

The Impact of the COVID-19 Pandemic in NYC

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1 ABSTRACT

In the past few years, the COVID-19 pandemic has had a significant impact on global economic activities and people's daily lives. New York City, the most economically developed region in the world, also experienced unprecedented changes in economic and employment activities. In this project, we aim to leverage big data technology to analyze the impact of the pandemic on business and employment in different industries in New York City. We have collected and processed abundant data from NYC official open sources and other government sources. We also identified relevant variables and performed exploratory data analysis to gain insights into how the pandemic has affected different industries in the city. We developed and tested our hypotheses using statistical analysis and deliver our findings through visualizations, reports, and presentations. Our analysis reveals that the majority of industries in New York City were negatively impacted by the pandemic. However, we also observed a few industries that were more resilient and even experienced growth during this period. Our results will provide insights to analyze the economic resistance to a long-lasting global pandemic in a highly economically developed city like New York City.

2 INTRODUCTION

The COVID-19 pandemic has caused unprecedented global disruption, with New York City experiencing significant changes in business and employment patterns. The pandemic's effects have been felt across almost all industries since its outbreak in early 2020 in NYC, causing labor shortages and widespread unemployment. However, some may have been more resilient than others, adapting to the new normal and even flourishing during these challenging times due to work-from-home ability or government policies. This project aims to analyze how COVID-19 has affected NYC's industries from 2019 to 2022 and determine which industry was the most resistant to the pandemic utilizing big data technology.

Our hypothesis is that the COVID-19 pandemic caused labor shortages and significant unemployment across most industries, although a few industries may have benefited and

developed rapidly between 2019 and 2022. To test our hypothesis, we collected 15 datasets from various sources. We will provide a brief data overview later. There are about 120 industries listed in the data we found, however, we mainly focus on four groups: hospitality industries, tourism industries, technology industries, and construction industries. Hospitality industries include services such as restaurants and hotels, and tourism industries involve traveling and transportation. Tech industries consist of software, e-commerce, internet services, and so on, while construction industries include residential construction, Commercial construction, etc. We performed data cleaning and pre-processing to classify all the industries and dropped the data before 2019 and after 2022 since we were only interested in the data during the pandemic. Then we conducted data analysis on these cleaned data to verify our hypothesis.

3 PROBLEM FORMULATION

To fully understand the impact of the COVID-19 pandemic on New York City's employment and labor and verify our hypothesis, we derived the following research questions to guide our study:

- (1) What has been the overall impact of the COVID-19 pandemic on employment rate and labor in New York City between 2019 and 2022, including trends in employment and wages across different industries?
- (2) How has the employment rate, hours worked, and wage of different industries changed in different stages of the COVID-19 pandemic?
- (3) How have hospitality industries, tourism industries, technology industries, and construction industries changed during the pandemic?
- (4) Which industries were more resistant to the pandemic and why?
- (5) How have the work-from-home policy and vaccinations affected the industries?

By addressing these research questions, our goal is to provide a more comprehensive understanding of the impact of the COVID-19 pandemic on different industries in New York City. We also aim to find out which industries were more resilient than others to the pandemic and which industries flourished during these challenging times.

4 RELATED WORK

There are several studies that have explored the impact of the COVID-19 pandemic on employment and labor in the United States and around the world. For instance, Forsythe et al. examined labor demand in the time of COVID-19 based on vacancy posting and UI(unemployment insurance) claims and concluded that the decline in the labor market was widespread across various occupations, despite their work conditions. They also found that job roles that allow work-from-home showed a slightly lesser increase in UI claims and job losses compared to those positions, but these positions still experienced a comparable reduction in job opportunities as compared to positions where remote work was not feasible[5]. This discovery supported our hypothesis that certain industries may have greater resilience toward the effects of the pandemic.

According to the Office of The New York State Comptroller, New York City had experienced significant job losses and wage cuts, particularly in industries such as hospitality and tourism due to a sharp decline in tourism in early 2020[7]. This finding is consistent with Lund et al.'s research on job postings, which revealed that the pandemic had an early and severe impact on the leisure and hospitality, and service industries[6]. Nevertheless, the researchers also observed an increase in demand for certain occupations such as interpreters and writers.

Some studies have also explored the shift to remote work and its impact on the labor market. For example, Brynjolfsson et al. analyzed US survey data and found that the prevalence of remote work had increased significantly during the pandemic, but that this had not necessarily translated into greater job security or wage growth for workers[4].

While several studies have indicated the effects of the COVID-19 pandemic on employment and labor in New York City, there remains a need for further research to comprehensively explore how employment and labor are impacted during various stages of the pandemic from 2019 to 2022. These related works inspired us to study and analyze the trend of employment and labor in the city and explore how different industries reacted in different stages of the pandemic.

5 METHODS AND DESIGNS

5.1 Data Overview

This research paper utilizes multiple datasets from various sources to analyze different aspects of New York City's economy, public health, transportation, and government policies. The following datasets were collected and analyzed:

- **U.S. Bureau of Labor Statistics**

- (1) New York City Employment Statistics: This dataset provides monthly employment statistics for New York City, including the number of employed and unemployed individuals, labor force participation rates, and unemployment rates.
- (2) New York City Labor Force Data: This dataset provides monthly labor force data for New York City, including the size of the labor force and labor force participation rates.
- (3) Total Nonfarm Employees in New York City: This dataset provides monthly data on the total number of nonfarm employees in New York City.

- **Labor Statistics for the New York City Region**

- (1) New York Nonagricultural Employment: This dataset provides monthly data on nonagricultural employment in New York State and the New York City metropolitan area.
- (2) Revised 2019-2022 Borough Labor Force Data: This dataset provides revised quarterly labor force data for the five boroughs of New York City.
- (3) New York City Benchmark Revisions: This dataset provides benchmark revisions for labor force data in New York City.

- **Health Department's COVID-19 Data**

- (1) New York City Covid-19 Detected Case by Day: This dataset provides daily data on the number of COVID-19 detected cases in New York City.
- (2) New York State Statewide COVID-19 Vaccination Data by County: This dataset provides data on the number of COVID-19 vaccine doses administered in each county in New York State.

- **Bureau of Transportation Statistics**

- (1) Air Carriers: T-100 Domestic Market (U.S. Carriers): This dataset provides monthly data on domestic air travel in the United States, including data on passenger and cargo traffic, revenue, and capacity.

- **Bureau of Economic Analysis**

- (1) Gross Output by Industry: This dataset provides annual data on gross output by industry in the United States, including data on industry-specific contributions to gross domestic product (GDP).

- **U.S. Survey of Working Arrangements and Attitudes(SWAA)**

- (1) Work from Home Series Monthly: This dataset provides monthly data on the prevalence of working from home in the United States, including data on the reasons for working from home and the perceived advantages and disadvantages of remote work.

- **NYC Government Food Policy**
 - (1) GetFood Historical Data: This dataset provides data on the GetFood program, a food assistance initiative by the New York City government, including data on the number of meals provided and the distribution locations.
- **NYC Open Data**
 - (1) DOB Permit Issuance: Provides information on building permits issued by the Department of Buildings in New York City.
- **NYC Taxi and Limousine Commission**
 - (1) TLC Trip Record Data: Provides information on taxi trip dates and times, pickup and drop-off locations, trip distances and duration, payment types, and other related information.

5.2 Data Cleaning

We found some common issues in the collected datasets. For instance, they have unbalanced and inconsistent records, containing duplicate entries or columns lacking year distinctions for identical month names. To correct these discrepancies, we performed data cleaning and repairing procedures with the help of the Python pandas package and the numpy package. Our initial cleaning process involved the following steps:

- Identify the data type for each dataset
- Remove nonsense data based on the data type
- Remove empty cells or null values
- Drop data that are not describing New York City
- Aggregate data records if needed
- Align the timeline from January 2019 to December 2022

We applied the initial cleaning to all the datasets we collected. For example, the **New York City Benchmark Revisions** has many duplicates in rows and columns, and the columns were not categorized by year, so there were many repeated months without year tags. In this case, we made an extra step to fix the data: Segregate the data into blocks by month clusters (January-December) and merge them based on duplicate items. After the initial cleaning, we created a simple plot for each dataset to identify any outliers, abnormal data blocks, or missing data.

5.3 Data Repairing

To address outliers, anomalous data blocks, and missing data in our datasets, we conducted an analysis to distinguish between explainable data and errors. We annotated the explainable data records and incorporated them into our result analysis. We consulted the national and New York City region datasets for missing data and errors to address them. We also combined the datasets obtained from **U.S. BUREAU OF LABOR STATISTICS** and **Labor Statistics for the New**

York City Region to accurately represent our data for presentation, ensuring that we avoided double-counting errors. Compare both datasets and, if necessary, take the average value of cells with significant discrepancies between the two sources.

6 RESULT

In this section, we will present the figures and describe our findings.

6.1 Employment vs COVID-19

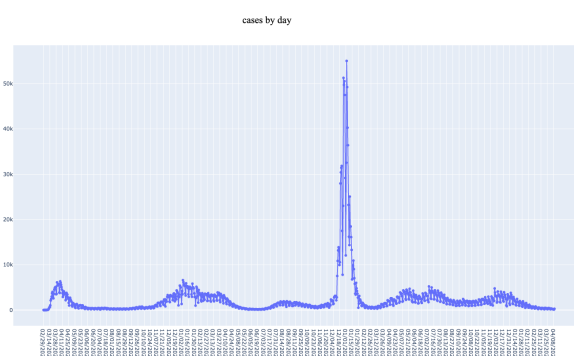


Figure 1: COVID-19 cases per day in New York City

Figure 1 shows the impact of COVID-19 through significant waves that occurred in early 2020 (February 2020 to May 2020), late 2020 (November 2020 to April 2021), and late 2021 (November 2021 to February 2022). The second wave is characterized by a long and gradual increase, while the third wave exhibits a sharp peak. We hypothesized that the distinct shapes of these waves may be attributed to the city's "stay at home" policy and changes in employment rates.

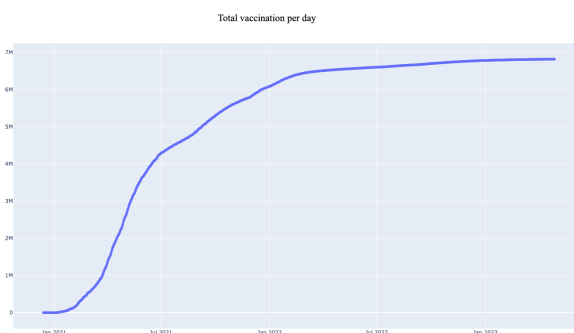


Figure 2: COVID-19 vaccinations in New York City.

Figure 2 shows the number of people who have completed two doses of the COVID vaccination in New York City. The

COVID-19 vaccine was first approved for emergency use by the US Food and Drug Administration (FDA) in December 2020, and health workers started to get vaccinated since then. Later in February 2021, the vaccine was gradually expanded to cover more and more of the general population. This number increased sharply between 2021 and 2020. By January 2022, there have been more than 6 million people getting vaccinated in NYC. About a year later in January 2023, the fully-vaccinated population increased to approximately 6.8 million and then maintained level.



Figure 3: The number of non-farm employees in New York City.

Figure 3 displays the number of registered non-farm employees in New York City. The timeline of Covid-19 impact waves, as shown in the daily Covid case chart, reveals that the first wave resulted in the largest employment rate decline. Subsequent waves had progressively milder impacts, with growth rates eventually returning to pre-Covid levels. We suspect that many industries changed their employee work patterns or implemented measures to mitigate the spread of Covid-19, and the availability of vaccines likely played a critical role.

6.2 Gross Domestic Product of Different Industries

Figure 4 presents a pie chart that categorizes the total Unemployment Insurance (UI) claims by industry. The chart shows that industries associated with city-based travel and customer service (Tourism industries) account for a significant portion of the claims, while burgeoning sectors such as Information, Professional, Scientific & Technical Services make up approximately 7% of the total claims. Our analysis focuses on how four industries, namely Construction, Hospitality, Tourism, and Technology, have responded and adapted during the pandemic, with a particular emphasis on the traditional industries and the contemporary technology industry.

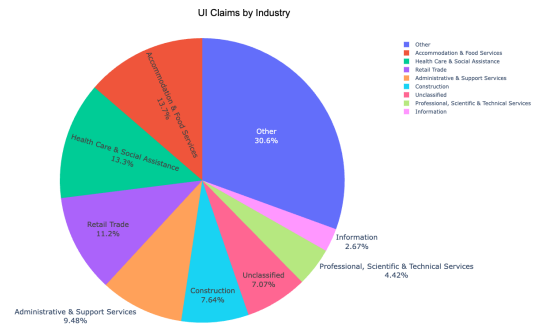


Figure 4: Unemployment Insurance(UI) claim industries in New York City.

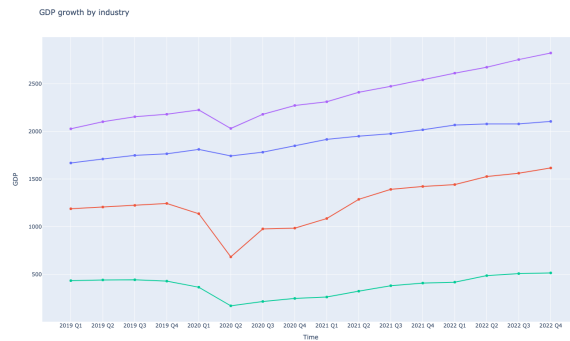


Figure 5: GDP for chosen industries.

Data from the national GDP by industry dataset reveals noteworthy trends across four sectors we have focused on: Construction, Hospitality, Tourism, and Technology, as shown in **Figure 5**. These industries each underwent distinct levels of impact during the first wave of Covid (2020 Q2), but their responses to the following waves varied. The Construction industry exhibited the least fluctuation in GDP growth among the sectors, consistently growing throughout the pandemic. Both Hospitality and Technology displayed similar trends; however, Technology saw the highest growth rate and rebounded rapidly from the initial hit. Conversely, Hospitality faced a downturn after the first shock but managed to recuperate in the second half of 2021. The Tourism industry's GDP growth showed a slow yet steady rise over the pandemic period, finally returning to pre-pandemic levels two years post the first wave (2020 Q2 – 2022 Q2), a recovery period longer than the other industries.

6.3 Transportation and Food Service

Tourism is a major source of income for New York City, with approximately 66.6 million visitors in 2019 generating \$47.4

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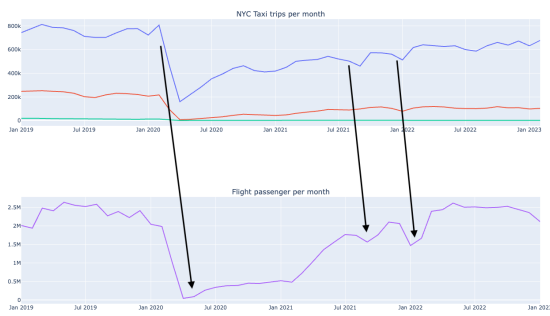


Figure 6: Taxi trips in New York City with the number of passengers flew to NYC.

billion in spending, according to the Office of the New York State Comptroller [2]. In order to examine the impact of the pandemic on the tourism industry, we gathered data on NYC taxi trips and the number of passengers flying to the city. Our analysis revealed that the number of taxi trips and flight passengers were closely related, experiencing three significant drops simultaneously. The first drop occurred in February 2020, coinciding with the first COVID-19 wave shown in **Figure 1**, as people became more aware of the pandemic and began to avoid traveling. The first drop reached its bottom in April 2020, which was the time when the first COVID-19 wave reached its peak shown in **Figure 1**. After January 2021, the industry began to recover until the second half of the year, as shown in **Figure 6**, indicating a resurgence in travel likely due to the vaccine roll-out. However, despite the vaccine's approval, two more drops occurred aligning with the second and third COVID waves in **Figure 1**, albeit less severe than the first. We speculate that people have adapted to living with the pandemic and are hopeful that the vaccine will bring an end to the pandemic.

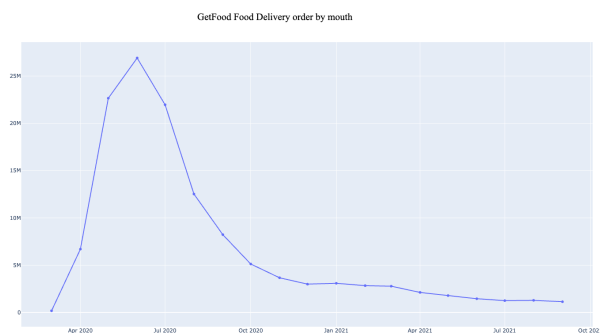


Figure 7: GetFood Service in New York City.

As the volume of travel decreased, the food service industry linked to tourism also felt a ripple effect. Utilizing official data from New York Food Policy, **Figure 7** depicts the monthly number of GetFood orders. GetFood was an Emergency Home Food Delivery program launched by The New York City Government, aimed at providing food delivery services to COVID-vulnerable residents who are unable to leave their homes to purchase food, have no one to assist them, or cannot afford private delivery options. The number of GetFood orders soared during the first wave of COVID infection in April 2020, highlighting a substantial increase in demand for food delivery. Simultaneously, the GDP growth for food services experienced a downturn, implying that certain restaurants found it challenging to adapt to the shifting customer demand. The initial lockdown, implemented in response to the pandemic, further constrained customer inflow to various restaurants, leading to their unprofitability.

However, as time progressed (from Q3 2020 to Q1 2021), emergency food delivery orders diminished and the GDP of food services rebounded to its pre-pandemic levels during the same timeframe. We deduce that a majority of restaurants adapted their business strategies, shifting their emphasis from dine-in to take-out to accommodate the heightened demand for food delivery. Concurrently, the growing acceptance of the vaccine led to customers returning to restaurants, reviving the restaurant industry to its pre-pandemic growth levels after approximately a year of downturn.

6.4 Technology Industry and Work From Home Percentage

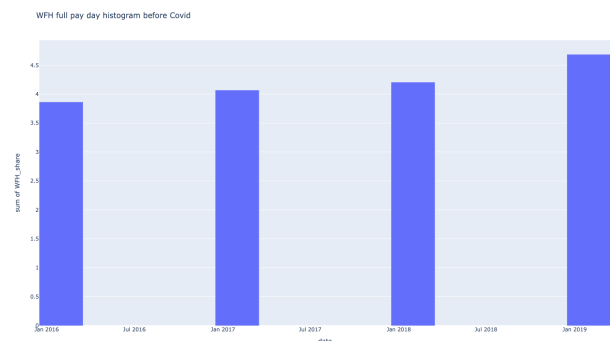


Figure 8: Work-from-home full-paid day percentage in the US before COVID-19.

Figure 8 illustrates the percentage of paid full days that were worked from home prior to the COVID-19 pandemic. The data shows that the percentage of paid full days worked from home was less than 5% before the pandemic, in sharp

contrast to the significantly higher percentage during the pandemic. This implies that prior to the pandemic, there was limited acceptance of remote work by employers and the demand for working from home was small.

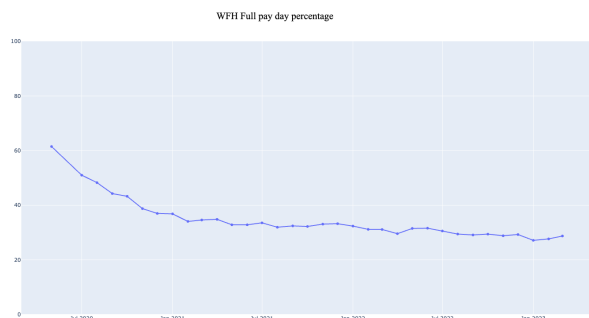


Figure 9: Work-from-home full-paid day percentage in the US.

According to the report from the Office of the New York State Comptroller, the technology sector experienced a significant surge in total wages between 2016 and 2021, with an increase of more than double, or 108 percent [3]. This growth rate is nearly four times larger than the expansion observed in total private sector wages, which saw an increase of 28 percent during the same period. While total private sector employment experienced a decrease of 12.6 percent, shedding 494,810 jobs in 2020, the technology sector bucked the trend, showcasing a robust growth of 9.4 percent and adding 14,340 jobs. The technology industry continues to demonstrate an upward growth trend, and we hypothesize that the implementation of work-from-home policies has significantly contributed to this expansion. To further investigate this, we computed the ratio of full-paid work-from-home (WFH) days at both the national level (Figure 9) and specifically for New York City (Figure 10).

Before the pandemic, the national acceptance of remote work was relatively low, with just around 4% of remote employees receiving salaries comparable to their peers working on-site (Figure 8). However, in the wake of the initial wave of the epidemic in 2020, there was a sharp increase in wages for remote work, pointing to a sudden uptick in the popularity of this work arrangement. New York City's data mirrored this pattern, reflecting the nationwide shift towards a more significant acceptance of remote work. After the first impact, because of the widespread of vaccination (Figure 2) and reopen policies, the remote work full pay day rate decreased slightly. But the wage parity for remote work remained stable at around 40% in the rest of the pandemic period, a trend that has persisted to the present. Given the nature of the technol-

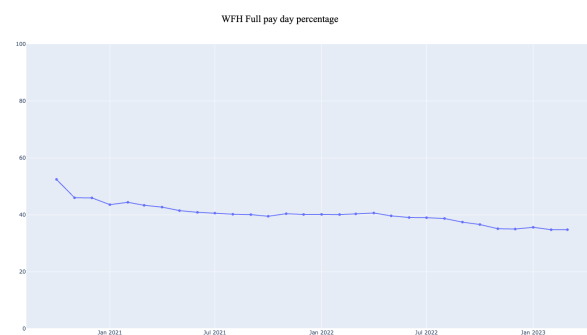


Figure 10: Work-from-home full-paid day percentage in New York City.

ogy industry, which favors streamlined work environments and heavily depends on the Internet for work-related tasks, the adoption of remote work arrangements is quite straightforward. In comparison to other industries, the reduced necessity for physical workspace creates more employment opportunities within the tech sector. The ability for a significant number of employees to work from anywhere eliminates the need for relocation near office premises, thereby expanding the potential talent pool. The widespread adoption of remote work has endowed the technology industry with increased flexibility in mitigating the effects of the pandemic. Following the initial disruption, major tech companies swiftly revised their work policies, demonstrating adaptability in toggling between remote and on-site work arrangements based on the evolving pandemic situation. Despite two subsequent waves of the pandemic, the technology industry as a whole managed to maintain its stability without any significant disturbances.

The proportion of remote work has maintained a consistent steady trajectory. We conjecture that the acceptance of working from home will not revert to pre-pandemic levels in the coming years. Instead, it is likely to become a standard practice across various sectors.

6.5 Construction

In order to gain a more comprehensive understanding of the construction industry's performance amid the pandemic, we delved into the records of building permit issuance.

The cumulative graph in Figure 11, which tracks building permit issuances, demonstrates a generally stable progression, albeit with an observable stagnation at the beginning of the first wave of the pandemic. This aligns with the government's report of the state experiencing its most substantial annual decline in over 25 years, marked by the loss of 44,400

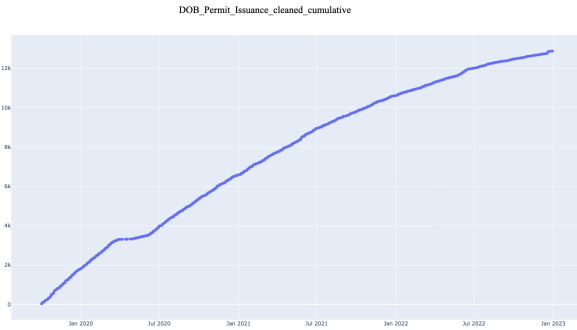


Figure 11: Department of Building(DOB) permit issuance.

construction jobs. Despite a temporary halt at the pandemic’s onset, the industry’s growth quickly rebounded. However, a mild deceleration in the overall growth rate becomes evident after mid-2021, as implied by the slight downward tilt in the curve.

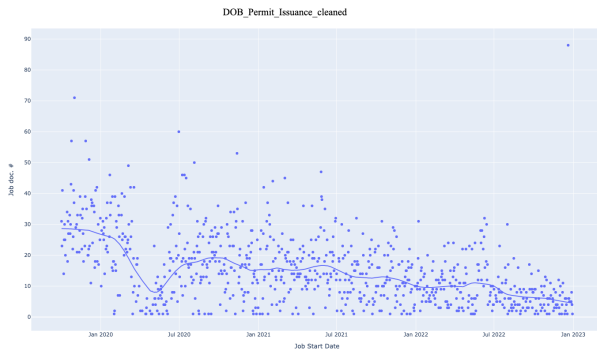


Figure 12: The number of construction jobs permitted by DOB

We further examined the daily issuance of building permits shown in **Figure 12**. Given the substantial variations in the daily data, we employed local regression to generate a curve illustrating daily changes for our analysis. The curves underscore a marked decline in daily issuance preceding the pandemic, which is in sync with the observations from the cumulative graph. However, it bounced back rapidly to the level observed before the pandemic and sustained this stability up until mid-2021. According to a report from the Office of the New York State Comptroller, the demand for city infrastructure surged significantly following the initial shock of the pandemic, in conformity with new city policies, leading to a spike in building permit issuance [1]. Yet, post-July 2021, daily issuance began to gradually taper off to levels considerably below those seen before the pandemic. We posit

that this trend could be attributed to the enhancements in the city’s facilities and the saturation in the reliance on the construction industry.

7 LIMITATIONS

Our study has some limitations that should be considered when interpreting the results. First, we encountered difficulties in obtaining direct datasets containing the number of orders or profits of the food service industry in New York City. As a result, we relied on the GetFood dataset as a proxy to support our hypothesis that the demand for food delivery services increased as people avoided dining out. However, this assumption may not accurately reflect the actual situation of the food service industry in NYC during the pandemic, and alternative data sources could provide additional insights.

Second, the data for the GDP of different industries in NYC was not directly accessible. To address this limitation, we combined national GDP data with NYC government reports to estimate how the pandemic affected the chosen industries in NYC on the aspect of GDP. Although New York City contributed a significant portion of the national GDP in the four industries, this approach may not fully capture the local impact of the pandemic. Additionally, the technology industry faced a similar issue, and we used a combination of national technology industry GDP and work-from-home data to infer changes during the pandemic.

Therefore, although we employed various methods to mitigate these limitations, the results should be interpreted with caution and future studies may benefit from additional data sources and alternative methodologies.

8 CONCLUSION

This paper utilizes data visualization technology to depict the impact of the COVID-19 pandemic in New York City, including the number of confirmed cases, employment rates, and vaccination distribution. Moreover, we analyze the effects of the pandemic on selected industries, such as hospitality, tourism, technology, and construction. Based on our analysis of four distinct industries during the pandemic, we can summarize the relative stability and adaptability of similar industries in such situations.

Industries such as tourism, which heavily depend on customer traffic and offline interactions as their primary business model, encountered substantial difficulties during the pandemic. The inability to swiftly adjust their business model hampered their recovery process. The market conditions for these industries largely rely on the pandemic’s status. Industries that were severely impacted during the epidemic,

struggle to recover promptly, and are extremely reliant on customer traffic are referred to as **traffic-driven recovery** industries.

Industries similar to construction share a common characteristic: they require government authorization to operate. As time progresses, the demand for these industries in urban areas tends to decline gradually. These industries are highly responsive to government policies and are dependent on real-time market demand, but such demand in NYC is limited. During an epidemic, industries that rely on real-time policies to revive growth are referred to as **policy-driven recovery** industries.

Both the technology and food service industries managed to adapt during the pandemic by transforming their operating models. The technology industry quickly adjusted its policies such as remote working, restoring growth levels to pre-pandemic rates in a short period. We refer to this type of industry as a **self-mitigating recovery** industry, which possesses the flexibility to change its working pattern while its work environment remains unaffected by the pandemic.

On the other hand, the restaurant industry initially faced reduced customer traffic and struggled to attract sufficient patronage for their offline services. This industry pivoted during the pandemic by directing traffic online, completing a business model shift. We categorize this as the **traffic redirection recovery** industry, characterized by its ability to restore growth by adapting to online transactions or interactions, replacing their original service functions.

Overall, the COVID-19 pandemic had a negative impact on the economy and employment across various industries, including hospitality, tourism, technology, and construction. However, as time passed, the adaptation to living with the pandemic, the widespread availability of COVID vaccines, and the adjustments within the industries brought renewed hope, and the industries began to recover at different rates. Among these industries, the construction and technology sectors showed more resilience to the pandemic, while hospitality and tourism were more vulnerable.

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