



# The Application of Data Analytics for Understanding Patterns of Mergers and Acquisitions and CEO Characteristics in and between Crisis Times

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**Abstract.** We examine patterns and dynamics of M&A occurrence with attention to three crises or instances of economic disruption—the dot.com bubble, the global financial crisis, and, for future evaluation, the covid-19 global pandemic—while also taking potential CEO demographic (e.g., age) and outcome (e.g., compensation) factors into consideration. Specifically, we examine the frequency, size, and characteristics of M&A transactions across different industries, and we analyze the age, gender, education, experience, and compensation of CEOs across various industries. Drawing on the SDC Platinum and BoardEx databases, we examine US M&A valued over 250 million USD in the 11 global industry classification standard (GICS) sectors from 1999–2018 for  $n = 14,405$  M&A and  $n = 20,745$  CEOs. Using clustering analysis, we define groupings of patterns of M&A transactions before and after the global financial crisis (circa 2008–2009) to show that M&A decreased and then resumed across sectors, although to different degrees for each sector. Using both clustering and PCA, we determine groupings of CEO characteristics before and after the global financial crisis, demonstrating variation in selected demographics of individuals leading organizations before and after that crisis. In addition, initial analysis of our CEO-level data indicates merging to be a predominantly male CEO-driven activity with inferred egoistic, reputational, and power rewards as well as longer-term wealth-building effects, as direct non-contingent compensation does not markedly change for CEOs in the aggregate before and after M&A.

**Keywords:** Mergers and acquisitions · CEOs · Crises · M&A motivations · M&A outcomes

## 1 Introduction

Mergers and acquisitions (M&A) are a common strategy for companies looking to enter new markets, grow, and gain competitive advantage [24]. However, these transactions can be complex and risky [21], and their success depends on various factors such as market conditions, industry trends, integration of the firms [6], and the characteristics of the companies and leaders involved [12]. With the increasing availability of data and advanced analytics tools, researchers and practitioners have turned to data analytics to explore M&A activities and identify crisis-delimited patterns in their frequency, size, and success [16]. This paper contributes to the literature by applying data analytics to M&A and CEO activity patterns.

CEOs are key decision-makers in organizations [14] and their characteristics [23] and interests [26] can have a significant impact on M&A outcomes [28]. We have therefore also turned to data analytics to explore characteristics of CEOs involved in M&A in various industries [2]. By analyzing these characteristics, we aim to identify patterns and trends that may have implications for firm leaders as well as policymakers and regulators [22].

The question of the optimal conditions for a firm in choosing to merge or not merge with another firm has been intensively debated for decades [8]. The question has arisen most proximately in relation to intermittent yet unpredictable crises such as bubbles, crashes, and large-scale health concerns, often creating additional uncertainty [25] and constraints in merging [3]. In evaluating the context of M&A occurrence in and between crisis times, some scholars have pointed to institutional-level economic and market robustness factors as preeminent [11], while other scholars have identified corporate governance [4] and CEO-level factors with respect to demographic background, motivations, and anticipated financial reward outcomes as strongly driving decisions to merge or not [10, 18]. Previous studies have not adequately addressed that each cycle of economic downturn and recovery has both commonalities and differences that can be considered as external drivers of market forces alongside internal (to the firm) demographic, motivational, and reward drivers at the CEO level [20]. There are many external and internal drivers that can impact M&A transactions [13]. However, a polarized consideration of external and internal drivers has created a conundrum. Isolating the economic and market circumstances from the dynamics at the leadership level inside the firm and not looking at each economic downturn and recovery as both unique and convergent with previous such incidents has led to a gap in the completeness of our understanding around the catalysts of M&A and the firm-, industry- and CEO-level consequences observed around the occurrence of these transactions.

In essence, we argue that both economic and market forces [7] and CEO level factors [19] should be taken into consideration in better comprehending merging. By exploring the convergence of economic and market factors alongside CEO demographic background, motivational [26] and reward factors [10], our research reinforces the importance of studying firms in conjunction with their leaders [5] and sheds light on the neglected issue of the previously perhaps excessive partitioning of M&A contributing factors into external and internal domains.

We can regard economic bubbles, international financial turmoil, and global pandemics as instances of environmental or external factors. Specifically, we concentrate

on the global financial crisis (GFC) as a type of external factor, and we explore its influence on different industries toward establishing commonalities or differences in impact on M&A volume and valuation across broad industry sectors. We also explore the GFC impact on the internal factor of CEO characteristics such as age, income, and nationality among the types of large US firms experiencing M&A activity before and after the crisis. We therefore examine the following research questions:

- (1) What are the impacts of market conditions and economic circumstances on the volume and valuation of M&A deals by sector, 1999–2018, before and after the global financial crisis (before and after 2008)?
- (2) What are any discernible patterns in CEO demographic characteristics before and after the global financial crisis?
- (3) What implications can be drawn for the projected impact of the global pandemic, beginning in 2019, on M&A occurrence?

It is possible that different industry sectors—being subject to difference balances of regulatory, market and technological pressures as well as to different vicissitudes in leadership styles and transitions—could experience different combinations of internal and external drivers of M&A. For instance, the technology sector could be more influenced by external factors, such as the level of competition and the pace of technological change. The financial sector, subject to perhaps more intense regulatory scrutiny and statutory oversight, could be more influenced by internal factors, such as the leadership desire for reputational or wealth enhancement via improving financial performance. Alternatively, in a sector such as healthcare, external factors such as regulatory changes and technological advancements could be the primary drivers of M&A activity, while internal factors such as leadership interest in achieving economies of scale and expanding market share could also be important.

## 2 Data Analysis and Visualization

### 2.1 Data

We collected data from SDC Platinum and BoardEx for firms and CEOs. Based on the intersection of specialized sources, we developed two customized datasets:

1. M&A: We obtained all M&A transactions from 1999–2018 with a deal size greater than or equal to 250 million USD. We limited both acquirer and target companies by restricting the time range and minimum deal value [15], and we similarly used a filter to obtain only US acquiring and target companies. We subsequently grouped all transactions from finer-grained sub-industries into broader industry categorization, according to the Global Industry Classification Standard (GICS) system. This system decreased our industry sector categorization, enabling clearer data visualizations later in our analysis. Furthermore, we intentionally excluded all deals from the legal sector, as M&A are highly regulated in this field and are not very reflective of the market environment.

2. CEOs and related corporate governance structure: Based on data from the SDC Platinum and BoardEx databases, we examine US M&A valued over 250 million USD in the 11 global industry classification standard (GICS) sectors from 1999–2018 for  $n = 14,405$  M&A and  $n = 20,745$  CEOs.

We now provide visualization and analysis with respect to the research questions.

### 2.2 Visualization and Statistics

For the first part, we view our data from a higher level to have a general understanding of M&A activity in the time frames we are evaluating. We find a distribution of transaction frequencies across different sectors. Industries with high M&A frequencies include financials (Fig. 1), consumer discretionary, industrials (Fig. 2) and utilities (Fig. 3). As these industries experienced more robust M&A activity, we examined them more closely in the relevant time ranges. Additionally, we note that all sectors experienced fluctuating volume and valuation in M&A activity from 1999–2018. The intermittent declines and rebounds correspond to the two major economic shocks of the time: the high-tech, dot.com meltdown around 2001 and the global financial crisis 2008–2009. Reduced rates of M&A activity occur in the approximately one to three years following the economic and market shock. The patterns in each sector may appear roughly similar in upswings, downturns, and recovery around each shock, but our later analysis with percentile clustering reveals a more detailed distinction and grouping in the patterns of M&A activity and resilience in the financials, consumer discretionary, utilities and industrials sectors previously mentioned.

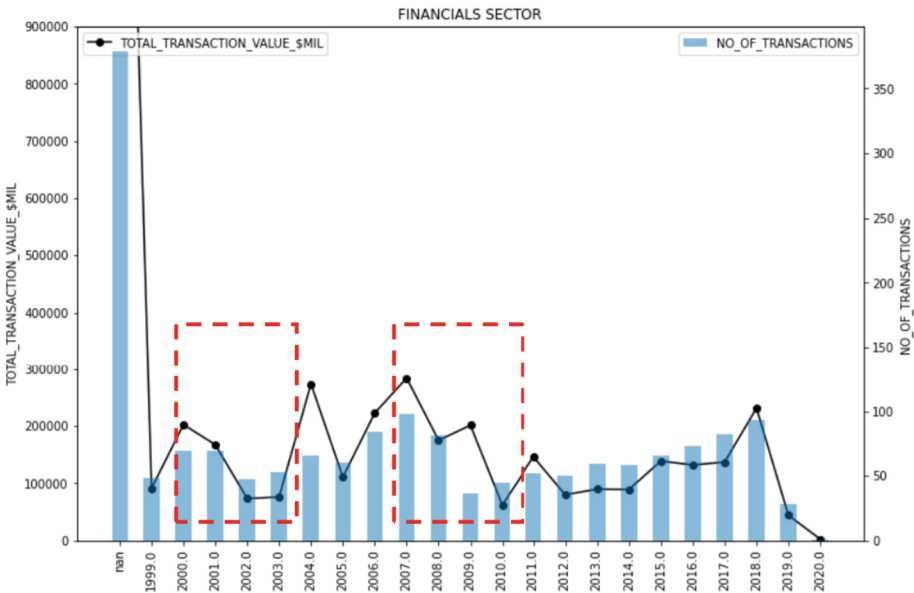
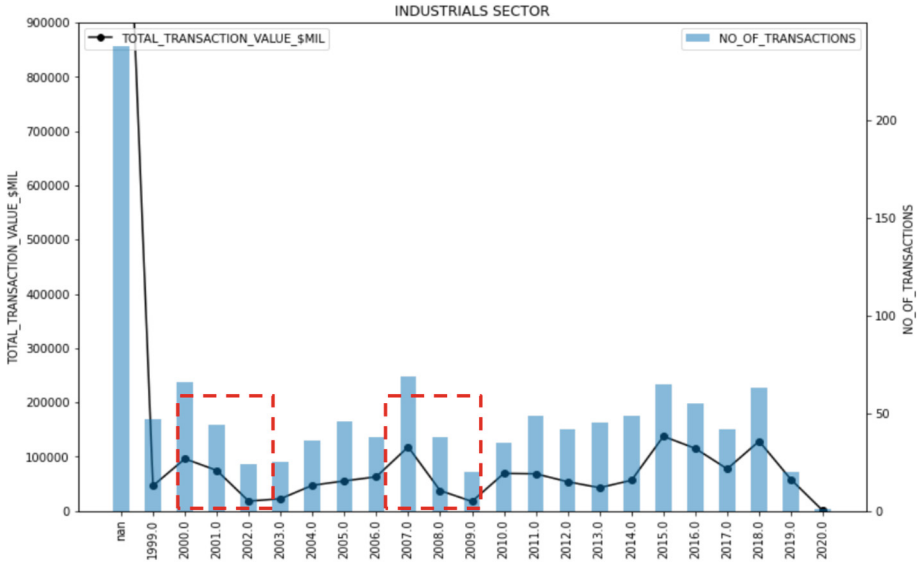
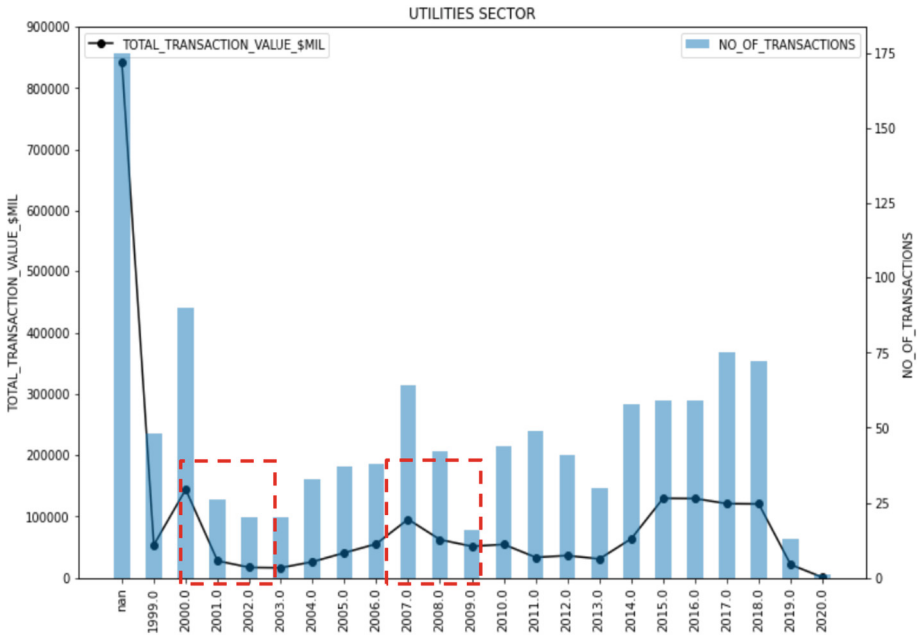


Fig. 1. M&A Volume and Valuation in the Financial Sector and Crisis Downturns, 1998–2018



**Fig. 2.** M&A Volume and Valuation in the Industrial Sector and Crisis Downturns, 1998–2018

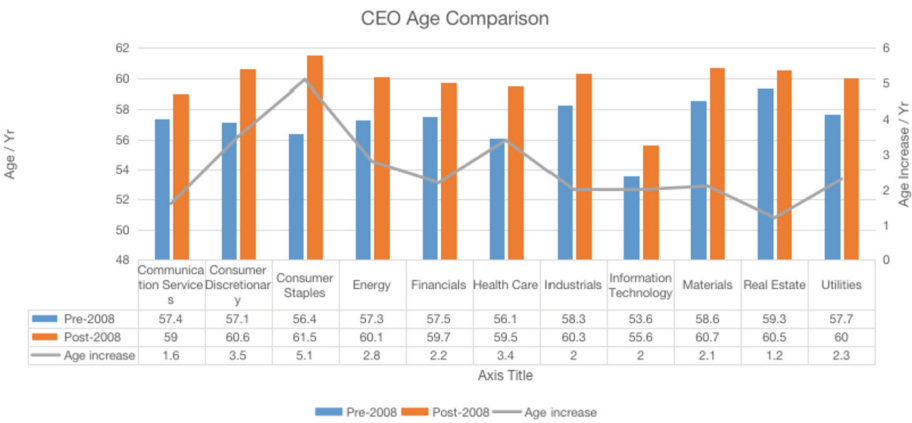


**Fig. 3.** M&A Volume and Valuation in the Utilities Sector and Crisis Downturns, 1998–2018

In the percentile groupings (Appendix A), we notice variations by specific sector when comparing before and after the GFC. The financial sector takes a dominant position,

leading in the both the volume (number) and valuation of M&A deals accomplished in any time period. Conversely, the real estate sector is consistently absent from among the high-value deals. However, after 2008 a shift occurs, with more high-value M&A deals in the “essentials” sectors of healthcare, industrials, and utilities. We further observe more diversity in industry among low-value transactions, possibly due to more distressed acquisitions of smaller companies facing dissolution, as well as some M&A occurring most likely to optimize resource allocation and market share.

From the CEOs data, the average age of CEOs increased two years across different sectors (Fig. 4) when comparing before (Fig. 5) and after 2008 (Fig. 6). Both periods show CEO age hovering around the high-50s, but all sectors show a slight age growth after the financial crisis (Fig. 7). This increase could result from companies seeking more senior candidates for the management team or the original members growing older. Either hypothesis suggests a more conservative and risk-averse attitude from companies after the crisis.

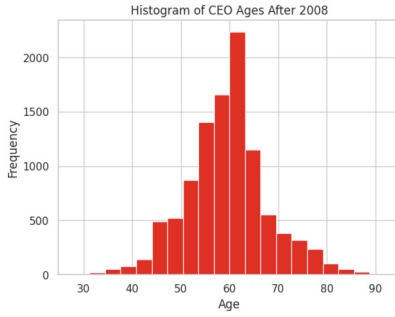


**Fig. 4.** CEO Age Comparisons by Sector and Before and After 2008

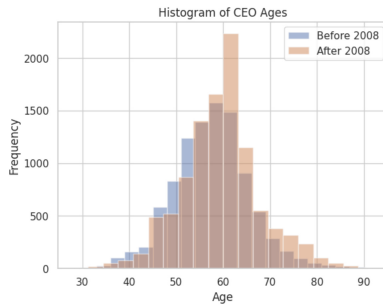


**Fig. 5.** CEO Age Distribution Before 2008

The role of CEO appears to be heavily dominated by US nationals before 2008 and even more so after (Fig. 8). The nationality status could be skewed in favor of US citizens

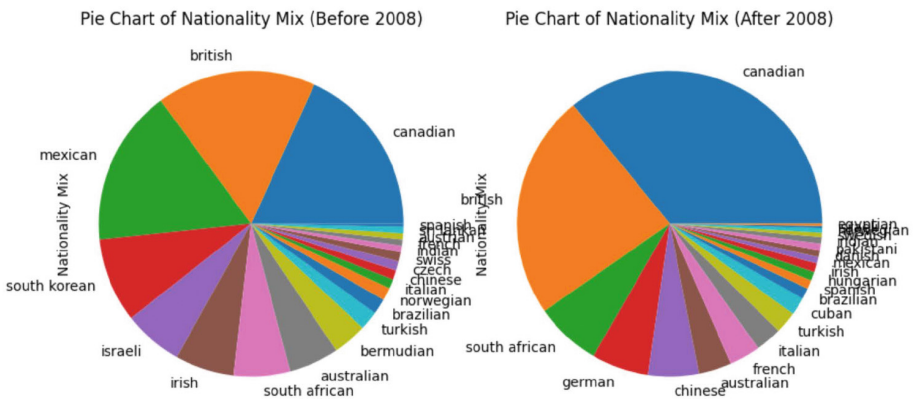


**Fig. 6.** CEO Age Distribution After 2008



**Fig. 7.** CEO Age Distributions Shift Before and After 2008

because this dataset is focused on companies based in or associated with the US in some capacity. Furthermore, the top three nationalities are Anglo (US, Canada, and UK). This too makes intuitive sense as this is fairly evident in the real world.



**Fig. 8.** CEO Nationality Mix Before and After 2008

Additionally, we draw attention to preliminary findings around CEO salaries and corporate governance structure variation by sector. CEO salaries, bonuses, and total wealth accumulation do not seem to vary significantly between CEOs who are and are not active in M&A. CEO salaries in our dataset remain high regardless of strategic innovations or variations in frequency or value of M&A (Fig. 9). This observation suggests that salary and wealth are not primary motivators of M&A for CEOs, at least in comparing CEOs leading M&A transactions before and after crisis times. We cannot directly measure personal or positional power increases, which may still be relevant as motivators for CEOs pursuing M&A. There could also be benefits to the CEO dealmakers such as receiving reputational boosts or media accolades. Moreover, we are here directly assessing CEO base salary, which is often the lowest portion of the total compensation or wealth accumulation. Bonuses, stock options, grants, severance, golden parachutes, and other forms of contingent or incentivizing compensation can also come into play and are not reflected in the present observations. Our data analytics in Sect. 3.2 take greater account of the multidimensional nature of CEO compensation and wealth accumulation.

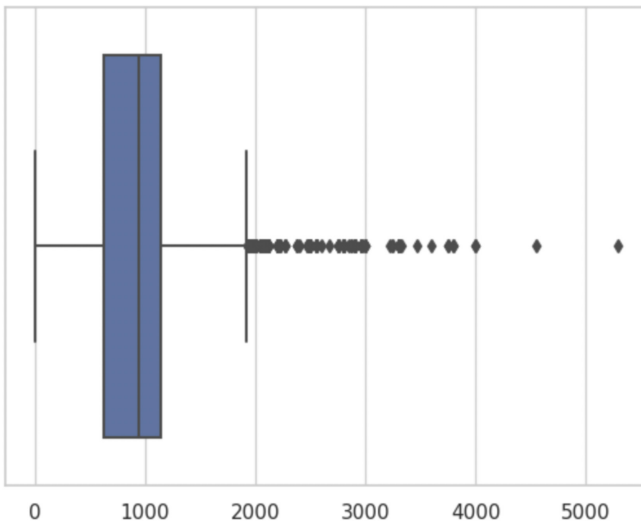


Fig. 9. CEO annual base salary dispersion in USD millions 000

CEOs are not the sole decision makers for pursuing M&A, as such high-level strategic decisions must also be supported by the board of directors. The CEO, chairperson, and other board members are three vital parts within the corporate governance structure of the firm. Interestingly, we find that the number of directors on the board varies considerably by industry (Fig. 10), with technology firms leading the way. In this case we use the finer grained industry level classifications rather than the broader GISC sectors to disaggregate the data at a more nuanced level of understanding of firm type. Within the tech world, the software and computer services firms have the largest number of directors, perhaps because of a greater interest for involvement or a greater need for oversight

given the increased popularity and rapid growth of these firms within the specified time. Pharmaceuticals and biotechnology firms are a close second.

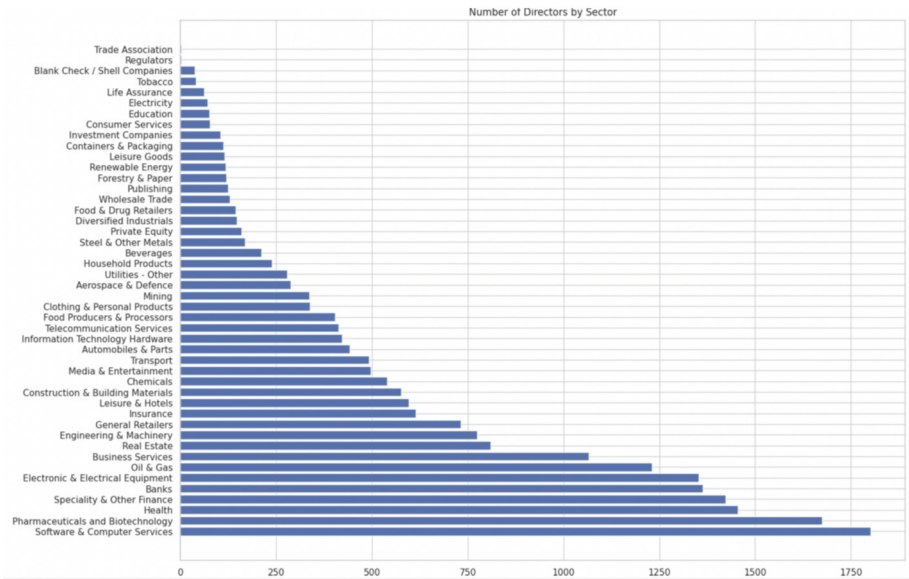


Fig. 10. Distribution of the size of the board directors by industry

### 3 Clustering and PCA

Clustering allocates data with similar characteristics into groups. Principal components analysis (PCA) reduces the features or dimensions of the dataset, while *k*-means clustering allocates the observations into groups by applying a distance metric. We divided the data into groups based on similarities in the data. Using a standard *k*-means clustering, we grouped M&A deals into *k* groups. We evaluated the centroids as arithmetic means of all the data points assigned to a cluster. Centroids represent typical members of the cluster.

#### 3.1 Cluster Trajectories

Our clustering analysis allocates observations of CEO characteristics into groups according to similarities in the characteristics. We do a standard *k*-means clustering to assign CEOs into *k* groups. The *k*-means algorithm typically iterates until the inter-cluster distance for each observation is less than the intra-cluster distance, with more specialized methods now available for minimizing the sum of the squared distance from each observation to a cluster, when different clusters have different value or cost [27].

Starting from  $X = \{x_1, x_2, x_3, \dots, x_n\}$  observations and  $V = \{v_1, v_2, v_3, \dots, v_n\}$  cluster centers, the algorithm proceeds as follows: first, randomly choose *c* centers. Then,

determine the distance between each CEO observation (also known as a data point) and cluster center. Next assign the observation to the cluster center whose distance from that center is the minimum of all the cluster centers. Subsequently, recalculate the new cluster center using:

$$v_i = (1/c_i) \sum_{j=1}^{c_i} x_j$$

where, ‘ $c_i$ ’ represents the number of observations in the  $i^{\text{th}}$  cluster.

Then, re-compute the distance between each CEO observation and CEO cluster center. If no observation was reassigned then stop, otherwise repeat the third step.

The above algorithm minimizes the following squared error objective function:

$$J(V) = \sum_{i=1}^c \sum_{j=1}^{c_j} (\|x_i - v_j\|)^2$$

where,

‘ $\|x_i - v_j\|$ ’ is the Euclidean distance between  $x_i$  and  $v_j$ .

‘ $c_i$ ’ is the number of observations in the  $i^{\text{th}}$  cluster.

‘ $c$ ’ is the number of cluster centers [17].

The centroid, an arithmetic mean of all observations assigned to a cluster, represents an idealized average for each cluster. In essence, a centroid captures a mathematically typical member of its cluster, although that member may not exist in reality. Our clustering analysis grouped CEOs based on characteristics such as gender, age, salary, bonus, and total compensation and wealth accumulation. In this graph, it is evident that cluster 2 is entirely separate from clusters 0, 1 and 3, whereas there is some overlap in clusters 3 and 1, and clusters 1 and 0, respectively. It is of value to note that in addition to cluster 2 being far apart from the other three clusters, the points within cluster 2 are far apart from one another as well as demonstrated by the one outlier in cluster 2.

### 3.2 PCA Dimensions

PCA involves a data matrix  $\mathbf{Z}$ , accompanied by a metric matrix  $\mathbf{I}_p$  defined in  $\mathbb{R}^p$ , and another metric  $\mathbf{N}_p$  defined in  $\mathbb{R}^n$  (generally  $\mathbf{N} = (1/n)\mathbf{I}_n$ ). The PCA process reduces a dataset from numerous dimensions into fewer, more parsimonious dimensions representing linear (re)combinations of variables from the original dimensions. The matrix  $\mathbf{Z}$  can be defined as follows:

- supposing a normalized PCA:  $\mathbf{Z} = \mathbf{X}\mathbf{S}^{-1}$ , where  $\mathbf{S}$  is the diagonal matrix of standard deviations.
- supposing a non-normalized PCA:  $\mathbf{Z} = \mathbf{X}$ .

The fit in  $\mathbb{R}^p$  has to do with:  $\mathbf{Z}^T \mathbf{N} \mathbf{Z} \mathbf{u} = \lambda \mathbf{u}$ , with  $\mathbf{u}^T \mathbf{u} = 1$ .

The fit in  $\mathbb{R}^n$  has to do with:  $\mathbf{N}^{\frac{1}{2}} \mathbf{Z} \mathbf{Z}^T \mathbf{N}^{\frac{1}{2}} \mathbf{v} = \lambda \mathbf{v}$ , with  $\mathbf{v}^T \mathbf{v} = 1$ .

The transition relations can be written as:

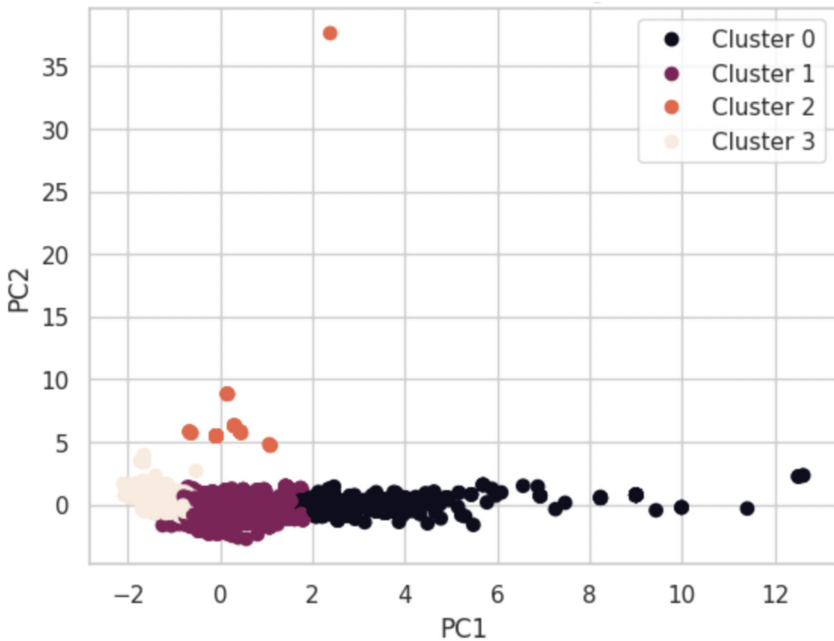
$$\mathbf{u} = \frac{1}{\sqrt{\lambda}} \mathbf{Z}^T \mathbf{N}^{\frac{1}{2}} \mathbf{v}$$

$$\mathbf{v} = \frac{1}{\sqrt{\lambda}} \mathbf{N}^{\frac{1}{2}} \mathbf{Z} \mathbf{u}$$

The symmetric matrix intended to be diagonalized is  $\mathbf{Z}^T \mathbf{N} \mathbf{Z}$ . This matrix accords with the correlations matrix for a normalized (rescaled to the properties of a normal distribution with  $\mu = 1$  and  $\sigma = 1$ ) PCA, or with a covariance matrix, for a non-normalized PCA [9].

PC1 and PC2 are the first and second principal components, respectively, obtained from PCA on our dataset (Fig. 11). As noted, PCA is a technique used to reduce the dimensionality of a dataset by finding the directions of maximum variance in the data and projecting the data onto a new coordinate system along these directions. In our analysis, PCA was used to reduce the original dataset with eight features (gender, nationality mix, sector, age, salary, bonus, total salary + bonus, and total wealth) into a two-dimensional dataset represented by PC1 and PC2.

PC1 and PC2 are linear combinations of the original features that account for the largest amount of variance in the data. Therefore, PC1 and PC2 are new variables that summarize the information contained in the original features. The scatter plot shows the data points in this new two-dimensional space, where the x-axis is PC1 and the y-axis is PC2. The silhouette score for the hierarchical clustering is 0.3229. The silhouette metric captures how well the data points have been clustered, with a range of possible values (-1,1) and values greater than 1 representing a good capture.



**Fig. 11.** PCA Hierarchical Clustering Results on CEO Characteristics

The values of PC1 and PC2 tell you how similar yet different CEOs are in terms of the variables included in the analysis. CEOs who have similar values on PC1 and PC2 are more similar to each other in terms of their characteristics, while CEOs who have different values on PC1 and PC2 are more dissimilar.

In the context of this analysis, clustering the CEOs based on their values on PC1 and PC2 allows us to identify groups of CEOs who have similar characteristics. By analyzing the differences between these groups, we can gain insights into the characteristics that distinguish successful CEOs from less successful ones.

## 4 Conclusion

In this paper, we have analyzed external and internal drivers of mergers and acquisitions (M&A) in the pre-pandemic decades of 1999-2018, as part of understanding strategic innovations in intercorporate combinations and variations in volume and valuation of mergers and acquisitions in and between crisis times.

The global financial crisis (GFC) in 2008-2009, like the dot.com bubble before it, had significant impacts on mergers and acquisitions (M&A) in several ways:

*Decreased Deal Activity:* Similar to the dot.com bubble bursting, the GFC led to a significant decrease in M&A activity as companies were hesitant to engage in transactions during times of uncertainty and economic instability. This led to a decrease in the number of deals as well as the overall value of transactions.

*Lower Company Valuations:* The dot.com meltdown and the GFC decreased stock prices and therefore corporate valuations, which made it more difficult for sellers to get the prices they wanted for their businesses. Buyers were also cautious and able to negotiate better deals as a result.

*Shift in Focus:* During both crises, there was a shift in focus towards more defensive sectors such as healthcare, utilities, and consumer goods. This led to a decrease in the number of deals in the technology and financial sectors, which were more heavily impacted by the crises.

*Increased Regulatory Scrutiny:* In the aftermath of both crises, there was an increase in regulatory scrutiny of M&A deals. The scrutiny particularly increased in the financial sector, where regulators were concerned about the potential for large companies becoming too big to fail. Consistent with the increased scrutiny at the firm level, the financial services industry also exhibited more risk-aversiveness in leadership choices, selecting typically older candidates for top management.

We have argued that both “external” economic and market forces and “internal” CEO level factors should be taken into consideration in better comprehending M&A occurrence and outcomes. As our present universe of data encompasses only US publicly traded acquirers and US targets, with M&A valued over 250 million USD, representing the 11 GICS sectors, and with limited corresponding CEO level data available, our findings also have implications for collecting additional US CEO level data and pursuing further studies involving M&A internationally. In conclusion, by closely examining the convergence of economic and market factors with CEO demographic background, motivational and reward factors, our research emphasizes the importance of studying firms in conjunction with their leaders and sheds light on the neglected issue of the

previously excessive partitioning of M&A contributing factors into external and internal domains.

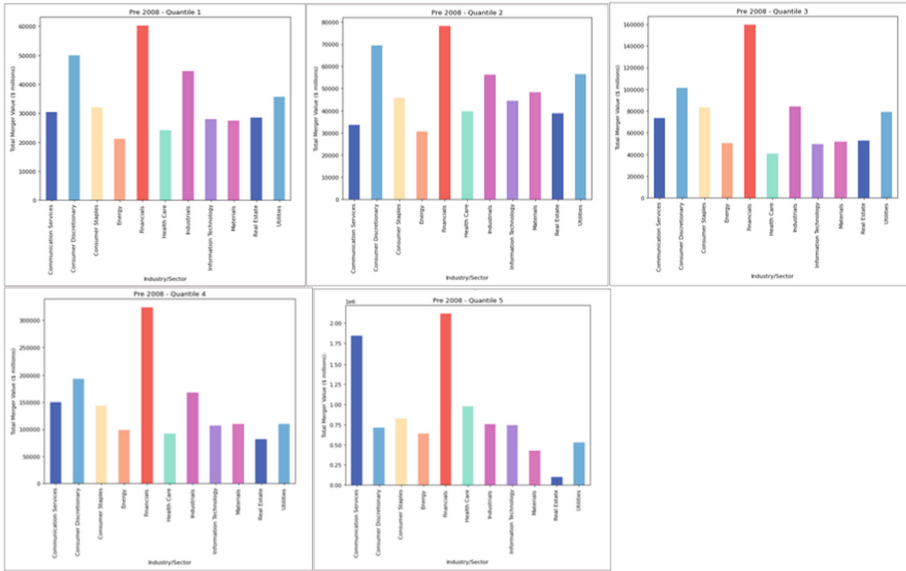
Our analysis uncovered patterns in M&A varying by the 11 global industry classification standard (GICS) sectors and by cycles of economic downturn and recovery. Using clustering analysis on M&A from SDC Platinum, with transactions valued over 250 million USD with publicly-traded US acquiring firms and publicly-traded or privately held US target firms, we determine similarities and differences in M&A activity by GICS sector and across economic eras. The economic cycles include two major market shocks: the high-tech dot.com meltdown around 2001 and the global financial crisis in 2008-2009. We find that the distributions of M&A by GICS sectors can be grouped into three major patterns, reflecting upsurges, downturns, and resilience for recovery even following major market upheavals. Additionally, combining CEO-level data from BoardEx with firm-level SDC Platinum transactions, we have preliminary findings regarding CEO demographic background and reward drivers of M&A transactions. We focus on the period before covid-19, and implications of our research are to consider the impact of the covid-19 pandemic on current and future M&A activity in various regions of the world [1], given current circumstances of global economic retrenchment and the associated decline in M&A. These findings and methods can be generalized into questions on other aspects of M&A as well. We aim to address such questions in our subsequent research.

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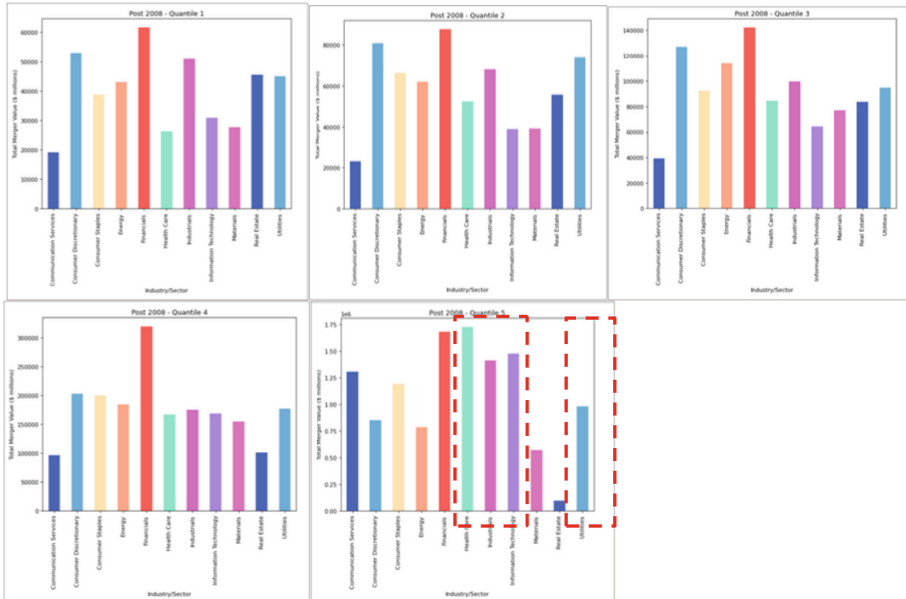
## **Appendix A: M&A Frequency by GISC Sector Before and After 2008**

Here are comparisons of percentile groupings by quartiles of M&A frequency and value for various GISC sectors before and after 2008:

1. Pre 2008:



2. Post 2008:



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