The Great Margin Call: The Role of Leverage in the 1929 Stock Market Crash

by

Karol Jan Borowiecki, Michał Dzieliński, and Alexander Tepper

Discussion Papers on Economics
No. 1/2022

FURTHER INFORMATION
Department of Economics
Faculty of Business and Social Sciences
University of Southern Denmark
Campusvej 55, DK – 5230 Odense M
Denmark
Email: astni@sam.sdu.dk

ISSN 2596-8157
https://www.sdu.dk/en/om_sdu/institutter_centre/oekonomiskinstitut

The Great Margin Call: The Role of Leverage in the 1929 Stock Market Crash

Karol Jan Borowiecki[1], Michał Dzieliński[2], and Alexander Tepper[3]

[1]Department of Economics, University of Southern Denmark; kjb@sam.sdu.dk

[2]Stockholm Business School, Stockholm University; michal.dzielinski@sbs.su.se

[3]Columbia University United States; at3065@columbia.edu

February 8, 2022

Abstract

The reasons for the Great Crash and why it occurred at that particular time are still debated among economic historians. We contribute to this debate by building on a new model developed by Adrian et al. (2021), which provides a measure of the financial system's potential for financial crises. The evidence suggests that a tightening of margin requirements in the first nine months of 1929 combined with price declines in September and early October caused enough many investors to become constrained that the market was tipped into instability, triggering the sudden crash of October and November.

Keywords: Leverage, financial crisis, stability ratio, great crash

JEL codes: G01, G10, N22

1 Introduction

The year of 1929 was the climax of a decade of unbounded optimism, reflecting unprecedented prosperity and a rate of sustained economic progress that had not been seen for at least a generation. The dissemination of new technologies such as electricity and radio spurred contemporary analysts to speak and write of a "New Era" of plenty. As Galbraith (1997, c1954) put it:

> "American capitalism was undoubtedly in a lively phase. Between 1925 and 1929, the number of manufacturing establishments increased from 183,900 to 206,700; the value of their output rose from $60.8 billions to $68.0 billions [amid slightly declining prices]. The Federal Reserve index of industrial production which had averaged only 67 in 1921 (1923-1925=100) had risen to 110 by July 1928, and it reached 126 in June 1929. In 1926, 4,301,000 automobiles were produced. Three years later, in 1929, production had increased by over a million to 5,358,000, a figure which compares very decently with the 5,700,000 new car registrations of the opulent year of 1953."

It was not just production but productivity that advanced. Manufacturing output per worker, having been essentially flat for two decades, rose by about half in the 1920's (Fisher, 1930). Inflation-adjusted earnings per share for S&P 500 companies rose from $9 per share in 1922 to $20 per share in 1929. Yet in the fall of 1929, the US stock market crashed, losing nearly half its value in two months, dragging the rest of the economy with it and triggering several years of the Great Depression. Ultimately, stocks bottomed out in 1933 about 90% below their 1929 peak.

Reasons for the crash and why it occurred at that particular time are still debated among economic historians. In a recent comprehensive account of financial bubbles

from the 18th century until modern times, Quinn and Turner (2020) postulate a key role for investor leverage made available in the form of broker loans:

> "The quantity of outstanding broker loans in the autumn of 1929 meant that any sufficient fall in prices would lead to a significant number of margin calls. This in turn would force traders to liquidate, depressing prices further."

In this paper, we aim to quantify whether the amount of leverage in the US stock market was indeed high enough to explain why stocks crashed with such ferocity during the two months from mid-September to mid-November of 1929. To this end, we apply the MinMaSS model proposed by Adrian et al. (2021). This framework provides a simple expression for the Minimal Market Size for Stability (hence, MinMaSS), which can be easily calculated even with limited historical data. We find that the degree of margin borrowing in late 1929 indeed created a situation where MinMaSS was dangerously close to the threshold for instability. In sum, we argue that the crash was the result of the interaction between three principal dynamics. First, in the months leading up to the crash, banks and brokers tightened margin requirements to unprecedented levels (Smiley and Keehn, 1988), which had the effect of sharply reducing the excess collateralization in many margin accounts. Then, the economy and market encountered a series of modest negative shocks, which began to force weak accounts to reduce exposure. Finally, the selloff turned into a rout because these accounts held a sufficiently high fraction of total stock market capitalization.

Our paper makes two principal contributions. First, although the historical record is clear that forced selling was abundant during the crash, economic historians have not, as yet, produced a quantitative explanation of why the crash happened when it did. To the best of our knowledge, ours is the first attempt to provide such an explanation. Second, we show how to apply a modern framework for evaluating

market stability to a historical setting with limited data availability. This could provide a template to study other episodes in financial market history.

The rest of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 provides a brief historical account of the Great Crash, with particular focus on the role of forced liquidations. Section 4 introduces the MinMaSS model. Section 5 discusses in detail the construction of variables required for the market stability analysis in Section 6. Section 7 concludes.

2 Previous Literature

There is obviously a large literature on the Great Depression that followed the stock market crash of 1929 and the "Great Depression analogy" continues to appear in discussions of contemporary economic crises (Bordo and James, 2010). However, despite the linkage in the popular imagination, economists have tended not to view the crash as having played a major role in the onset of the Depression.[1] As a result of this, the academic literature on the anatomy of the crash itself is rather thin.

The first systematic study of the crash was undertaken by (Fisher, 1930). Fisher evaluated a number of potential causes of the crash that had been proposed by contemporary financiers, politicians, and economists. Among these were overvaluation of stocks, changes in economic fundamentals, excessive speculation, excessive margin borrowing and forced liquidation, excessive new issuance and undigested securities, stock pools and manipulation, foreign selling, and capital gains tax laws. While economists have debated the various potential causes of the crash in the decades since Fisher's work, virtually no new potential causes have been proposed.

[1]Exceptions are Romer (1990), who cites the increase in uncertainty resulting from the crash in depressing consumption, Kindleberger (1973), who cites a liquidity crunch resulting from the crash as having led to cancellations of industrial orders, calling of loans, and deflation, as well as Mathy (2016), who advocates for the role of crash-induced uncertainty.

Fisher's list of explanations can be divided into four main categories. First, previously existing unsustainable or unstable conditions that were due to be corrected, for which the crash was the mechanism (overvaluation, excessive speculation, excessive margin borrowing). Second, economic or financial shocks that were sufficiently large and rapid to cause a crash (changes in economic fundamentals, stock pools and manipulation, excessive new issuance). Third, small shocks that acted as a triggering mechanism for a larger crash (various news items, foreign selling). Fourth, amplifying mechanisms (capital gains tax laws, forced liquidation).

These causes are, for the most part, not mutually exclusive, and it is possible, perhaps probable, that many of them were operating in concert. They also fit well into the "bubble triangle" framework, recently proposed by Quinn and Turner (2020):

> "The three sides of the bubble triangle are marketability, credit and money, and speculation – these correspond to oxygen, fuel and heat in the fire triangle."

As we will argue in the quantitative analysis, market conditions in 1929 were such as to allow the bubble to first inflate - heavy margin borrowing in particular adding fuel to the fire - and subsequently deflate, due to tightening margin requirements and small negative shocks removing both fuel and heat (i.e. discouraging speculation).

Perhaps the most hotly contested issue is whether stocks were, indeed, overvalued in 1929. The issue was debated at the time, and there is still no consensus among economists today. As has been documented by Fisher (1930), Allen (2000, c1931), Friedman and Schwartz (1963) and others, many market observers, regulators, and large and sophisticated investors in 1929, including (contrary to popular belief) Fisher himself, believed that stocks were overvalued. However, aside from the doomsayers such as contemporaneous columnists Alexander Dana Noyes and Roger Babson, the consensus view among the informed was that the overvaluation was mainly speculative

froth: stock prices required a correction to more reasonable levels before continuing to grow with the economy. As Fisher (1930) put it, "My own impression has been that the market went up principally because of sound, justified expectations on earnings, and only partly because of unreasoning and unintelligent mania for buying." (p. 50) Stocks had their cheerleaders, too, of course - John J. Raskob, a senior executive of General Motors and Democratic National Committee Chairman from 1928-1932, gave his famous "everybody ought to be rich" interview to Ladies' Home Journal just months before the crash.

Time has done little to shed light on the question. Galbraith (1997, c1954) scoffed at the idea that stocks were anything other than a massive bubble, and Shiller (2000) provided quantitative evidence.[2] Rappoport and White (1994) go so far as to argue, based on rising margin requirements at broker-dealers, that the crash was actually expected by market insiders months in advance. By contrast, McGrattan and Prescott (2004) conclude that in light of the information available at the time, stocks were appropriately valued for the future economic prosperity that was rationally anticipated, and even Kindleberger (1973) does not claim that stock prices were obviously excessive.

A more careful examination by Wigmore (1985) demonstrates that stock prices were not monolithic, with some industries such as utilities, investment trusts and banks showing extreme valuations of as much as 100 times earnings while valuations in other industries remained quite reasonable.[3] This view is shared by Bierman (2013), who also notes the role of regulators in trimming the valuations of utility stocks in particular as well as the role played by unusually high leverage among investors in

[2]At the peak, stocks were valued at about 20 times 12-month earnings and more than 30 times ten-year trailing inflation-adjusted earnings. The Shiller price-earnings multiple crossed 20 in April of 1928 and 25 in November. The long-term average has been approximately 16.

[3]Stocks traded on the Curb Exchange (forerunner of the American Stock Exchange) generally also reached higher valuations than NYSE stocks, although this varied by industry - see Kuvin (1930) for price indexes for the Curb Exchange.

spreading those price drops to the broader market.

In any event, the inability of economists and investors to agree, even decades later and with ample time to study all the facts, on whether the state of the world in 1929 justified the high level of stock prices at that time makes it difficult to rely on overvaluation of stocks as an explanation for the crash. If we believe that prices are determined by expectations of fundamentals, and time has not appreciably changed opinions on whether those expectations were rational, then the crash was probably not due to a realignment of prices with rational expectations.[4]

Of course, rational expectations may be revised in response to deteriorating fundamentals, which brings us to another potential cause of the crash—a revision of expectations to reflect the worsening of the economy and the onset of the Depression. Industrial production peaked in June and declined at an annual rate of more than 10% over the next three months before falling off a cliff in November and December. The pace of deflation, which had been ongoing at a modest rate in response to the Fed's tight monetary policy, accelerated before and during the crash as well. But, as Kindleberger (1973) pointed out, the worst of these data were not public at the time of the crash, although certainly the nation's top businessmen would have had a feel for the state of business activity independent of government data. Temin (1989) investigates actual expectations at the time of the crash and finds that neither a severe deflation nor a deep depression was anticipated. Perhaps the strongest evidence that rational changes in expectations could not justify the crash is the failure of perhaps

[4]An exception to this argument is if the mechanism is as described in Abreu and Brunnermeier (2003), whereby a bubble can persist even if all investors recognize that prices are out of line with fundamentals because speculators prefer to ride the bubble rather than bet against it. In such cases, any piece of news may act as a coordination device that causes speculators to liquidate all at once, leading to a crash. While Abreu and Brunnermeier (2003) do not apply their model to the Great Crash of 1929, their story does fit a big part of the narrative quite well. In particular, despite many traders in the industry believing that stocks were overvalued, these traders appear to have attempted to trade on their short-term beliefs about the path of stock prices, rather than long-term fundamental value.

the most respected American economist of the day, Irving Fisher, to attribute the crash primarily to a weakening economy, even after the fact. Fisher (1930) also notes that several large corporations actually increased their dividends during the crash in a show of confidence about the future, but that "the market had no ear for such news, because it was deafened by the stentorian voices calling upon individuals and brokers to repay their loans."

Some authors, most notably Allen (2000, c1931) and Galbraith (1997, c1954), point vaguely to stock pools and manipulation as a cause of the crash and bubble, with large investors manipulating stock prices up and down for profit. Fisher, too, addresses this assertion, without a firm conclusion. While it is well-documented that such pools were in operation, Wigmore (1985) explains that the pools were not omnipotent and suffered severe losses during the crash. If bear-raiding stock pools engineered the crash, then they defeated well-financed and apparently incompetent bullish pools as well. Mahoney (1999) conducts a systematic study and finds that pools were not successful at manipulating prices for profit, arguing that the primary purpose of pools was for market making and improving liquidity. However, his analysis focuses narrowly on the issue of pools buying and selling stocks for profit and does not address many of the schemes described in the sources he cites, such as profits on options. Further, he makes a few assumptions that may weaken the power of his tests,[5] so that a negative result should not necessarily be taken at face value. In any event, transcripts of the Committee on Banking and Currency (1934) contain explicit admission by pool participants that some practices of pools were "bad" and designed to create enthusiasm by exaggerating trading volumes.[6]

[5]For example, he restricts his attention to pools that operated pursuant to a written agreement; presumably pools that were engaged in untoward activities would have been less likely to have a written agreement. He also excludes from his analysis pools in more thinly traded stocks not found in the CRSP database, which would have been easier to manipulate because there was less liquidity.

[6]Directed by Ferdinand Pecora, this commission was chartered by Congress to investigate causes of the crash.

Overall, the literature contains some evidence that pools manipulated the prices of individual stocks over periods of a few days or potentially weeks, mainly through "pump and dump" style schemes. Pools were also formed to facilitate insider trading, which was legal at the time. However, the primary purpose of the pools appears to have been to engage in distribution of large blocks of securities and to stabilize markets during those distributions. There is no evidence that pools were responsible for sustained excess valuations of stocks generally, or for the broad-based declines of the autumn of 1929. Indeed, during the crash itself, some prominent pools attempted to stabilize the market by publicly buying stock, and so were a mitigating, rather than aggravating, factor.

1929 also marked a high point for new issuance of securities. Galbraith (1997, c1954) and Wigmore (1985) claim that this produced significant selling pressure, while White (1990) conjectures that it could not have because it was too small to do so. In one sense, White is clearly correct in that new issuance of more than 1% of stock market capitalization, as occurred in September 1929,[7] was clearly not enough to account for the full measure of decline in stock prices. However, this was a sizable shock to supply, and if (as we shall argue) the market was already on the verge of instability, this could have pushed it over the edge. Indeed, newspaper accounts of the time cited a glut of undistributed securities being carried by dealers as a source of selling pressure.

Foreign liquidations in September have also been cited as one cause for the crash, most notably by Fisher (1930). Fisher and others after him, including Bierman, Harold, Jr. (1991), argue that the discovery of Clarence Hatry's fraud in London on September, 21st, and the subsequent bankruptcy of his companies, caused London financiers to sell their American holdings to cover some £12.5 million in unsecured credit exposure. To support this claim, Fisher notes that the dollar-sterling exchange

[7]Banking and Monetary Statistics.

rate moved rather rapidly from the British gold export point to the gold import point (a dollar depreciation) as foreigners sold their stock holdings and converted the proceeds into sterling for repatriation.

However, despite the splash that Hatry's fraud made in both the London and New York papers, the economic impact was relatively small. Relative to the capitalization of the stock markets, Hatry's £12.5 million bankruptcy was comparable to the collapse of two subprime-focused Bear Stearns hedge funds in June 2007, not the thirty-fold larger bankruptcy of Lehman Brothers in September 2008. A more likely candidate for the London liquidations was the Bank of England's hike in Bank Rate of one full percentage point on September, 26th. This increase was anticipated for the same reason it occurred: the Bank of England was losing gold reserves at an alarming rate, having suffered outflows of nearly a quarter of its reserves in the preceding 12 months. The Bank of England raised rates to stop gold outflows and encourage investors to invest in the UK instead of abroad. It worked, at least temporarily, and some other European central banks followed.

There are no solid data on international capital flows sufficient to trace the link between this foreign selling and the stock market decline. However, even in a world with no frictions, this one percentage point rise in interest rates would have been responsible for a several percentage point selloff in equity markets, simply by lowering the net present value of future cash flows. While this is clearly insufficient to account for the full measure of the crash, it could certainly have been a triggering factor in an unstable market.[8]

The Hatry affair, together with the October, 11th refusal of the Massachusetts Department of Public Utilities to allow Boston Edison to split its stock on the grounds it was wildly overvalued, have been cited by Fisher as shaking investors' confidence,

[8]See Accominotti and Eichengreen (2016) and Cadorel (2021) for a more detailed account of the linkages between international capital flows and stock market volatility during the 1920s.

and thus contributing to the crash. Yet the Massachusetts decision did not even trigger a selloff: the Dow Jones Industrial Average was down just 0.05% on Friday, October 11 and 0.49% on Monday. The selloff accelerated on Tuesday and Wednesday, but the Wall Street Journal attributed this to worsening economic data and triggering of stop-loss orders.

Ultimately, the picture that emerges from a close look at September and October 1929 is that markets were buffeted by a series of modest negative shocks, including interest rate hikes, the Hatry affair and Massachusetts decision, and worsening economic data.

Together, these sent the Dow Jones Industrial Average down 12.5% from its high on September 3 to the end of the orderly part of the market decline on October 18. Yet, over the next month, to November 14, the DJIA fell a further 40%, with little news aside from price declines. Over this period, declines became self-fulfilling as they forced liquidations in an unstable manner. We shall demonstrate next that selling from this point on was accompanied by heavy margin calls, and based on the MinMaSS framework we will show that the market was near a point of instability, suggesting the possibility of a self-fulfilling downward spiral.

3 Forced Liquidations During the Crash

Virtually all discussions of the 1929 stock market crash, including Fisher (1930), Allen (2000, c1931), Galbraith (1997, c1954), Sobel (1965), Wigmore (1985) and Quinn and Turner (2020), give a starring role to margin calls and forced liquidations. A reading of the Wall Street Journal 's "Abreast of the Market" column, which summarized each day's market developments and the drivers of stock price movements, during the period of the crash gives a similar impression. Using the market color provided in the Journal, at least seven of the ten down days between the beginning of the

crash proper on October 24 and the local minimum of stock prices on November 15 were accompanied by forced liquidations. In the two months from September 16 to November 14, the average day when forced liquidations were reported saw the Dow Jones Industrial Average decline 2.8% for the day, with an average intraday low of 5.6% below the previous day's close. By contrast, days with no forced liquidation reported saw an average gain of 0.5%. While declines clearly cause forced liquidations, some inferences may also be made as to causality from margin calls to price declines, because margin calls often went out overnight and then margin selling overwhelmed the market the next morning.

In addition to margin selling, the Journal's narrative provides a window into another source of forced selling: stop-loss orders.[9] The less severe declines of late September were accompanied by triggering of stop-loss orders, and the period prior to the primary crash from October 24-29th saw first a buildup of stop-loss orders and then their liquidation as short sellers reportedly sold in the hope that these orders would be triggered. The declines triggered by the stop-loss orders then triggered truly forced liquidation. These stop-loss orders reflect a sort of soft margin call. According to the Journal, these orders were employed to "protect" weak margin accounts by reducing leverage as account values declined. The idea was to ensure that accounts would not be forcibly liquidated and to control risk.

The Journal's account of the crash also makes clear that the forced liquidation of speculators took place over a period of several weeks, as compared with the model's prediction that the crash should be instantaneous in the absence of frictions. The explanation for this is likely complex, but there appear to be three major themes.

First, the actual act of liquidation took time. Each undermargined account required a determination by a clerk that the account was undermargined, a decision of the broker to sell out the account, and a formulation, transmission and execution

[9] A stop-loss order is an order to sell at the market if the price falls below a certain level.

of the orders to do so. The back offices had to perform the clearing and settlement functions. Margin determinations were not automatic (there were no computers back then), so that these calculations were generally (though not always) undertaken daily, with margin calls sent out by telegram after the market close. During the crash, the Journal 's reports indicate that the sheer volume of this work overwhelmed the infrastructure of the financial system, and many firms fell days behind in their work of actually executing the forced liquidations.

Second, insiders appear to have engaged in the kind of predatory trading that Brunnermeier and Pedersen (2005) described, selling short along with the forced liquidations and then covering their positions when the forced liquidation had temporarily completed. This resulted in several days where forced selling in the morning led to sharp losses, and short covering in the afternoon led to a recovery. Examples include Black Thursday, October 24th, when the Dow Jones Industrial Average was at one point down 11% intraday before recovering to close down only 2%[10]; Black Tuesday, October 29th, when the Dow was down a whopping 18.5% intraday before closing down about 12%; and Thursday, November 7th, when the Dow fell more than 6% intraday before closing up 2.6%.

Third, information dissemination and processing was not instantaneous, and it took some time for smaller investors to step in and provide liquidity, as they eventually did.

In any event, it does seem clear that margin calls and forced liquidations were the major driving force behind the crash. In the next section, we illustrate with a simple model why it could have been the case that the market in late 1929 was inherently unstable and as vulnerable as it turned out to be to a spiral of forced liquidations.

[10]Although here the bankers' pool intervention also had an effect.

4 The MinMaSS Model

The basic intuition of the model is that instability and market crashes occur when aggregate asset demand becomes upward sloping. This can happen if enough wealth invested in the asset is commanded by highly levered investors. A practical measure capturing this phenomenon is the *minimum market size for stability* (*MinMaSS*) first introduced by Adrian et al. (2021). It is the smallest market size that is required to maintain stability, given the wealth of levered investors.

To formally derive an expression for MinMaSS, assume a market for a single risky asset, which is populated by two types of investors. The first type are *levered investors*, who are so enthusiastic about the asset that they leverage their purchases to the maximum degree that lenders permit. Such simple behavior is assumed for tractability but it is supported by the literature investigating optimal portfolio choice in the presence of net worth and credit constraints (Grossman and Vila, 1992; Liu and Longstaff, 2004). The demand of levered investors for the asset, assuming they reinvest profits back into the asset with leverage, can be expressed as:

$$m_t^{lv} = \frac{m_{t-1}^{lv}}{\lambda} \cdot \left[1 + \frac{d_t \Delta t - (1-\lambda)(1 + r_t \Delta t) p_{t-1}}{p_t}\right] \tag{1}$$

where p_t is the price of the asset at time t, m_t^{lv} is the quantity of the asset held by the levered investor at time t, λ is the margin requirement imposed by lenders or by regulators[11] and d_t and r_t are, respectively, the dividend paid by the asset and the interest rate charged on margin loans in each period Δt. The numerator within the bracket is almost certainly negative (the dividend would otherwise have to be unrealistically high relative to the interest rate) and hence the levered investors' demand for assets is upward sloping.

[11] A margin requirement of five percent (λ=0.05), for example, would indicate that at least five percent of the investor's assets have to be covered by equity.

The second type are *fully funded investors*. They do not use leverage and so are limited in their asset purchases by their equity, which makes their demand for the asset a downward sloping function of its price. The fully funded investors' asset demand, m_t^{ff}, is expressed as:

$$m^{ff} = (1-\mu)N \cdot D(p) \tag{2}$$

where μ is the proportion of investors that are levered, N is the total number of investors in the economy and $D(p)$ is the number of assets that the average fully funded investor demands as a function of price. It is assumed that $D'(p) < 0$ so that demand is downward-sloping and demand does not depend upon the investor's net worth.[12]

Adding up the demand from both types of investors, aggregate demand is obtained as:

$$m_t = m_t^{ff} + m_t^{lv} = (1-\mu)N \cdot D(p_t) + \frac{m_{t-1}^{lv}}{\lambda} \cdot \left[1 - \frac{(1-\lambda)p_{t-1}}{p_t}\right] \tag{3}$$

Differentiating (3) with respect to price yields:

$$\frac{dm_t}{dp_t} = (1-\mu)N \cdot D'(p_t) + \frac{(1-\lambda)}{\lambda}\frac{p_{t-1}m_{t-1}^{lv}}{p_t^2} \tag{4}$$

The condition for stability is $\frac{dm_t}{dp_t} < 0$ (downward-sloping demand). Define $A \equiv (1-\mu)NpD(p)$ (the total dollar amount fully funded investors in the aggregate wish to hold of the asset) - substituting into equation (4) and rearranging, the stability condition becomes:

$$\frac{NW_{t-1}}{\lambda^2} + (1-\eta_D)A < p_{t-1}m_{t-1}^{lv} + A \tag{5}$$

[12]The latter assumption is for tractability, the fully funded investors' demand remains downward-sloping even if we allow for wealth effects.

where η_D (a positive number) is the fully funded investors' price elasticity of demand $-pD'(p)/D(p)$. The right hand side of the inequality is the market size: the total assets held by levered investors, plus the total assets held by fully funded investors.

The left-hand side of Equation (5) is the net worth of levered investors divided by the square of the margin requirement, plus the amount fully funded investors hold of the asset adjusted for their elasticity of demand. This quantity defines MinMaSS, the smallest market size that is consistent with stability; if $\eta_D = 1$ then MinMaSS is just the net worth of levered investors divided by the squared leverage ratio:

$$MinMaSS = \frac{NW_{t-1}}{\lambda^2} \tag{6}$$

We can form a ratio of the actual market size to MinMaSS, which we call the *stability ratio*. If the stability ratio is greater than one, the market is stable. The closer the stability ratio falls toward one, the closer is the market to becoming unstable. Note that if (minimum) leverage ratio is low, then even a small fraction of levered investors is dangerous to market stability. For example, with $\lambda = 0.1$, it is enough for levered investors' net worth to equal 1% of market size to bring the market to the verge of instability.

For the sake of clarity, this simple version of the MinMaSS model is restricted to a market with only one asset, no short selling, and only one class of levered investors. However, as Adrian et al. (2021) show, the framework can be extended to allow different investors to lever to differing degrees, sell short and take positions using derivatives, as well as markets with multiple assets - even then it still holds that the net worth of levered investors divided by the square of their leverage ratio is the key driver of MinMaSS.

In the next section, we take the simple MinMaSS model to the data available for the Great Crash period and show that market conditions at the time were in fact

pushing the limits of stability.

5 Leverage in the Stock Market in 1929

Leverage in the stock market in 1929 came essentially from two sources. The first was investment trusts, and the second was ordinary margin borrowing.

Investment trusts were essentially mutual funds with a tiered liability structure. The trusts' assets consisted of common stocks, including other investment trusts. Their liabilities consisted of senior debt and preferred stock, which entitled the holder to fixed interest or dividend payments, and of common stock, which held the residual value. The investment trusts thus embedded leverage, typically of about 1:1 (see, for example, (Wigmore, 1985), or (De Long and Shleifer, 1991)), because the debt and preferred stock would be entitled to the same payments as long as the value of the assets was sufficient to cover them, and any change in the value of the assets would be fully gained or lost by the common equity. Many investment trusts were pyramided, in that they held shares of other investment trusts, magnifying the leverage.

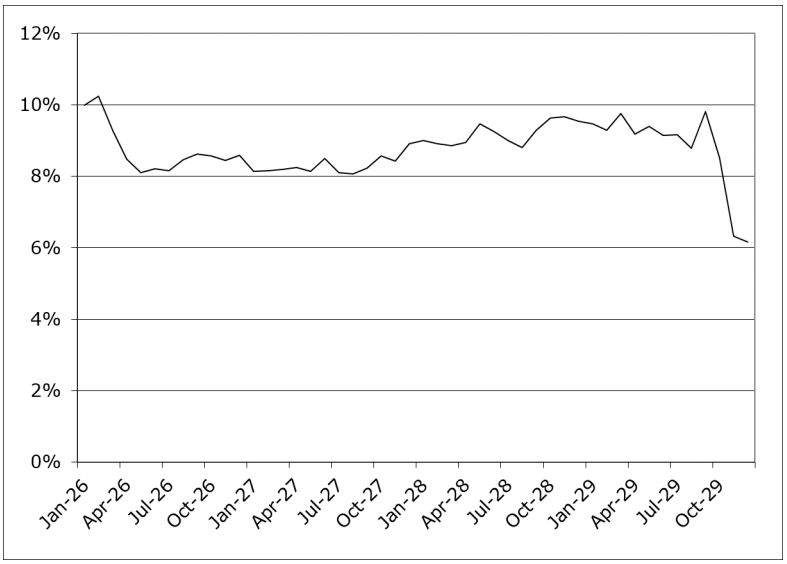
It would seem that we should simply increase our estimates of leverage to take account of investment trusts. The correct treatment is a bit more complicated, however. First, the debt instruments issued by investment trusts were term instruments, which means that investment trusts would not be forced to liquidate simply because the value of their assets declined. Instead, an investment trust would enter forced liquidation only when it could no longer raise sufficient cash to meet current contractual commitments. This means that the trust would not behave like a levered investor in the model. Holders of investment trust equity, however, could be required to liquidate their holdings faster during a crash if they had bought on margin, because the percentage decline in investment trust equity would be greater than the percentage decline in the underlying stocks in the investment trusts' portfolio. But again, there

are caveats. Brokers typically required different margin for different stocks, and they presumably would have had higher margin requirements for the riskier investment trusts, in effect offsetting the embedded leverage. Further, it is unclear whether there were rational arbitrageurs ensuring that the value of the investment trusts accurately reflected the value of the underlying portfolio. Indeed, De Long and Shleifer (1991) claim evidence of a divergence between the value of investment trust shares and the underlying portfolios.

Investment trusts dominated the issuance of new stocks for much of 1929. Despite the prominence of the explosion of investment trusts in late 1928 and 1929 in many narratives of the crash, however, these narratives have generally not drawn clear causal lines from the investment trusts to the crash. Rather, they have cited investment trusts as one manifestation of increased leverage and financial chicanery of the period leading up to the crash. What role they played in actually causing the crash is left unsaid. More than likely, the trusts, which traded at a premium to the value of their underlying assets (De Long and Shleifer, 1991), contributed somewhat to the overvaluation of stocks, although the macro effect of this would have been small because the total capital raised by investment trusts through 1929 was only $3.4 billion (ibid.), or less than 3% of total U.S. market capitalization.

A second source of leverage is traditional margin borrowing in the call money market, where banks and corporations lent money overnight to investors, secured against their stock holdings. Most discussions of the crash cite the vast increase in margin borrowing that occurred in 1928 and 1929. Yet while it is true that margin borrowing on the New York Stock Exchange rose sharply during the second half of the 1920's, so did the market capitalization of the exchange. In fact, the percentage of the market capitalization of the NYSE that was funded with broker loans (which were primarily used for margin credit, and were its largest single source) stayed roughly constant from 1926 until the crash in 1929, at which point it fell precipitously to its

Figure 1: Share of Market Cap on the NYSE Financed with Broker Loans



This figure shows the ratio (in %) of total broker loans outstanding to the market capitalization of NYSE-listed stocks, for each month between January 1926 and December 1929. The data is compiled from *Banking and Monetary Statistics* and Smiley and Keehn (1988).

lowest level since data began to be collected - see Figure 1.

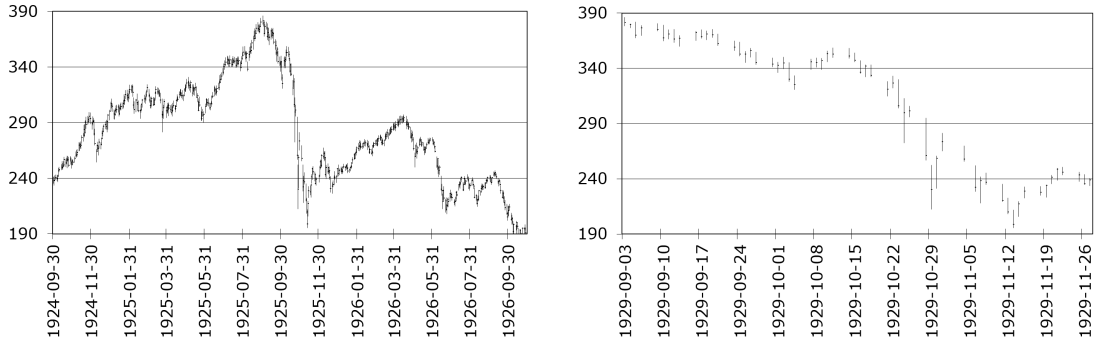
This does not tell the full story, however: the institution of margin investing did undergo at least one unprecedented change prior to the crash. From late 1928 through the summer of 1929, banks and brokerage firms tightened margin requirements from about 10-20% to about 50%, levels that were without precedent.[13] While good data are lacking, this doubling or tripling of margins would probably have made more investors act in a constrained manner - that is, more like the speculators than the

[13]There is no comprehensive data on margin requirements or funding constraints during the 1920's. However, a few authors have investigated the issue by compiling selected primary sources. During peacetime, margin requirements during the 20th century prior to 1928 generally ranged from 10 to 30 percent (Smiley and Keehn, 1988). However, in late 1928, banks grew concerned about valuations and began increasing margin requirements (or haircuts) on loans to brokers, and brokers passed this increase on to their customers. Margin requirements rose from as low as 10-20 percent up to 40-50 percent by the middle of 1929. At the tail end of the crash, margins were quickly loosened, beginning in late October and November. See, for example, Wigmore (1985), Rappoport and White (1994), Smiley and Keehn (1988).

retail investors in our model - for two reasons. Most obviously, the tightening margins may have forced some investors to post collateral and squeezed them financially. Secondly, for investors who would have wished to be more levered than the 1:1 ratio subsequently permitted, the collateral constraint became binding and they would rationally have behaved more like the speculators in the model.

Figure 2: The Dow Jones Industrial Average around the Great Crash

(a) Oct 1928 - Oct 1930 (b) Sep - Nov 1929



This figure shows the daily evolution of the Dow Jones Industrial Average stock market index in the years and months surrounding the Great Crash of 1929. Each vertical segment in the plots spans the high-low range on that day, with the daily close highlighted as a solid rectangle. Panel (a) shows the broader 3-year perspective, while Panel (b) zooms in on the three months beginning with the all-time high on September, 3rd 1929 and until the market reached its first bottom in November 1929.

It seems almost obvious that such a severe tightening in margin requirements would lead to a sell-off amid forced liquidations. Yet just a few years later, on April 1, 1936, the Federal Reserve used its new-found powers to tighten margin requirements generally from as low as 25%, depending on the security, to 55%.[14] While equity prices did fall temporarily in April, there was no instability, and they soon recovered and made new highs. The reason for the differing behavior in 1929 and 1936 is no mystery, of course: margin loans were much less significant in 1936 than in 1929. But the MinMaSS framework, for the first time, is able to provide a theoretically grounded

[14]Banking and Monetary Statistics, Table 145.

quantitative argument for why the 1929 market was unstable while the 1936 market was not.

To estimate MinMaSS, we need to determine the net worth of constrained investors, as well as their leverage ratio. We then compare this with the total market size in order to evaluate the stability of the market. For 1929, as for most crises, data of sufficient granularity are not available. However, financial statistics and reports from the time allow a rough calculation, which we undertake next.

5.1 Market Size

The total market capitalization of the New York Stock Exchange was $87 billion at the end of September 1929 (NYSE). For the Curb Exchange[15], we estimate that the figure was $22 billion.[16] We follow McGrattan and Prescott (2004) in assuming that total market capitalization in the United States was 1.45 times the value of the NYSE, implying that the total market value of U.S. stocks at the beginning of October 1929 was about $126 billion. Together, these imply a market cap for over-the-counter and regional exchanges of $17 billion (126 - 87 - 22), which is not unreasonable, especially given that all banks traded in the over-the-counter market to avoid exchange disclosure requirements (Wigmore, 1985). This same method yields a market capitalization of $52 billion for the NYSE and $75 billion for all U.S. stocks in March 1936.

[15]Later the American Stock Exchange.

[16]Kuvin (1930) finds a market cap for the Curb Exchange of $17.1 billion in January 1929. Assuming the Curb grew in tandem with the NYSE over the first nine months of 1929, gives a figure of $22 billion at the end of September.

5.2 Quantity of Margin Credit

Compilations of data from the Federal Reserve indicate that the total value of margin loans outstanding against stocks at the end of September 1929 was around $22.1 billion, of which perhaps $17.7 billion was to constrained investors. The remainder of this section explains this estimate in detail. Margin loans to investors came from two main sources: banks and brokerage firms. Brokerage firms, in turn, funded their share of those loans on the call money market. Data are available on direct bank lending to investors on collateral of securities, as well as on brokers' borrowings on the call market.

Beginning in 1928, US banks were required to report to the Federal Reserve a classification of their loans at quarterly frequency.[17] Of interest for our purposes is the category "Loans on securities, except to banks." As of October, 4th 1929 such loans totalled $9.994bn, of which $1.885bn was to broker-dealers in New York City, $0.939bn was to broker-dealers in other parts of the US and $7.17bn was to others.

Separately, the Federal Reserve compiled data on the sources of borrowing by broker-dealers in New York City.[18] As of October, 4th 1929, broker-dealers in New York City had total borrowings of $8.525bn, of which $1.885bn came from banks[19] and $6.640bn from other, non-bank, sources. The fact that broker-dealers had roughly 3.5 times as much in borrowings from non-banks than from banks was a striking feature of 1929 and, according to (Smiley and Keehn, 1988), contributed to the speculative boom in stock prices.[20] Unfortunately, the amount of borrowing from non-banks by broker-dealers outside New York City is not reported in the data. However, as

[17] Banking and Monetary Statistics, Table 19.

[18] ibid., Table 139

[19] As evidenced earlier in ibid., Table 19

[20] Saleuddin (2021) also points out that the levels of non-bank "shadow" credit were unprecedented during the 18 months leading up to the Great Crash and argues that this also limited the influence the US Federal Reserve could have had on limiting speculation.

mentioned earlier, we do know that broker-dealers outside New York City borrowed $0.939bn from banks as of October, 4th 1929. Hence, assuming the structure of their borrowings was similar to broker-dealers in New York City, we can estimate the amount borrowed from non-banks by broker-dealers outside New York City to be approximately $3.3bn, bringing their total borrowings to $4.24bn. In sum, we estimate total borrowings by broker-dealers in and outside New York City to be $12.77bn as of October, 4th 1929.

However, this represents broker-dealers' total borrowings on the call market, and could include loans used to finance their own inventories, meaning that potentially only part of this total represents margin loans to their customers. On the other hand, these loans were also not the only source of financing for margin loans; brokers also used their own capital and other customers' credit balances for this purpose. According to the Federal Reserve, brokers' borrowings are mainly an indication of margin loans made by brokers.[21] Beginning in November of 1931, the Fed explicitly collected data on margin loans to customers.[22] These significantly exceeded loans to brokers, typically by about 2.5% of the capitalization of the NYSE in the early 1930's. We thus assume that brokers' loans to customers in September 1929 exceeded brokers' borrowings on the call market by the same fraction, or about $2.2bn.

This important source of credit to securities markets has been left out of all previous analyses of margin borrowing during the 1920's of which we are aware. The notes to the Banking and Monetary Statistics make clear that these were also loans extended for the purpose of carrying securities and should thus be included. Beckhart (1932), pp. 155-160, discusses the shifting back and forth of securities credit between bank loans and broker loans.

Combining the $7.17 billion in bank lending to non-broker-dealers, $12.77 billion

[21]See Banking and Monetary Statistics, p. 435.
[22]ibid., Table 143

in broker-dealer loans, and $2.2 billion in margin loans from brokers funded outside the call market, gives total margin loans to stock investors (excluding banks) of $22.1 billion at the beginning of October 1929. Compare this to March 1936, when direct bank loans to non-broker-dealers were $2.832bn and broker-dealers' margin loans to customers were $1.351bn, for total margin loans of $4.183bn.

For both of these time frames, the Fed does not break out the data by type of security, meaning that bonds as well as stocks may be included. Because the total value of bonds outstanding in the U.S. totaled at least $70 billion in 1929 (more than half the value of the stock market), an appreciable portion of margin loans could theoretically have been made against bonds. However, the literature appears to contain no discussion of bond purchases on margin in the 1920's. Indeed, with call money rates well above other fixed income benchmark rates in 1929, it would have made little sense to engage in such an investment strategy. Thus, it seems reasonable to assume all the margin lending was against stocks. Finally, not all margin loans would have been to investors that were near-maximally levered. There were 600,000 margin accounts out of a total of 1.55 million (Galbraith, 1997, c1954). If margin accounts had, on average, the same net worth as cash accounts (a doubtful assumption but a useful benchmark), then these margin accounts would have been worth a total of $42 billion, and would, on average, have been levered with about 43 cents of debt for each dollar of equity. Equity in margin accounts probably varied widely however. Data on this is not available for the 1920's, but it is available for the 1970's and early 1980's when approximately 70% of margin debt was held by accounts with less than 60% equity in the account, within 10% of the margin requirement (New York Stock Exchange, 2022). We assume that in light of the sharp tightening in margin requirements from the autumn of 1928 through the summer of 1929, the percentage of constrained accounts in 1929 was probably somewhat larger than this, and therefore that 80% of margin loans were held in accounts that behaved like the speculators in

the model.

This leads to an estimate of margin loans to constrained investors of $17.7bn in September 1929 and $3.35bn in March 1936.

5.3 Leverage Ratio of Speculators

Smiley and Keehn (1988) survey evidence on margin requirements prior to the crash, and find that they were generally between 40 and 50 percent, depending on the security. We assume that net worth (equity) of constrained investors is divided equally between accounts with 40, 50 and 60% margin requirements. This implies an average equity-to-assets ratio of 0.49 with variance 0.12. For 1936, we assume that constrained investors faced the Fed's margin requirement of 55%, leading to an equity-to-assets ratio of 0.55, with zero variance.

Since assets are equal to the sum of debt and equity, we can combine our estimates of constrained investors' leverage with the amount of their borrowings calculated in the previous Section to derive their net worth (that is the amount of assets financed with equity). We obtain $16.8bn for 1929 and $4.1bn for 1936.

6 Stability Analysis

We are now able to put all the components together to complete our stability analysis. We use equation 6 to compute MinMaSS and summarize the results in Table 1.

The results of the stability analysis are striking. In 1929, margin borrowings were of the right order of magnitude necessary to destabilize the stock market. By 1936, they were nowhere close. In light of the simplistic behavioral assumptions in the model, quality of data available for the period, and uncertainty around demand elasticity, the results suggest that with proper portfolio data, the instability or near-

Table 1: U.S. stock market stability in 1929 vs 1936

	September 1929	April 1936
Margin Borrowings of Constrained Investors	\$17.7bn	\$3.35bn
Average Equity-to-Assets (λ)	0.49	0.55
Net Worth of Constrained Investors	\$16.8bn	\$4.1bn
MinMaSS	\$70.8bn	\$13.5bn
Market Capitalization of U.S. Stocks	\$126bn	\$75bn
Stability Ratio	1.78	5.54

instability might have been even more apparent. We have also not attempted to model the additional embedded leverage of investment trusts, which could have raised MinMASS in 1929 further.[23]

The events of September and October of 1929 back up the model presented in this paper in qualitative ways as well. Almost since the time of the crash, commentators have noted that there was little news in the autumn of 1929 that would seem capable of sufficiently altering expectations to produce a crash of the magnitude that occurred. The two most widely cited events were regulatory disapproval for a utility stock split and the unearthing of a modest financial fraud in London. Prominent commentators like Irving Fisher that were bullish in early summer were still bullish in early fall; similarly for bearish commentators like Roger Babson. Some modern commentators, such asRappoport and White (1994) have argued that market participants foresaw the crash months before it actually happened. Economic historians have had difficulty making convincing arguments that changes in expectations were responsible for the crash.

Similarly, while forced liquidations were a major cause of the crash, it is not

[23]One can bring the stability ratio in comparison with the calculations conducted by Adrian et al. (2021), who evaluate the buildup of vulnerability in the run-up to the 1998 Long-Term Capital Management crisis. The authors find the stability ratio in the markets for equity volatility and bank funding to be equal to 3 and 3.2, respectively (Table 2). This was sufficient to bring various asset markets to a collapse and precipitate a financial crisis.

clear that general credit was, in fact, tightening significantly in the period just prior to the crash. Despite increases in the Fed's discount rate in the summer, the Fed simultaneously cut the rate at which it would buy bills outright. Interest rates on stock exchange call loans peaked in July. As the Fed urged caution with regard to loans for speculative purposes and non-bank lenders withdrew from the call loan market, banks stepped in to pick up much of the slack.[24] Banks did not experience distress during the crash, and even brokers were not distressed in large numbers. There was thus no general credit crunch during the crash of 1929. This did not come until later.

The shocks that are strong candidates for being triggers of the crash are more consistent with the present theory of instability. We have already discussed the tightening of margin requirements that caused more investors to behave approximately like the model's speculators, mechanistically leveraging to the maximum degree permissible. But there was another large shock in late 1929: a tremendous explosion in new issuance of stocks, $6.6 billion in the twelve months through September 1929, 5% of the value of the equity markets and as much as in 1920-1927 combined. More than $1 billion was issued in September alone, the largest month ever by a factor of two for common stocks and about 1% of the value of the exchange.[25] Wigmore (1985) points out that much of this issuance was initially held by dealers and pools as they aimed to distribute the securities in an orderly manner to the public, but that these institutions began to sell more aggressively to limit their losses as prices fell during September. In the context of the theory presented; this is a supply shock to the quantity of securities that need to be absorbed by retail investors with a downward-sloping demand curve, depressing prices. When markets have significant numbers of

[24]Banking and Monetary Statistics. This has been noted by many other commentators, including Friedman and Schwartz (1963).

[25]Banking and Monetary Statistics, Table 137.

constrained investors, as we have proposed they did in 1929, it is the actual issuance, rather than the announcement of it, that causes the price decline.

7 Conclusions

Many causes have been proposed for the Great Crash of 1929, but while there has been a great deal of debate in the academic literature about their relative importance, there have been virtually no new theories proposed since the comprehensive assessment in Fisher (1930). In this paper, we argue that tightening margin requirements in the first nine months of 1929 caused levered investors to become constrained, so that a series of modest negative shocks that buffeted markets in September and October were sufficient to force liquidations and cause a severe crash.

All discussions of the crash of which we are aware, give a starring role to the forced liquidations of margin loans, yet none of these have explained why, in a quantitative sense, the stock market was particularly vulnerable to such a crash at the time that it occurred. Here, we have applied the micro-founded measure of financial stability developed recently by Adrian et al. (2021) to provide such a quantitative estimate. The obtained stability ratio shows that the stock market of 1929 was indeed particularly vulnerable to instability. We have also used this measure to show how the tightening of margin requirements that occurred in 1936 was much less of a threat to the stability of the stock market.

The qualitative evidence on the crash fits the results of the model as well. The timing of the crash does not appear to have been tied to changes in expectations or fundamentals, but rather to the technical conditions of the market. The contemporaneous stories are of investors who pyramided leverage upon leverage, and doubled down when their bets paid off. During the crash itself, these investors who wished to buy stocks because their expectations were bullish, were forced to sell instead. While

good data are difficult to come by, our simple model can nevertheless explain a good deal of the sudden and uncontrolled nature of the Great Crash of 1929.

References

Abreu, D. and Brunnermeier, M. (2003), 'Bubbles and crashes', *Econometrica* **71**(1), 173–204.

Accominotti, O. and Eichengreen, B. (2016), 'The mother of all sudden stops: Capital flows and reversals in Europe, 1919-32', *Economic History Review* **69**(2), 469–492.

Adrian, T., Borowiecki, K. J. and Tepper, A. (2021), 'A leverage-based measure of financial stability', *Journal of Financial Intermediation* (January), 100907.

Allen, F. L. (2000, c1931), *Only Yesterday: an Informal History of the 1920's*, Perennial Classics, New York.

Beckhart, B. H. (1932), *The New York Money Market, Vol. III*, Columbia University Press.

Bierman, H. (2013), *The 1929 stock market crash*, Routledge.

Bierman, Harold, Jr. (1991), *The Great Myths of 1929 and the Lessons to be Learned*, Greenwood Press, New York.

Bordo, M. and James, H. (2010), 'The Great Depression analogy', *Financial History Review* **17**(2), 127–140.

Brunnermeier, M. and Pedersen, L. (2005), 'Predatory Trading', *Journal of Finance* **LX**(4).

Cadorel, J.-L. (2021), 'An international monetary explanation of the 1929 crash of the new york stock exchange', *Working Paper* .

Committee on Banking and Currency (1934), *Stock Exchange Practices*, United States Senate, 72nd Congress. Available at http://fraser.stlouisfed.org/publications/sensep/.

De Long, J. B. and Shleifer, A. (1991), 'The stock market bubble of 1929: Evidence from closed-end mutual funds.', *Journal of Economic History* **51**(3), 675–700.
URL: *http://www.jstor.org/stable/2122941*

Fisher, I. (1930), *The Stock Market Crash and After*, The MacMillan Company, New York.

Friedman, M. and Schwartz, A. J. (1963), *A Monetary History of the United States, 1867-1960*, Princeton University Press.

Galbraith, J. K. (1997, c1954), *The Great Crash: 1929*, Houghton Mifflin, New York.

Grossman, S. J. and Vila, J.-L. (1992), 'Optimal Dynamic Trading with Leverage Constraints', *Journal of Financial and Quantitative Analysis* **27**(2), 151–168.

Kindleberger, C. P. (1973), *The World in Depression, 1929-1939*, Allen Lane, London.

Kuvin, L. (1930), 'Stock price indexes of the new york curb exchange', *Journal of the American Statistical Association* **25**(169), pp. 51–62.
URL: *http://www.jstor.org/stable/2278494*

Liu, J. and Longstaff, F. A. (2004), 'Losing Money on Arbitrage: Optimal Dynamic Portfolio Choice in Markets with Arbitrage Opportunities', *Review of Financial Studies* **17**(3), 611–641.

Mahoney, P. G. (1999), 'The stock pools and the securities exchange act', *Journal of Financial Economics* .

Mathy, G. P. (2016), 'Stock volatility, return jumps and uncertainty shocks during the Great Depression', *Financial History Review* **23**(2), 165–192.

McGrattan, E. R. and Prescott, E. C. (2004), 'The 1929 stock market: Irving fisher was right', *International Economic Review* **45**, 991–1009.

New York Stock Exchange (2022), 'NYSE Exchange Proprietary Market Data: Facts and Figures'.

Quinn, W. and Turner, J. D. (2020), *Boom and Bust: A Global History of Financial Bubbles*, Cambridge University Press.

Rappoport, P. and White, E. N. (1994), 'Was the crash of 1929 expected?', *American Economic Review* **84**(1), pp. 271–281.
URL: *http://www.jstor.org/stable/2117982*

Romer, C. D. (1990), 'The great crash and the onset of the great depression', *The Quarterly Journal of Economics* **105**(3), 597–624.
URL: *http://ideas.repec.org/a/tpr/qjecon/v105y1990i3p597-624.html*

Saleuddin, R. (2021), 'Shadow credit, the fed and the crash of 1929', *Working Paper* .

Shiller, R. J. (2000), *Irrational Exuberance*, Princeton University Press.

Smiley, G. and Keehn, R. H. (1988), 'Margin purchases, brokers' loans and the bull market of the twenties', *Business and Economic History* **17**.

Sobel, R. (1965), *The Big Board: A History of the New York Stock Market*, Free Press, New York.

Temin, P. (1989), *Lessons from the Great Depression*, MIT Press, Cambridge, MA.

White, E. N. (1990), 'The stock market boom and crash of 1929 revisited', *Journal of Economic Perspectives* .

Wigmore, B. A. (1985), *The Crash and its Aftermath: A History of Securities Markets in the United States, 1929-1933*, Greenwood Press, Westport, CT.