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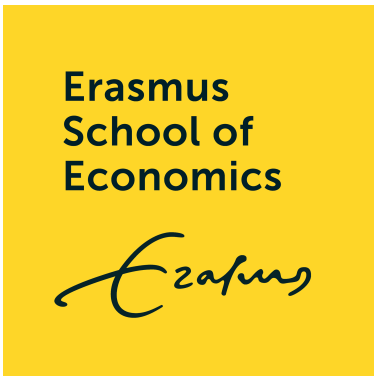

Banking Crisis Transmission: The Spillover Effects of the Signature Bank's Collapse on the U.S. Banking Sector

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Abstract

This research thesis delves into the ramifications of the Signature Bank depositor run on the US banking sector, represented by a sample of 43 US-based banks, containing both regional and diversified banks. Drawing motivation from the empirical studies, this study undertakes a tripartite analysis, which consists of an event study, a Difference-in-Differences (DiD) estimation, as well as an OLS Regression analysis. The results derived from the event study suggest a statistically significant negative impact of the Signature Bank depositor run having spilled over on the Cumulative Average Abnormal Returns (CAAR) of the sample banks, with remarkably pronounced effects for the diversified banks. The geographical proximity between the sample banks and the Signature Bank was considered as a potential channel to transmit contagion effects; the results, even though statistically significant, demonstrated a weak magnitude in the context of the DiD estimation. The OLS regression results highlight that relatively lower levels of bank liquidity amongst the sample banks, captured by proxy through relatively higher ratios of net loans & leases to total deposits, revealed a consistent statistically significant negative effect on the respective banks' CAAR. Other bank-level characteristics of interest such as uninsured deposit levels and shareholding position that the sample banks respectively held in the Signature Bank, both turned out to have statistically significant negative effects on the CAAR of the sample banks, with a substantially weaker magnitude of effect in the case of shareholding positions value. While this research study provides valuable insights, on the basis of which associated policy and research recommendations have been derived, it also entails some inherent limitations with regard to the data selection and accessibility, geographical coverage, and the presence of smaller levels of endogeneity. Nonetheless, this research study highlights the complex implications of bank runs in the post-COVID period and underscores the importance of regulatory and market interventions to be strongly aligned with market developments and their increasingly dynamic pace.

Keywords: Bank run, Spillover effect, Contagion, Contagion channels, Banking sector, Banking regulation, Banking Supervision, Signature bank, Silicon Valley Bank, Geographical Proximity, Interbank Linkage, Transmission channel, Deposit Insurance.

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1. Introduction

The history of bank runs throughout the global financial system has been a source of immense learning and guidance for policymakers, banking professionals, as well as researchers on how to solidify the banking sector mechanisms while mitigating the associated risks. Importantly, even in the decades-long presence of banking solidifying mechanisms, such as deposit insurance (Diamond & Dybvig, 1983), the world has nonetheless witnessed numerous episodes of such bank runs. The discourse on whether these episodes of bank runs are borne out of systemic risks that endanger multiple banks or idiosyncratic risks driven by bank-specific factors has been inciting the curiosity of researchers to pursue comprehensive research studies. However, as a researcher, it is imperative to understand the driving force behind the foundation of banking activities and bank runs.

On the 12th of March 1933, then-U.S. President Franklin D. Roosevelt, in an attempt to address and alleviate the intensifying concerns of the people of the United States borne out of the catastrophic financial implications of the Great Depression of 1929, spoke the following words in his speech: -

> *"After all, there is an element in the readjustment of our financial system more important than currency, more important than gold, and that is the people's confidence."*

Such remarks in times of deep crises that keep the financial system hostage, signify the paramount factor that keeps the banking system sustainable: people's faith in the ability of the institutions to keep their money safe. Therefore, to ensure that a sufficient level of confidence and trust is achieved, banking institutions need to maintain their financial health and keep their activities well-regulated according to their capacity for risk management.

However, the banking system, having undergone substantially complex functional changes driven by regulatory, technological, and financial innovations, has stepped into new sources of business expansion and diversification (Buch & Goldberg, 2022). Consequently, this evolutionary effect would tend to open new sources of risk that not only the banks but also the entities involved in the banking sphere such as regulatory institutions, individuals, corporations, and cross-border entities should be cognizant of. Due to this vast complexity, the relationship structure among the stakeholders in the global financial sector strongly rests upon the degree of interconnectedness of the entire economy, as well as the direct linkages among these stakeholders.

The fall of the Silicon Valley Bank on the 10th of March, 2023 (bank-run) has been widely regarded as one of the biggest financial downturn events of the 21st century and since the global financial crisis of 2008. Some academic researchers have made an effort to uncover the factors and events that led to this collapse. For instance, the scholars Vo and Le (2023) identify the internal financial position of the bank, expanding on the bank's decisions to invest heavily in large-debt securities in the period of low-interest rates, as well as a heavy concentration of deposits in the hands of a few venture capital players, as the key contributors to the large-scale bank run. However, as it is a recent event, there are limited studies that investigate the fall of Silicon Valley Bank, hence it is important to conduct a thorough analysis to understand the foundational gaps that led to the bank's fall.

Just days after the Silicon Valley bank's bank run, another U.S. bank known as Signature Bank, later changed to Flagstar Bank, also witnessed large-scale deposit withdrawals, eventually culminating in a large-scale bank run. On the 12th of March, 2023, Signature Bank was shut down, the liquidated assets subsequently having been transferred to Flagstar Bank. A significant portion of investors labeled this bank run as a contagion effect of the fall of the Silicon Valley Bank. However, there haven't been enough research efforts to substantiate this claim, therefore, the empirical literature on this event is also limited.

The case of Signature Bank run presents an opportunity to explore deeper channels of spillover or contagion effects by understanding the ramifications of such a shock on the rest of the US banking system. Based on the empirical literature, there exists a credible starting point for this study. However, it is imperative to evaluate the subtle channels of contagion such as the effect of exposures related to institutional investments by one bank to another, or the geographical positioning of the banks which could trigger the effects of crowd psychology and panic-based irrational deposit withdrawals. While it may come across as an intuitive idea that the relevance of such channels in the era of financial insulating mechanisms such as deposit insurance and the 'Bank Term Funding Program' (Board of Governors of the Federal Reserve System, 2023) is not worth the time of the researchers and the policymakers investigating this phenomenon, the cases of bank runs like that of Silicon Valley Bank, Signature Bank, and First Republic Bank, even after the existence of such policy mechanisms, calls for a necessary degree of discourse on the possibility of such channels creating the unintended consequences on the depositors that put their valuable faith in the financial system.

Therefore, to address the potential blindspots of academic research with regard to these channels of contagion and to contribute to the still limited body of existing research around the Signature Bank's bank run, this paper aims to answer the following research question:

"To what extent did the bank run at Signature Bank trigger contagion and spillover effects in the broader banking system, and how do firm-level characteristics and the nature of exposure of individual banks to the Signature Bank contribute to the magnification of such effects?"

In pursuing this question, the primary goal of this paper is to open the room for discussion on the spillover effects of bank runs in the post-Covid era and to use appropriate empirical methods to conduct a first-level diagnosis of the activity of contagion in the transmission channels mentioned above. The research study in this paper tracks stock price movements as a measure for spillover effects and has been divided into three subsequent parts of statistical analysis, that aim to provide an indication of any disturbances in the above-stated channels. The two main proxy variables for these channels are the shareholding value as a proxy for interbank linkage, and the ZIP code matching to allow for a study of geographical proximity as a potential channel of contagion.

In the first part of the empirical analysis and by employing a sample of 43 banks that are headquartered in the U.S., the spillover effects of the Signature Bank's bank run have been estimated using the parametric event study technique. Moreover, the two separate event study analyses will also be conducted on two sub-samples of the master sample, based on the banks' size of total assets for the financial quarter Q1 of 2023. The second part of the analysis focuses on the role of geographical proximity in affecting the overall contagion effect of the bank run on regional banks in the U.S.

For this, the second sub-sample shall be used to run a difference-in-differences analysis, to aid in estimating the treatment effect (geographical proximity) in driving the stock returns of the banks. The final part of the empirical analysis then focuses on examining the explanatory variables related to the hypotheses, as well as the bank-level characteristics that could explain the drivers behind the stock returns witnessed in the event study analyses.

In the subsequent sections, this research paper systematically explores the core areas of interest and provides a comprehensive context into the research problem at hand. Beginning with section 2, the Literature Review outlines the previous literature pertinent to the research problem and delves into the specific aspects of these literature studies, eventually highlighting the motivation behind this research paper. Section 3 describes the hypotheses statements that are the foundational aspects of the statistical analyses and the subsequent discussion and recommendations. In section 4, the data and methodology approach has been stated including the data sources and statistical techniques employed for this research study. Section 5 lays down the details of the empirical analyses that includes the characterization of the three statistical methods employed for

conducting the research study, which leads to the results from these methods in section 6. In section 7, a discussion on the limitations of this research study along with the relevant policy and research recommendations is presented, which is followed by the conclusion in section 8, which summarizes the main findings, their implications, and the broader significance of the study within the academic and practical realms of the subject matter. Finally, sections 9 and 10 contain the references and the appendix (including relevant tables) respectively.

2. Literature Review

In terms of studying the intricacies and implications of bank runs and the contagion effects of such runs as well as government bailouts, global academia has witnessed several research studies that add their contribution to the recommendations of bailout designs, the presence and the characterization of the types of contagion effects concerning the bank runs, such as Information based-contagion and panic-based contagion.

For instance, the implications of such categories of contagion effects have been witnessed in a multitude of bank-run events throughout the history of capitalism, from the occurrence of a panic-based contagion during the run on the Bank of the United States in 1930 (Friedman and Schwartz, 1963) to an information-based contagion during the Housing Crisis of 2007-08 (Chakravarty, Fonseca, and Kaplan 2014). This section discusses all the identified themes based on an extensive reviewing process of the previous literature relevant to this research study. There are a total of nine sub-sections that discuss all the associated themes that were relevant for this research study.

2.1. Diamond-Dybvig Model - Bank Run as an Undesirable Equilibrium

Based on the research published by numerous authors in this field, the occurrence or the possibility of a bank run is a significantly fragile issue with many complexities due to multiple stakeholders and the interconnectedness of a bank with other banks or savings institutions (Roncoroni et al., 2019). Such interconnectedness could potentially exacerbate the spillover effect of such bank runs and the subsequent contagion effects on the rest of the economy, or even cross-border banking institutions (Gropp, Duca & Vesalas, 2006).

However, it is imperative to grasp the rationale behind the phenomenon of a bank run from the mindset of the depositors. In some of the previous studies, the role of liquidity of a bank in the form of traditional demand deposits has been emphasized, further explaining how these traditional

demand deposits as contracts for the agents display more than one equilibrium outcome, one of which (undesirable equilibrium) is a bank run (Diamond & Dybvig 1983). The authors of this paper further describe certain contexts or possibilities in which the bank deposit contracts can be tweaked to provide superior allocation; employing government-provided deposit insurance on these deposits. Moreover, the authors extend their analysis of this outcome by presenting a model that proposes a 'transformative' role of banks; transforming illiquid assets into liquid liabilities that provide a relatively smoother set of returns compared to illiquid assets (also considering their early liquidation costs). The authors claim that this is the first research paper of their time that sheds light on the banks' role of such nature.

Even though the works of Douglas W. Diamond and Philip H. Dybvig have often been the guiding force for literature in the field of banking, there have been some extensions witnessed to their proposed model later on. One such extension of this model talks about the difficulty of the emergence of a bank-run equilibrium as a second (pure-strategy) Nash equilibrium (Huo & Yu, 1994). Furthermore, the authors of this extension model cite a potential limitation of the original Diamond-Dybvig Model by citing the claim of another research paper by Postlewaite and Vives (1987), that states "a potential problem with this approach is that bank runs should not be observed in equilibrium since no one would deposit anticipating a run." This, in turn, raises the question of the accommodation of intricacies in the real-world contexts in the original Diamond-Dybvig Model.

2.2. Deposit Insurance - Impact on Contagion

As the research evidence suggests, the policy of deposit insurance has been nothing short of a breakthrough for the banking industry, specifically in terms of dodging the potential contagion effects due to deposit run at one institution. There have been multiple attempts to uncover the implications of such tools as deposit insurance for the banks, which has also been compared to the function of 'lender of last resort' of the central banks based on their mechanism of rescuing the banks in times of extreme crises (Diamond & Dybvig 1983).

The Federal Deposit Insurance Corporation (FDIC) was established on 1st January 1934, as a response to the failure of thousands of banks in the country after The Great Depression of 1929. The launch of FDIC turned out to be a success since in the year 1934, only 9 banks failed in the entire country compared to almost 9,000 bank failures in the previous four years (Federal Deposit Insurance Corporation [FDIC], 1998).

Though, the introduction of the facility of deposit insurance in the United States was hailed as a success for the banking industry till the 1980s (Keeley, 1990), the critical analysis of its implications towards the behavior of stakeholders as well as the evaluation of its need concerning the devotion of resources has been attempted numerous times since the 1980s. In that respect, one of the papers (Gibson, 2009) talks about the requirement for evaluating the impact of deposit insurance by imagining the scenario of frequency of bank runs (panics and deposit losses) in the absence of the deposit insurance facility. Furthermore, there has been a continuous addition to the literature on the behavioral drawbacks associated with the deposit insurance mechanism. Specifically, the impact on risk-taking by the banks in the presence of deposit insurance facilities has been thoroughly studied. One such paper describes a hypothesis test that banks that have deposit insurance take on excessive risks in the form of asset risk increase and capital reduction indirectly caused by the competitive environment in which the banks operate (Keeley, 1990). In addition, deposit insurance has also been portrayed to have banks' excessive risk-taking as an unintended consequence stemming from the reduction in the incentive to constantly monitor the risk-taking behavior of the banks by the associated depositors (Anginer et al., 2014). This paper further demonstrates the two effects related to the above-mentioned behavior, namely the 'moral-hazard effect' and the 'stabilization effect' that dominate in good and turbulent times respectively.

2.3. Previous Research - Prevalence of Event Studies

In this research paper, an event study, as exemplified by the scholar MacKinlay (1997) serves as the central methodology to demonstrate the potential spillover effect of the Signature Bank deposit run (March 10th, 2023), on a subset of the banking sector of the U.S.

Such a methodology has been cited and has been used quite extensively in several research use cases of the financial sector such as in the events of Mergers and Acquisitions (Manne, 1965), stock splits (Dolley, 1933), IPO underpricing (Ibbotson et al., 1994), damage assessment in legal liability cases (Mitchell & Netter, 1994) and regulatory change impact on firm value (Schwert, 1981)**.** While such a methodology has been proven to be effective in detecting significant changes in the indicators of interest in many research areas, corporate finance has been the dominant field that has employed the rationale and technique of event studies more than any other field. In addition, the most common use of this technique has been towards common equity as a class of security for detecting the significance of price changes due to certain financial and non-financial events.

The empirical analysis by the scholars Goldsmith-Pinkham and Yarulmazer (2009), serving as one of the most significant works of inspiration for this research thesis, also pursues an event study to calculate the spillover effect of the Northern Rock bank run on the U.K. banking industry by tracking subsequent stock market prices of the sample banks.

2.4. The Case of the Northern Rock Bank Run

As a consequence of the 2008 Global Financial Crisis, the UK-based Northern Rock turned out to be one of the unfortunate financial institutions that had undergone a deposit run, which, according to some academic researchers, was expected to create some level of spillover on the rest of the banking system in the United Kingdom. To evaluate the intensity of such a phenomenon, a study conducted by the scholars Paul Goldsmith-Pinkham and Tanju Yorulmazer (2009), employed the event study analysis technique to measure the short-term spillover effects of the above-mentioned bank run on the UK banking system, followed by multiple OLS regression analyses to overhaul the value of the indicator being tracked (abnormal stock returns). In its sample, the above-mentioned research study focuses on the 10 largest U.K.-owned banks that collectively make up approximately 90% of all UK-owned banks' assets.

2.5. Contagion vs. Spillover

Before proceeding to the research hypotheses for this study, it is imperative to understand the distinction between the terms 'contagion' and 'spillover'. These two terms have been extensively used in numerous scientific papers, and while their intuitive meanings may appear similar on the surface, they hold distinct underlying connotations within different contexts.

According to the scholars Brown, Trautmann, and Vlahu (2012), 'contagion' is a condition where the failure of one financial institution results in the subsequent default of other financial institutions**.** This phenomenon has been explored, both empirically and experimentally in a large number of academic efforts, yielding a vast pool of literature. The scholar Rigobón (2019) attempts to create a technical distinction between the concepts of contagion and spillover by identifying the pattern of co-movement, and model dependence. Specifically, the author states that 'spillover' is a type of interdependence, the occurrence of which has been already modeled by researchers studying a concept. Hence, the existence of spillover effects does not come across as a surprise to the researchers, since it is believed that they have sufficient information about the linkages of the two areas that display such nature and magnitude of interdependence.

‘Contagion’ on the other hand is considered to be a type of interdependence that occurs beyond the order of magnitude that the researchers expect, hence, comes across as a surprise (ibid.). Furthermore, ‘contagion’ is a phenomenon that intensifies especially during a crisis, whereas spillover is expected at almost all times (ibid.).

2.6. Signature Bank, New York: Existing Literature

The issues of deposit withdrawals leading to bank runs, and the associated contagion (or spillover) effects, have been studied by numerous researchers in the history of capitalism. One may find that while some of the symptoms of l bank runs might share similarities in different cases throughout history, the geographical and regulatory contexts in which such bank runs occur might however be very different from one another. For instance, the bank runs that occurred in the aftermath of the Great Depression of 1929 and before the introduction of deposit insurance in 1934, took place without the existence of such a financial safety net for the banks (FDIC, 1998). Similarly, the bank runs that occurred after the introduction of Basel 3 (as a response to the Great Financial Crisis of 2008) took place under different regulatory environments compared to the ones that occurred before, such as revised minimum risk-based capital requirements, leverage ratio requirements, as well as the introduction of the ‘Net Stable Funding Ratio’ and the ‘Liquidity Coverage Ratio’ (Basle Committee on Banking Supervision, 2022).

In the case of the most recent and significant bank runs that occurred in the post-Covid era, there are essentially three such major events in the U.S. banking sector to be identified: Silicon Valley Bank, Signature Bank, and First Republic Bank. Since these events took place in the latter part of the first quarter of 2023, the empirical literature on the analysis of internal and external factors that led to such events is currently still limited. One of the research papers analyzing these bank runs highlights the items of the balance sheets of the Silicon Valley Bank and Signature Bank and in doing so, especially identifies the levels of uninsured deposits as a significant contributor to the banks’ downfalls (Allen, Baig & Winters, 2023). The authors further conclude that both of these banks can be regarded as outliers, meaning that the run on these banks does not indicate the presence of systemic risk. While the paper managed to identify the two banks’ uninsured deposit levels, which exceeded the limit set by the FDIC, as the reason for the outlier status for both banks, other contributing factors may have nonetheless been neglected, as there may be additional unexplored paths in adequately overhauling the trajectory of these bank failures. For instance, the relevance of US Treasury Securities that the Silicon Valley Bank had to off-load to meet the liquidity requirements, or the Signature Bank’s risky exposure levels in the crypto market, which could have significantly contributed to the fall, haven’t been adequately addressed in the authors’ study. Moreover, the paper does not present the behavior of deposit levels, or the stock returns of

these banks and the rest of the banks from the industry during the bank run and subsequent closure by the FDIC. In addition, the study's sample size being limited to five banks from the benchmark peer group could constitute a limitation, since a sample of such size could be susceptible to biases such as availability bias or confirmation bias. In addition, the research paper not yet being peer-reviewed could possibly restrict the reliability of the methodology and the results derived and presented.

However, the behavior of deposit flows has been discussed in another research study conducted by the scholars Caglio et al. (2023). Specifically, this research study touches upon the phenomenon of 'flight to safety' deposit flows from smaller regional banks towards larger banks in the first quarter of 2023, along with tracking the bank-level characteristics such as uninsured deposit levels in all the banks as part of their sample.

In drawing inspiration from the above study, the levels of uninsured deposits will be analyzed in relation to the Cumulative Average Abnormal Returns in the context of this research study. However, tracking the deposit flow behavior remains beyond the scope of this research paper, for reasons outlined in the data and methodology chapter of this thesis.

2.7. Uninsured Deposits

When a bank or a savings institution goes bankrupt, the status of depositors' savings is one of the primary resolutions that the stakeholders such as the bank management, the government, institutions such as the FDIC, and of course, the depositors pay special attention to. The prevalence of institutions that step in to wear the shoes of a guardian for thousands of institutions in the unfortunate events of bank runs has further created bank performance/strength indicators in times of stress. Based on the preceding discussion of the existing literature on the trajectory of deposit insurance since its origin, it can be inferred that the percentage of insured deposits in a given financial institution could potentially shed light on the available cushioning effect on the depositors of the respective banks. Consequently, the percentage of uninsured deposits in a bank (depository institution) has gradually become one of the most glanced at indicators to assess its surface-level risk profile. In this regard, the scholar Rezende (2023) identified high percentages of uninsured deposits as one of the common denominators amongst the regional banks in stress due to the Silicon Valley Bank and Signature Bank collapse.

Accessing the historical context, the case of the Continental Illinois National Bank's bank run in the 1980s (1982 and 1984) shows that the share of uninsured deposits, the major portion of purchased funds, turned out to be one of the most significant factors that exacerbated this bank run

event (Baer & Brewer, 1986). However, while building an argument in support of such uninsured sources of funds, the researchers through their results of the study imply that eliminating the uninsured deposits from the banks will eliminate a source of funding that could potentially contribute towards fostering market discipline by reducing the incentives for these institutions to take on further risk by resorting to other risky, relatively inflexible sources of funding. While this research study is not adequately conclusive to declare such a claim as relevant for the entire market, further research studies/experiments could be implemented to conduct a deeper analysis of this topic.

2.8. Geographical Proximity - a Channel of Contagion

The scientific community is driven towards exploring the origins of panics and bank runs and has sought to identify various transmission channels of contagion, as the identification of possible networks of contagion, represents a prerequisite to allowing for controlling and ultimately avoiding such adverse phenomenons. This would further enable the institutions to develop policies and mechanisms to break and isolate the rest of the economy from the bank that may face imminent collapse.

While the factor of geographical proximity has rarely been employed to estimate its impact as a transmission channel, some researchers have attempted to explore its validity as a channel of spillover in other aspects of banking. For instance, the scholars Pino et al. (2019) investigate the relationship between a bank's risk-taking behavior and its market power, using the factor of geographical spillover. Additionally, the authors argue that risk-taking can be transmitted across banks and that geographical proximity tends to be one of the determinants of such a phenomenon. However, in the above research study, the authors pursue spatial econometrics to incorporate geographical spillovers in their analysis, which differs from the method of ZIP Code matching employed in this thesis. However, given the fact that the authors found evidence of strong geographical spillovers during the crisis period from 2003-2012, it adds to the validity of such a channel's ability to transmit spillover effects of risk-taking behavior.

In another research paper by the scholar Hansen (2021), the concept of 'mental' and 'physical' contagion has been referred to, which aims to explain the role of crowd psychology during a financial crisis. Furthermore, this author discusses the amplification of the financial crisis due to sentiment exchange amongst people mentally/physically connected in the financial markets.

To allow for the incorporation of the factor of geographical proximity, this thesis draws the inspiration of using the ZIP Code matching approach by combining the arguments presented in the

two papers referred to above, as ZIP Code matching in the US arguably provides a more precise measure of proximity when compared to the city or province matching approach. In this research study, the factor of geographical proximity as a possible channel of contagion has been analyzed using the difference-in-differences estimator study. Further details on this part of the analysis will be outlined in the data and methodology section.

2.9. Shareholding Network - Possible Channel of Contagion

The previous literature related to bank runs has witnessed numerous research papers that have examined the interbank linkages as a possible source of contagion (Iyer & Peydro, 2010; Deb, 2016; Freixas et al., 2000). However, most of the studies have primarily focused on channels such as the interbank lending channel or debt channel in their statistical models. Having said that, this research study focuses on an interbank channel that has been rarely explored in previous research studies, the cross-shareholding network of banks. The motivation of pursuing hypotheses related to this channel of contagion is based on the previous research on cross-shareholding networks, which concluded that these networks have the capacity to amplify the external shocks in the financial ecosystem (Feng & Li, 2021). However, unlike the study of the scholars Feng & Li, this research study focuses on unilateral shareholding relationships rather than a bilateral one. By including this factor, the validity of a channel of contagion could possibly be detected, which could be further explored in the context of future research efforts, using complex mechanics of 'Network Theory' in the financial system (ibid).

2.10. Concluding Remarks

Based on the extensive literature review above, the motivation for this research thesis boils down to the limitations and potential blindspots in the current pool of existing research, which have been identified as follows: -

- Based on personal opinion, after the introduction of deposit insurance by FDIC in the US, there has been a reduction in the production of research literature with respect to the contagion effects of bank runs. However, the collapse of Signature Bank opens the possibility of exploring this aspect of the banking crisis.
- The current literature resources seem to have insufficient diversification on the intensity of spillover effects in terms of the relationship of a corporate entity (associated banks) to the affected entity (the bank run). Most of the literature expands on interbank exposure in terms of linkages in the interbank market, term loans, bond holdings, etc. However, financial institutions that have shareholdings of a bank that experienced a run on its deposits, are a

relationship that hasn't been explored adequately yet in the context of contagion or spillover effect.

- In the era of deposit insurance in the U.S., the current literature fails to expand on the behavioral aspect of a bank run. As mentioned above, panic-based bank runs have been experimentally proven to exist in the past, but the relevance of such an issue has been insufficiently explored in the post-2008 financial crisis period. Using the factor of geographical proximity, this research study has attempted to explain the presence of a contagion effect based on panic-based sentiment amongst individuals who have their deposits in the banks that are situated in proximity to the Signature Bank branches.

3. Hypothesis Development

In light of all the research efforts by scholars in the past as mentioned in the literature review, this research study aims to empirically test multiple hypotheses to obtain sufficient empirical insights in order to allow for a comprehensive answer to the research question outlined in Section 1.

The first hypothesis deals with the presence of spillover effects stemming from Signature Bank's bank run on the sample banks that have been considered for this research study. Such tests of detecting spillovers have been performed several times in the previous research literature, including in the research paper by the scholars Goldsmith-Pinkham & Yorulmazer (2010) concerning the case of the Northern Rock bank run. Using the data of stock prices of all the sample banks, the following hypothesis is tested using the parametric event study technique:

Hypothesis I: *The event of the Signature Bank run on 10th of March 2023 led to negative abnormal stock returns of publicly listed sample banks situated in the geographical territory of the US.*

For the second hypothesis, the uninsured deposit level has been considered as a measure to partially explain the abnormal stock returns of the sample banks. Based on the literature review and for the purposes of this study, the second hypothesis, based on the results of the OLS regression analysis, has been formulated as follows:

Hypothesis II: *The uninsured deposit levels of the sample banks had a negative impact on the cumulative average abnormal stock returns of the sample banks from the event study analysis for the event date 10th March 2023.*

This thesis' third hypothesis relates to the interbank linkage reflected in the shareholding value in the Signature Bank for the sample banks in order to test for the presence of contagion effects. As mentioned in the preceding sections of the literature review, using shareholding positions as a proxy for interbank linkage has been rarely pursued in previous studies. However, in drawing inspiration from the empirical process of the research paper by Feng and Li (2021), the following hypothesis has been formulated and subsequently tested in the OLS regression analysis:

Hypothesis III: *The equity exposure in the form of the shareholding positions that the sample banks hold in the Signature Bank, had a negative impact on the cumulative average abnormal stock returns of the sample banks in the US for the event date of 10th of March 2023.*

For the final hypothesis, the possible contagion channel and dimension that is geographical proximity has been considered. In order to test this hypothesis, the ZIP Code matching technique has been used to create a proxy dummy variable of ZIPCode to test the possibility of contagion effects. This hypothesis has been tested using the difference-in-differences estimation technique, in which the ZIPCode has been taken as the treatment indicator alongside the time dummy variable to check for the pre-treatment and post-treatment effects. Furthermore, the subset of the sample, which consists of 22 regional US banks has been employed to run this analysis. Based on these considerations, the following hypothesis has been developed:

Hypothesis IV: *The geographical proximity as a channel of contagion had a negative impact on the cumulative average abnormal stock returns of the subset of sample banks for the event date of the 10th of March 2023.*

On the basis of the above-mentioned hypotheses associated with the research question, the subsequent section discusses the most appropriate statistical techniques to draw insights that would contribute towards answering the research question, hence deciding upon the treatment of the hypotheses.

4. Research Methodology and Data

In keeping the case of Signature Bank as a focal point for the statistical analyses in this research project, the literature review has provided ample motivation and the necessary guidance on the most suitable techniques for attaining conclusive results on the proposed hypotheses, which will be discussed and outlined in detail in the subsequent sections.

The main objective of this research paper is to study the potential spillover effects of the signature bank deposit run on banks and savings institutions that are headquartered in the geographical territory of the United States.

The study of such effects of one of the first post-COVID-19 bank runs, as well as the sample selection criteria of affected banks, which will be discussed later in this section, present key differentiating factors of this paper.

4.1. Methodology - Technique and Motivation

The inspiration for the data selection process and statistical methodology in this paper has been drawn from the extensive body of existing literature pertaining to spillover effects (Goldsmith-Pinkham & Yorulmazer, 2009; Canlas, Ravalo, & Remolona, 2018).

As discussed in the previous section, the empirical analysis starts off with the employment of the parametric event study technique (MacKinlay, 1997) in order to perform the first-level analysis of detecting and measuring the spillover effects of the event of a bank run in the case of Signature Bank, New York. Consistent with existing research, the abnormal stock market returns of the banks in this study's sample will be used as a proxy for the spillover effects in this research paper. Focusing on stock market pricing data is indeed arguably most suitable owing to the frequency interval (daily) of the data availability, its higher explanatory power when compared to weekly or monthly data (MacKinlay, 1997), as well as the ability of stock prices to capture new information in the market, based on the theory of Efficient Market Hypothesis (Fama et al., 1969; Malkiel & Fama,1970).

In this regard, deposit levels are rendered unsuitable as a potential alternative metric of analysis, due to the limitation with regards to the lack of available high interval frequency (daily level) data for the deposit levels of the sample banks. This lack of data availability, owing to the confidentiality of such deposit flow data, would therefore render their deployment as a metric to capture the accurate effects of the bank run on the movement in deposit levels, infeasible.

Consequently, this would most likely represent a hindrance to assessing the contagion effect on the behavior of the depositors of the sample banks. Specifically, based on the publicly available data resources, the data for such an indicator is available with quarterly frequency only. This would arguably be insufficient to capture the intricate effects of such events on the sample banks, significantly compromising the robustness of any results derived from such an analysis.

4.2. Sample Design

In the work of Goldsmith-Pinkham and Yorulmazer (2009), the selection criteria for the inclusion of banks into the authors' sample is based on the size of the banks and their collective proportion of total United Kingdom-owned bank assets at roughly 90%. Following this sample collection methodology, the authors' sample, comprising the UK's ten largest banks, was constructed and the event study test was conducted on the stock prices of these banks.

In this study, the criteria for selecting the sample size have been expanded to accommodate two essential features; shareholder banks of the Signature Bank, as well as the geographical proximity of the banks' branches to the branches of the Signature Bank as on 10th March 2023 (the date of the bank-run event). Moreover, to compare the spillover effect on banks in geographical proximity, a peer group of banks that is dissociated from both factors has been added to the sample. Considering this, a total of 43 U.S.-based banks are contained in the sample under study. A detailed description of sample characteristics follows below:

- Banks that are publicly listed on a U.S.-based stock exchange (for stock prices).
- Banks with headquarters situated in the U.S.
- Banks where the majority of deposits pertain to the domestic population of the U.S.
- Banks that are members of the FDIC.
- For peer group[1], regional banks are listed on a recognized U.S. stock exchange (NYSE, NASDAQ).

4.3. Sequence of Analyses

To culminate the research study, three different statistical analyses have been conducted. These analysis methods have been arranged according to the sequential stages of results required for testing the proposed hypotheses. The stages are described as follows:

1. First Stage Conduct: To test the presence of significant changes in the stock returns due to the event of interest, an event study on all the sample banks has been conducted. However, for the event study, a total of two event dates of significance will be tracked. The list of events being tracked will be discussed later in this section.

2. Second Stage Conduct: The second stage of conduct will be based on the difference-in-differences methodology between the sample of banks differentiated by their

[1] For including the peer banks, Refinitiv Eikon's peer list is based on analysts' reports, which has been collected and used for constructing such a sample.

geographical proximity to the Signature Bank branches. For this, the ZIP-code[2] approach has been used to construct the banks' samples. It must be noted that only the sample of Regional Banks in the U.S. has been used for this stage.

3. Third Stage Conduct: Post-event study analysis, it is essential to discern the drivers of such statistically significant returns (if any). For this, OLS Regressions (multiple linear regressions) have been conducted, using bank-level characteristics that will be discussed in the list of variables later in this section. These bank-level characteristics have been adequately checked for heteroscedasticity, multicollinearity, and normality by taking the natural logarithms of the variables.

4.4. Data Sources

In order to conduct the multiple-stage analyses mentioned above, the research study primarily required bank-level characteristics, since there are only two dates of significance associated with the Signature Bank's bank run. Some of the performance indicators of banks in the United States, such as interbank linkages via loans, daily deposit level data of the banks and savings institutions, and common asset exposure amongst banks, are not accessible to students, the scope of this research study has been limited to the financial statements data of the sample banks. To calculate the stock returns, specifically, the cumulative abnormal returns, the daily-level stock price data has been sourced collectively from Bloomberg and Yahoo Finance. For the stock prices, the prevalent closing prices have been sourced, excluding the consideration of stock splits and dividends.

Most of the balance sheet items employed as bank-level characteristics and subsequently incorporated as independent variables into the analysis have been sourced from the online portal of the FDIC. Additionally, information on the banks' branch addresses, by proxy of ZIP Codes has also been obtained from the FDIC. The data for variables such as uninsured deposits of the banks under consideration have been collectively sourced from both FDIC's online portal and Refinitiv Eikon.

[2] The ZIP Codes for all the banks' branches have been sourced from the FDIC Bank Find Suite tool. Based on the ZIP Code matching between the branch/HQ of a bank in the sample and the branch of Signature Bank (same ZIP Code address), a variable as a proxy for Geographical Proximity has been constructed.

5. Empirical Analysis

5.1. Event Study

Based on the methodology section, the first line of analysis for this research study is related to the parametric Event Study technique to measure the impact of the Signature Bank Depositor run and the announcement of the rescue package by the FDIC and the Treasury Department for the two banks i.e. Silicon Valley Bank and the Signature Bank. In that regard, the two dates (10th March 2023 and 13th March 2023) will be the dates of focus for the event study analysis, with five event windows ([-2, 0], [-1, 3], [0, 0], [0, 1] [0, 2]) for the first event date (10th March 2023) and three event windows ([0, 0], [0, 1], [0, 3]) for the second event date (13th March 2023). The details for all the associated events can be found in the Appendix section (Table 8, Page 49).

This line of analysis will use two Models out of numerous other benchmarks and Stock Market Models for calculating the abnormal returns: the Mean-Adjusted Model (the primary model), and the Market Adjusted Model (for the robustness check). To calculate the Abnormal Returns, Expected Returns will be calculated first using the above two models. Following this, a sample period for the number of days before the event, also called the estimation window must be selected. For this, the estimation window of [-20, -5] days has been taken. However, another estimation window for 120 days [-140, -20], based on the recommendation of using 100 days or more for the estimation window (Aït-Sahalia et al., 2010, Sorokina et al., 2013) has been taken as part of the robustness check for the event study analysis.

The formulas displayed below serve as the basis for calculating the Abnormal Returns for the model. As part of this analysis, the daily logarithmic returns have been calculated: -

$$(1) \qquad \text{Abnormal Return}_{it} = \text{Actual Return}_{it} - \text{Expected Return}_{it}$$

$$(2) \qquad \text{Expected Normal Return}_{i,t} = \mu_{i,t} + \varepsilon$$

$$E(\varepsilon) = 0 \quad \text{Var}(\varepsilon) = \sigma^2$$

The next step in the process is to implement cross-section aggregation for the sample of US banks (Pacicco 2018 et al, p. 464). For this, Average Abnormal Returns are to be calculated for better comparison between the sample banks. The formula for Average Abnormal Returns is described as follows: -

$$(3) \qquad AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{i,t}$$

The next and the final step is to calculate the sum of Average Abnormal Returns over time i.e. Cumulative Average Abnormal Returns. The main rationale behind this step is to estimate the

impact of an external shock on the stock returns of the sample entities in a multi-day period. The formula for calculating the Cumulative Average Abnormal Returns is displayed below: -

$$(4) \qquad CAAR(t_1, t_2) = \sum_{t=t_2}^{t_1} AAR_t$$

5.2. Difference-in-Differences

The factor of geographical proximity as a transmission channel of the bank run contagion effect is one of the crucial factors as part of the hypotheses. To carry out the proposed analysis, the technique of Difference-in-differences has been employed to estimate the effect of geographical proximity (treatment indicator) on the Cumulative Abnormal Returns of the sample banks.

For this research study, the two sample sub-groups (treatment and control) have been taken, for which a total of twenty-two regional banks have been identified. The ZIP Code Dummy has been taken as the cross-section comparison factor between the treatment and control group, while the bank-run event date of 10th March 2023 has been taken as the time-series comparison factor for this analysis. The treatment and the control group have an equal number of regional banks (eleven each). For this analysis, the event window of 2 days (before and after the event) i.e. [-2,0] and [0,2] has been taken to calculate the Cumulative Abnormal Returns of the sample banks to control the effects of Silicon Valley Bank's collapse on the stock returns of these banks (8th March 2023).

Based on the above information, the regression equation comes out as follows: -

$$\gamma_{it}(CAR) = \alpha + \beta_1 * (Time) + \beta_2 * (ZIPCode) + \beta_3 * (Time - ZIPCode) + \varepsilon_{it}$$

In the above equation, the term 'Time - ZIPCode' is the interaction term that represents the treatment factor for time-series and cross-section analysis. The dependent variable γ is the Cumulative Abnormal Returns for twenty-two banks.

5.3. OLS Regression

The third and final step of this paper's research methodology is the OLS Regression for the cumulative average abnormal returns calculated during the event study analysis. To perform this analysis, various bank-level characteristics have been employed to determine the driving forces behind the CAARs during the Signature Bank run crisis. Following this, the regression equation has been formulated as follows: -

$CAAR_{it}$ (t_1t_2) = α + β_1*UninsuredDeposits + β_2*Tier-1RiskBasedCap.Ratio + β_3*TotAssets + β_4*ShareholdingValue+ β_5*NetLoans&Leases/TotalDeposits + β_6*DepositGrowth+ β_7*EfficiencyRatio + β_8*NetLoans&Leases/TotalAssets + β_9*ReturnOnAsset + β_{10}*CashBalances/TotalAssets + ε_{it}

The regression equation displayed above is a cross-section regression that uses Cumulative Average Abnormal Returns for bank 'i' at event time 't' in the five-event windows for a single event date of 10th March 2023. A detailed explanation of all the explanatory and control variables can be found in the 'List of Variables' section in the Appendix (Table 9, Page 50). Moreover, the summary of the descriptive statistics of all the variables can also be found in the Appendix (Table 10, Page 52)

Based on the formulated hypotheses, the variables UninsuredDeposits and ShareholdingValue have been included in the equation to examine their statistical significance and their relationship with the dependent variable. The data for all the independent variables are based on the bank's financial statements for the first quarter of 2023. The regression analysis has been accompanied by adequate checks for heteroscedasticity using the Breusch–Pagan/Cook–Weisberg test, and the regression results have subsequently been tested for robustness in standard errors. Furthermore, the variables have been examined for multicollinearity using the Variance Inflation Factors.

6. Results

6.1. Event Study

In order to comprehensively accommodate the effect of events in the week following the Silicon Valley Bank Collapse, along with the Signature Bank depositor run, two event dates i.e. 10th March 2023 and 13th March 2023 have been analyzed for estimating Cumulative Abnormal Returns of the sample banks. For the first event date, a total of five event windows have been constructed, whereas for the second event date i.e. 13th March 2023, three event windows have been built and analyzed.

On the 10th of March 2023, we can observe a statistically significant decline in Cumulative Average Abnormal Returns for all the event windows at p-values less than 1%. These declining values of CAARs were incredibly huge for the event windows of [-1,+3] and [0,+1] with a fall in CAARs of approximately 17% and 14% respectively. Furthermore, it can be clearly observed that First Republic Bank is the largest contributor to such strong negative values of CAARs, with

negative cumulative abnormal returns of approximately 126% and 111% for the event windows of [-1,+3] and [0,1] respectively. Some of the other banks also significantly drove the steep declines on the two event windows in consideration, such as Comerica Inc. (37.54%, 36.29%), Key Bank (36.32%, 33.54%), Zions Bank (39.36%, 31.2%), and Truist Bank (29.03%, 24.74%). The Cumulative Average Abnormal Returns for the master sample for the event window [-2,0] had witnessed a statistically significant decline of 8.26%, suggesting that the spillover effects may have strongly originated from the event date of 8th March when Silicon Valley Bank announced a substantial loss of $1.8 Billion and experienced a downgrade in its bond rating by Moody's.

Table 1: Mean-Adjusted Model

Event Windows	Dates	
	10th March 2023	13th March 2023
CAAR [-2, 0]	-8.2628%***	---
CAAR [-1, 3]	-17.3017%***	---
CAAR[0, 0]	-2.9165%***	-11.6061%***
CAAR [0, 1]	-14.4867%***	-7.729%***
CAAR [0, 2]	-10.5733%***	---
CAAR [0, 3]	---	-6.1909%***

Note: The above displayed results have applied logarithmic returns to calculate CAARs. For both the event dates, all the event windows have shown statistically significant CAARs at a 1% level of significance.

For the events that occurred on March 13th, 2023, the Cumulative Average Abnormal Returns have been calculated for all the observations of the banks' master sample. After performing the event study, it can be observed that for the event window of [0, 0] i.e. cumulative average abnormal returns for the event date itself, there is a significant decrease in the CAAR for all the banks, which is also statistically significant at p-values of less than 1%. However, it must be noted that the decrease in CAAR for this event date is substantially higher when compared to the decrease in Cumulative Average Abnormal Returns on the 10th of March 2023 (a decrease of 2.9%). This may signify that the effect of the announcement by the FDIC on the 12th of March 2023 was not sufficiently effective to allay the negative market sentiment in the US banking sector by that time. However, there exists a possibility that the market as a whole turned out to be relatively slow in reacting to the announcement news as the negative market sentiment had existed for almost five days. One of the possible reasons could be the timing of the announcement i.e. the announcement

took place on Sunday, 12th March 2023 (which was a weekend). One of the papers pertinent to such an observation talks about the abnormal volatility of stock prices in the Post-Closing and Pre-opening periods of the stock market and has concluded that pre-opening announcements tend to have a slower reaction time for investors when compared to Post-Closing announcements (Lyle et al., 2018). Though, the paper mentioned talks primarily about the earnings announcements, the indicator of reaction is the same, which could partially explain such a phenomenon.

When we take into account the results of the other two event windows of this date, we see that the Cumulative Average Abnormal Returns had slightly improved, with a total decrease of approximately 7.72% for the event window of 1 day after [0, 1] and decrease of 6.19% for the 3-day event window [0, 3]. This could signify the potential recovery of falling stock returns as a consequence of the announcement of the bailout by the Treasury Department and the FDIC. However, it must be noted that some of the banks in the master sample still demonstrated incredibly high negative Cumulative Abnormal Returns, such as First Republic Bank, KeyBank, Comerica Inc. etc. These banks also showed substantially high negative returns for the event date of 10th March 2023, which could mean that there could be a commonality factor between the Signature Bank and these banks. Some of these factors are overlapping portfolio exposures and counterparty risk associated with relationships in the interbank market (Caccioli, Farmer, Foti & Rockmore, 2015). However, it is imperative to note that based on the scope of data availability and research hypothesis scope, this research paper does not demonstrate a deeper analytical framework to explain such extreme observations. Therefore, such a question could be a part of future research scope in this field of study.

6.1.1. Robustness Test

As part of the robustness test for this round of analysis, the Market-Adjusted Model for calculating the Cumulative Average Abnormal Returns has been employed. As an additional layer of credibility, the master sample has been divided into two sub-samples based on the bank category. The first sample consists of large-sized diversified banks that also happen to be a subset of the top twenty largest banks in the United States for the year 2023, based on the size of their total assets.[3]

The second sample consists of regional banks of the United States, most of whom have a total assets size of less than $100 billion. As part of conducting the Market-Adjusted Model event study, the first sample used the S&P 500 as the benchmark index to calculate the Abnormal Returns, while the second sample used the KBW Regional Banking Index to calculate the abnormal returns.

[3]Database for the list: https://www.statista.com/statistics/799197/largest-banks-by-assets-usa/

As the results suggest, substantial declines in the Cumulative Average Abnormal Returns were observed for all five event windows for the first event date i.e. 10th of March 2023. The results can be observed in the table given below: -

Table 2: Market-Adjusted Model (All Banks)

Event Windows	Dates	
	10th March 2023	13th March 2023
CAAR [-2, 0]	-9.3033%***	---
CAAR [-1, 3]	-19.3477%***	---
CAAR[0, 0]	-3.4975%***	-12.6579%***
CAAR [0, 1]	-16.1554%***	-8.1551%***
CAAR [0, 2]	-11.6526%***	---
CAAR [0, 3]	---	-7.0705%***

Note: The above-displayed results have applied logarithmic returns to calculate CAARs. For both the event dates, all the event windows have shown statistically significant CAARs at a 1% level

Based on the above results, it is noteworthy that the decrease in value of CAAR for all the five event windows for the event date of the 10th of March 2023, is not substantially different from the results based on the Mean-Adjusted Model for the same date. Furthermore, for the event date of 13th March 2023, the decline in the value of CAAR for all three event windows also turned out to be statistically significant at a 1% level, and the results are also significantly close to the values observed in the Mean-Adjusted Model for the same date. Now, the results of the event study for the two sub-samples have been displayed as follows: -

Table 3: Market-Adjusted Model (Large Banks, Total Assets>$100 billion)

Event Windows	Dates	
	10th March 2023	13th March 2023
CAAR [-2, 0]	-9.0317%***	---
CAAR [-1, 3]	-19.1492%***	---
CAAR[0, 0]	-3.3458%***	-10.3248%***
CAAR [0, 1]	-13.6706%***	-6.0494%***
CAAR [0, 2]	-9.3952%***	---
CAAR [0, 3]	---	-7.9138%***

Note: The above-displayed results have applied logarithmic returns to calculate CAARs. For both the event dates, all the event windows have shown statistically significant CAARs at 1% level of significance.

Table 4: Market-Adjusted Model (Regional Banks, Total Assets < $100 billion)

Event Windows	Dates	
	10th March 2023	13th March 2023
CAAR [-2, 0]	0.098%***	---
CAAR [-1, 3]	-2.4395%***	---
CAAR[0, 0]	-0.9262%***	-6.1084%***
CAAR [0, 1]	-7.0346%***	-4.3703%***
CAAR [0, 2]	-5.2965%***	---
CAAR [0, 3]	---	-2.1759%***

Note: The results highlighted above (for 22 sample bank observations) based on the Market-Adjusted Model for the Event Study, that has utilized KBW Regional Bank Index as the benchmark index for calculating the abnormal returns.

We can clearly observe that for all the five event windows for the first event date in the first sample, all of the estimated values of Cumulative Average Abnormal Returns turned out to be statistically significant at a p-value of 1%. The highest decline of approximately 19.15% was observed in the event window [-1, 3] which could possibly be due to the accumulation of returns over the four-day period of negative sentiment in the market. The lowest decline of 3.345% was witnessed on the day of the event, i.e. event window [0, 0]. However, for the second sub-sample, the results turned out to be significantly contrasting from the first sub-sample. For the first event window [-2, 0], the decline in the CAAR value was just 0.098% which turned out to be statistically insignificant at a conservative 10% level. For the event window [-1, 3], the decline in the value of CAAR was approximately 2.44%, which is substantially lower when compared to the decline in the value of CAAR for the same event window in the first sub-sample i.e. a decline of approximately 19.15%. Furthermore, the highest decline for the second sub-sample on the 10th March 2023 event date was witnessed in the event window of [0, 1] which was approximately 7.03%, while the decline for the event window [0, 2] was approximately 5.3%, which could imply a slight recovery in the returns.

For the second event date, the first sub-sample experienced statistically significant declines for all three windows, with the highest decline of 10.32% for the event window of [0, 0] i.e. the date of the event itself. For the second sub-sample (regional banks), the declines were, even though statistically significant, lower than the ones observed in the first sub-sample for the same event date. However, we can observe that with the increasing size of the event window moving further away from the event date, the magnitude of the decline in CAAR lowers gradually, which could imply the recovery post the event of the announcement of the bailout.

The results of the event study based on these two sub-samples for the two event dates suggest that there was a comparatively higher level of spillover effect of the Signature Bank's depositor run on the stock returns of large banks with assets worth more than $100 billion, than the regional banks with asset size less than $100 billion. Furthermore, we can also observe the effect of Silicon Valley Bank's depositor run was not as substantial on the regional banks as the effect of Signature Bank's depositor run. However, the slow reaction time to bad news by the investors in the market could also explain such a result. The choice of two different indices for this part of the event study could also partially explain such a significant variation in the results of the two sub-samples. Another robustness test has been conducted by increasing the size of the estimation window. In the primary Mean-Adjusted Model, an estimation window of 15 days has been incorporated for estimating the CAAR, however, for the robustness check, this window has been increased to 110 days i.e. (-130, -20), since 100 days are considered as reasonable estimation window based on

empirical literature (Armitage, 1995). Based on the results from this round of event study analysis, it can be inferred that increasing the size of the estimation window had a minute effect on the estimated CAAR values in all the event windows for both event days. The results can be observed in the table given below: -

Table 5: Mean-Adjusted Model (Expanded Estimation Window: 110 days)

Event Windows	Dates	
	10th March 2023	13th March 2023
CAAR [-2, 0]	-9.2828%***	---
CAAR [-1, 3]	-18.9920%***	---
CAAR[0, 0]	-3.2564%***	-11.9042%***
CAAR [0, 1]	-15.1579%***	-8.3351%***
CAAR [0, 2]	-11.5866%***	---
CAAR [0, 3]	---	-7.4087%***

Note: The above-displayed results have applied logarithmic returns to calculate CAARs. For both the event dates, all the event windows have shown statistically significant CAARs at 1% level of significance.

6.2. Difference in Differences

As part of this aspect of the study, two different rounds of regression have been performed: -

1. Multiple linear regression with Cumulative Abnormal Return (2 days event window) as the dependent variable, and Time-series dummy variable, ZIP Code Dummy Variable, and the Interaction Term ‘Diff’ (Time-ZIPCode) as the independent variables.
2. Linear Regression with Cumulative Abnormal Return (2 days event window) as the dependent variable, and the Interaction term ‘Diff’ (Time-ZIPCode) as the sole independent variable.

The results of the two rounds of OLS regression are presented in the table below:

Table 6: Regression Table for Dependent Variable CAR (Cumulative Abnormal Returns)

Independent Variables	Models	
	Model 1	Model 2
Time_Dummy	-0.0312411	---
	(0.018)	---
ZIPCode Dummy	-0.0280727	---
	(0.02)	---
Diff (Time_ZIPCode)	-0.0420954	-0.0816379***
	(0.046)	(0.026)
Constant	-0.0708797***	-0.0906509***
	(0.013)	(0.0131)
No. of observations	44	44
R-Squared	0.2083	0.1863
Root MSE	0.07644	0.07563

Note: The above-displayed regression variables for 44 observations have robust standard errors to control for heteroscedasticity. The mean and standard deviation of the dependent variable CAR are -0.1110604 and 0.012491 respectively

Based on the regression table displayed above, the following results can be inferred:

- In Model 1, all three independent variables; Time_Dummy, ZIPCode Dummy, and the Diff, have negative coefficients that signify an inverse relationship with the dependent variable CAR. Specifically, the time series dummy variable that represents the effect of the event date, would result in a reduction of CAR by approximately 3.12%, the ZIPCode dummy (treatment factor) which is associated with the geographical proximity of a bank's branch to the branch of Signature Bank, would result in a reduction of CAR by approximately 2.9%, and the interaction term 'Diff' that represents the effect of treatment in the post-event period would result in the reduction of CAR by approximately 4.2%. However, these three independent dummy variables are statistically insignificant at a conservative p-value of less than 10%. Furthermore, Model-1 has roughly 20.83% explanatory power (R-Squared) of variation in the dependent variable CAR.
- In Model 2, the interaction term 'Diff' (Dummy variable Time_ZIPCode) is the sole independent variable. This term represents the treatment factor (geographical proximity) in the post-event period, which is the factor of interest for the hypothesis. Based on the OLS regression results for Model 2, it can be observed that 'Diff' has an inverse relationship with

the Dependent Variable CAR, denoted by the negative coefficient after running the regression. Going deeper, we can infer that a single unit increase in the interaction term 'Diff' results in a reduction of CAR by approximately 8.2%, with a robust standard error of 2.6%. Furthermore, this result is statistically significant at a p-value of less than 1%. This shows that Model 2, which has approximately 19% explanatory power (R-squared), has the coefficient of the independent variable 'Diff' which can confidently predict the value of the dependent variable CAR to some extent (with a significantly weaker magnitude of relationship of 8.2%).

As the results suggest, the treatment effect of geographical proximity, when analyzed in a one-to-one relationship dynamic with the Cumulative Abnormal Return of the banks, shows a statistically significant relationship. This further shows that there exists a possibility of a panic-based contagion effect in regions where the Signature Bank branches co-existed with the sample bank branches. However, the limitations of this research study open up alternative explanations for such a result for the treatment effect, which has been discussed in the Limitations & Recommendation section. However, in order to successfully execute and interpret the result of the treatment effect (Difference-in-Difference estimator), the assumption of parallel trends between both the treatment and control groups needs to be examined.

To establish parallel trends for the above analysis, the dependent variable CAR has been regressed with the treatment factor ZIPCode Dummy in the pre-event period (Time Dummy = 0). The result for this regression is presented as follows: -

Table 7: Regression for Dependent Variable (CAR)

Independent Variables	Results
ZIPCode Dummy	-0.0280727
	(0.0206)
Constant	-0.070879
	(0.01326)
No. of observations	22
R-Squared	0.085
Root MSE	0.04831

Note: The above regression results (for 22 observations) have used robust standard errors. The mean and standard deviation for the dependent variable CAR are -.084916 and .0105081 respectively.

The above-displayed results suggest that the treatment factor ZIP_Dummy has an inverse relationship with the dependent variable CAR in the pre-event period. However, the relationship based on linear regression turns out to be statistically insignificant, which further shows that there is no confident indication that the treatment indicator had a tangible effect on the value of CAR in the pre-treatment period. This goes on to show that there is a strong possibility of parallel trends amongst both samples in the pre-treatment period. However, it must be noted that due to lack of data availability, the sample size could not be altered. Due to this, adequate sensitivity tests for this analysis couldn't be performed, therefore these results should be interpreted with caution. However, on the basis of these results, we do not reject Hypothesis IV.

6.3. OLS Regression

The results from the OLS regression with CAAR as the dependent variable strongly indicate that specific characteristics of the sample banks have stood out in explaining the variations in values of the dependent variable across all five event windows. Based on the hypotheses outlined in section 4**,** we can identify that uninsured deposits have a statistically significant negative relationship with the Cumulative Average Abnormal Returns in three out of five event windows. For the event window (-1, 3), the result suggests that a 1 percentage point increase in uninsured deposits of the sample banks would result in approximately 50 basis points decline in the Cumulative Average Abnormal Returns for the four-day period. For the event window (0, 1) it can be inferred that a 1 percentage point increase in Uninsured Deposits would result in a decline of approximately 47 basis points in the value of CAAR for the two-day period that includes the date of the event. Finally, for the event window (0, 2) it was observed that a 1 percentage point increase in Uninsured Deposits would result in a decline of approximately 31 basis points in the value of CAAR for the three-day period. Importantly though, while for the remaining two event windows, the relationship between uninsured deposits and the CAAR turned out to be statistically insignificant, the regression coefficient still turned out to be negative in the majority of the cases. These results are partially consistent with the claim that the higher share of uninsured deposits in a stressed bank can increase the risk levels (Rezende, 2023), which would negatively reflect on the stock prices of the given banks. This notion of a negative relationship between levels of uninsured deposits and CAARs, as exemplified by the Silicon Valley Bank and Signature Bank, who were heavily overexposed to those types of deposits (Allen, Baig & Winters, 2023), is thus further corroborated through the empirical results of this analysis. Consequently, this result turned out to be consistent with the third hypothesis (H3) about the relationship between uninsured deposits and the CAAR. Hence, we do not reject the hypothesis H3.

The effect of bank size (Total Assets) turned out to have a positive effect that was statistically significant at a 5% level in three event windows i.e. (-1, 3), (0, 1) and (0, 2). While the effect of this variable turned out to be positive on the dependent variable CAAR, the value of the coefficient suggests that the effect is substantially weaker, as for all three event windows a 1 percentage point increase in the size of total assets resulted in only 1 to 3 basis points increase in CAAR. Furthermore, it must be noted that the three windows include the time period portion after the event in focus, which could mean that the bank size has a small-scale effect on the recovery process of the stock returns after the event. With that being said, this result is somewhat consistent with the empirical literature on the relationship between bank size and stock prices (Wuryani et al., 2021).

Another variable of interest based on the proposed hypotheses for this paper, 'Shareholding Value', turned out to have significantly weaker negative coefficients that were statistically significant at a 5% level for three event windows i.e. (-1, 3), (0, 1) and (0, 2), and statistically significant at 10% level for the event window (0, 0). Based on these four event windows, a one percent increase in this variable would result in a decline of the value of CAAR by 0.1 to 0.8 basis points. Though this relationship based on the empirical results turned out to be significantly weaker, it is still consistent with the second hypothesis (H2), hence we do not reject the hypothesis.

The variable 'Net Loans & Leases/ Total Deposits', which is one of the most important static liquidity indicators of a bank, turned out to have a consistently significant effect on the value of the dependent variable across all the five event windows. Moreover, all the coefficients turned out to be statistically significant at a 1% level, which demonstrates a high level of confidence associated with this result.

To put it in detail, for the first event window (-2, 0) a 1 percentage point increase in this variable results in approximately a 21 basis points decline in the CAAR value, which shows that the liquidity position of banks turned out to have a significant impact on the stock returns before the Signature Bank's bank run. However, the declining position of Silicon Valley Bank that started on the 8th of March 2023 could partially explain such a result. For the event window (-1, 3), a 1 percentage point increase in this variable results in a decline in the value of CAAR by 95 basis points. This suggests that this liquidity indicator played a significant role in determining the stock returns of the banks for the period of 9th March - 15th March 2023, which covers almost the entire period of crisis.

For the last three event windows (0, 0), (0, 1) and (0, 2), a 1 percentage point increase in the value of this variable turns out to reduce the value of CAAR by approximately 11.4, 87.1, and 68 basis points respectively. This suggests that the value of this ratio had a relatively stronger effect on the stock returns for the days after the event. This could further suggest that the announcement of the Signature Bank's shutdown could have impacted the stock returns of banks with relatively high net loans & leases to deposit ratios.

To explain the above result from the perspective of the empirical literature, traditionally the loans-deposit ratio has been linked to higher levels of risk in banks (Disalvo & Johnston, 2017), which could explain such a strong negative correlation between the CAAR and this ratio. Furthermore, the empirical literature also suggests that a high net loan & leases to deposit ratio could also mean that the banks have inadequate stable funding sources i.e. stable deposits (Van den End, 2014; Disalvo & Johnston, 2017), which would often compel them to rely on wholesale funding. An increase in such sources of funding has already proven to be negatively correlated with the CAARs of the banks during the event of a bank run, for instance, in the case of the Northern Rock Bank run (Goldsmith-Pinkham & Yorulmazer, 2009). Hence, the results for this indicator based on the OLS regression in this research study highlight the importance of healthy lending to deposit ratios for the banks in times of crisis.

The above-mentioned results for the Mean-Adjusted Model are displayed in the Appendix section (Table 11, Page 52).

6.3.1. Robustness Test

The results from the empirical analysis demonstrated above were based on the dependent variable CAAR, which was derived using the 'Mean-Adjusted Model'. To add an additional layer of robustness to the derived results, a round of multiple linear regressions for all the independent variables has been conducted for the dependent variable CAAR, which was estimated using the 'Market-Adjusted Model'.

Based on this round of regression, it was observed that the negative effect of the variable 'Net Loans and Leases to Deposits Ratio' was found to be statistically significant across all five event windows with slight variation in the coefficient values. The positive effect of the variable 'Total Assets' was found to be statistically significant for the event windows (0, 1), and (0, 2), which is partially consistent with the results from the 'Mean-Adjusted Model' as for the event window (-1, 3) the result turned out to be statistically insignificant for the latter model. The variable 'Shareholding Value' was found to have a negative effect with statistical significance at a 5% level

for the event windows (-1, 3), (0, 0), (0, 1), and (0, 2). This result is consistent with the results from the former model with a slight change in the coefficient values.

It is noteworthy that the variable 'Cash and Balances to Total Assets' was found to have a negative effect on the dependent variable CAAR, which was statistically significant at a 10% level for the event windows of (-2, 0), (0, 0) and (0, 1). This result, being contradictory to the empirical literature that discusses the relationship between cash holdings and stock returns (Garavito & Chion, 2021; Jansen, 2021), could potentially be explained by the omitted variable bias due to the unstable nature of the coefficients.

The variable 'Uninsured Deposits' turned out to have a statistically significant negative effect on the dependent variable CAAR in the event windows (-1, 3), (0, 1), and (0, 2) which is consistent with the results from the regression based on the 'Mean-Adjusted Model'.

The above-mentioned results for the Market-Adjusted Model are displayed in the Appendix section (Table 12, Page 53).

6.3.2. Alternative Test

It is noteworthy that the variable 'Tier-1 Risk-Based Capital Ratio' turned out to have a negative effect on the dependent variable CAAR for the event window of (0, 1), which is contrary to the evidence in the empirical literature that shows a positive relationship between strong capital positions and higher stock returns during a crisis (Demirguc-Kunt et al., 2013). Moreover, based on the correlation matrix, both CAAR and Tier-1 risk-based capital ratios have a positive correlation value. This occurrence could possibly be explained by the existence of an omitted variable bias as a source for endogeneity. This bias usually occurs when a variable gets omitted in the regression analysis, which could result in the causal effect of that variable getting intertwined with the coefficient of another correlated variable. After observing the correlation matrix for all the available variables, it was inferred that the correlation coefficient between the variables Net Loans & Leases to Total Deposits and Tier-1 Risk-Based Capital Ratio was about -0.6, which denotes a moderate negative correlation amongst these variables (Ratner, 2009).

Therefore, in order to test for endogeneity for the dependent variable associated with the event window (0, 1), an Instrumental Variable (IV) regression has been performed by taking Net Loans & leases to Total Deposits as the endogenous variable and Tier-1 risk-based capital ratio as an instrumental variable. Subsequently, using the Durbin–Wu–Hausman test[4] for endogeneity, it

[4] https://www.stata.com/support/faqs/statistics/durbin-wu-hausman-test/

was observed that the p-values for both the Durbin Score and Wu-Hausman were less than 0.05 which shows that the hypothesis (H0: Variables are exogenous) was rejected, hence indicating the presence of endogeneity. Moreover, this test has been performed for all the other four event windows, and based on the resulting p-values, the hypothesis H0 was not rejected, hence giving a strong indication of variables being exogenous for these four event windows.

Since the problem of endogeneity exists in one out of five event windows, this occurrence has been accepted as a research limitation but does not seem to have a substantial influence on the overall results of the OLS regression analysis.

In order to clarify this matter even further, an alternative regression analysis has been performed for the dependent variable CAAR belonging to the event window (0, 1) in which the variable Net Loans & Leases to Total Deposits has been excluded. In this round of regression, it was observed that the variable Tier-1 risk-based capital ratio, though statistically insignificant, turned out to have a positive coefficient value in the absence of the variable Net Loans & Leases to Total Deposits. This further adds to the theory of endogeneity.

Another alternative explanation for this occurrence could be partially ascribed to the empirical literature. Tier-1 risk-based capital ratios are known to be good quality predictors of bank distress, and a higher ratio usually signifies a lower distress rate for the banks (Buehler et al., 2009). However, an alternative explanation could be that a higher Tier-1 risk-based capital ratio also has a negative impact on the return on equity, since in order to maintain a higher Tier-1 risk-based capital ratio, more incremental capital needs to be preserved which negatively affects the return on equity, subsequently negatively affecting the stock returns due to less return for the shareholders. While these theories could potentially explain the behavior of the Tier-1 risk-based capital ratio in the results, the true explanation is still unknown.

The above-mentioned results for the modified Mean-Adjusted Model are displayed in the Appendix section (Table 13, Page 54).

Overall, the results from this stage of analysis demonstrate that the treatment variables such as Uninsured Deposits and Shareholding Value tend to have a moderate to low level of influence on the average abnormal stock returns, which further shows the amplification of spillover effects based on these two bank-level variables. Hence, based on these results, we fail to reject the hypotheses II and III.

The following section illustrates some of the limitations of this research paper that must be taken care of while interpreting the results from the empirical analysis. This is followed by subsequent policy and research recommendations that are also based on the results and the limitations of this research study.

7. Limitations and Recommendations

7.1. Limitations

Until now, this research study has attempted to answer the questions reflected in the research hypothesis associated with the presence of spillover effects due to the Signature Bank's depositor run. However, it is important to note that the research design and the subsequent results derived from the empirical analysis may not be exempt from possible constraints and limitations, which may possibly partly lessen the robustness and validity of this thesis' findings. For instance, the thesis' findings with regard to the numerous bank-level factors in the form of variables that have been examined in this study and their role in potentially aggravating the scale of potential contagion in the context of the bank-run crisis, may to some degree be specific to the studied event and may thus not be universally applicable to all such bank runs. Therefore, it is important to note that the conclusions derived from this research study are not uniformly applicable in all contexts. With that being said, this research study needs to be carefully reviewed and utilized by keeping the limitations in consideration.

The first limitation is related to the sample selection, as well as the resulting sample size. For the methodological purposes of this research thesis, a non-random technique of sample selection has been employed. Since, the sample of 43 banks has been selected based on the bank size, their geographical presence, and their geographical scope of operations, the sample may not adequately represent the overall population of banks in the United States. However, the list of regional banks used for this sample has been matched with other research studies and can be conclusively regarded as a good representation of publicly-listed regional banks. Moreover, the list of diversified banks used for this research study is based on the bank rankings based on the size of their total assets for the financial year 2023. The size of the sample which is 43 banks could also turn out to be a limitation since there were a total of 4135[5] commercial banks insured by the FDIC in 2022, leading to the sample just marginally covering only around 1% of the respective existing peer group, possibly partially compromising the representative power of the sample.

[5] Source: https://www.statista.com/statistics/184536/number-of-fdic-insured-us-commercial-bank-institutions/

One of the major challenges in pursuing this research study was the lack of data accessibility. The primary motivation to pursue this topic was to understand the contagion effects of the bank runs as reflected in the deposit flows from one bank to another, such as the phenomenon of 'flight-to-safety' deposits (Caglio et al., 2023). However, in order to pursue such an avenue of research, it is imperative to have access to the daily frequency level data for deposits for the banks in the sample, the sources for which are not accessible publicly. Furthermore, the empirical literature on this topic is rife with discussions on interbank linkages, overlapping portfolios, or common asset exposures as transmission channels of contagion during banking crises. However, similarly to the deposit data, the data accessibility for such variables is extremely limited, which renders the study of these channels in the scope of this thesis infeasible as well.

With regards to the methodology, the employed difference-in-differences approach may also incur some potential limitations that should be considered when analyzing the results. Firstly, the sample size for this technique is 22 banks, which could arguably be deemed relatively small, also when considering the above-described scale of the United States banking industry. Secondly, the approach to employing ZIP Code-matching as a proxy for geographical proximity has not seen very frequent use in similar studies, which could challenge its effectiveness in credibly gauging the geographical effects. Moreover, it is important to note that in the era of social media and the constant cycle of innovation in communication technology, the effect and thus relevance of such a channel could potentially become redundant to a certain extent in the future, which further reduces the incentive to explore such channels of contagion for policy and regulatory purposes. In addition, the small size of the sample for Difference in Differences estimation borne out of the limitation of data availability hampered the process of adequate analysis on the sensitivity of the results.

In the broader context, despite all the limitations that this research study has been performed under, the results that were derived from various stages of analyses can certainly be incorporated into the empirical literature, based on which, the relevant policy implications can be brain-stormed and further addressed into the prospective research studies. Some of these policy implications along with research recommendations have been described in the subsequent sections.

7.2. Policy Recommendations

Every now and then, certain territories in the global financial system experience exogenous shocks that create both short-term and long-term repercussions on the entities exposed to the focal point of this shock. Consequently, the regulatory authorities and the governing bodies are compelled to take drastic measures intended to keep the financial health of the overall system in a secure position. The financial history features an ample amount of instances where certain

catastrophic shocks to the financial system have opened the discussion to overhaul the current market practices and design new policy mechanisms that make sure the mistakes made, as well as their implications, would not be repeated. However, due to the rapid technological advancements that quickly trickled down in the financial system of most of the developed countries, the ideal manifestation of these policy designs is becoming increasingly complex and thus necessitating a dynamic approach to regulation.

"A financial regulator will never be able to match the speed with which depositors can run"

The professor of Financial Economics at Warwick Business School, John Thannasoulis, quoted the above-mentioned words while explaining the depositor run at the Silicon Valley Bank (Thanassoulis, 2023). This quote has been directed to the fact that with rapid technological development, it has become increasingly convenient for depositors to withdraw money as quickly as possible. This was particularly witnessed in the case of the Silicon Valley Bank when total withdrawals of approx $42 billion were attempted by the institution's depositors in a single day on 9th March 2023, which is approximately 24% of the total deposits of $175 billion at the year-end of 2022 (Son, 2023). This extremely fast rate of deposit withdrawals has been enabled by the ease of financial transactions through technology's incorporation into the financial services sector. Consequently, this could further exacerbate the contagion effects of a bank run caused by the irrational sentiment of the depositors. There is a reason why the motivation for this thesis is to study the contagion effects of a bank run in the post-COVID era; the rapid adoption of technology in the financial sector caused by the pandemic (Pierri & Timmer, 2020). The image of people standing in line outside a bank's branch to withdraw their deposits is a fading reality in today's times. Consequently, the ease of such transactions taking place so rapidly has made the job of regulators, supervisors, and bank managers even harder. As a result, regulatory supervision has to adapt to such a velocity of financial transactions, otherwise, such episodes could make the financial system even more vulnerable than the crises witnessed in the past.

Certain contributing factors that are said to increase the odds of the occurrence of bank runs have been identified by numerous scholars in the field of finance. Specifically, some of these factors include interbank linkages and exposure, asymmetric information (Chen, 1999), common asset exposure (Roncoroni et al., 2019), and confidence spillovers (Iyer & Peydró, 2011). In response to such factors driving issues at hand, numerous policy mechanisms have been introduced at different points in time such as deposit insurance to reassure and maintain the confidence of people and make deposits an attractive source of funding for the banks (FDIC, 2023). The Comprehensive Capital Analysis Review (CCAR) by the Federal Reserve represents another such mechanism, designed for stress testing large banks to check their capital adequacy to maintain

banking resilience and faith of depositors in times of stress (Board of the Governors of Federal Reserve Board, 2022). However, with the increasing prevalence of technology and the fast-paced dissemination of information on social media, it may be essential to revisit such mechanisms as the challenge to reassure people has become even tougher. In that regard, the role that social media played in the collapse of Silicon Valley Bank and Signature Bank could be an indication of a new transmission channel of contagion effects of a bank run. In fact, the top executives of the Silicon Valley Bank and the Signature Bank partly blamed the negative sentiment on social media for a catastrophic depositor run on both banks (Dumas, 2023). While the true reason for the banks' collapse cannot be reliably attributed to social media yet, its role as a relevant transmission channel of a bank run should nevertheless be considered.

To thus adequately mitigate the risks of the above-described channel of contagion, policies related to enhancing financial transparency could curb the volume of such adverse rumors, whilst promoting financial education for the market players could also be prioritized in order to lessen panics amongst depositors induced by an incorrect interpretation of such news. In addition to maintaining confidence, improved public disclosure on banking activities, stress tests, and simplified financial statements promote market discipline, as active and responsible participation by market participants reinforces the disciplinary efforts of supervisory institutions like the Basel Committee on Banking Supervision (Basel Committee on Banking Supervision, 2023). Even though it is an increasingly challenging task for regulators to match their response time to the pace of activity fuelled by the combination of social media and digital banking, the uncompromising execution of these policy checks and supervisory guidelines could reduce the likelihood of such bank runs happening at such a rapid pace as witnessed.

Based on the empirical results of this research study, the relationship between uninsured deposit levels and the net loans and leases to deposits ratio has been proven to be negatively correlated and statistically significant. Adding to that, the literature review also suggested that uninsured deposit levels happened to be one of the critical indicators that explained the mass panic surrounding the case of Signature Bank and Silicon Valley Bank. While the role of deposit insurance by the FDIC has been primarily assigned to providing a safety net to the depositors in times when the questionable state of a bank's financial health gets magnified enough by market forces, the reassurance to the uninsured depositors still rests upon the response programs by the government such as the Systemic Risk Exception provision (Labonte, 2023). This points to the arguable effectiveness of the deposit insurance mechanism towards protecting depositors and enhancing financial stability, especially when the growth of uninsured deposits as a percentage of

domestic deposits has increased substantially, with approximately 47% of total domestic US deposits having been uninsured in 2021(J. Gruenberg, 2023).

Here, a two-pronged approach can be manifested to maintain stability in times of rising uninsured deposit levels. First, the FDIC needs to revisit and contemplate the criteria for providing deposit insurance to the banks. Second, government institutions need to create incentive mechanisms for depositors not to engage in a bank run.

The first approach points to the insurance coverage criteria along with the regulatory supervision such as stress testing and capital requirements for mitigating the moral hazard effect (excessive risk-taking by banks) in the presence of deposit insurance. The current system of coverage is the limited coverage system, in which there is a limited amount of deposit coverage on depositor accounts. As a criteria reform, FDIC could consider increasing this limited coverage, especially in the case of deposit accounts such as large institutional depositors that could pose a threat in case the possibility of a bank run is higher. In addition, the targeted coverage system which represents a combination of unlimited coverage and limited coverage could also be tested, as this criteria is flexible enough to include the benefits of expanded coverage without compromising on financial stability.

The second approach relates to altering the behavior of depositors during episodes of financial stress for the banks. Minimum Balance at Risk (MBR) is one of the policy mechanisms that could be explored further to achieve the result mentioned above. Having been designed primarily for the investors of the Money Market Funds, the MBR works in such a way that the investors' preferences of liquidity stand at a tradeoff with the principal amount that they have invested in the fund (Cipriani et al., 2023). This works by restricting a certain percentage of their invested amount for withdrawal on any given day. This amount shall only be available after a brief delay (say 50 days) to the investors. In a similar way, this mechanism could be used for the uninsured depositors to disincentivize them from withdrawing their deposits on the day of bank failure as there would be a cost attached to it. This cost shall be witnessed in the form of subordination of the restricted amount of the uninsured depositors account who decide to withdraw, into the account of those who do not. As a result, the section of uninsured depositors that decides to withdraw in the event of bank failure absorbs some of the losses of this event, since their demand for immediate liquidity would now cost them their total principal deposit amount in the bank. Eventually, this would add an extra layer of disincentive for such depositors to initiate a bank run. (ibid.). In addition, employing the policy of MBR could potentially reduce the burden on FDIC by increasing their insurance coverage. This policy in place may also solve the problem of a bank run as an undesired equilibrium in the Diamond & Dybvig Model (1983) as it removes the first mover

advantage for the depositors in case they are to consider withdrawing their deposits in the event of bank stress. However, it is important to understand that this policy approach is only limited to exerting influence on the depositors' behavior, and is not extendable to managing risks that the banks take on in the first place. Therefore, this approach can most likely be interpreted as an accessory to the risk management mechanisms of the banks (ibid.).

In conclusion, while there can be numerous policy proposals to maneuver the effects of bank runs or insulate the rest of the banking system from the spillover/contagion effects of these events, the primary incentive to evaluate these proposals must be to keep the confidence of stakeholders intact and sustainable.

7.3. Research Recommendations

The analysis of a bank run is an extremely complex and fragile phenomenon, owing to the contribution of a vast set of causal factors, along with comprehensive and carefully assembled mechanisms in place to mitigate and neutralize related risks. Moreover, in the wake of rapid technological advancements and an increasing number of market participants, as well as newly competing modes of payment, as exemplified in the cryptocurrency market, the banking environment has added more intricate layers of interconnectedness to its complex design. Hence, it is imperative to stay in line with the market developments that impact such types of phenomena, in order to conduct further research studies that could develop tangible insights for the policymakers and other stakeholders.

In the above limitations section, several constraints with regard to the data availability for certain indicators have been outlined. These include interbank exposure, interbank lending, and common asset exposure, as well as the periodic frequency of available indicators, such as total deposit levels, uninsured deposits, or daily level shareholding data of the banks holding the Signature Bank equity. Given this shortcoming, the scope of research in this area could be substantially expanded to carefully examine the behavior of these indicators relative to other bank-level characteristics. For instance, the daily level deposits of the associated banks could be analyzed to further study and possibly understand the existence of any contagion effects reflected in the depositors' behavior. Moreover, the daily level report on reducing or increasing shareholding positions of multiple banks for the Signature Bank could indicate the type of sentiment in the market, or even detect the presence of leakage of information which could be tested by the event study tool by taking the appropriate event window that takes into consideration the possibility of information leakage prior to the event. While it may be difficult to test for the leakage of information in the case of Signature Bank's downfall, as the event coincided with the event of the

Silicon Valley Bank's depositor run, potentially distorting the derived results, as it may be difficult to separate the effects of the two events. The study of information leakages using event studies may prove more feasible in other cases of bank runs that do not incur a timely overlap of bank runs of multiple institutions.

The study of interbank linkages could be further expanded using the concepts and assumptions of Network Theory in finance (Petrone & Latora, 2018). The network theory being a dynamic model provides the advantage of combining the contagion effects with the credit risk models of the banks on the overall interbank connectedness.

In addition, the rise in novel markets of cryptocurrency, which was proven to have a deep impact on Signature Bank's financial health, could be incorporated within future avenues of research. Adding to this, the rise of information dissemination on social media platforms such as Twitter, Facebook, or Threads could potentially provide a significant transmission channel to be incorporated into the Network Theory in finance.

Since the indicators of uninsured deposit levels and the net loans and leases to deposit ratio turned out to have a statistically significant effect on the dependent variable (CAAR) in this research study, research efforts could be expanded to study the implications of such indicators in other bank runs. The empirical method of difference-in-differences estimation could be employed to specifically target such factors as the treatment indicators with respect to numerous events reliably characterized as exogenous shocks to the banking sector.

Looking into the research recommendations collectively, these research efforts could also be expanded to other geographical territories such as the United Kingdom, the European Union, or Asia. The reliability of results with respect to factors, such as social media channels, could also be examined in the above territories in order to develop reliable complex models and further add to the pool of potential research avenues that could guide and direct the policy initiatives of policymakers.

8. Conclusion

The gradual escalation in the interconnectivity and technological advancement in the banking sector may have created avenues to expand the horizons for economic growth and improve the efficiency of the fundamental functions of banking. However, the flipside turns out to have some considerations that need to be comprehensively analyzed to control the inevitable perils of such an evolutionary process. This research thesis has attempted to answer some of the requisite

questions that have arisen in the wake of the Signature Bank's depositor run. In this pursuit, this thesis aimed to provide an answer to the following overarching research question:

"*To what extent did the bank run at Signature Bank trigger contagion and spillover effects in the broader banking system, and how do firm-level characteristics and the nature of exposure of individual banks to the Signature Bank contribute to the magnification of such effects?*"

Using a sample of 43 US-based banks, a three-step series of analyses has been conducted for this research study to test the presence of spillover and contagion effects, along with identifying and estimating the degree of bank-level factors that influenced such effects.

From the first round of analysis i.e. the event study, the results suggest that the Signature bank's depositor run had a statistically significant negative effect on the average abnormal stock returns of the banks in the sample. Specifically, the four-day event window from the 9th of March 2023 to the 15th of March 2023 witnessed the highest degree of spillover, reflected in average abnormal returns for the sample under study. Moreover, the average abnormal returns on the 13th of March 2023 were significantly lower than the average abnormal returns on the 10th of March 2023 (the day of the event), which possibly suggests that the market experienced a lag in absorbing the negative news of this event, or its possible implications. To expand the scope of this step, the event study analysis was also employed to explore the differentiated spillover effects on the subset of diversified banks and the regional banks in the US. Looking at the results, it was observed that the spillover effects in the case of diversified banks were stronger for all the five event windows under consideration. However, the difference in stock market indices could have partially affected the reliability of this result, which could be one of the limitations of this line of analysis under the current context.

For the second analysis, a difference in differences estimation technique was used to analyze the effect of geographical proximity in explaining the magnitude of such spillover effects in the case of regional banks that were a subset of the overall sample. Based on the results, the treatment factor of geographical proximity was found to have a statistically significant negative effect on the average abnormal returns of the subset of regional banks, which could indicate the presence of contagion based on the geographical proximity of the banks' branches with the Signature Bank's branches. However, the magnitude of this effect was significantly weaker. Furthermore, due to the lack of data availability, this analysis hasn't been subjected to adequate sensitivity tests which could represent a limitation in this regard.

For the third round of analysis, an OLS regression was conducted to evaluate the effects of the bank-level characteristics. The results from the regression for the dependent variable CAAR for all the five event windows suggested that the variable 'Net Loans & Leases to Total Deposits', which was taken as one of the proxy variables for liquidity and lending, had a consistently negative effect with statistical significance at a 1% level. Moreover, this negative effect was relatively stronger when compared to the effects of any other variable under consideration. 'Uninsured Deposits', a variable of interest, had a negative effect on the dependent variable CAAR, which was statistically significant for three out of five event windows. The variables such as 'total assets' (a proxy for bank size) and 'Shareholding Value' (a proxy for interbank linkage) turned out to have a positive and negative effect on the dependent variable CAAR respectively, with statistical significance for three out of five event windows. However, these effects were extremely mild, reflected in the significantly low beta coefficient values.

On the back of the empirical analysis, the research question stated above can be answered in the following way: -

The event study results on the current sample of banks strongly suggest that the Signature Bank depositor run created a substantial amount of spillover effects on the broader banking system as according to the sample, this effect was witnessed in the cumulative abnormal returns of both the regional and diversified banks. However, the extent of these spillover effects was more pronounced in the case of diversified banks. In addition, the results from the OLS regression analysis suggest that firm-level characteristics such as net loans and leases to total deposits and uninsured deposits were observed to have aggravated the spillover effects on these banks. Moreover, variables such as ‘Shareholding Value’ and ‘ZIPCode’ in their respective analyses displayed statistically significant negative effects. This goes on to show that the nature of exposures of interbank linkages and geographical proximity was observed to negatively affect these banks with a significantly weaker magnitude.

As for the results derived from the above three stages of analysis, it is important to note that this paper has been subjected to numerous limitations such as the sample selection and size, problems with data accessibility for certain essential variables such as the deposit levels, interbank linkages indicators, and the funding sources for banks, which possibly contributed to the omitted variable bias in the OLS Regression analysis. Moreover, inadequate sensitivity tests for techniques such as the difference in differences analysis could pose another limitation when drawing conclusions from the results.

A set of policy recommendations and improvements such as enhancing transparency and improving public disclosure of banking activities, dealing with high levels of uninsured deposit levels by tweaking the deposit insurance coverage criteria, or introducing disincentivizing mechanisms for depositors such as the 'Minimum Balance at Risk' system. In addition, the limitations of this research paper have also paved the way for some recommendations for future research such as accessing the daily deposit level data for the banks to improve the accuracy of detecting the contagion effects and analyzing the interaction of the banking sector with the cryptocurrency market to understand the nature and volatility of related interlinkages, etc. In addition, this thematic research scope could be expanded beyond the US economy, and the comparative studies between two bank runs in varied geographical contexts could also be conducted.

To conclude, this research study has certainly cultivated a starting point in understanding the roots of an event of a bank run in the post-COVID era. Furthermore, the research recommendations could serve as the possible direction for future research on such a phenomenon. Owing to the limitations concerning the research methods and data collection, this particular study could also be expanded further to solidify the claims that have been made surrounding the research hypotheses.

The case of a bank run that has empirically proven to create economic crevices through contagion, needs to be handled with all the necessary monetary policy and regulatory instruments that should ideally be well-aligned to the market developments.

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Appendix

Table 8: Event Timeline to the Collapse of the Signature Bank[6]

Event Date	**Description**	**Significance**
8th March 2023	Silicon Valley Bank announced a loss of $1.8 Billion, with Moody's downgrading the bank's bond ratings.	The possible spillover of the event would be taken into account for the event study.
9th March 2023	Panic induced on social media erupted into deposit withdrawals of about $40 Billion, with the bank's stock plummeting by 60%.	The beginning of the depositors' panic signifies an escalation of the negative sentiment toward the bank
10th March 2023	● Silicon Valley Bank collapsed, with FDIC taking over the institution. ● Signature Bank's depositor run erupted after the depositor/investor panic due to the collapse of SVB, with the bank's stock plummeting significantly.	Event of interest: Since the significant decline in the deposits at Signature Bank occurred on this day, It has been treated as Day 0 for the event study analysis.
12th March 2023	● Signature Bank was shut down by the New York-based regulators ● Federal Reserve, in conjunction with the Treasury Department and the FDIC, announced hundred percent access to deposits for all depositors of the Signature Bank.	The response by the regulators and the pertinent regulatory and supervisory institutions signifies the resolution attempt of the bank run.
13th March 2023	● The stocks of regional banks fell after the announcement of the closure of Silicon Valley Bank and Signature Bank. ● President Joe Biden assured in his speech that none of the taxpayers' dollars would be used for the bailouts.	Continuity of the resolution effort for easing down the agitated market sentiment, while answering questions about the position of depositors at the affected institutions.

[6]Source: https://www.nytimes.com/2023/05/01/business/banking-crisis-failure-timeline.html

Table 9: List of Variables[7]

Name	**Description**	**Significance**
Cumulative Average Abnormal Returns (CAAR)	Dependent variable: the sum of all abnormal returns over a specified window.	It is the most common indicator used to ascertain the stock price reactions of an external shock to a corporate entity.
Total Assets	It is the total of cash and balances, securities, net loans, and leases, real estate in ownership, and goodwill (and other intangible assets).	This measure has been used as an indicator of bank size. It serves the advantage of easy accessibility of the size approximation for both listed and unlisted financial institutions.
Uninsured Deposits	It is the portion of any deposit of a customer at an insured depository institution that exceeds the applicable FDIC insurance coverage for that depositor at that institution.	It is one of the most important ratios for this research study since based on empirical literature.
Net Loans, Leases/Total Deposits	The ratio of net loans and leases (asset side) to total deposits in a financial period.	It is one of the traditional liquidity measures recommended by the FDIC in the member banks' balance sheets.
Tier-1 Risk-Based Ratio	The ratio of tier-1 capital to risk-weighted assets	This ratio represents high-quality sources of capital that banks and other financial institutions are required to keep to be protected against bankruptcy. This measure of minimum capital requirement shows how well a company can absorb losses in the occurrence of market stress.

[7] The variables list has been compiled from the online portal of Federal Deposit Insurance Corporation..

Return on Assets	It is one of the measures of profitability of a bank based on the company's net income and the stock of total assets in that period.	This variable is significant in examining if the magnitude of spillover effects in a bank run is related to the profitability
ZIP Code Matching	It is the number of branches of a sample bank that are situated in the same ZIP code as the Signature Bank's branch locations.	This variable has been taken as a proxy for geographical proximity to check for panic-based contagion effects.
Efficiency Ratio	It is the ratio of a bank's non-interest expense to revenues.	It indicates a bank's ability to generate revenues from its non-funding-related expense base. A higher efficiency ratio indicates a less efficient bank.
Cash and balances due from accounts to total assets	Liquidity measure: ratio of total cash and balances due from depository institutions to total assets in a financial period.	This ratio is necessary to assess whether the level of liquid cash in a bank has any impact on the stock return during a bank run
Net Loans and Leases to Total Assets	Liquidity Measure: It is the ratio of net loans and leases (asset side) to the total assets	It is one of the liquidity measures of the banks. The higher the ratio, the less liquidity

Table 10: Descriptive Statistics

Variables	Observations	Mean	Std. dev.	Min	Max
RoA	43	0.011807	0.0062775	-0.007	0.0329
Tier1 Risk-Based Capital Ratio	43	0.1251309	0.0310512	0	0.2123
Uninsured Deposits	43	0.4397744	0.2005754	0.124	0.9657
TotalAssets	43	3.54E+11	6.84E+11	4.54E+08	3.27E+12
NetLoans and Lease to Total Deposits	43	0.7283442	0.2563619	0.1028	1.6512
Deposit Growth	43	0.0019419	0.132854	-0.408	0.53
Cash Balances to Total Assets	43	0.1063488	0.0986645	0.0092	0.3986
Efficiency Ratio	43	0.585307	0.0984451	0.3765	0.7554
Net Loans and Leases to Total Assets	43	0.5896977	0.1497396	0.1185	0.8089
Shareholding Value	43	1.05E+07	5.59E+07	0	3.67E+08

OLS Regression Tables

Table 11: Mean-Adjusted Model CAAR (Event Windows)

Independent Variables	CAAR (-2, 0)	CAAR (-1, 3)	CAAR (0, 0)	CAAR (0, 1)	CAAR (0, 2)
UninsuredDeposits	-0.054490	-0.502069***	-0.020790	-0.473434**	-0.309314**
	(0.083969)	(0.176689)	(0.046087)	(0.199311)	(0.139315)
Tier-1 Risk-Based capital Ratio	-0.101909	-1.746865	-0.391660	-2.070064*	-1.259194
	(0.431770)	(1.245165)	(0.268882)	(1.023154)	(0.894024)
Total Assets	0.000686	0.018287*	0.002737	0.025493**	0.023007**
	(0.004294)	(0.010596)	(0.002708)	(0.011545)	(0.008410)
Shareholding Value	0.000065	-0.008371**	-0.001037*	-0.007748**	-0.007354**
	(0.000983)	(0.003370)	(0.000576)	(0.002988)	(0.002746)
Net Loans & Leases/Tot. Deposits	-0.214217***	-0.950430***	-0.114377***	-0.871343***	-0.679955***
	(0.062280)	(0.214406)	(0.025569)	(0.152405)	(0.131888)
Deposit Growth	0.096748	0.233849	0.063145	0.408736	0.270412
	(0.131236)	(0.420065)	(0.071472)	(0.332400)	(0.293151)
Efficiency Ratio	0.095177	0.150055	0.060218	0.155416	0.173868
	(0.085529)	(0.191157)	(0.050410)	(0.220243)	(0.150796)
Net Loans & Leases/Tot. Assets	0.112534	0.242262	-0.005586	0.042005	0.128191
	(0.111631)	(0.265750)	(0.054388)	(0.238222)	(0.203194)
Return on Asset	1.145453	-2.562780	0.307004	-2.521153	-1.565382
	(1.796142)	(4.828167)	(0.994162)	(4.488157)	(3.408382)
Cash Balances to Total Assets	-0.124441	-0.257877	-0.119928*	-0.337234	-0.274671
	(0.123997)	(0.246903)	(0.069139)	(0.208046)	(0.187395)
Constant	-0.029967	0.369654	0.028178	0.314290	0.015034
	(0.177737)	(0.539652)	(0.098342)	(0.406363)	(0.360816)
No. of observations	43	43	43	43	43
R-Squared	0.4861	0.7275	0.4493	0.6789	0.6985
Root MSE	0.04456	0.11486	0.02758	0.12472	0.09247

Note: The above regression results have utilized robust standard errors to control for heteroscedasticity. Using the Variance Inflation Factor, the results have been examined for multicollinearity.

Table 12: Market-Adjusted Model CAAR (Event Windows)

Independent Variables	CAAR (-2, 0)	CAAR (-1, 3)	CAAR (0, 0)	CAAR (0, 1)	CAAR (0, 2)
UninsuredDeposits	-0.042111	-0.481438**	-0.016664	-0.465182**	-0.296935**
	(0.086178)	(0.182225)	(0.046552)	(0.201250)	(0.143993)
Tier-1 Risk-Based capital Ratio	0.017452	-1.547930	-0.351873	-1.990489*	-1.139833
	(0.458986)	(1.294527)	(0.273740)	(1.044630)	(0.926416)
Total Assets	0.000538	0.018041	0.002687	0.025395**	0.022860**
	(0.004448)	(0.011030)	(0.002752)	(0.011741)	(0.008745)
Shareholding Value	-0.000074	-0.008604**	-0.001083*	-0.007841**	-0.007493**
	(0.000982)	(0.003475)	(0.000584)	(0.003040)	(0.002836)
Net Loans & Leases/Tot. Deposits	-0.225205***	-0.968743***	-0.118040***	-0.878668***	-0.690943***
	(0.065245)	(0.219640)	(0.026375)	(0.154555)	(0.135312)
Deposit Growth	0.096971	0.234219	0.063219	0.408884	0.270634
	(0.137527)	(0.435431)	(0.072737)	(0.339166)	(0.302786)
Efficiency Ratio	0.104332	0.165314	0.063270	0.161519	0.183023
	(0.089951)	(0.201628)	(0.051163)	(0.223481)	(0.157021)
Net Loans & Leases/Tot. Assets	0.112692	0.242526	-0.005534	0.042110	0.128349
	(0.117207)	(0.274297)	(0.056081)	(0.241536)	(0.208760)
Return on Asset	1.780136	-1.504975	0.518565	-2.098032	-0.930699
	(1.897790)	(5.104225)	(1.007662)	(4.596812)	(3.596436)
Cash Balances/ Total Assets	-0.161791	-0.320129	-0.132377*	-0.362135	-0.312022
	(0.130822)	(0.254924)	(0.070531)	(0.211697)	(0.194780)
Constant	-0.057778	0.320098	0.016559	0.285861	-0.013244
	(0.189153)	(0.561676)	(0.100822)	(0.415961)	(0.374561)
No. of observations	43	43	43	43	43
R-Squared	0.5126	0.7258	0.4598	0.6788	0.6957
Root MSE	0.04606	0.11886	0.02801	0.12625	0.09529

Note: The above regression results have utilized robust standard errors to control for heteroscedasticity. Using the Variance Inflation Factor, the results have been examined for multicollinearity.

Table 13: Mean-Adjusted Model CAAR (Excluding Net Loans & Leases to Deposits)

Independent Variables	CAAR (0, 1)
UninsuredDeposits	0.021070
	(0.315529)
Tier-1 Risk-Based capital Ratio	0.103460
	(1.538659)
Total Assets	0.010441
	(0.017135)
Shareholding Value	-0.005382
	(0.003773)
Deposit Growth	1.383543
	(1.008024)
Efficiency Ratio	-0.026320
	(0.443498)
Net Loans & Leases/Tot. Assets	-0.629929
	(0.510558)
Return on Asset	5.128884
	(9.298755)
Cash Balances/ Total Assets	-0.457330
	(0.686140)
Constant	-0.022678
	(0.847794)
No. of observations	43
R-Squared	0.2732
Root MSE	0.19172

Note: The above regression results have utilized robust standard errors to control for heteroscedasticity. Using the Variance Inflation Factor, the results have been examined for multicollinearity.