and services.

4. Invest in More Big Data/ AI Solutions for Social Initiatives

Another recommendation is to increase efforts in social initiatives. One way to connect the public with AI technology is to invest in more projects that are of social benefit. To get the public to understand the technology and how their lives are affected can be accomplished through many different types of projects. “Artificial intelligence has the potential to help tackle some of the world’s most challenging social problems. AI technology capabilities could contribute to tackling cases across all 17 of the UN’s sustainable development goals, potentially helping hundreds of millions of people in both advanced and emerging countries.” (Chui et al., 2018) The future capabilities of AI are greatly unknown, however, it is understood that AI can have a great impact on social problems. More investment is needed in social initiatives to allow both AI technology and overall public sentiment to improve.

5. Increased Exposure of Data Security and Data Rights

As the above-mentioned recommendations are pursued another aspect that needs attention is data security and data rights. Through the initial research done in this study it was found that the public has concerns about their data security. As the public begins to understand how they generate data and how it is used, even more issues and potential negative sentiment

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will arise. There are already powerful data security practices and services, however with increased development comes the potential for security to diminish (Segal, 2020). As more people understand the uses of public data there will come a point where human rights may come into question as it already may have in many cases (Andersen, 2018). If a person generates data points that are specific to them is it their right to own that data? The public should be made aware of the rights they currently have with regards to data security and privacy. Ultimately this recommendation will allow the development of technology to happen more smoothly and to bring more of a connection between the public and AI technology (Adams & Burall, 2019).

A. Theoretical Implications

1. Understanding the Implications of Big Data

The present study revealed an association in the public discourse between the topics of “big data” and “use of technology”. The paper explored several current applications of big data technologies, highlighting their potential usefulness in solving business and regulatory problems. Businesses that seek to profit during the current pandemic are those who are investing in a wide variety of big data technology integration in areas such as product development, predictive maintenance, and fraud detection. Our economy needs to be more proactive in understanding the potential benefits of these applications to allow businesses to make better decisions about their own investment into research and implementation. This paper highlights the potential benefits of big data adoption in some areas but further research should be directed at understanding new and potential applications for big data and their effectiveness.

2. Exploring Specific Issues of Public Concern Surrounding AI

The present study examined the mixed sentiment of the public towards AI in general. A knowledge gap between the public and experts in the field of AI creates pushback against the

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adoption of these useful technologies by businesses and regulatory agencies. This paper identifies specific areas of concern by the public such as privacy, data security, and automation and the future of work. Understanding which issues create negative sentiment towards AI will allow businesses and regulators to better direct their public outreach and education most effectively. Therefore, further research should be done to identify the key areas of public discourse around AI issues, as well as the public opinion towards these issues. This will allow businesses and regulators to be more proactive about involving the public in discussions about these issues in the future.

3. Assessing Public Opinion Towards Healthcare Measures against COVID-19

The present study addressed some of the ways in which AI technologies can be used in the fight against the spread of COVID-19. This included things like contact tracing, analyzing travel data, and the sharing of patient information. Unfortunately, there is negative public sentiment that reduces the adoption of these technologies, as people are concerned for their privacy. When the public fails to cooperate fully, this reduces the effectiveness of these initiatives. Therefore it is critical to understand more fully the key issues that prevent the adoption of these technologies and direct resources to improving education and community outreach. More research should be conducted to assess this issue and develop strategic recommendations to address it.

4. Impacts of Technology Adoption Post-COVID 19 Pandemic

The present study examines the way in which businesses are adopting new technologies to survive in the new reality of the pandemic. However, it also briefly explores what some researchers are calling the 'new normal', the post-COVID-19 era. There is no doubt that the technological shifts that have happened during COVID-19 will remain and continue to change the landscape even after the vaccine is distributed. It is no exaggeration to say that the investment made into artificial intelligence in 2020 has changed the course of technology and society forever.

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However, not much is known about the effects that this will have in the post-COVID-19 world. Many of these solutions are only being assessed for their effectiveness in a locked down environment, not how they will perform once society returns to this 'new normal'. Businesses and regulators would benefit from examining the long term impacts of these technologies and so more research should be done to assess how key areas such as the labor market, supply chain management, global trade and employment, etc. will be affected in the following years after the pandemic is over.

B. Research Implications and Limitations

This study was conducted to gain insights into public sentiments about the use of AI in businesses during the COVID-19 pandemic. The findings of this study will contribute to the existing knowledge on the public sentiment and the main interest areas of AI uses by businesses.

The nature of sentiment analysis is to provide a broad overview of a topic by analyzing the public discourse surrounding it. This leads to identifying specific sub-topics and areas for research. Further in depth research is recommended to expand knowledge of the following topics: 1) on understanding how these identified areas of public interest inter-play in the use of AI in businesses, 2) on how to improve public sentiment about the adoption and use of AI, and lastly 3) on understanding new and potential applications for AI technologies including big data and their effectiveness, not only during, but more importantly post COVID-19 pandemic.

Furthermore, the data analyzed for this study included only English language tweets on a single social media platform and it contained some duplicates, thus the findings of this study has a limitation in the generalization of the findings.

In addition, the data analyzed solely came from the Twitter social media platform. This presents a potential limitation as the user base of Twitter may not represent the true proportions of the global population. Certain demographics may be over-represented on Twitter such as

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affluent English speakers and others may be under-represented such as those without reliable access to digital technology or the internet. Therefore, the opinions of the sample may not be truly representative of the entire public.

Finally, users can express opinions through social media in many different ways creating different data formats and structures to analyze. This study only focused on analyzing results from text data. This resulted in collecting only a fraction of the data that could be summarized from public sentiment. Future study should look into different social media platforms and other formats of data (ie. picture, video, likes, counts, post reactions and shares.)

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Conclusion

This paper examines the public sentiment about the increasing use of artificial intelligence (AI) by businesses amid the coronavirus pandemic using tweets from the Twitter platform. The study found the sentiment overall was more negative than positive. The public has positive sentiment towards specific technological tools such as big data but less positive opinion towards the broad concept of AI. Sentiment towards AI was mixed, indicating misgivings in the public. This presents an obstacle to the adoption of AI solutions by businesses and policy makers. The study also explored the ways in which AI technology can be used to help restore the global economy and fight the spread of COVID-19. Therefore the study offers recommendations that can help to educate the public about the benefits of AI as well as include the public into discussions about future issues involving the rollout of AI in new applications after the pandemic is over.

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