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Article

The effect of economic downturns on the frequency of mass shootings

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SUMMARY

In the United States, researching the multitude of factors that contribute to the increase in gun violence and mass shootings remains challenging. There is no entity or agency that systematically and consistently collects data related to gun deaths and injuries. Using available data, several studies have shown a link between individuals carrying out mass shootings and workplace issues, job loss, and financial stress. While these past studies suggest that economic and financial stress may lead to mass shootings, there is very little formal research and analysis looking at the effect of broad financial and economic downturns on the incidence of mass shootings. We hypothesized that there would be an inverse relationship between the frequency of mass shootings and the performance of the stock market and broad economic indicators. We chose the S&P 500 index and the unemployment rate to represent the performance of stocks and the broader economy. We ran a correlation study over time to determine whether the frequency of mass shootings was related to these indicators. We found a correlation indicating that these financial and economic indicators might be linked to the frequency of mass shootings via other unifying factors. This suggests that, along with other drivers, the state of the overall economy is related to the probability of mass shooting incidents. Hence, governments, communities, and families may consider stronger mitigation strategies, especially during periods of financial stress.

INTRODUCTION

Gun deaths are an enormous problem in the United States: they are the leading cause of child mortality, and 80% of all murders involve a firearm (1). Among 31 high-income countries that have a population of at least one million inhabitants, the US has a 24.9 times higher firearm homicide rate compared to the pooled rate of all the others (2). The federal government has not been able to effectively address gun violence. Despite numerous proposals with broad public support, including expanded background checks, banning certain firearms and accessories, and closing gun law loopholes, no substantial federal gun control measures have been successfully implemented (3). The government's inaction on restricting and controlling gun availability seems to be a persistent problem, and the number of active shooter incidents has been on an upward trend over the first two decades of the twenty-first century (4, 5).

The history of gun control legislation in the United States is marked by periods of increased regulation countered by cultural and constitutional emphasis on individual rights underpinned by the Second Amendment (6). In the 1990s, two significant regulatory measures became law. The Brady Act of 1993 mandated federal background checks for firearm purchasers and imposed a five-day waiting period between application and completion of a gun sale (7). The 1994 Federal Assault Weapons Ban, which lasted until 2004, prohibited the manufacture of certain semi-automatic firearms and large-capacity magazines (8). The repeal of the assault weapons ban in 2004 seems to fall within an extended period of legislative deference to the Second Amendment.

The first two decades of the twenty-first century have seen an uptick in the number of mass shootings per year (**Figure 1**). While the period with fewer regulatory measures coincides with the recent uptick, the trendline shows an increasing frequency of mass shootings over a longer period of time, going back to the 1980s (9). However, no significant gun control measures have been enacted even in the face of high-profile shootings like the ones at Sandy Hook Elementary in 2012 and Parkland High School in 2018. Rulings like the 2008 Supreme Court decision in District of Columbia v. Heller affirmed an individual's right to possess firearms unconnected with service in a militia, solidifying the cultural view that the right to bear arms is a fundamental right (10). Given this legislative impasse, more studies that shed light on additional factors, other than access to guns, contributing to mass shootings and corresponding mitigation strategies are needed.

Past research has relied on two important sources of data to study mass shootings: the media and the government (11, 12). Both types of sources have their merits and limitations. Media data is based on reports of mass shootings from various media sources, which typically cover most mass murder incidents and include additional data not found in police records. However, limitations in media data include a disproportionate focus on certain types of crimes, particularly murders and other violent offenses (13). Some databases consider a shooting incident where three people or more are killed as a mass shooting, while others require a higher number (12). Government datasets, systematically collected by official agencies, provide more reliable data compared to media data, which can be rushed and less accurate due to law enforcement agencies' reluctance to share information during ongoing investigations. Police records are valuable for determining the number of victims in homicide incidents, but limitations in the form of non-random omissions exist even in the Supplementary Homicide Reports (SHR) data maintained by the Federal Bureau of Investigation (12).

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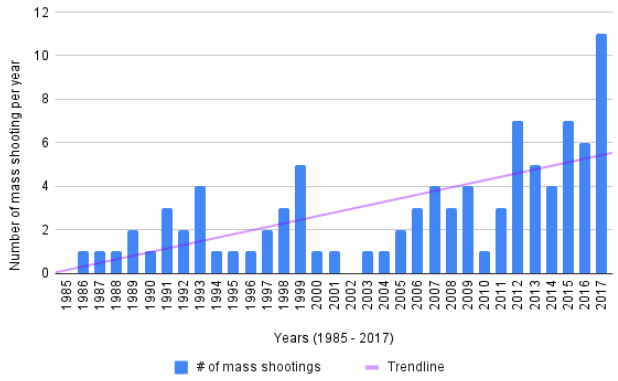

Figure 1: Number of mass shootings per year. The number of mass shootings has been increasing over the 1985-2017 period as the trendline indicates. The database focused on indiscriminate rampages in public places resulting in four or more victims killed by the attacker. Data from Mother Jones' Investigation (9).

For our study, we used a curated dataset from Kaggle that sourced shooting information from Wikipedia, Mother Jones, Stanford, USA Today, and other web sources (14). This dataset uses a consistent methodology to compile data from multiple sources, covering a 50-year period. For example, mass shootings were defined as events that resulted in 4 or more deaths across the whole time period.

To address the danger that guns pose to the American public, additional strategies beyond gun control measures must be understood. Research on how economic and financial market indicators affect mass shootings could lead us to alternative strategies to mitigate gun violence. Approximately 40% of shooters involved in mass shootings experienced financial distress in the form of being fired from a job, difficulty making payments, or having financial disputes with the victims, suggesting a potential link between economic distress and mass shootings (15). Additional research has revealed a positive correlation between the unemployment rate in a geographic area and school shootings at K-12 and post-secondary schools (16). Housing affordability, related economic stresses, as well as changes in income inequality, may also contribute to rates of gun violence (17, 18). By considering income levels in combination with trends in income inequality, we can capture the effect of more regional factors that contribute to mass shootings (19).

Previous analysis of over 100 studies conducted in different parts of the world has found an association between economic recessions and worsening mental health in the population (20). The widespread availability of guns in combination with the increased incidence of mental health conditions in people may heighten the chances of shootings (21). However, there is a lack of studies that look at the correlation between national economic indicators and mass shootings. While in the US, there is prior research looking at regional economic indicators and school shootings (16), we propose a study that considers all types of mass shootings and incorporates broad economic and financial metrics. This type of research is needed to explore the interplay between broad macro-level economic factors and mass shootings and inform evidence-based strategies for prevention and intervention.

Some good indicators of the economic mood of the population include the health of the stock market and measures of joblessness. The S&P 500 index, which is composed of the stock prices of the 500 largest corporations in the US, could represent the health of the financial markets (22). As the stock market is a leading indicator of economic health, this variable may capture early indications of upcoming economic pain. Variance of the S&P 500 index captures the volatility of the stock market, representing the level of anxiety in the financial markets. The unemployment rate captures the employment status of the working population, which is an aggregate measure at the national level. A large number of mass shootings are due to work-related issues (23). As a result, the unemployment rate reported by the U.S. Bureau of Labor Statistics could be a relevant variable (24).

In this paper, we examined mass shooting data throughout the United States over a 32-year period (Q2-1985 – Q4-2017) to determine if stock market indicators and economic metrics are correlated with the aggregate number of mass shootings. We hypothesized that worsening economic conditions, represented by a higher national unemployment rate, a drop in stocks, and uncertainty in financial markets, would result in an uptick in mass shootings, and conversely, fewer mass shootings occur when the economy is healthy, and the stock market is strong. We found a weak correlation between broad economic and stock market indicators and the occurrence of mass shootings. It indicates that while economic indicators such as unemployment rate, stock price volatility, and overall stock price levels may be linked with the occurrence of these tragic events, there are likely many other factors that play a role in the incidence of mass shootings. Our study underscores the need for a holistic approach to addressing mass shootings, in particular one that considers economic conditions as an integral factor.

RESULTS

To examine the relationship between economic factors and mass shootings, we created a linear regression model that included time, S&P 500 index, variance of S&P 500, and unemployment rates as variables. We chose these economic variables to capture broad metrics that represent the health of financial markets and the economy. To visualize the data, we plotted the economic variables against quarterly mass shootings. We plotted each of the natural log of the S&P 500 index, the variance of the S&P 500, and the unemployment rate alongside the number of mass shootings (**Figures 2-4**). Visual inspection of these figures did not immediately show any correlation between the economic variables and the number of mass shootings. Seeking qualitative as well as quantitative insights that were not apparent from visual inspection of the charts, we performed regression analysis.

We elected to use linear regression to identify the potential association between the economic metrics and the number of mass shootings. Linear regression aims to find a linear correlation to make a line of best fit, which can then provide insights into the relationship between the variables. The regression statistics from the linear regression analysis showed an r^2 of 0.218 with a standard error of 4.983, which provides a baseline representation of the correlation between the economic metrics and the number of mass shootings (**Table 1**). The regression coefficients summary offers insight into the predictive power of each metric and the nature of the correlation that exists (**Table 2**). Considering the coefficients and p-values, we evaluated the relationship and

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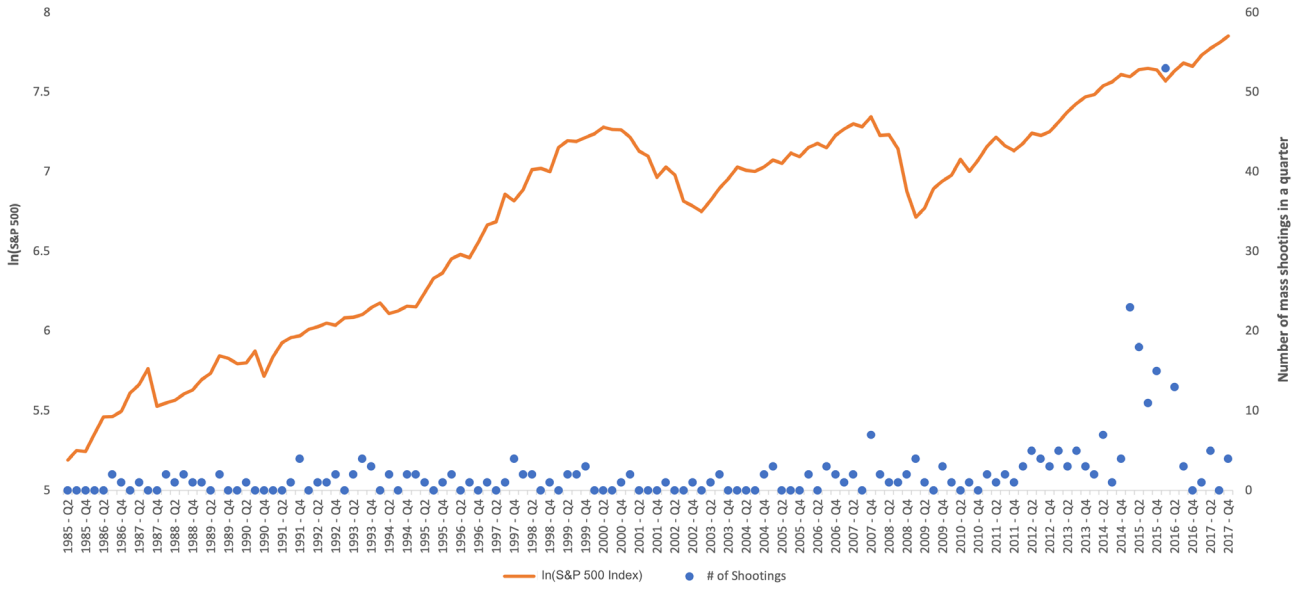

Figure 2: Natural logarithm of the S&P 500 index and the number of mass shootings in a calendar quarter from 1985 to 2017. The orange curve represents a line plot of the natural log of the S&P 500 index. Each blue dot represents the number of mass shootings in that quarter.

potential explanatory power of each metric. Variance, which represents volatility of the stock market, did not explain mass shootings (p=0.117). In contrast, time (p=0.000), stock market performance (p=0.001), and unemployment rate (p=0.001) showed significant correlations with the number of mass shootings.

Our final equation for the predicted number of mass shootings (N) in each quarter was:

$$N = 55.152 + 0.773t - 8.508\ln(SP500) - 1.45U \qquad \text{(Equation 1)}$$

where t is the time since Q2-1985, in quarters; SP500 is the adjusted close of the S&P 500 index at the end of the first month of the quarter; and U is the unemployment rate (U-3 as defined by the Bureau of Labor Statistics). Hence, our equation showed that the number of mass shootings in a given quarter increased with the passage of time, a drop in the S&P 500 index, and a decrease in the unemployment rate.

DISCUSSION

We hypothesized that time and three economic metrics, the S&P 500 index, stock market volatility, and the unemployment rate, would have substantial explanatory power in predicting mass shootings. We ran a linear regression study that tested whether each of these four variables is correlated with mass shootings. While the statistical output showed that stock market volatility does not have a significant correlation with the number of mass shootings, the other three variables, time, S&P 500 index, and unemployment rate, are part of the linear model and have statistically significant correlations.

We found that 21.8% of the variation in mass shootings is explained by time, S&P 500 index, and unemployment rate. The coefficient of determination ($r2$) is a statistical measure that indicates how well the regression model fits the data. It represents the proportion of variance in quarterly mass shootings that can be explained by time and the economic metrics in the model. While there is no universally accepted threshold that distinguishes strong, moderate, or weak levels of correlation, an $r2$ of 0.218 suggests that other factors not included in this analysis play a role in explaining 78.2% of the variation in the number of mass shootings. Our study suggests that economic conditions must be included along with other factors in devising strategies to reduce mass shootings. Factors like political events, geography, and local indicators like regional job losses or foreclosure rates may increase the $r2$ and add to the predictive power of a holistic model (16).

The number of mass shootings is positively correlated with time, perhaps due to the unchecked proliferation of guns (25). Additionally, we found a negative correlation between the number of mass shootings and the performance of the stock market as represented by the S&P 500 index. While the inverse relationship between the number of mass shootings and the S&P 500 index was as expected, we did not anticipate the negative correlation between the unemployment rate and the number of mass shootings. Instead, an increase in the unemployment rate was expected to correspond to more shootings, i.e., a positive correlation. Upon reflection, we realized that the unemployment rate is a lagging indicator of the health of the economy, while the stock market tends to be a leading indicator (26). Lagging economic indicators show a trend only after the economy as a whole has changed. Conversely, a leading indicator tends to change before a particular trend is manifested. Given that mass layoffs take time to plan and execute, job uncertainty might be experienced by employees at an earlier point in time. Additionally, our choice of a quarterly snapshot of the unemployment rate instead of monthly reports causes additional lag, looking backward and reflecting what happened in the previous

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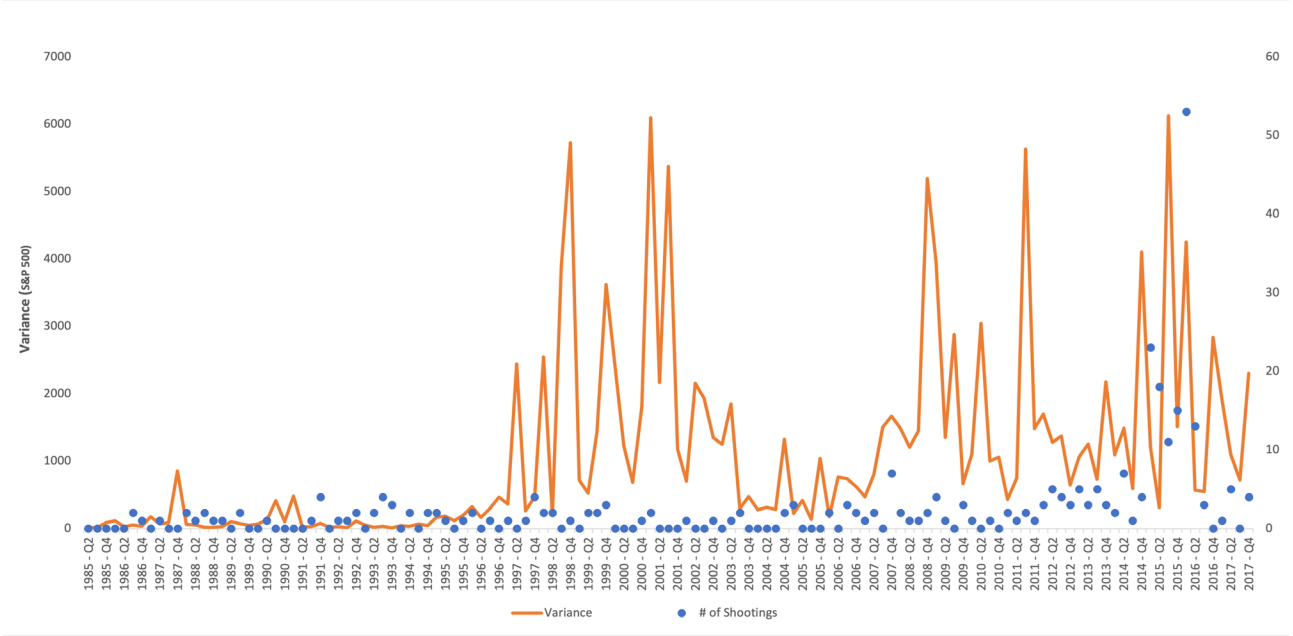

Figure 3: Variance of the S&P 500 index and the number of mass shootings during a calendar quarter from 1985 to 2017. The orange curve represents a line plot of the variance of the S&P 500 index from the opening to the close of the quarter. Each blue dot represents the number of mass shootings that occurred in that quarter.

three months. Hence, a lag may exist between impending job losses and U-3 (the unemployed population in the prior period seeking employment, as a percent of the civilian labor force), as reported by the Bureau of Labor Statistics (24). This lag, combined with the cyclical nature of economic growth, may be one potential explanation for the unexpected inverse relationship between unemployment rate and the number of mass shootings. The economic cycle might have turned by the time a quarterly snapshot of the national unemployment rate reflects the state of the economy in a local area. In other words, the peaks and valleys in the unemployment rate might be sufficiently shifted in time that it is reflecting an economic reality that has changed in the opposite direction. In the early phase of a downturn, the unemployment rate could take time to rise while financial and job anxiety felt by individuals start to mount. By the time the unemployment rate catches up and captures the initial wave of economic pain, the worst impacts could be in the past. Similarly, when the

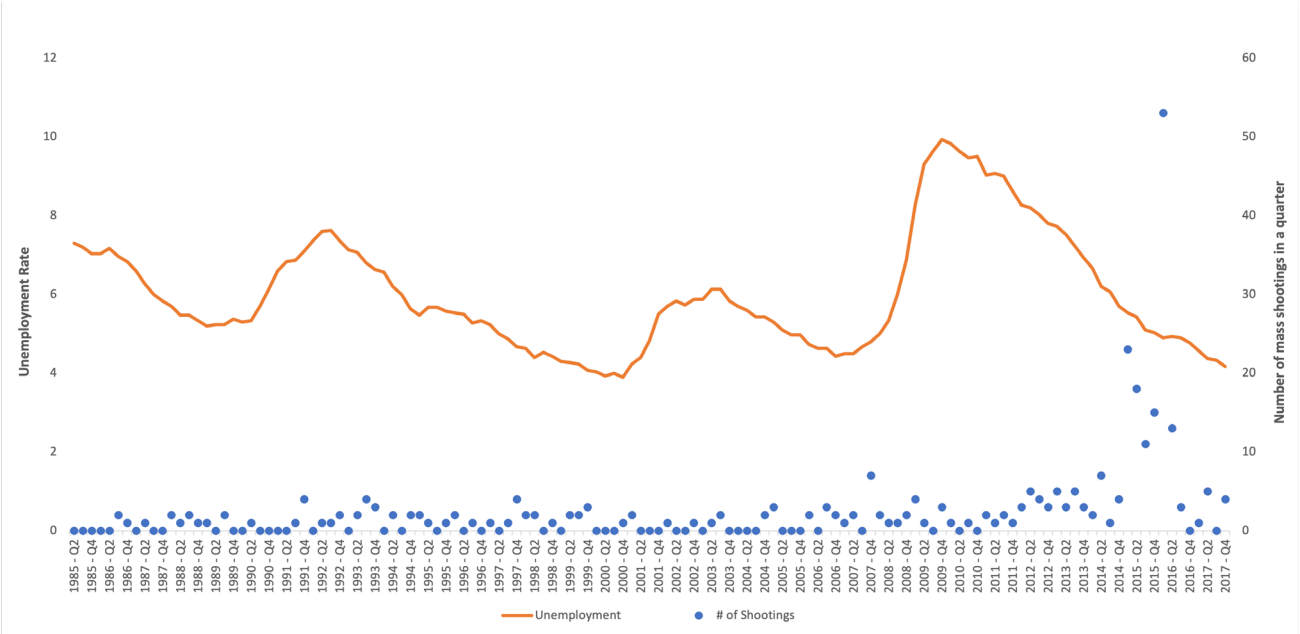

Figure 4: Average unemployment rate and number of mass shootings in a calendar quarter from 1985 to 2017. The orange curve represents a line plot of the unemployment rate averaged across the three months in the quarter. Each blue dot represents the number of mass shootings that occurred in that quarter.

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Regression Statistics	
R Square	0.218
Standard Error	4.983
Observations	131

Table 1: Results from statistical analysis using linear regression with the chosen variables. 131 observations at a quarterly frequency spanning 32 years were included in the analysis. 21.8% of the variation in mass shootings is explained by the chosen variables - time, S&P 500 index, variance of S&P 500 index, and unemployment rate.

economy is recovering, the unemployment rate may reflect job gains with a lag. As noted before, approximately 40% of shooters involved in all mass shootings experienced financial stress, and about 70% of workplace-related shooters were in financial distress (15). This previous study notes that "the perpetrators are often recently fired employees," and 45% of the workplace-shooters were unemployed at the time of the shooting (15). Our study, which included all mass shootings irrespective of location and used the national unemployment rate, found a negative correlation. However, another study that considered only school shootings found a positive correlation between shootings and local unemployment rate (16). School shootings constituted a small percentage of all shootings: K-12 accounted for 7.6%, and colleges or universities had 5.2% (23). Further study is warranted to analyze how school shootings might differ from shootings at large. We also need to determine the reason for the negative correlation in our study between shootings and the unemployment rate. Incorporating the local unemployment rate into our analysis might also shed some light on the reasons for the unexpected correlation.

Our investigation had several limitations. Firstly, we gathered data for a specific time frame (1985-2017) and geographical region (the United States), which may restrict the generalizability of the findings to a broader context. Additionally, several potential variables may influence the observed relationship between mass shootings and economic indicators. For instance, demographic changes, gun law changes, political events, and other factors that were not captured in this analysis could have influenced the variables indirectly (23, 27). Furthermore, a linear regression model may not capture the full complexity and potentially non-linear relationship between mass shootings and economic indicators. Future research could consider employing more sophisticated models to better capture non-linear associations and potential time lags between events. Future research could also expand to other datasets, such as using SHRs from the FBI. Additionally, there are many definitions of mass shooting, which may weaken the reproducibility of modeling approaches (28). While we did not find a definitive study on whether datasets of mass shootings suffer from under-reporting, we do note that in more recent times, there has been increased media focus on mass shootings (29). Thus, it is plausible that more recent mass murders are over-represented compared to ones from several decades ago, which may give the time variable an artificially high weight. In light of this potential bias, further research could experiment with different time frames, data sets, and definitions of mass shootings.

Summary of Regression Coefficients				
	Coefficient	Standard Error	t-stat	p-value
Intercept	55.152	16.149	3.415	0.001
Time Since 1985	0.773	0.179	4.321	1.0E-3
ln(S&P 500 adj close)	-8.508	2.524	-3.371	0.001
Variance of S&P 500	0.001	3.6E-4	1.578	0.117
Unemployment Rate	-1.450	0.438	-3.314	0.001

Table 2: Summary of regression coefficients of the chosen variables. Time, natural logarithm of S&P 500, and unemployment rate showed a statistically significant correlation with the number of mass shootings ($p<0.05$). Adjusted close of the S&P 500 index takes into account corporate actions like stock splits and dividends.

Overall, we have identified correlations between economic factors and the number of mass shootings. Our work suggests that policymakers could create strategies that consider fluctuations in the economy and their impact on public safety. This research bridges the gap between the fields of economics and public safety, opening the door for further collaboration and exploration. It is also important to acknowledge that the complex nature of drivers of mass shootings may involve multifaceted relationships that are not entirely captured by economic indicators alone. Future studies could benefit from utilizing different datasets, refining definitions of mass shootings, and exploring additional variables to enhance the predictive power of the model.

MATERIALS AND METHODS

Data sources

We obtained the mass shooting data from Kaggle (14). The dataset contains information including location, date, description, fatalities, injuries, total victims, mental health issues, race of the shooter, and gender of the shooter. We primarily used the date of each event to determine the number of shootings within the time period of our analysis. The data includes records of 398 mass shootings in the United States over 50 years, which resulted in a total of 1,996 fatalities and 2,488 injuries. The dataset from Kaggle was compiled by the authors using various public datasets and web pages, including Wikipedia, Mother Jones, Stanford, USA Today, and other web sources.

Monthly unemployment rate data was sourced from the U.S. Bureau of Labor Statistics (BLS) (24). The monthly BLS report measures the percentage of unemployed people in the civilian workforce who are at least 16 years old and have actively sought work in the past four weeks. The monthly opening and closing values of the S&P 500 index, a broad composite metric based on the stock performance of 500 large companies, were obtained from Yahoo Finance (22). Monthly data from the S&P 500 index was used for simplicity and to match the monthly frequency of unemployment reports available from the BLS.

Data preparation and analysis

The collected datasets from the three sources, Kaggle, Yahoo Finance, and BLS, were cleaned and preprocessed to ensure data integrity and consistency. Extraneous data that were not relevant to our analysis were removed. The date of the shootings, adjusted close of the S&P 500 index, and the monthly unemployment rate were compiled. Data cleaning was performed using Excel.

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Three possible time periods (weekly, monthly, and quarterly) were considered for aggregating the number of mass shootings, the change in the stock market, and the unemployment rate. The weekly aggregation period did not work well because mass shootings are typically rare events: generally, zero or only one mass shooting would happen within a given week. Hence, we decided to aggregate the data quarterly. There was also the issue of finding the optimal start date. Examining the data set, we saw that mass shootings only began to increase in the 1980s, with non-zero mass shootings in most quarters. Therefore, we use a start time of quarter 2 of 1985.

Using Excel's XLOOKUP and other data processing functions, quarterly data was compiled starting in Q2-1985 and ending in Q4-2017. The number of shootings in each quarter was determined by counting the number of events in the Kaggle dataset that fell within the quarter. Alongside the number of mass shootings, the adjusted closing value of the S&P 500 index at the end of the first month of the quarter and the average of three monthly unemployment reports from the BLS were tabulated. We determined the variance of the daily S&P 500 index. We ran the Analysis ToolPak in Excel to create a multi-dimensional linear regression model. The model was used to determine potential correlations between a set of predictive variables and the occurrence of mass shootings over a 32-year period (1985 – 2017). Four predictive variables (time, S&P 500 index, variance of S&P 500 index, and unemployment rate at a quarterly frequency) were chosen for the linear regression model.

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