Assessing the Impact of COVID-19 on US Job Openings: An ARIMA Model Analysis of the Total Labor Market, Professional and Business Services, and Finance Sector

Tiancheng Daniel Dai

College of Letters & Science, University of California, Los Angeles (UCLA), Los Angeles, California, 90024, United States
danieldai21@ucla.edu

Abstract. The COVID-19 outbreak has disrupted lives and shattered the global economy, particularly impacting the labor market. This paper quantifies the pandemic's effect on US job openings within the labor market, specifically on the professional and business services and finance sectors. Weekly job openings data from these three sectors were analyzed using ARIMA models to predict and compare post-COVID job openings. The analysis reveals that both the professional and business services and finance sectors experienced a more severe impact compared to the total labor market. This study finds that COVID-19 led to an immediate reduction of approximately 2.5 million job openings, marking a 35% decline from the anticipated figures in April 2020. Over time, this impact has stabilized to a persistent 12% loss. In the professional business services sector, there was an initial reduction of around 513,000 job openings, accounting for a 38% drop in April, which later settled to a 19% long-term loss. The finance sector displayed substantial volatility, with a notable decrease of around 150,000 job openings, culminating in the greatest discrepancy of a 36% drop in November, showing no signs of recovery thus far. Therefore, this study aims to provide job seekers and policymakers with a comprehensive perspective for evaluating labor market conditions in the wake of the pandemic.

Keywords: Covid-19, Job Openings, Times Series Model.

1 Introduction

The COVID-19 pandemic, with cases first identified in Wuhan, China, in December 2019, rapidly spread worldwide, resulting in cases in over 100 countries by early 2020. Caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), this pandemic led to a range of symptoms, from asymptomatic to lethal, with fever and cough being the most common. To mitigate the spread of COVID-19, governments globally implemented lockdowns and social distancing measures, which in turn caused significant disruptions, including global supply chain interruptions and business closures. Consequently, the pandemic has caused the greatest economic

shock of the 21st century, resulting in a 3% contraction of the global economy in 2020 and an estimated total loss of $9 trillion USD [1].

Specifically, the pandemic has caused a significant and potentially long-term impact on the US labor market. Due to restriction measures, people were advised to stay at home and work remotely, leading to the disruption of essential services such as food, transportation, entertainment, and many more. This resulted in the temporary shutdown of many businesses and widespread job losses. Between February and April 2020, the US experienced the most significant and abrupt job loss in decades, with 22 million jobs, or 15% of the workforce, being lost [2]. The labor supply was also affected, as the labor participation rate dropped from 63% to 56% in early 2020, largely due to early retirements prompted by COVID-19 [3]. Additionally, the pandemic accelerated digitalization, as remote work required the adoption of new technologies. This shift towards digitalization further promoted job automation, leading to a permanent loss of 2.9 million jobs [4].

The financial activities sector is integral to the labor market and the broader economy. As of May 2024, this super sector employs around 9.2 million high-skilled workers [5], who are mainly within the finance and insurance sector, as well as real estate and rental and leasing services. By optimally allocating capital and managing risk, the finance sector ensures that businesses across different industries have sufficient funding to invest in innovation, improve performances, and create jobs, which leads to a positive and monotonic effect on the economy [6]. However, the COVID-19 pandemic has significantly disrupted economic activity, leading to increased unemployment and reduced wages. This has heightened investor perceptions of risk and uncertainty in financial markets, resulting in a decrease in capital flow [7]. This reduction in capital flow exacerbates economic harm, creating a vicious cycle of economic decline and rising unemployment.

The professional and business services super sector is also a crucial component of the labor market, comprising three sub-sectors: Professional, Scientific, and Technical Services (such as lawyers and accountants); Management of Companies and Enterprises; and Administrative and Support and Waste Management and Remediation Services. With a total of 22.985 million high-skilled workers [5], this sector leverages its expertise to address various business needs and improve outcomes. Evaluating this super sector provides insights into the overall well-being of businesses nationwide. The impact of COVID-19 on this sector is debated. While the pandemic caused significant business closures, potentially reducing demand for professional services, Wojcik and Ioannou argue that there was a concurrent increase in demand for business services: firms sought additional help from lawyers and accountants to minimize costs and navigate the challenging economic environment [8].

This study aims to analyze the impact of COVID-19 on the entire labor market in the US, with a focus on the professional and business services and financial activities sectors. By combining the effects on the overall labor market and these two critical sectors, the pandemic's impact on businesses can be thoroughly understood, which contributes to recovery efforts and resilience strategies. Additionally, it will help job

seekers and policymakers gaining deeper insights into these super-sectors regarding their labor market conditions, strengths and volatility, and distinct characteristics.

The rest of this study is structured as follows: The data sources, data stability, and models used are described in depth in Section 2. A thorough explanation of the ARIMA model's findings is given in Section 3, along with extra analysis on the effects of COVID-19, sector volatility, and other pertinent variables. Following this, the findings are compared with existing literature, the implications are discussed, and practical applications are explored. In conclusion, Section 5 provides a brief overview of the study's findings.

2 Research Design

2.1 Data Source

This study's time series data came from the Federal Reserve Economic Data (FRED), an authoritative database managed by the Federal Reserve Bank of St. Louis, a part of the central banking system of the United States. In order to examine how the epidemic has affected the job market, this study focuses on job openings across three sectors: total nonfarm, professional and business services, and financial activities. Job openings serve as a crucial indicator of labor demand and market vitality. The selected data spans from December 2000 to April 2024. However, for the purpose of this analysis, data from January 2010 to March 2020 is extracted to accurately capture the labor market conditions before the pandemic's start.

Logarithmic transformations of the job openings series were performed using STATA data analysis software. First-order differencing, which calculates the change between consecutive observations in the logarithmic series, was applied to obtain the differenced logarithmic series for total nonfarm, professional and business services, and financial activities. Subsequently, the data was analyzed using STATA, and ARIMA models were built using the differenced logarithmic job series data up to March 2020. These models were then used to forecast job openings and to investigate the pandemic's impact on the three job openings series.

2.2 ADF Unit Root Test

Before applying the ARIMA model to the series, it is crucial to conduct the Augmented Dickey-Fuller (ADF) test to assess the stationarity of the series. When a time series is stationary, it indicates that its values are time-independent. The ADF test evaluates its test statistic by estimating a regression model that incorporates both the lagged level and the first differences of the series, and then assessing the significance of the lagged level's coefficient [9]. Under the ADF test, the null hypothesis assumes the presence of a unit root, indicating non-stationarity; a significant p-value allows for the rejection of this hypothesis in favor of the alternative, which states that the series is stationary.

Table 1. Weak stationarity test

	t	p
	Job Total	
Ln value	-2.508	0.3241
1st order difference	-15.330	0.0000
	Professional and Business Services	
Ln value	-3.780	0.0176
1st order difference	-11.716	0.0000
	Financial Activities	
Ln value	-7.782	0.0000
1st order difference	-20.764	0.0000

The ADF test statistics and associated p-values for the logarithmic job openings series and its first differenced counterparts are shown in Table 1. The logarithmic total job series exhibits a p-value of 0.3241, which exceeds the significance threshold of 0.05, so it is concluded that this series is non-stationary. However, all other series analyzed—namely the first order differenced series—demonstrate p-values well below 0.05, some approaching zero, allowing us to reject their respective null hypotheses and confirm their stationarity. Given these results and adhering to standard ARIMA modeling practices, the first-order differenced logarithmic job openings series are suitable for use in the ARIMA framework.

2.3 ARIMA Model

An effective forecasting method that uses past time series data to project future values is the Autoregressive Integrated Moving Average model, or ARIMA model. The three parameters, p, d, and q, respectively, represent the autoregressive, integrated, and moving average components of the model [10]. ARIMA is versatile for various predictive scenarios, since it is particularly effective in predicting time series data that exhibit trends, seasonality, or both.

$$y_t = c + \varphi_1 y_{t-1} + \cdots + \varphi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (1)$$

$$y_t = c + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + \varepsilon_t \quad (2)$$

The parameter p represents the autoregressive component, where the current value of the series is regressed on its previous values up to p lags, incorporating an error term assumed to be white noise.

The parameter d denotes the degree of differencing required to achieve stationarity in the data series. In this study, d is set to 1, because first-order differencing has been applied to all three logarithmic job openings series to ensure stationarity.

$$y_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (3)$$

The moving average component, denoted by the parameter q, represents the present value as a linear combination of the past errors in the series. The term c in this context represents an arbitrary constant.s

3 Empirical Results and Analysis

3.1 Order determination and residual test

The Partial Autocorrelation Function (PACF) and the Autocorrelation Function (ACF) are evaluated to establish the proper order of p and q in ARIMA models for the three differenced logarithmic series. In Figure 1, the rectangular boundaries represent the 95% confidence intervals for the coefficients.

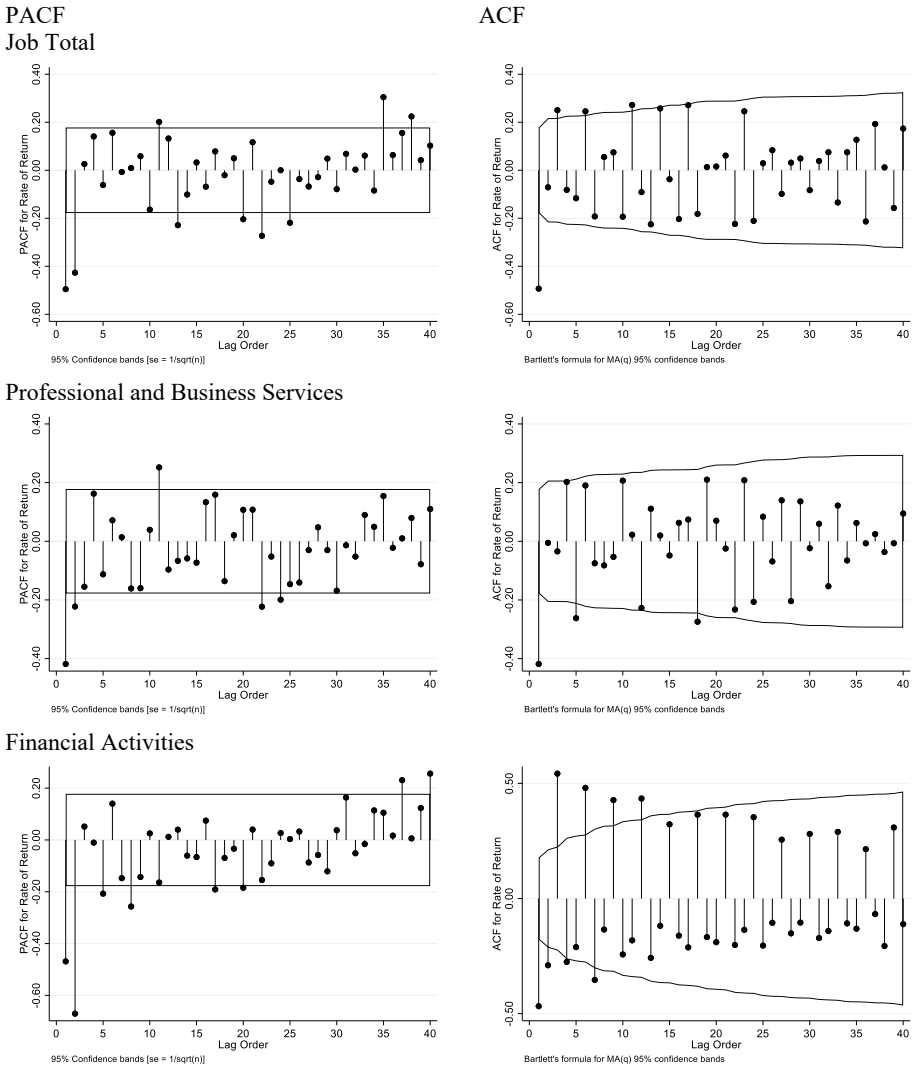

Fig. 1. ARMA (p, q) identification (Photo credit: Original)

Spikes that exceed these bounds indicate a PACF or ACF value significantly different from zero, suggesting the corresponding lag as a potential order for p or q in the ARIMA model. Orders of p and q are restricted to a maximum of 10 to avoid excessive model complexity and to ensure more reliable and accurate coefficient estimation.

Following this analysis, the highest significant lag orders less than 10 are identified from the spikes and set as parameters. Therefore, for the total job openings series, p and q are set to 2 and 6; for the professional and business services series, the parameters are set to 2 and 5; finally, for the financial activities series, p and q are set to 8 and 9. Since first-order differenced logarithmic transformations are utilized for all three series, d is uniformly set to 1 across all three ARIMA models.

Table 2. Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
Job Total – ARIMA(2,1,6)	84.0178	0.0001
Professional & Business Services – ARIMA (2,1,5)	28.3286	0.9166
Financial Activities – ARIMA(8,1,9)	28.8980	0.9037

Residual tests are performed on the ARIMA models (Table 2): if the p-values exceed 0.05, the residuals can be considered white noise, fulfilling a key assumption of the ARIMA model. For the professional & business services and financial activities series, the p-values of 0.9166 and 0.9037, respectively, indicate that the residuals are white noise. Although the residual for the total job openings model is not white noise, the model's adequacy is maintained by the trend characteristics of the series and by adjusting its order to minimize the impact of the error term. Once the ARIMA models are validated and the residuals examined, they are employed to forecast job openings in the three sectors post-pandemic.

3.2 Forecast Results and Interpretation

Tables 3, 4, and 5 present the fitted and actual values of job openings across three sectors following the onset of the pandemic, alongside the deviations between these values. The pandemic induced a significant negative shock on total job openings, with the most substantial impact observed in April 2020. This was one month post-outbreak, where COVID-19 resulted in a decrease of approximately 2.5 million job openings, equal to 35% of the predicted job openings, and representing about 10.8% of the unemployed population, which totaled 23.1 million at the time. This analysis is consistent with the observed surge in the unemployment rate, indicating severe disruptions in labor market conditions. After reaching a nadir in April, the labor market began to recover, and job openings started to increase. The difference between the fitted and actual job openings narrowed in May 2020, with the discrepancy reducing to just 21%. However, from June through August 2020, the discrepancy in job openings stabilized at around 800 thousand, representing approximately 12% of

the forecasted job openings. This consistent shortfall indicates a long-term gap created by COVID-19 in labor market conditions.

Table 3. Total Job Openings Forecasting Results – ARIMA(2, 1, 6)

	Actual Values	Predicted Values	Difference	% of Change
Sep - 19	7124			
Oct - 19	7289			
Nov – 19	6888			
Dec - 19	6699			
Jan - 20	7170			
Feb - 20	6974			
Mar - 20	5924	6940.623	-1016.62	-14.65%
Apr - 20	4637	7126.045	-2489.04	-34.93%
May - 20	5593	7162.285	-1569.28	-21.91%
Jun - 20	6156	7036.644	-880.64	-12.52%
Jul - 20	6491	7339.376	-848.38	-11.56%
Aug - 20	6369	7241.824	-872.82	-12.05%

The pandemic also had a severe impact on the professional and business services sector. The most significant disruption occurred in April 2020, with the sector losing 510 thousand jobs, representing 38% of the projected job openings—a proportion similar to that of the total labor market. In contrast to the overall labor market, the recovery of job openings in the professional and business services sector has been sluggish, with the difference narrowing from 28% in May to 23% in June, and further to 19% in July. These percentages remain notably higher than the 12% average across the labor market. This trend may indicate that, due to the economic shock, businesses across all sectors are curtailing costs and showing a reluctance to engage additional services from this sector.

Table 4. Professional & Business Services Forecasting Results – ARIMA(2, 1, 5)

	Actual Values	Predicted Values	Difference	% of Change
Oct - 19	1205			
Nov – 19	1202			
Dec – 19	1237			
Jan – 20	1303			
Feb – 20	1290			
Mar – 20	1089	1298.655	-209.65	-16.14%
Apr – 20	846	1359.955	-513.96	-37.79%
May – 20	1008	1399.438	-391.44	-27.97%
Jun – 20	1077	1403.445	-326.44	-23.26%
Jul - 20	1156	1428.307	-272.31	-19.06%

Unlike the other two sectors, the financial sector endured a more severe and prolonged effect. In contrast to the initial sharp declines seen in April in other sectors, the financial sector experienced a consistent 28% reduction in job openings during both April and May 2020. Although there was a brief recovery to a 20% deficit in June, the gap widened again, averaging 31% in July and August. A similar pattern recurred with a temporary improvement to 20% in September, followed by a

deterioration to 28% and then a peak deficit of 36% in October and November. Rather than displaying a stable recovery trend, the financial activities sector exhibited a more volatile cycle. This periodic fluctuation of the pandemic's impact may reflect the inherent seasonal patterns in finance sector's job openings, which vary month-to-month. Overall, this volatility may suggests that the pandemic's enduring impact has diminished investor confidence in the economy, leading to increasing pessimism over time, leading to the trough observed in November.

Table 5. Financial Activities Forecasting Results – ARIMA (8, 1, 9)

	Actual Values	Predicted Values	Difference	% of Change
Jun – 19	363			
Jul – 19	384			
Aug – 19	386			
Sep – 19	362			
Oct – 19	453			
Nov – 19	338			
Dec – 19	309			
Jan- 20	462			
Feb – 20	409			
Mar – 20	333	387.367	-54.37	-14.04%
Apr – 20	308	425.623	-117.62	-27.64%
May – 20	280	393.718	-113.72	-28.88%
Jun - 20	315	392.437	-77.44	-19.73%
Jul – 20	321	478.888	-157.89	-32.97%
Aug - 20	284	404.096	-120.09	-29.72%
Sep - 20	297	369.642	-72.64	-19.65%
Oct – 20	350	481.272	-131.27	-27.28%
Nov - 20	263	413.297	-150.30	-36.37%

4 Discussion

Combining the results, the analysis clearly shows that the pandemic significantly impacted job openings, particularly in the professional & business services and finance sectors. This reflects the broader economic downturn which reduced labor demand and increased unemployment. However, the observed recovery trend in total job openings underscores the effectiveness of government measures like support for small businesses and the promotion of remote work. These interventions have been crucial in revitalizing the labor market, suggesting that individuals who exited the workforce due to market concerns should consider re-entering to take advantage of improving conditions.

These findings regarding the professional and business services sector conflict with those of Wojcik and Ioannou [8], who predict a growth trend driven by increased demand for accountants and lawyers. While they correctly highlight the expansion of high-skilled roles, they overlook the significant presence of low-skilled positions such as customer service representatives, data entry clerks, cleaning staff, and receptionists. The pandemic has accelerated digitalization and automation, posing a

greater risk of job displacement for these low-skilled workers. Consequently, the recovery in this sector is more gradual than in the overall labor market due to the dual effects of high-skilled job growth and the automation of low-skilled roles. Job seekers considering this sector should focus on acquiring high-skilled qualifications to access better opportunities.

The finance sector has demonstrated considerable volatility during the pandemic, with its labor market conditions heavily influenced by macroeconomic factors. The underperformance of the stock market throughout 2020 eroded industry confidence, leading to significant labor market fluctuations. Job seekers in recent years should be aware of the sector's volatility and the associated risks of layoffs. However, given that the finance sector primarily comprises high-skilled labor and plays a crucial role in the economy, it is believed that the sector will eventually recover from the negative impacts of COVID-19. Thus, the finance sector remains a promising field for job seekers over the long term.

5 Conclusion

This paper's main objective is to investigate how the pandemic has affected job opportunities in the labor market, with a particular emphasis on the financial and professional services industries. This analysis seeks to clarify the pandemic's wider effects on the economy while giving job searchers useful information about the state of the market and available prospects. To facilitate this investigation, monthly data on job openings in these sectors were selected for a comparative analysis, employing an ARIMA model to both track their responses throughout the pandemic and quantify its impact on job openings.

The analysis indicates that the pandemic has had a severe negative impact on job openings across all three sectors, potentially leading to a loss of up to 2.5 million jobs—a 35% decrease from the forecasted values. Notably, the professional and business services sector has experienced a disproportionately larger impact compared to the total labor market. This outcome suggests that a significant portion of the low-skilled workforce faced substantial job loss threats due to factors such as business closures and an accelerated shift towards job automation triggered by COVID-19. The finance sector has also demonstrated volatility with a fluctuating job loss pattern, indicating that it is highly influenced by investor confidence in the economic conditions. Despite these challenges, a return to normalcy for the finance sector is anticipated in the future, owing to its high-skilled nature and critical role in the economy.

Numerous inferences and implications for further research can be made in light of these findings. First, the study emphasizes that large events, like the epidemic, usually have their greatest influence immediately after their occurrence. Therefore, it is crucial for policymakers to implement responsive measures promptly to mitigate further adverse effects and to facilitate recovery. Second, future research should pay more attention to the risks of automation to different labor markets and how significant events can accelerate this process. Additionally, the use of empirical

analysis in this research provides innovative ideas and methodologies that can improve future quantitative models aimed at assessing the impact of market fluctuations on various labor sectors more precisely. It is expected that these enhancements would lead to the provision of more insightful and helpful guidance, which will increase job prospects in the labor market.

References

1. Naseer, S., Khalid, S., Parveen, S., Abbass, K., Song, H., & Achim, M.V. (2023). COVID-19 outbreak: Impact on global economy. Frontiers in Public Health, 10, Article 1009393.
2. Groshen, E.L. (2020). COVID-19's impact on the U.S. labor market as of September 2020. Business Economics, 55, 213–228.
3. Coibion, O., Gorodnichenko, Y., & Weber, M. (2020, April). Labor Markets During the COVID-19 Crisis: A Preliminary View. National Bureau of Economic Research Working Paper Series, No. 27017.
4. Stevenson, B. (2020, July). The Initial Impact of COVID-19 on Labor Market Outcomes Across Groups and the Potential for Permanent Scarring. The Hamilton Project, Brookings Institution. Retrieved from https://www.brookings.edu/wp-content/uploads/2020/07/Stevenson_LO_FINAL.pdf
5. U.S. Bureau of Labor Statistics. (n.d.). Industry at a Glance. Retrieved June 2023, from https://www.bls.gov/iag/home.htm
6. Popov, A. (2017). Evidence on finance and economic growth. ECB Working Paper No. 2115. European Central Bank, Frankfurt am Main. ISBN 978-92-899-3031-4.
7. Shabir, M., Jiang, P., Wang, W., & Işık, Ö. (2023). COVID-19 pandemic impact on the banking sector: A cross-country analysis. Journal of Multinational Financial Management, 67, Article 100784.
8. Wójcik, D., & Ioannou, S. (2020). COVID-19 and finance: Market developments so far and potential impacts on the financial sector and centres. First published: June 12, 2020.
9. Mushtaq, R. (2011, August 17). Augmented Dickey Fuller Test. Available at SSRN: https://ssrn.com/abstract=1911068 or https://doi.org/10.2139/ssrn.1911068
10. Hyndman, R., & Khandakar, Y. (2008). Automatic time series forecasting: the ARIMA way. Computational Statistics & Data Analysis, 52(12), 5080-5096.