Essays in Financial History

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TESI DOCTORAL UPF / ANY 2014

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Acknowledgements

Although the cover only shows one name, I am indebted to many people. Without the support of friends, professors, and my family a lot of these pages still would be blank.

Daily life at university was influenced by my office mates and other students. I thank all of them for good discussions while solving problem sets and good company during coffee breaks. I especially thank Philipp Ager and Fabrizio Spargoli, which shared an office with me for several years.

Feedback is an important part of the learning process. I therefore thank the participants of the International Lunch Seminar. A special thanks goes to Fernando Broner, Alberto Martin, Ander Perez, and Jaume Ventura.

To stay focused and motivated, life outside the university matters. I thank the members of the Barcelona Road Cycling Group and the people from Pave Culture Cicliste for sharing several (sometimes cruel) hours on the bike with me. These rides not only provided challenges and great conversations, but led also to a fresh mind.

A very special thank you goes to my advisor Joachim Voth. He provided invaluable advice and guidance throughout my PhD. He spotted flaws, saw features of my work I did not realize, and if necessary also provided advice on decisions not related to academia. During the stressful time of my job-search, his assistance and preparation was second to none.

The last lines are reserved for the people closest to me, my parents and my wife. They provided the most valuable task of all – bringing my motivation back when I was stuck in endless regression tables and equations. They supported me on every single step along my way. Without them, this thesis would not exist.

Abstract

Do market frictions influence asset prices? The first part examines whether financial intermediaries' balance sheet capacity, their funding liquidity, can influence market liquidity, volatility, and price patterns. Using a historical case study this part suggests that when a liquidity provider is balance sheet constrained, markets become illiquid and prices move. The second part looks at Germany's 1927 stock market crash. It sheds light on the relationship between leverage and asset price behavior. The results indicate that a bank's credit policy influenced asset prices – an expansive policy dampened volatility and increased returns. A sharp cut in margin credit led to larger price fluctuations. The third part looks at the connection between the financial side and the real side of the economy. Testing the theory of rational bubbles, it suggests that in 18th century England government debt increased consumers' welfare by giving them a safe store of value.

Resum

Les friccions del mercat influeixen en els preus dels actius financers? La primera part examina si la capacitat del balanç dels intermediaris financers, si la seva liquiditat financera, pot influir sobre la liquiditat del mercat, la volatilitat i l'estructura de preu. Mitjançant l'estudi d'un cas històric aquesta part suggereix que quan un proveidor de liquiditat tè limitat el balanç, els mercats passen a no tenir liquiditat i els preus varien. La segona part se centra en el crac borsari alemany el 1927. Explica la relaciò entre l'apalancament i el comportament dels preus dels actius financers. El resultat indica que la poltica de crèdit dels bancs va influir els preus dels actius financers una política expansiva reduia la volatilitat i feia augmentar els rendiments. Una gran retallada en el marge de crèdit portava a majors fluctuacions dels preus. La tercera part analitza la connexió entre el sector financer i el sector real de l'economia. La teoria de les bombolles racionals suggereix que a l'Anglaterra del segle divuit el deute del govern va fer augmentar el benestar dels consumidors, tot donant-los dipòsits de valor segurs.

Preface

"History is a good place to look for answers" – *The Economist* introduced an Essay on financial crises with these words.[1] The aim was to come to grips with the current crisis by learning lessons from the past. This thesis takes such an approach. In each of its chapters, it asks a specific question relevant for todays financial system: Does financial intermediaries' balance sheet capacity matter for asset prices? Does a sudden shock to leverage lead to price dislocations and volatility? Can consumers gain from government debt in an underdeveloped financial system?

A main benefit of turning to history in the search for answers to current questions is the decrease in complexity. Empirical studies face several difficulties in modern financial markets. Assets are traded at multiple venues; examining one market place in isolation can post problems. Fair value accounting forces financial intermediaries and traders to change the value of their balance sheets daily – feedback effects from asset prices to balance sheets may occur. The first two parts of this thesis deal with these concerns. They take a look at the German Stock Exchange in interwar Germany. A small set of players dominated the market, trading took place at a single venue, and balance sheets of traders did not change during the period of observation. But history does not only provide guidelines for todays highly developed financial markets. Questions concerning developing markets often struggle with data problems. For less developed economies financial data are hardly available. The third part turns to 18th century England. Reliable data on England are abundant and allows us to examine a financial system in its infancy.

The first part looks at a particular explanation for short run price patterns. A V-shaped price pattern is often observed in financial markets – in response to a negative shock, prices fall "too far" before reversing course. This part looks at one channel of such patterns: the link between a liquidity provider's balance sheet and asset prices. I examine a well-identified historical case study where a large exogenous shock to a liquidity provider's balance sheet resulted in severe capital constraints. Using evidence from German universal banks, who acted as market makers for selected stocks in the interwar period, I show in a difference-in-differences framework that binding capital constraints made stocks 15–20 percent more likely to be illiquid if they were connected to the distressed

[1] *The Economist*, 12 April 2014

liquidity provider. This resulted in V-shaped price patterns during times of illiquidity, where prices declined on average 2.5 percent and reversed over the next one to three days. Investing in these particular stocks would have yielded substantial gains. These findings can be rationalized by a model that incorporates imperfect competition and asymmetric information. Under this model, banks' market–making reduces price volatility (and uninformed traders' reactions to price movements) in normal times whereas in distressed times, the price impact of noise trading is high and leads to sharp price declines that are unrelated to fundamentals.

The second part turns to the relationship between margin credit and asset prices. Leverage is often seen as villain in financial crisis. Sudden deleveraging may lead to fire sales and price pressure when asset demand is downward-sloping. This chapter looks at the effects of changes in leverage on asset prices. It provides a historical case study where a large, well-identified shock to margin credit disrupted the German stock market. In May 1927, the German central bank forced banks to cut margin lending to their clients. However, this shock affected banks differentially; the magnitude of credit change differed across banks. Using the strong connections between banks and firms in interwar Germany, I show in a difference-in-differences framework that stocks affiliated with affected banks decreased over 12 percent during 4 weeks. Volatility of these stocks doubled. Relating directly bank balance sheet information to asset prices, I find that a one standard deviation decrease in lending to investors increased an affected stock's volatility by 0.22 standard deviations. These results are robust to the problem that banks' lending decisions may be influenced by asset prices. The Reichsbank threatened banks to cut their short-run funding. Using the differences in exposure towards this threat, an instrumental variable strategy provides further evidence that a sharp decrease in leverage may lead to stock price fluctuations.

The third part moves away from interwar Germany to examine the question whether additional stores of value in an underdeveloped financial system can bring benefits to consumers. Between 1680 and 1780, English National debt rose to levels never seen before, made possible by the Financial Revolution. At the same time, the consumption pattern of the Middle Class changed: Expenditure on luxuries increased and as total wealth increased, consumption increased in absolute terms as well. Together with the literature on the crowding out effect of government debt, this view states a puzzle: How can low capital accumulation and low growth rates of output go in line with increases in consumption? This part of the thesis claims that the puzzle can be solved by assuming the presence of financial constraints in eighteenth-century England and a lack of a store of value for consumers. The introduction of government debt provided consumers an efficient store of value. Capital accumulation was largely unaffected since entrepreneurs did not rely on outside financing, but consumption increased by the use of a more efficient vehicle to transfer wealth through time.

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Chapter 1

SLOW CAPITAL, FAST PRICES: FUNDING LIQUIDITY SHOCKS AND STOCK PRICE REVERSALS

1.1 Introduction

V-shaped price patterns are common in financial markets – in response to a negative shock, prices fall "too far" before reversing course. Kraus and Stoll (1972) showed how prices decline excessively in response to block sales. Index deletions and mutual fund portfolio rebalancing produces similar patterns (Chen and Noronha 2004, Coval and Stafford 2007). The convertible securities market in 2008 is an extreme example of such temporary mispricing. In asset pricing models without frictions, such price overshooting should not occur because it represents an unexploited arbitrage opportunity that only vanishes slowly over time. One leading explanation, put forward by Duffie (2010) amongst others, is that price reversals reflect the need for capital to be reallocated. Slow reallocation of capital in turn may reflect frictions in financial markets, such as the wealth of a liquidity provider (Gromb and Vayanos 2002, Brunnermeier and Pedersen 2009) and immediacy can only be guaranteed if a trader does not face binding capital constraints.[1] If capital constraints bind, asset prices start to move and diverge from fundamentals.

There is growing empirical support for the slow-capital interpretation of price overshooting. For example, when typical buyers and arbitrageurs are both constrained, prices and fundamentals may diverge for an extended period (Mitchell et al. 2007). The inventory positions of specialists on the New York Stock Exchange (NYSE) have predictive power for a stock's liquidity (Comerton-Forde et al. 2010) and are negatively correlated with contemporaneous returns (Hendershott and Seasholes 2007). Also, changes in dealers' repo positions can predict future asset price movements (Adrian and Shin 2010). Despite this evidence, it has proved difficult to establish a causal link between a liquidity provider's balance sheet and asset prices. In today's markets, the role of liquidity provider is often amorphous and can change over time. Furthermore, to establish a causal relation between funding liquidity and asset prices, the balance sheet shock has to be large and exogenous. For all these reasons, there is currently no compelling evidence establishing a causal link between capital–constrained liquidity providers and price overshooting in asset markets.

In this chapter of the thesis, I examine a well-identified historical case study where an exogenous shock to a market maker's balance sheet resulted in serious capital constraints. I use evidence from German universal banks during the interwar period, which acted as market makers for selected stocks. A difference-in-differences framework shows that binding capital constraints made stocks 15 to 20 percent more likely to be illiquid if they were connected to the distressed liquidity provider. In these periods of illiquidity, V-shaped price patterns emerged and prices fell by an average of 2.5 percent, before reversing over the next one to three days. These return reversals led to a large increase in the short-run volatility of stocks. Returns of other stocks associated with the constrained liquidity provider began to exhibit strong co-movement. An investment strategy that bought these stocks during supply order imbalances returned 50 percent in a single month.[2] These findings can be rationalized in a model based on Kyle (1989) that features both asymmetric information and imperfect competition. This model allows me to show that banks' market–making reduced price volatility, but increased the effect of noise trading. When a better–informed trader can provide liquidity to noise traders, overall noise becomes insignificant. However,

[1] One obvious alternative interpretation is predatory trading (Brunnermeier and Pedersen 2005).
[2] This would amount to an annualized return of nearly 13,000 percent.

if a market maker is unable to counteract noise trading then prices decline sharply in response to asset supply shocks.

Before World War II, large universal banks based in Berlin dominated German stock markets, especially the Berlin Stock Exchange. Banks supplied commercial banking services to firms and other customers and were the main creditors for firms. At the same time, bank managers often sat on the supervisory boards of their clients. These customs established strong connections between banks and firms. Fohlin (1991) describes this situation in detail. On the stock market, a firm typically expected a bank to prevent large fluctuations of the firm's stock price (Wermert 1907, Prion 1929, Lehmann 2011). Banks used their capital and stock inventory to make markets. During periods of high demand, banks would sell stock; when pressure to sell was high, they would buy. Adolf Weber's 1915 manual about the German stock market describes this situation:

> ...The current demand and supply of a stock is responsible for the current market price...only a few shares, if they come to the market at the wrong time, can lead to an unreasonable price increase or decrease. It is the role of the banks to...establish an orderly price setting by buying the shares brought to the market or by adding shares to the existing supply. The underwriting bank will be able to do this better, since it is mostly better informed...because it constantly stays in touch with the firm's leaders.[3]

The strong connections between banks and firms provide cross-sectional variation in a difference-in-differences framework. Each bank supplied liquidity to a different set of stocks, those of their associated firms. A sample of firms listed on the Berlin Stock Exchange is sorted into bank–specific portfolios so that each portfolio consist of stocks having a common liquidity provider. I then identify a large exogenous shock to the balance sheet of one of these liquidity providers and examine the behavior of its connected stocks during this time of distress.

German history reveals an exogenous shock to a liquidity provider's balance sheet. On 11 May 1931, one of the big banks, the Danatbank, discovered that its biggest creditor, the Norddeutsche Wollkaemmerei (Nordwolle), had for several years been forging its balance sheets; in fact, Nordwolle was close to bankruptcy.

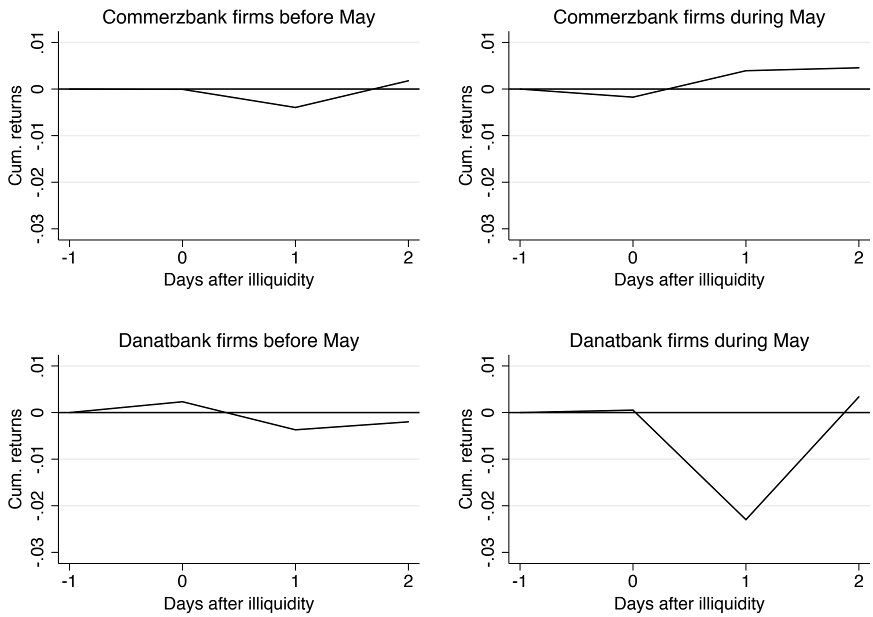
[3] Some of the historical sources cited here pre-date the 1930s. Although the Weimar Republic witnessed important changes, the main workings of the stock exchange remained relatively constant.

Instead of releasing this information to the public, the Danatbank decided to keep it a secret (Born 1967, Feldman 1995). The bank committed itself to providing Nordwolle with additional funds. Undetected from other market participants, it began purchasing its own stock. These decisions severly constrained Danatbank's balance sheet. During May 1931, the bank's trading arm was less able to provide liquidity to shares of its other connected firms.

During the period when Danatbank kept its troubles secret, stocks of affiliated firms continued to experience normal, occasional spells of selling pressure. Now, however, Danatbank was not able to smooth out the peaks. The empirical section provides evidence of an increase in illiquidity and strong price reversals during times of low funding liquidity. I use daily stock market data for 87 firms from November 1930 through June 1931. Bank–firm connections are identified through the underwriter prospectuses and firm–specific annual reports held at the German Federal Archives in Berlin. When Danatbank was unable to provide liquidity, the probability of supply order imbalances increased for connected stocks by 15–18 percent. During May 1931, the returns of Danatbank–connected firms became predictable after supply imbalances. In these cases, prices deviated substantially and more than in the case of other banks. The increasing illiquidity of stocks associated with Danatbank is not uniform across the sample and more volatile stocks show stronger reactions.

This market illiquidity had implications for pricing, summarized by Figure 1.1. The figure looks at return behavior of firms connected to two different liquidity providers, the Commerzbank and the Danatbank, after days of illiquidity, which is measured by the existence of supply order imbalances. Each panel plots the average cumulative return after such days. Returns of firms connected to the Commerzbank are shown in the upper two graphs, and returns of firms connected to the Danatbank are shown in the lower two. When the relevant liquidity provider is constrained, asset prices show a pronounced V-shaped pattern (lower left panel). This pattern is visible neither for stocks unassociated with Danatbank nor for Danatabank stocks prior to the funding liquidity shock. Traders who provide liquidity to stocks connected to Danatbank, earned positive expected returns. An investment strategy of investing in illiquid stocks does not lead to positive returns on average. However, returns to the same strategy were much higher for Danatbank–connected stocks during the period of constrained funding liquidity. In particular, during May 1931 a liquidity–provision strategy would have had accumulated returns in excess of 50 percent during a single

Figure 1.1: **Returns after days of illiquidity.** These graphs plot the average cumulative returns for firms associated with two different liquidity providers, the Commerzbank and the Danatbank. Cumulative returns are plotted after days of illiquidity as indicated by the existence of supply order imbalances. Averages are taken across firms and within two periods: before May (1 November 1930–10 May 1931) and during May (11 May 1931–4 June 1931).



month. These high returns reflect the strength of "V-shaped" price patterns in the days after order imbalances.

In the theoretical section these findings are placed in a more general context that helps explain the effects of banks' liquidity provision on both price volatility and the price impact of noise trading. There I describe a simple model, in the spirit of Kyle (1989), with asymmetric information, imperfect competition, and noise trading. Uninformed traders and an informed bank trade an asset that pays an uncertain dividend in the second period. The bank has a dual role because it trades for informational reasons, using a private signal about dividends, and also commits itself to counteracting the demand of noise traders. Thus the bank adds noise to the total demand, although this added noise is negatively correlated with noise trader demand. For reasonable parameter values, the model indicates that the negative correlation between the bank's market–making demand and noise trading results in less volatile prices. Yet this reduced volatility renders the bank less able to trade on its private information and thereby restricts its speculative demand. Under these conditions, uninformed traders will also react less to changes in prices and the price impact of noise increases. In normal times this noise is small, so the bank can successfully reduce price volatility. But if the bank is unable to act as a market maker, then prices react strongly to fluctuations in noise trader demand and so sharp price declines away from fundamentals can occur.

This study relates to several strands in the literature. It is closely connected with the literature on traders' funding conditions and asset markets. These papers are part of the research agenda on slow–moving capital that seeks to explain several asset pricing "puzzles".

Several empirical studies find a correlation between traders' balance sheets and asset price movements. Adrian and Shin (2009) and Adrian and Shin (2010) show that changes in dealers' balance sheet positions have predictive power for changes in market volatility. Coughenour and Saad (2004) examine the movements in market liquidity of stocks traded by a given market maker at the NYSE and find that market liquidity changes after mergers of market maker firms. These authors argue that such changes result from larger firms having a greater balance sheet capacity. Coughenour and DeLi (2002) find that liquidity provision changes with the organizational form of the firm; Comerton-Forde et al. (2010) use inventory positions of NYSE specialist firms as a proxy for a market maker's funding liquidity. During times of distressed funding liquidity, illiquidity and asset volatility are positively correlated. Furthermore, specialists' inventory positions are negatively correlated with contemporaneous returns (Hendershott and Seasholes 2007). The price pressure (and reversals) are greater for smaller firms (Hendershott and Menkveld 2013). Andrade et al. (2010) show that trading imbalances on the Tokyo Stock Exchange lead to price declines and reversals.

While my study looks at the effects of a decrease in the asset demand side, recent studies show the existence of price reversals during periods of supply pressure. Coval and Stafford (2007) examine large capital withdrawals from mutual funds that led to fire sales in certain assets. They find that asset values are depressed for several months in stocks that were traded mainly by funds with large outflows. Edmans et al. (2012) use a related measure and confirm that after large selling pressure from mutual funds stock prices decline and revert fully within two years.

Several theoretical models establish a causal relationship between funding and market liquidity. In Gromb and Vayanos (2002), market makers are margin constrained and asset valuations affect the wealth and the margin requirements of a market maker. Falling prices can thus constrain the market maker's ability to provide liquidity; Gromb and Vayanos (2010) offer a dynamic version of this model. Brunnermeier and Pedersen (2009) extend this line of research by introducing financiers with a value-at-risk constraint, which yields the micro foundations for fluctuations in the margin requirement. In their model, a feedback effect arises from changes in margins and wealth that alter asset prices—margin and wealth spirals drive asset prices downward. Gârleanu and Pedersen (2007) also link changes in liquidity to risk management practices.

All of these studies are part of a broader research agenda on slow–moving capital. This literature seeks to explain why in some situations capital reallocation takes more time. Examples of this slow movement of capital are the predictable price patterns after earnings announcements (Bernard and Thomas 1989) and after index deletions or additions (Chen and Noronha 2004). Looking at the relation between order imbalances and price pressure, Kraus and Stoll (1972) find that block trades cause prices to overshoot. Mitchell et al. (2007) document mispricing in markets for convertible securities; Mitchell and Pulvino (2012) show that, after the bankruptcy of Lehman Brothers, several assets may have been mispriced because arbitrageurs were capital constrained. In all these situations, it seems that arbitrage was limited by capital moving too slowly. This chapter looks at one possible explanation for these price patterns—namely, the link between balance sheets and asset prices—but several other explanations have been proposed. Early market microstructure models accounted for the deviation of prices from fundamentals either by risk-averse market makers (Grossman and Miller 1988) or asymmetric information (see Brunnermeier (2001) for an overview). DeLong et al. (1990) explain limited arbitrage with noise trader risk: the danger that mispricing increases because of uninformed traders. Shleifer and Vishny (1997) add informational frictions, while Duffie et al. (2005) and Duffie et al. (2007) show that search frictions can give rise to V-shaped price patterns. Search frictions are especially relevant for over-the-counter markets, where trade is bilateral. Another explanation offered for slow–

moving capital is rational inattention (Biais et al. 2011).

This chapter is also related to the literature on commonality in liquidity. Chordia et al. (2000) show that asset-specific measures of liquidity co-move with measures of marketwide liquidity. That co-movement extends to such measures of funding liquidity as the T-bill–eurodollar (TED) spread (Brennan et al. 2009). Moreover, co-movement is stronger when illiquidity originates on the sell side.

The investment strategy proposed here is related to return predictability and the literature on contrarian trading strategies. Nagel (2012) argues that a "return–reversal" investment strategy resembles the trading motives of a liquidity provider.[4] This strategy delivers high returns during times of illiquid markets—for example, after the collapse of Lehmann Brothers in 2008. Rinne and Suominen (2010) arrive at similar conclusions.

The theoretical section is related to the issue of intervention in financial markets. Ever since Bagehot (1873), there has been an ongoing debate over whether or not monetary authorities should intervene in financial markets. DeLong and Becht (1992) connect this controversy to the literature on noise traders. Noise trading leads to price fluctuations, and DeLong and Becht (1992) suggest that an informed institution could increase welfare by smoothing such fluctuations.

From a historical perspective, this chapter relates to the literature on interwar Germany and the German financial system. James (1986) describes in detail the turbulent times of hyperinflation, high unemployment, rapidly changing governments, and the crisis of 1931.[5] Fohlin (1991) reviews the role of German banks before World War II. Several papers examine the German stock market, but most deal with the pre-WW I period (see, e.g., Burhop (2011) or Lehmann (2011) on IPO underpricing). Comparing the German stock market with the US stock market, DeLong and Becht (1992) find that the German market was different in the first half of the twentieth century: unlike the United States, Germany did not experience excess volatility. These authors speculate that market–making activities of banks smoothed price fluctuations. Voth (2003) is one of the few studies on the German stock market in the interwar period. This work explores the pricking of a seeming "bubble" by the Reichsbank in 1927.

Relative to the existing literature I make the following contributions: Illiq-

[4]Return reversal strategies are also developed in Lo and MacKinlay (1990) and Lehmann (1990).

[5]For discussion of whether the 1931 crisis was a currency crisis or a banking crisis (or both), see Ferguson and Temin (2001), Temin (2008) and Schnabel (2004).

uidity and price reversals can stem from many sources, one of which may be a liquidity provider's balance sheet. In this chapter I supply clear evidence that funding liquidity affected market liquidity during a particular historical period. This historical case allows us to observe an exogenous shock to intermediation capital and also enables us to test for stock market illiquidity. Reduced funding liquidity did lead to less market liquidity, as predicted by the theoretical literature. During periods of illiquidity, asset prices moved as expected and exhibited a V-shaped pattern. By documenting illiquidity and return reversals I contribute to the empirical literature on return predictability. Further, this study is complementary to the literature on price behavior after supply pressure. In contrast to these papers that focus on sudden increases in asset supply, this study looks on the effects of a sudden decrease in asset demand. While in the literature on mutual funds' outflows prices decline and take a long time to rebound, this study shows large effects on short-run volatility when the demand side is constrained. The empirical part also adds to the historical literature and tests the hypothesis of DeLong and Becht (1992) that banks actually reduced the volatility of German markets. The theoretical discussion suggests that the banks' intervention in markets came at the cost of greater price impact. In normal times, banks' market–making demand can reduce volatility, although price impact increases. In times of constrained liquidity provision, this greater reaction of prices to noise induces large price fluctuations.

Section 1.2 details the historical background and the shock to funding liquidity. The data is described in Section 1.3. Section 1.4 shows how the funding liquidity shock affected market liquidity and Section 1.5 examines the behavior of asset prices during these periods of illiquidity. The empirical findings are rationalized by the model presented in Section 1.6. Section 1.7 concludes.

1.2 Historical background: The Berlin Stock Exchange and the "big banks"

This section places the study in its historical context. It describes the tasks of German banks, how the Berlin Stock Exchange worked, and the exogenous shock to funding liquidity.

Since the 19th century, universal banks played a prominent role in Germany's financial system. Investment banking and commercial banking are by the same institutions. Comparing the German system to banking in England, *The Economist* of 21 October 1911 noted that:

> German banks have a much wider sphere of action than our English deposit banks...they are stock, bill, and exchange brokers and dealers, banker-merchants, trust, financial, and promoting companies, etc...Not only have the banks promoted most of the industrial joint-stock companies, and retain part of their share capital, but their managing directors remain members of the board of these companies for their services in that capacity. [6]

Until WW I firms could choose from a wide variety of banks (Reisser 1910). This choice narrowed during the 1920's, when Germany experienced a major consolidation of the banking industry. By the 1930s, the financial system was dominated by just a handful of big banks. Five in particular towered over all others: The Berliner Handels-Gesellschaft (BHG), the Commerzbank, the Deutsche Bank und Diskonto-Gesellschaft, the Darmstaedter und Nationalbank (Danatbank), and the Dresdner Bank. These "big Berlin banks" had connections to an extensive portfolio of firms ranging from small family businesses to large manufacturers such as Siemens.[7] A bank's CEO typically sat on the supervisory board of a firm; when the latter went public, a connected bank was the natural choice for underwriter (Lehmann 2011).[8] In a typical equity offering, the bank bought the shares at a fixed price and placed them in the market, serving its own clients first. However, banks did not sell all shares and kept some stocks in their portfolios. This custom was meant to align the incentives of a firm and its bank, as it emphasized the connection and dedication of the bank to its client. Even without a large credit outstanding, the firm's risk was still part of the bank's balance sheet. Yet this balance sheet position was not static because banks were active on the exchange in making markets for stocks of connected firms. In a country that just had experienced times of financial turmoil, investors sought security and stability. Firms seeking to accommodate this need preferred their stock prices to

[6]Although these remarks were made prior to WWI, they remained valid in 1931. According to the *Wall Street Journal* of 5 May 1931: "Bank heads hold directorships in scores of companies, and the banks themselves retain holdings in shares they have issues".

[7]These banks were referred to as "big Berlin banks" because each of these banks had their headquarter in Berlin

[8]The close connections between banks and firms are well documented and lend credence to several arguments that such connections stimulated economic growth after the German Reich was founded(Gerschenkron 1962).

exhibit low volatility. Prices should not fluctuate solely because of market illiquidity and firms believed that a specific trader would keep markets liquid and establish a smoothly functioning price environment. Firms expected their connected bank to provide this service and to act as a market maker in their stocks. Better insights into current affairs and into the long-run outlook of connected firms gave banks an advantage in estimating a given firm's fundamental value, enabled them to establish an appropriate price level. Banks used their capital and their inventory to smooth stock price fluctuations during periods of order imbalances at the Berlin stock exchange (Fohlin 1997). This "important role that banks play in the daily trading" (Prion 1929) was an accepted fact at German stock markets and acknowledged by newspapers, books, and stock market manuals.[9] For example, Prion (1929) describes the typical bank trading behavior as follows:

> At the Berlin Stock Exchange it is impossible that supply and demand match daily. Fluctuations from one day to the other that are based on these imbalances and do not represent the fundamental value can be prevented through the intervention of the connected banker...Through this a constant possibility to sell is assured: the banker takes on excess supply to sell it over time again.

However, providing this "service of immediacy" (Grossman and Miller 1988) to connected firms had its limitations. Market–making required bankers to have deep pockets as well as immediately available capital.[10] Note also that, unlike specialists at the NYSE, banks were never officially appointed as market makers. They could refrain from providing liquidity or withdraw liquidity altogether without stating a reason for doing so. Their behavior could perhaps best be described as akin to that of traders following a contrarian investment strategy.

A closer look at the Berlin Stock Exchange's microstructure helps explain exactly how banks made markets in stocks of connected firms. After the founding of the German Reich in 1871 the Berlin Stock Exchange became one of the world's major exchanges and during the 1920s it was the only stock exchange

[9]The elimination of large fluctuations may have hindered prices to fully reveal all information. But Dang et al. (2013) show that banking is inherently opaque and that this opaqueness can be welfare enhancing. See also Gorton (2013), who describes opaqueness in the US banking system.

[10]"But the power of the banker to supervise the stocks is not unlimited. For the execution of his activity he might need considerable capital or rich clients, which are willing to buy the stocks on offer at the moment."*(Prion 1929:64)*

in Germany with notable volume.[11] Only the Berlin Stock Exchange drew the attention of politicians, the Reichsbank, the banks, and the media.

Each trading day, the exchange held a single call auction. A single stock had two official market makers or *Kursmakler*, which were located at a designated post inside the stock exchange. Similar to specialists at the NYSE, these official market makers could trade on their own account to ensure price continuity, but this procedure was seldom used.[12] For one and a half hours, orders could be submitted to the official market maker either as limit orders or as market orders. Afterward, the process of price setting began. The market makers brought together their order books, and a public discussion about the unique market-clearing price followed. Meanwhile, traders were still able to submit bids and offers until a single price was set that maximized trading volume. As a minimum requirement, all market orders had to be filled.[13] The last step was acceptance of the price by a committee, which was mainly concerned about large price swings. Sometimes prices were rejected in order to keep volatility within certain bounds.[14] All possible trades were settled at the established price.

If markets did not clear at the settled price then the market was left with supply or demand order imbalances. In extreme cases, order book imbalances were too great to enable trades and so it was not possible to establish a price quote. The official share price list reported the existence of order book imbalances. A lowercase letter appended to the price quote figure informed traders about any imbalances and also their direction. Table 1.1 gives an example of the price setting and shows a stylized order book. In this example, matching all sell orders without limit requires the auctioneer to go deep into the order book. The price drops, and there remains unmatched supply at the established price.

Often in cases of such imbalance, the connected bank intervened to prevent prices from fluctuating too widely. The bank placed an employee at the post of each market maker for its associated firms; that employee followed the price-

[11]See Davis et al. (2003)

[12]Trading on their own account was risky for official market makers. Stock exchange officials constantly checked the order books; if a market maker held a stock inventory for more than one day, he was suspected of insider trading and had to pay a large fine.

[13]The price set by the auctioneer is described by Prion (1930) as "the price, which reflects demand and supply...the price, which, given the limits on the orders, maximizes the number of trades."

[14]These bounds were not officially established, but it was accepted that before WW I a 5–10 percent change was viewed as an upper bound on price swings. During the 1920s this bound was expanded to 15–20 percent.

setting process, ready to step in whenever order imbalances arose. In normal times he had the means to satisfy all orders without limits and to keep price fluctuations low. Trading then proceeded without major price effects and the market remained liquid.[15]

Traders were well aware of this special role, which banks fulfilled most of the time. Yet situations occurred where banks did not immediately provide liquidity. There are many reasons why a bank might decide against doing so. In most cases the bank merely required assurance that no major fundamental event was driving the order book imbalances. Until the bank was satisfied on that score, traders had to decide whether to follow its lead and thus, perhaps, miss an investment opportunity.[16]

Despite the overall goal to keep prices from fluctuating, order imbalances were not symmetric. Few stocks were listed as having excess supply, but excess demand was commonplace because "bankers do not like an excess supply quotation" (Wermert 1907: 636). Wermert (1907) also notes that a bank's objective was to achieve a "high quotation or the quotation of excess demand that at least the stock appears as demanded in the stock price list." In normal times, a bank would more than satisfy the supply side while taking the risk of unexpected large supply shocks.

The notion of supply order imbalances is my main measure of market illiquidity. When such imbalances existed, some traders were unable to sell at current market prices. If the imbalances were large enough, liquidity could even evaporate and leave traders unable to sell at any price. A connected bank could prevent such situations, but doing so required capital. In Section 1.4 I test whether this measure of a stock's liquidity deteriorated for firms associated with Danatbank after that bank experienced a large exogenous balance sheet shock that strongly affected the bank's intermediation capital. On 11 May 1931, Danatbank discovered that its biggest creditor was on the verge of bankruptcy. The bank did not disclose this information, but its balance sheet capacity and trading ability were thereby severely constrained.

[15] If banks were to maximize trading gains, a low price would be optimal. But as Lehmann (2011) shows, underwriter switching was not unusual and can be explained by a stock's post-IPO performance. If it maximized trading gains, the bank risked losing its connected firm and the future revenues from it equity offerings.

[16] "If the connected banker only buys little from a stock with excess supply...then the speculators, who normally always are on the look for an opportunity, do not dare to intervene immediately, even if they themselves think that prices are wrong. "*(Prion 1929)*

The Danatbank had grown in importance after its merger with the Nationalbank in 1920. It was now the main lender for several German municipalities and an active underwriter. Its CEO, Jacob Goldschmidt, sat on more than a hundred supervisory boards. He enjoyed the public spotlight, and he made the trading business a top priority when he took over as CEO. Newspaper comments on the Danatbank's active role in the stock market were frequent, and Goldschmidt himself commented on stock market issues in the bank's annual reports. On the corporate business side, the Danatbank's main client was the textile company Norddeutsche Wollkaemmerei und Kammgarnspinnerei, known as Nordwolle. This company was a family firm that had financed its expansion during the interwar period with huge credits from Danatbank. In 1931, Nordwolle had credit of 48 million Reichsmark (RM) outstanding with the bank, a sum that amounted to 80 percent of Danatbank's equity.[17]

During April 1931, Goldschmidt was alerted to the gradual withdrawal of money from German banks by foreign creditors (Ferguson and Temin 2001). If foreign withdrawals were to increase, then the liquidity of Nordwolle's credit would be crucial for Danatbank.[18] Bank employee Max Droehner therefore looked deeper into the books of Nordwolle. What was supposed to be a routine check brought disastrous news for Danatbank. Nordwolle had been falsifying its books since 1925. Most recently it had speculated on the rise of wool prices by purchasing a year's supply, after which wool prices fell. Nordwolle did not disclose the losses and it was on the edge of bankruptcy. Goldschmidt received this devastating news on 11 May 1931. A letter from Droehner confirms that Goldschmidt immediately saw the consequences of Nordwolle's likely bankruptcy: "Nordwolle goes down! Danat goes down! I go down!" That verbal response was the next day followed by a physical action. When the CEO of Nordwolle came to Danatbank's headquarters Goldschmidt threw a chair at him.[19]

Although angry and fearful, Goldschmidt hesitated to reveal his discovery.[20]

[17]For a more detailed description of the German banking crisis in 1931, see Born (1967).

[18]This suspicion turned out to be true. After the bankruptcy of Nordwolle in June 1931, Danatbank closed its offices at 12 July; that closing set in motion a run on other banks.

[19]A detailed description of these events is given in a letter from Droehner to Georg Solmssen, in 1931 a member of the board of directors of the Deutsche Bank and Disontgesellschaft; that letter is held at the Historical Archive Deutsche Bank, file "Georg Solmssen".

[20]That this information was not disclosed is documented in historical sources. The main source is the afore mentioned letter from Droehner to Solmssen. A second source is the commission set up in 1933 to investigate the banking crisis. Another source is my reading of several interregional

In his account of the events, Droehner stresses that Goldschmidt knew immediately the possible consequences if the bad Nordwolle news were to become public. Danatbank owned a huge package of Nordwolle stock and was also extremely susceptible to creditor withdrawals. To save Nordwolle and his own bank, "during the ensuing weeks, Goldschmidt sought desperately to find means of supporting Nordwolle and refused to inform either the Dresdner Bank or the Reichsbank of the situation" (Feldman 1995). The Danatbank committed its financial resources to saving Nordwolle (Feldman 1995); in particular, a large offer of seasoned equity (some 30 million RM) was planned, with Danatbank as a major buyer of the new stock.[21] If the information about Nordwolle were to become public, Goldschmidt wanted to maintain control of his bank's stock price and prevent it from dropping. The stock price was the predominant indicator of a bank's health and that of its creditors; a precipitous decline relative to other bank stocks would have led to rumors and possibly to revelation of the bank's and Nordwolle's problems. Goldschmidt was afraid to send any kind of negative signal to the market. After informing the managerial staff Danatbank's about the Nordwolle fraud, he immediately went to the Berlin Stock Exchange. Goldschmidt's intention was to assure that any panic sales by his colleagues would not be noticed. As an institution, Danatbank accumulated large sums of its own stock over the course of May and June. At the time of its bankruptcy, it owned more than half of its total stock.

This strong commitment of funds to one firm put severe constraints on Danatbank's trading ability. After 11 May 1931, the bank was unable to provide liquidity to stocks of all the other firms of which it was connected. Hence this episode provides a setting in which a major trader suffers a large and exogenous shock to its liquidity-providing capacity.

No direct evidence has survived that Danatbank restricted funds to its trading business after it found out about Nordwolle's problems. Even so the Danatbank reactions just described offer indirect evidence that the news about Nordwolle affected the bank's balance sheet and limited its market-making abilities. Furthermore, investment banking was a significant part of any large bank's business—but it was also the most liquid part and so, if money was urgently needed, then

newspapers, published during this time, in which no news can be found (during May) regarding possible losses at Nordwolle.

[21] In pre-WW II Germany it was common practice for an underwriter to purchase the entire equity offering; only after some time had elapsed would the underwriter start selling the new shares on the stock market. See Fohlin (2010).

this was the business section to supply it.[22] Other ways to finance the Danatbank's role as a liquidity provider can be ruled out. Today banks can finance their trading operations through an interbank market; however, this form of financing was not developed in interwar Germany, where most financing went through the Reichsbank. No evidence can be found of an increase in Danatbank's dealings with the Reichsbank, and neither did Danatbank ask other banks for help. Staring into the abyss in June and asked about the possibility of other banks stepping in, the proud Jacob Goldschmidt responded: "The people in the Mauerstrasse[23] would feel triumphant because they think that I am finished. I will not give them the satisfaction of this triumph."[24] Other banks would have been reluctant to help in any case. Even after the Danatbank's problems surfaced, no other bank offered to rescue it—a failure strongly criticized for example by the main banking union: "The central directorate highly disapproves that the other big banks were not willing to prevent the shortage of cash of the Danatbank and all the related miseries, even with a guarantee of the Reich."[25] I focus on the month of May and stress that the information on Nordwolle was not disclosed. That the the situation remained a secret rules out several scenarios. First, other banks could not step in and provide either credit lines to Danatbank or liquidity to the distressed stocks at the same price that Danatbank had before. The secrecy of Nordwolle's distress also rules out the possibility of other banks initiating predatory trading schemes (Brunnermeier and Pedersen 2005). With these channels shut down, I can reasonably attribute most of the findings reported here to the shock endured by Danatbank's balance sheet.

Goldschmidt did not succeed with his rescue. On 17 June, Nordwolle published a short note stating that it might face some losses in the near future. In the three weeks of June during which rumors about Danatbank were circulating,

[22]Between 1928 and 1930, German firms issued securities worth 2.87 billion RM that were intermediated by the five big banks in Berlin. In 1930, the investment banking division accounted for more than half of Danatbank's total revenue. The bank's heavy reliance on this business had its risks: in 1930, Danatbank had to write off stocks worth 10 million RM. In one of the first paragraphs in its annual report, the bank stated that "because of the development of the stock market the bank had to take large responsibilities to take care of the stock market, responsibilities we could not escape from."

[23]The Mauerstrasse was the street where the Deutsche Bank und Discontgesellschaft were located.

[24]Priester (1925), "Das Geheimnis des 13. Juli" p. 25

[25]"Letter of the Zentralvorstand des Allgemeinen Verbandes der Deutschen Bankangestellten, BAr R 43-I/646."

creditors withdrew 355 million RM. From this point forward, one can no longer assume that the information about Danatbank's distress was private.

Having supplied the historical background necessary for this case study, in the next section I describe the data used and the construction of a liquidity measure.

1.3 Data description

This study uses three main data sources: contemporary newspapers for stock market quotes; IPO prospectuses to establish the bank–firm connections; and contemporary books, stock trading manuals, and other archival sources for background information and anecdotal evidence.

The main data source for identifying the bank–firm connections are files from the *Reichskommissar bei der Berliner Börse*, which are held at the German Federal Archives.[26] Nearly 300 files of firms survived World War II; of these firms, 68 were still active in 1931.[27] A firm file contains all prospectuses from the initial public offering and later seasoned equity offerings. A prospectus gives information about the underwriting banks. I use this information to identify firm–bank connections, where a firm is considered to be connected to a bank if it had one or two large banks. This source yields only 14 firms connected to the Danatbank, so I employ a second source—bank annual reports—to augment the sample. From 1927 onward, all Berlin banks reported their underwriting activities of the previous year. If a firm had a public offering during the period 1927–1931, I connect it to Danatbank if that bank was the sole underwriter. This gives an additional 19 firms connected to Danatbank, resulting in a total sample of 87 firms (i.e., 33 connected and 54 not connected to Danatbank).[28] For most of the empirical analysis, bank–firm connections are used to sort stocks into liquidity–provider specific portfolios. Every stock in a given portfolio has a common underwriter

[26] The files are listed in BAr R 3103 *Abteilung H: Aktiengesellschaften*.

[27] On 3 February 1945, Berlin was attacked by nearly 1000 B-17 bombers of the Eighth Air Force. During this one and a half hour raid, led by Lieutenant-Colonel Robert Rosenthal, the Berlin Stock Exchange burned almost completely down.

[28] Manually entering stock price data for all firms also connected to other banks was not feasible, but all the results in this chapter still hold if I use only the smaller sample of firms that were identified via firm prospectuses. The larger sample offers the advantage of enabling comparisons when the sample is restricted to Danatbank–connected firms between such firms as regards their reaction to constrained liquidity provision.

bank and therefore a common liquidity provider on the Berlin Stock Exchange. Table 1.2 provides descriptive statistics of book values and dividends for 1930 by industry, which are taken from firms' balance sheets in 1930. Table 1.3 shows the number of firms connected to each of the five banks.

I use firms connected to the Danatbank as a treatment group and firms connected to other banks as a control group. Comparing these two subsets (Table 1.2) shows that firms of the former are slightly smaller in size, though the medians are not statistically different. Because the shock is induced by a firm in the textile industry, it is important that textile companies not be overrepresented in the treatment group. The whole sample includes six textile companies, only one of which is connected to the Danatbank. Firms are disproportionately located in Berlin (in comparison with other German cities), which is reflected in the sample: about one fourth of the firms are situated there. Of the Danatbank-connected firms in the sample, 26 percent are located in Berlin; 24 percent of the other firms are located there. The remaining sample firms are situated all over Germany, with small clusters in the mining area around the river Ruhr. This distribution indicated that the firms in the treatment group are not geographically clustered in such a way that would bias the results.

Daily stock market quotes are from the evening issues of the *Berliner Börsen Zeitung* between 1 November 1930 and 4 June 1931. In addition to prices, the *Berliner Börsen Zeitung* also provides data on order imbalances: each price is followed by a "tag" describing differences in demand and supply. Table 1.4 summarizes the meanings of these tags.

History dictates the sample's endpoint. Early in June 1931 Danatbank declined a credit to the city of Bremen, and on 5 June a Berlin newspaper published the first negative story about Danatbank. One day later, the newspaper was forced by Danatbank to publish a retraction, but rumors persisted. This situation may have affected the stock prices of firms connected to Danatbank. In order to clearly identify the impact of a shock on the bank's balance sheet, I limit my sample period to the time before 5 June 1931.

Crucial for the analysis is a measure of liquidity. Although there exists no perfect measure, widely used ones include bid–ask spreads, measures of price impact (e.g. Kyle's λ), and negative autocorrelation of returns. Unfortunately, neither bid–ask spreads nor volume data are available for the Berlin Stock Exchange during the period under study. Yet behind all measures of liquidity stands the following question: How hard it is to sell a stock at the current price? When there are large order book imbalances, some traders are unable to fulfill their trading needs. This information is provided by the tags appended to the price quotes in German newspapers. Specifically, the existence of supply order book imbalances at the established price tells us that some sellers were unable to unwind their positions. This conclusion accord with the results of Chordia et al. (2002), who find that "changes in liquidity are strongly associated with order imbalances." My main measure of illiquidity is therefore a dummy variable set equal to 1 if there existed supply order imbalances—that is, for prices tagged "b" or "bb"—and set equal to zero otherwise.

1.4 A funding liquidity shock and market illiquidity

This section shows the effects of Danatbank's constrained intermediation capital on market liquidity. The frequency of supply order imbalances significantly increased for stocks connected to the Danatbank during May 1931. A difference-in-differences framework provides more evidence that this relationship between constrained intermediation capital and market illiquidity is causal, after which I show that this finding is robust to a wide range of robustness checks.

1.4.1 Frequency of illiquidity

A first glance at the data reveals how the order book imbalances of firms connected to the Danatbank behaved over time and how this behavior compares with that of firms connected to other banks. In Table 1.5, stocks are sorted into portfolios whose constituents have the same liquidity provider; the table shows the percentage of supply and demand order imbalances for each portfolio. Before 11 May, the Danatbank portfolio actually had a slightly lower frequency of supply order imbalances than did the portfolios of other banks. To some extend, this difference reflects the importance that Danatbank CEO Jacob Goldschmidt assigned to the investment banking business. After 11 May, the frequency of illiquidity for the Danatbank portfolio nearly triples—rising from 6 percent to 23 percent—while the corresponding frequency for other banks' portfolios does not change significantly.[29] The Danatbank's frequency of demand order imbalances declines after that date from 45 to 21 percent. This decrease can be understood

[29] In this chapter I treat the terms "illiquidity", "excess supply", and "supply order imbalances" as synonyms and use them interchangeably

by recalling the quote of Wermert (1907) that "banks had a preference for excess demand." This preference is evidenced by the high frequency of excess demand before May between 21 and 45 percent. Note also that posting limit buy orders ran the risk of being picked off, and once Danatbank became wealth constrained it stopped taking that risk.

Although these descriptive statistics tell us that illiquidity increased on average during May 1931, they say nothing about the timing of that illiquidity. If different firms faced illiquidity at different times, then Danatbank's constraints were unlikely to be the underlying reason. But if insufficient funding liquidity did play a role, then commonality in liquidity should have increased and the stocks in the Danatbank portfolio should have become less liquid at about the same time. Figure 1.2 plots the proportion of illiquid stocks in the Danatbank portfolio as compared with the Deutsche Bank portfolio (plotted values are based on a three-day moving average). Although practically identical before May 1931, after that month the number of stocks becoming simultaneously illiquid is much higher for firms connected to Danatbank. This illiquidity was driven mainly by commonality after the Nordwolle–induced exogenous shock to Danatbank's balance sheet.[30]

1.4.2 Order imbalances and market illiquidity: Baseline results

An increase in illiquidity and commonality in illiquidty deliver the initial evidence suggesting that the Danatbank's constrained funding liquidity resulted in market illiquidity. In order to undertake a proper assessment of possible causality, I employ a difference-in-differences approach in which the treatment group consists of firms connected to Danatbank and the control group consists of all other firms. The question to be answered is this: Were the shares of firms connected to Danatbank more likely to experience supply imbalances because of that bank's liquidity constraints?

The baseline regression tests whether stocks of firms connected to Danatbank underwent changes in May 1931 as compared with (a) preceding months and (b) the stocks of other firms. Assuming a linear functional form, I estimate

[30]This conclusion holds also for daily frequencies and not only for three-day moving averages.

the regression

$$Imbalance_{it} = \beta_1 Danat_i + \beta_2 May_p + \beta_3 (May_p \times Danat_i) + \beta_4 X_{it} + \epsilon_{it} \quad (1.1)$$

Here $Imbalance_{it}$ is an indicator variable set equal to 1 if the stock of firm i has a supply order imbalance at time t (and zero otherwise). $Danat_i$ is a dummy for firms that are underwritten by no large bank(s) other than Danatbank. May_p is a dummy set to 1for the period $p = DuringMay$ (after 11 May) and to 0 for the period $p = BeforeMay$. We are mainly interested in β_3, the coefficient for the interaction between the two preceding variables. After corrections for several fixed effects, β_3 captures the variation in illiquidity of the Danatbank portfolio over time and across other portfolios. The matrix variable X includes firm-specific dummies, industry dummies and time dummies.

The main results are reported in Table 1.6. Qualitatively speaking, these results confirm the findings of the descriptive statistics: the Danatbank portfolio had a significantly higher probability of being illiquid during May 1931. The simple linear probability model predicts that, during May 1931, stocks connected to Danatbank were 15 percent more likely to have supply imbalances than stocks connected to other banks. In light of studies establishing that liquidity and liquidity risk are important pricing factors (Pastor and Stambaugh 2003, Acharya and Pedersen 2005), this amount of increase would have had significant pricing implications once it became known to the market.

These results are based on comparisons of two sets of firms: those connected to the Danatbank and those connected to other banks. Yet averaging over different liquidity providers may have biased the results. If other banks all behaved differently, then the respective effects may have cancelled each other out. To address this concern, I use the complete set of bank–firm connections and create bank-specific dummies for each of the five big banks. I then estimate the following linear model:

$$Imbalance_{it} = \beta_1 \times Bank_i' + \beta_2 May_p + \beta_3 \times (May_p \times Bank_i') + \beta_4 X_{it} + \epsilon_{it}, \quad (1.2)$$

where $Bank_i$ is a dummy row vector that includes the indicator variables for all five big banks. The coefficients of interest are within the vector β_3, which contains the interaction coefficients of the single banks:

$$\beta_3 = (\beta_3^{BHG}, \beta_3^{Commerz}, \beta_3^{Deu-Dis}, \beta_3^{Danat}, \beta_3^{Dresdner}) \quad (1.3)$$

. Our prior is that the probability of excess supply should increase for firms connected to Danatbank after 11 May and $\beta_3^{Danat} > 0$. Column (2) of Table 1.6 gives the results for the interaction terms; the other coefficients are omitted for clarity. In this linear model the point estimate is close to that from the simpler model estimated previously: the probability of imbalances increases by about 17 percent for a firm connected to Danatbank during May 1931. Controlling for firm fixed effects, industry fixed effects, and time fixed effects does not change the results; neither does clustering the standard errors across different groups.[31]

The results of the baseline regression are not affected by averaging over different liquidity providers. The same concern might arise along the time–series dimension, so we need to establish that May 1931 was the only exceptional month for the Danatbank portfolio. Towards this end, I perform a stringent test to see whether stocks connected to Danatabank behaved differently only when that bank was constrained. The baseline regression is given by

$$Imbalance_{it} = \beta_1 Bank_i + \beta_2 Month_p + \beta_3 (Month_p \times Bank_i) + \beta_4 X_{it} + \epsilon_{it} \quad (1.4)$$

Table 1.6 reports results for the case when $Bank = Danat$ and $Month = May$, but now I estimate this equation for every possible bank–month combination. The results of this placebo test are displayed in Figure 1.3, which plots the regression coefficient β_3 for each of the possible regressions and shows (on the x-axis) which month was used as the placebo period. In only 6 out of the 35 possible regressions was the interaction's coefficient significantly different from zero. More importantly, two coefficients stand out. When the regression is performed using Danatbank firms during either May or June, the coefficients are not only significantly different from zero but also significantly larger than all other coefficients in this placebo test.

1.4.3 Order imbalances and illiquidity: Extensions

The baseline results have established a causal link between Danatbank's reduced funding liquidity and a decrease in market liquidity. This section discusses the

[31] Because we consider only five banks, it is not feasible to cluster the standard errors at the bank level. Yet firms in the Danatbank portfolio were not clustered geographically or within a given industry, which addresses some of the concerns that make clustering at the bank level desirable.

robustness of these results to non-linear regression models, firm size, information on firm fundamentals, and other factors. It provides a more detailed look at the illiquidity of the Danatbank portfolio and shows which of its constituent stocks inside the portfolio are mainly responsible for the observed illiquidity.

The first concern about the robustness of the results is the assumption of a linear model. Although easy to interpret, a linear model has its shortcomings; in particular, a linear model restricts the parameter estimates because it is not bounded between 0 and 1. Nonlinear models can circumvent this problem. Most of the variation in the dependent variable is captured by variation across time, which suggests a fixed–effects logit setup. The results, reported in Table 1.7, are qualitatively the same as those derived from the linear probability model. Taking a logit model without fixed effects, the predicted probability of a supply imbalance before May 1931 is 6 percent for a firm connected to Danatbank before May 1931. However, that probability increases by 15 percentage points (to 21 percent) during May 1931, which is similar to the results from the simple frequency counts. When this model is used to evaluate other firms during May 1931, the predicted probability is only 11 percent. Thus, firms connected to the Danatbank have a much greater likelihood of experiencing imbalances in May 1931 when compared with the previous months and also when compared with other firms during May 1931.

Column (2) of Table 1.7 shows the results from logit estimations of the interaction model.[32] The average marginal effect for the interaction term, 20 percent, is even larger than the one under the simple model. If fixed effects are excluded, the predicted probability of a supply imbalance for a Danatbank firm is 5.8 percent—a value close to that obtained under the previous model. The probability increases almost threefold, by 16 percentage points, during May. We can compare this increase to that for a firm connected to the Deutsche Bank. For such a firms, the predicted probability is 10 percent before May. During May, this probability increases by just a single percentage point, an increase that is not statistically different from zero. Thus the richer framework does not alter the conclusion derived from the baseline model: illiquidity of Danatbank–connected firms surged during May 1931.

A further concern for the robustness of the results is firm size. The Danatbank portfolio includes relatively smaller firms, which are known to be riskier

[32]Estimating a fixed–effects logit model comes at the cost of assuming serial independence of the dependent variable when it is conditioned on the regressors.

and more volatile; hence the results might be driven by an increase in the volatility of small–firm shares during May 1931. To deal with this concern, I group the stocks into ten size classes according to their book value. I then estimate both the linear probability model and the logit model while including dummies for each size class. Each size dummy is also interacted with the indicator variable for May 1931. The results are given in column (3) of Table 1.6 and Table 1.7 for the linear and non-linear model, respectively. These results are not driven by differences between small and large firms and the previous conclusions still hold.

Firms differ not only in size but also in the number of their underwriting banks. Several firms had two or more large underwriting banks. Even though the lead underwriter had the most responsibility, the other banks also participated in the unofficial market making. I use these observations to strengthen further the finding of illiquidity for Danatbank–connected firms. When the Danatbank was unable to provide liquidity, stocks of firms with an additional underwriter should have exhibited a smaller increase (or none at all) in market illiquidity. To test this hypothesis, I restrict the sample to firms for which Danatbank was one of the main underwriting banks. Table 1.8 reports the results for a regression of imbalances on a dummy set equal to one only if the Danatbank was the sole underwriter and on the interaction of this dummy with the May dummy (Column 1). Column (2) reports a similar regression in which the dummy variable is set to 1 if a firm had two or three large underwriting banks. Column (3) reports all effects jointly. During May 1931, order imbalances increased only for cases where the Danatbank was the only underwriter; if a firm had one or two additional underwriting banks, the effect vanished. That is, other underwriters were still able to provide market–making services. These results shed light on which firms within the Danatbank portfolio drive the previously reported findings—namely, those firms that were most closely connected to Danatbank.

Brunnermeier and Pedersen (2009) provide further theoretical support for the claim that illiquidity does not affect all stocks alike. In their model, more volatile stocks are more illiquid than less volatile stocks. The reason is that providing liquidity for more volatile stocks requires more capital because the imbalances of more volatile firms are likely to be larger and more frequent. In times of capital shortage, liquidity providers might therefore prefer to concentrate on providing liquidity for less volatile stocks; Brunnermeier and Pedersen (2009) and others call this phenomenon a "flight to quality". In order to test this prediction, I estimate the conditional variance for each stock using a Garch(1,1) model. Using the average before May 1931 of the estimated variances, I separate the stocks into quartiles. Table 1.11 reports the results of a fixed–effects regression of supply imbalances on the May dummy—performed for each variance quartile separately. In Panel A of this table the sample is restricted to firms connected to Danatbank. The coefficients are increasing over the variance quartiles, and stocks with a higher average variance were more likely to experience illiquidity during May 1931. Neglecting the first (insignificant) coefficient, a simple t-test confirms that the May dummy coefficient for the fourth quartile is significantly different from the coefficients for the second and third quartile. This effect is not evident for firms connected to other banks (Panel B).

The main results have thus been shown to be robust as regards firm size. I have demonstrated that only the Danatbank that are different and that illiquidity surges only in May. Despite these findings, it is still possible the results are driven by shocks to fundamentals of the firms connected the Danatbank. One main identifying assumption is that the exogenous shock to Danatbank was unknown to other market participants during May 1931. Bad news about Danatbank could influence investors' outlook about firms connected to the bank, since those firms could find it more difficult to obtain credit from that bank in the future. It is well established among historians that the shock to Danatbank's balance sheet was initially a well-kept secret; however, it is still necessary to rule out the possible effects of firm-specific news, rumors, and speculations must be ruled out. Contemporary newspapers provide at least anecdotal evidence that firm news is not driving the results. Figure 1.4 shows an accumulated monthly news count for Danatbank firms for the period February–May 1931. News items are counted in the national newspaper *Vossische Zeitung*.[33] No significant difference between May and other months is observed.

No newspaper or weekly publication ran any story on the Danatbank itself during the period in question, and the Danatbank's share price also indicates that the Nordwolle-induced shock was unknown to the public. Figure 1.5 plots the share prices of all Berlin big banks before and during May 1931. Owing to the fall of the Oesterreichische Credit-Anstalt and some foreign withdrawals, bank stocks as a group trended downward in May. But all prices moved in lockstep

[33] Although the news count is performed on only one newspaper, the resulting graph is representative of other leading national newspapers such as the *Frankfurter Zeitung*, the *Berliner Börsen Zeitung* and the *Berliner Börsen Courier*.

and, in the eyes of the market, the Danatbank was no different than other banks. Note that the Danatbank returns are not significantly different from the returns of other banks. Furthermore, Ferguson and Temin (2001) examine bank balance sheets and argue that deposit outflows were no cause for concern even during May. Early summer 1931 was a turbulent period in Germany. Although Danatbank was the focus of the banking crisis that emerged in June, during May 1931 it was not receiving any special attention.

Absent firm–specific news, fire sales by Danatbank itself could have been the source of the order imbalances. A huge literature on asset fire sales indicates that a distressed trader might sell his assets at depressed prices.[34] Did the Danatbank sell stocks from its own portfolio, thus making the bank itself the source of the order imbalances? Unfortunately, detailed portfolio data before the 1931 bank crisis is not available. After 1931, the *Deutsche Revisionsgesellschaft* examined Danatbank more closely, providing a detailed list of the portfolio as of December 1931. One third of the firms connected to the Danatbank were still in the portfolio and so, for two-thirds of the stocks, the possibility of fire sales cannot be ruled out with certainty. Nevertheless, the following tests suggest that fire sales are not the main cause of the order imbalances.

Accounting standards gave banks ample room to choose which stock price to report in their balance sheets. If a stock price was higher than the nominal value, banks could at most value the stock at its nominal value. But if a price was lower than the nominal value, banks could opt for the lower value or any other price up to the nominal value. Banks normally accounted stocks at their nominal value and devalued them only in extreme cases (as in 1932, after all stocks had severely fallen in value during the second half of 1931). If a bank sold assets below their nominal value, its balance sheet declined. Inspecting the monthly balance sheets of Danatbank establishes that the equity position hardly changed during the first half of 1931.

Assuming that assets were booked at their nominal value, Danatbank should have sold any assets with prices above their nominal value because doing so would have improved their balance sheet position. Conversely, sales of assets at prices below their nominal value would have resulted in balance sheet deterioration. A distressed trader does not want to send such a signal to the market. Given these suppositions, we can test indirectly for the occurrence of fire sales by checking for whether assets priced above their fundamental value exhibited

[34] For a recent review of the literature on fire sales, see Shleifer and Vishny (2011).

greater imbalances than did other assets in the Danatbank portfolio. For this test, the sample is restricted to stocks connected to Danatbank. I create a firm–specific dummy set to 1 if the price on 1 November 1930 is greater than the nominal value; the regression results are reported in column (1) of Table 1.9. The interaction term with the May dummy shows that stocks with higher prices were less likely to see imbalances during the period of financial distress. This result holds also when the price at the beginning of the sample is directly interacted with the May dummy (Column 2). Hence there were nor fire sales of the stocks Danatbank most likely would have sold first.

Moreover, Danatbank's 1930 annual report stresses the bank's reluctance to sell assets at prices below nominal value:"The unusually strong decline at the stock market...prohibited the liquidation of a big part of ongoing transactions."

In view of these indirect test and anecdotal evidence, it is doubtful that fire sales originating with Danatbank were the main drivers of the observed supply imbalances. Order imbalances seem rather to have been driven by demand-side considerations (i.e., funding liquidity). The next section addresses the behavior of asset returns during these times of market illiquidity.

1.5 Funding liquidity and price reversals

Illiquidity is of substantial interest because of its possible asset pricing implications (see, e.g., Acharya and Pedersen (2005)). This section therefore examines asset price behavior during the period of Danatbank's constrained intermediation capital. Section 1.5.1 describes the behavior of prices and return volatility of firms connected to the Danatbank and compares this behavior with that of other firms. In Section 5.2 I show that the returns on stocks in the Danatbank portfolio exhibited a high degree of co–movement. Section 5.3 assesses return predictability and demonstrates that when Danatbank was constrained, returns became predictable after days of order imbalances; this is when V-shaped price patterns emerged. Finally, Section 5.4 describes an investment strategy for investing in illiquid stocks. I show that if restricted to Danatbank–connected firms this strategy would have yielded substantial returns during May 1931.

1.5.1 Prices and volatility

When prices deviate from fundamentals and rebound, volatility increases. This dynamic increases the uncertainty of investors and renders liquidity risk a main pricing factor (Acharya and Pedersen 2005). After describing the average stock price behavior, this section establishes that—in response to increased market illiquidity, stocks connected to the Danatbank became more volatile during May 1931.

Figure 1.6 displays price indices for two portfolios. One portfolio consists of Danatbank–connected firms; the other portfolio consists of firms connected to other banks. After being normalized to unity as of 11 May, both indices show the same movements. These price indices add to the evidence that the bad news about Nordwolle and Danatbank was unknown at this time. However, an important aspect of prices is not clearly visible in the graph. Whereas the average daily returns during May of stocks within the two portfolios was the same (0.07 percent), the standard deviation differed significantly. For the portfolio of non–Danatbank firms it increased from 0.029 before May to 0.033 during May. In contrast, the standard deviation of returns for the portfolio of Danatbank firms increased from 0.029 to 0.041 during the same time span. Yet it is not only the volatility of the overall portfolio returns that changes; a more important and meaningful statistic is the volatility of returns for a single firm. I therefore calculate the standard deviation for each firm during the periods before May and during May and then compare the averages of Danatbank–connected firms versus other firms. Prior to May, the average standard deviation of daily returns was 0.026 for Danatbank firms and 0.028 for other firms. During May,however, this statistic increases to 0.035 for Danatbank firms but to only 0.029 for other firms.

This volatility is portrayed in more detail by Figure 1.7, which plots the average firm-specific variance calculated within a ten-day rolling window. The variance is calculated for each firm separately, after which averages are taken across the two sets of firms. The graph shows that the return variance of Danatbank–connected and other firms is similar during most of the sample period. But when the Danatbank is liquidity constrained, the return variance of its connected firms spikes. This sudden increase in short-run volatility is in sharp contrast to papers that look at supply pressure. In papers of index deletions or mutual fund redemptions, prices show V-shaped price patterns in the medium run; prices decline and rebound within several months. However, in the short-run prices do not fluctuate as they do in this historical case study.

1.5.2 Co-movement of returns and the flight to quality

Before moving to the average price behavior of single stocks, this part takes a closer look at how returns co-move. Several empirical studies have shown that, in times of illiquidity, returns co-move across assets and sometimes even across asset classes (Chordia et al. 2000, Chordia et al. 2002, Coughenour and Saad 2004). These findings can be explained via the introduction of a wealth-constrained liquidity provider (Brunnermeier and Pedersen 2009). If the same trader provides liquidity to several assets, they will all be affected by a binding wealth-constraint.

To test for co-movement of stock prices, I estimate firm–specific time–series regressions of excess returns on bank-portfolio returns:

$$r_{i,t} = \alpha + \beta \sum_{j=N_b, j \neq i} r_{j,t} + \epsilon_{i,t} \tag{1.5}$$

Here $r_{i,t}$ is the excess return of stock i at time t, and N_b is the set of all firms connected to bank b.[35] After obtaining the firm–specific values of β, I calculate the mean across all firms connected to each bank. Table 1.10 reports the average β–values for two separate periods—namely, before and after 11 May 1931. Stocks connected to Danatbank co-move more so in May than before, a sign of commonality with respect to liquidity. This effect is not present for stocks connected to other banks.

1.5.3 Return reversals and V-shaped price patterns

The literature on slow–moving capital revolves around the question of why capital sometimes seems reluctant to move immediately to investment opportunities. Empirical studies describe this slow movement of capital in terms of a V-shaped price pattern: prices decline, only to revert after some time (Mitchell et al. 2007). Reversals can occur within minutes, as with the so–called Flash Crash of May 2010, or prices can take months to bounce back (Coval and Stafford 2007, Mitchell et al. 2007, Mitchell and Pulvino 2012).[36] This section establishes that V-shaped price patterns were present in the historical case investigated

[35] See appendix for the calculation of excess returns.

[36] 6 May 2010, the S&P 500 declined 6 percent within six minutes; it regained its previous level in less than half an hour.

here. During May 1931, returns of Danatbank firms showed (on average) significant return reversals after days of illiquidity. Order imbalances allowed returns of Danatbank firms to be predictable . That predictability was not possible before May.

Figure 1.8 shows that, in general, imbalances cannot predict returns. The figure plots the predicted returns after market illiquidity by regressing excess returns r_{it} on a set of lags of the dummy for imbalances; it also shows the parameter estimates and the confidence intervals from the predictive regression. Returns from providing liquidity after supply imbalances are not significantly different from zero. The same conclusion can be drawn for firms not connected to the Danatbank before and after 11 May 1931; this is confirmed by the lower two graphs in Figure 1.9. After a day with a supply imbalance, prices declined and the subsequent (small) increase is not statistically different from zero. Although some reversals are present in the data, a distinct V-shaped price pattern cannot be found. The situation is different, however, for the case of Danatbank-connected firms (upper two graphs in Figure 1.9). The returns to liquidity provision for these firms are similar to other stocks before 11 May. Yet after that date the returns suddenly became predictable: they reversed significantly after a day of supply imbalances. Thus prices exhibited, on average, a V-shaped pattern. The shock to the Danatbank's funding liquidity therefore had important pricing implications. Specifically, a trader could expect on average a daily return of almost 2.5 percent (assuming no trading costs) by purchasing shares of a firm connected to Danatbank after an imbalance was reported.

This predictability persists when the regressions are refined. I estimate the following equation:

$$r_{it} = \alpha + \beta_1(Imbalance_{t-j} \times Danat_i \times May_t) + \beta_2 X_{it} + \epsilon_{it} \qquad (1.6)$$

The term $(Imbalance_{t-j} \times Danat_i \times May_t)$ is the interaction of the supply order imbalance dummy with the Danatbank and the May dummy; it includes several lags. Here X_{it} is a vector that includes all other interactions of the three dummies and also the dummies as single variables. The question is : Are returns are significantly different for firms connected to the Danatbank after a day of order imbalances? Column (1) of Table 1.12 reports the results. Lagged excess supply predicts significantly negative returns for all stocks. During May, only the stocks of firms connected to Danatbank have more strongly negative returns, which are reversed later on.

So far, I have shown the effects only of supply–side order imbalances. Column (2) of Table 1.12 reports the predictive regression with excess demand interactions. Unlike the case of supply imbalances, information on demand imbalances cannot be used to predict returns.

1.5.4 Investing in illiquidity: A contrarian trading strategy

An immediate question that arises from the predictability of returns is how much an investor could have earned by providing liquidity to stocks associated with the Danatbank. Nagel (2012) shows that a contrarian long–short strategy would have yielded high returns during the long-term capital management crisis of 1998 and around the time of the breakdown of Lehman Brothers in 2008. Nagel (2012) argues that a contrarian trading strategy is the natural equivalent of market–making activities, and the returns to such a strategy can be viewed as returns to providing liquidity.[37] This section shows that May 1931 delivered high excess returns to a trader that followed such a strategy.

I construct an "Illiquidity" investment strategy as follows. Buy all stocks one day after a supply imbalance is noted and hold them for one day. The portfolio weight of a single stock is related to the price behavior directly after excess supply was present. The greater the decline in price, the higher the positive weight in the portfolio. Following Nagel (2012), the weight w_{it} for stock i at day t is given by

$$w_{it} = -\frac{(R_{i,t}|t-1 : \text{Imbalance})}{(\sum_i |(R_{i,t}|t-1 : \text{Imbalance})|} \tag{1.7}$$

Given a supply imbalance, the strategy will go long on a stock after its price declined. The weight is increasing in the absolute size of the price decline.[38]

Figure 1.10 shows the daily returns and accumulated returns to this strategy for all stocks during the time of the sample. Using the whole sample, the strategy has a mean daily return of minus 0.0013 and a standard deviation of 0.0287. Overall, following such a strategy was not the best investment advice: between

[37] Lehmann (1990) and Lo and MacKinlay (1990) have shown that a contrarian trading strategy delivers positive excess returns.

[38] Constructing a weight that depends on the price on day t is feasible because the price discussion was public before the final price was set. Yet when calculating returns to this strategy, I assume that the contrarian trader who follows it has no price impact—in other words, that trader is not the marginal buyer action drives the price up.

November 1930 and June 1931, an investor would have lost about 30 percent of his initial investment. When return reversals occurred for Danatbank firms, I showed that on average a daily return of 2.5 percent could be obtained. Following the “Illiquidity” investment strategy, such daily returns would be rare. Spikes are larger on the downside, so an investor would most likely have lost money following this kind of strategy.

Figure 1.11 shows the cumulative returns to a more refined version of this investment strategy. Cumulative returns are plotted only for May 1931, and the strategy is now limited to stocks connected to a given liquidity provider. For most bank-specific portfolios, accumulated returns during May are small. But an investor who restricted himself to Danatbank–connected stocks would have made large gains. Following the “Illiquidity” strategy in May and investing only in stocks connected to Danatbank, an investor would have enjoyed a return in excess of 50 percent during a single month.

Given these huge returns and several episodes of price reversals, it is noteworthy that traders failed to deduce that Danatbank was in trouble. However, it was not unusual for banks to refrain from smoothing order imbalances. There were situations before May 1931 where a bank did not provide immediate liquidity, and a number of reasons could explain that behavior. In such cases, “speculators do not always dare to intervene, even if they think the price is not correct” (Prion 1929). Return reversals sometimes occurred for other stocks and also before May 1931. On average, however, returns did not reverse. Therefore, the “Illiquidity” investment strategy will usually deliver negative returns. The situation is different for stocks connected to the Danatbank in May 1931 because many more cases of return reversals can be observed. To show this, I look at those episodes where stocks exhibited supply imbalances and prices declined afterwards; then I group stocks according to the size of their initial price decline. Figure 1.12 shows box plots of the returns over the two days following such a price decline for each group. All panels show that, after price declines, price reversals did occur. However, in three of the figure’s four panels, prices did not reverse on average. Thus a general “Illiquidity” investment strategy yields negative returns. For firms connected to the Danatbank during May 1931, price reversals were much more common. For price decline’s of less than 1 percent, prices always rebounded. For price declines of up to 5 percent, prices rebounded in about half of the cases.

In sum: this section showed has established that, on average, more supply order imbalances existed for firms connected to the constrained liquidity provider. During times of illiquidity in May 1931, there were significant price reversals. The next section provides a model to rationalize these findings.

1.6 A theory of noise trader risk and banks as liquidity providers

The historical case study shows that a constrained liquidity provider led to greater order book imbalances; prices responded with V-shaped price patterns. While the case study shows the causal influence of funding liquidity on market liquidity, it does not show how banks' market–making service interacted other variables—their own informational trading, and the effect on price volatility and price impact. Based on Kyle (1989), this section therefore describes a static model of asymmetric information and strategic traders. This provides guidance on the effects of the institutional setup in interwar Germany and rationalizes the empirical findings. In the model, better informed banks trade a risky asset with uninformed traders. Asset supply is random, since noise traders are present. This presence allows banks to hide part of their informational advantage. A bank demands a risky asset for two reasons: informational trading and market–making. A bank receives an informative signal about the asset's future dividend before it submits its demand schedule. With this information, a bank makes its informational trading decision. But a bank also trades for market–making reasons. It is able to extract the noise trading component from prices and intervenes in the market by adding own noise. However, this noise is negatively correlated to noise traders' demand. This intervention is intended to smooth price fluctuations due to noise trading. Over a range of reasonable parameter values, this results in a lower price volatility. However, banks restrict their information-based trading since they take on more demand for market making reasons. Furthermore, the noise component in prices decreases, making banks less able to hide their informational advantage. Information–driven trading decreases further. Examining the reaction of uninformed investors, one can notice that they react less to movements in prices when banks make markets. Prices reflect less noise; a price decrease is more likely to come from bad news about fundamentals. Price impact of noise shocks is higher as compared to a situation where banks do not make markets. Nevertheless, in normal times banks can effectively counter-balance supply from noise traders and total noise is small. Yet when a bank cannot intervene in the market, noise trading is not reduced and prices react strongly. Prices are more likely to decrease because of supply shocks, and in repeated trading rounds this effect will vanish and give rise to V-shaped price patterns. The next section describes the model formally. Following the setup, expectation formation is characterized and I provide the definition of the equilibrium in the model. Section 1.6.3 then shows a numerical example of the behavior of price impact and price volatility and relates the model to the historical case study of the Danatbank in 1931.

1.6.1 Setup

The model consists of two periods. There are i informed bankers, o other, uninformed, traders, and noise traders that trade a risky and a risk–less asset in the first period. The risk–less asset pays interest r, normalized to one. The risky asset pays an uncertain dividend d in the second period. d is normally distributed with mean $\overline{d}$ and variance $(\tau_d)^{-1}$. In the first period, trading takes place by a unit price auction. Bankers and traders submit complete demand schedules which depend on their respective information. Noise traders submit aggregate random demand u with $u \sim N(0, \tau_u^{-1})$. The price p of the risky asset is set such that the market clears.

Bankers have a close connection to the firm that issued the risky asset. This gives them an informational advantage. Before they choose their trading, they observe a signal s about the dividend: $s = d + \epsilon$, where $\epsilon \sim N(0, \tau_\epsilon^{-1})$. Each banker observes the same signal. The close firm–connection introduces the market–making role of bankers (Dang et al. (2013) provide a theoretical reasoning why it can be welfare enhancing that banks with private information try to keep their information secret). While bankers have their own speculative demand (the optimal solution to their utility maximization problem), they commit themselves to decrease the impact of noise trading on prices. This service leads to a market–making demand, which is exogenously given by αz. z follows a normal distribution with $N(0, \tau_z^{-1})$. However, the added noise by the bank is negatively correlated with noise trader demand u and the correlation is given by the correlation coefficient ρ_{uz}.

Given the signal s and the additional market making demand, one can conjecture a linear demand function x_i for banker i, which is the sum of the speculative demand x_i^{spec} and the market making demand x_i^{mm}:

$$x_i = x_i^{spec} + x_i^{mm} \tag{1.8}$$
$$= as + b_i - c_i p + \alpha z \tag{1.9}$$

Each banker uses his private signal about the dividend, but takes into account that he has market power and his own trading moves the price against him.

Uninformed traders do not observe the informative signal s. Nevertheless, before submitting a demand schedule x_o, an uninformed trader o observes the price and bases his best estimate of d on the market price p. For an uninformed trader o the conjectured demand function is

$$x_o = b_o - c_o p \tag{1.10}$$

Uninformed traders base their demand only on the price signal, but they also take their market power into account.

All traders submit their demand schedules and the market clearing condition is given by

$$i(x_i^{spec} + x_i^{mm}) + ox_o + u = 0 \tag{1.11}$$

Using the conjectured linear demand functions, the market clearing condition can be solved for the market clearing price. The trading mechanism is a unit price auction, where all stocks are traded at the same price. This price is given by

$$p = \lambda(ias + ib_i + ob_o + u + i\alpha z) \tag{1.12}$$

where $\lambda = (ic_i + oc_o)^{-1}$. λ is a measure of price impact: The greater λ the more do prices react to noise trader demand.

All investors maximize second period utility according to a CARA utility function. Bankers have risk aversion ρ_i and uninformed speculators have risk aversion ρ_o. Investors derive utility from the gains from trading $\pi_m = (d-p)x_m$ and the problem of investor m is

$$\max_{x_m} E_m(-e^{-\rho_m \pi_m}) \tag{1.13}$$
$$\Rightarrow \max_{x_m} E_m(d-p)x_m - \frac{1}{2}\rho_m Var_m(\pi_m) \tag{1.14}$$

All moments are conditional on investor m's information set. The second line follows because prices and dividends are normally distributed and

$$E_m(-e^{-\rho\pi_m}) = -e^{\rho_m E_m(\pi_m) - \frac{1}{2}\rho_m Var_m(\pi_m)} \tag{1.15}$$

The original optimization problem is equivalent to maximizing the last expression in the stated problem. As shown by Kyle (1989), investors face a residual supply curve and the optimal solution to their problem takes the form

$$x_i = \frac{E_i(d) - p}{\lambda_i + \rho_i Var_i(d)} \tag{1.16}$$

$$x_o = \frac{E_o(d) - p}{\lambda_o + \rho_o Var_o(d)} \tag{1.17}$$

where $\lambda_i = ((i-1)c_i + oc_o)^{-1}$ and $\lambda_o = (ic_c + (o-1)c_o)^{-1}$. When trading, each trader takes his price impact into account. Because the market's microstructure is a unit price auction, the marginal increase in the price due to a trader's demand increases the price of all stocks for this trader. As a result, investors react less aggressively to price fluctuations or new information. Apart from restricting trading due to market power (λ_m), an investor trades less if he is more risk averse or if the conditional price variance is higher. To complete the description of the model, the next section describes the formation of expectations and provides a definition of the equilibrium.

1.6.2 Expectations and equilibrium

Before observing signals or prices, all traders have the prior expectation that dividends will be equal to $\overline{d}$. Informed bankers observe a signal s and will update their prior belief about the dividend d. Using Bayes rule, their optimal forecast of d and the conditional variance are given by

$$E_i(d|s) = \overline{d} + \frac{\tau_\epsilon}{\tau_\epsilon + \tau_d}(s - \overline{d}) \tag{1.18}$$

$$Var_i(d|s) = (\tau_\epsilon + \tau_d)^{-1} \tag{1.19}$$

Uninformed traders do not observe a private signal, but are able to observe the price. They will condition their estimate of d on this noisy signal. The price p is informationally equivalent to the variable $\tilde{p}$:

$$\tilde{p} = \frac{1}{ia}(p\lambda^{-1} - ib_i - ob_o) \tag{1.20}$$

$$= d + \epsilon + \frac{1}{ia}(u + i\alpha z) \tag{1.21}$$

We can use this equivalence to derive the conditional moments, because $E_o(d|p) = E_o(d|\tilde{p})$ and $Var_o(d|p) = Var_o(d|\tilde{p})$. The conditional variance is the inverse of the precision of the prior, τ_d, and the precision of the price signal, $\tau_{\tilde{p}}$. Using this, the conditional moments are given by

$$E_o(d|p) = \frac{\tau_{\tilde{p}}}{\tau_d}\tilde{p} + (1 - \frac{\tau_{\tilde{p}}}{\tau_d})\overline{d} \tag{1.22}$$

$$Var_o(d|p) = (\tau_d + \tau_{\tilde{p}})^{-1} \tag{1.23}$$

The precision of the price signal is given by

$$\tau_{\tilde{p}} = \tau_\epsilon \frac{i^2 a^2 \tau_u}{i^2 a^2 \tau_u + \tau_\epsilon(1+\gamma)} \tag{1.24}$$

with $\gamma = i^2\tau_u\alpha(\alpha\tau_z^{-1} + \frac{2}{i}\rho_{uz}(\sqrt{\tau_u\tau_z})^{-1})$. For the remainder of the section, I will denote by $E_m(x)$ the expectation of x conditional on trader m's information set.

The unconditional price variance is given by

$$Var(p) = \lambda^2 i^2 a^2(\tau_d^{-1} + \tau_\epsilon^{-1}) + \lambda^2(\tau_u^{-1} + \alpha^2\tau_z^{-1} + 2\alpha\rho_{uz}(\sqrt{\tau_u\tau_z})^{-1}) \tag{1.25}$$

Having described the optimization problem of traders and their optimal expectation formation, we can now define an equilibrium in this trading game. The equilibrium concept is that of a symmetric linear Bayesian equilibrium. Kyle (1989) states the conditions for existence of such an equilibrium in this model of rational expectations with imperfect competition.

Definition 1 *A symmetric linear Bayesian equilibrium is a set of demands $x_i(s,p)$ and $x_o(p)$ and a price function $p(s,u,z)$ such that*

1. *Traders optimize:*

$$x_i(s,p) \in \arg\max_{x_i} E_i(U(\pi_i))$$
$$x_o(p) \in \arg\max_{x_o} E_o(U(\pi_o))$$

2. *Markets clear:*

$$ix_i(s,p) + ox_o(p) + i\alpha z + u = 0$$

The definition of an equilibrium, the optimal demand functions, and the price function derived from the market clearing condition, allows us to verify the conjecture of the linear demand functions. The following proposition together with the conditional moments, the price function, the demand functions, and with the system of equations for the coefficients provides a complete description of the equilibrium.

Proposition 1 *In equilibrium, the price function is given by* $p = \lambda(bas + ib_i + ob_o + u + i\alpha z)$ *and the linear demand functions are given by* $x_i = as + b_i - c_i p + \alpha z$ *and* $x_o = b_o - c_o p$.

The coefficients are the solution to the following system of equations:

$$a = \left(\frac{\tau_\epsilon}{\tau_d + \tau_\epsilon}\right)\left(\frac{1}{(\lambda_i + \rho_i(\tau_d + \tau_\epsilon)^{-1})}\right) \tag{1.26}$$

$$b_i = \overline{d}\left(1 - \frac{\tau_\epsilon}{\tau_d + \tau_\epsilon}\right)\left(\frac{1}{(\lambda_i + \rho_i(\tau_d + \tau_\epsilon)^{-1})}\right) \tag{1.27}$$

$$c_i = \left(\frac{1}{(\lambda_i + \rho_i(\tau_d + \tau_\epsilon)^{-1})}\right) \tag{1.28}$$

$$b_o = \left(\overline{d}\left(1 - \frac{\tau_{\tilde{p}}}{\tau_d + \tau_{\tilde{p}}}\right) - \frac{\tau_{\tilde{p}}}{\tau_d + \tau_{\tilde{p}}}(ib_i + ob_o)\frac{1}{ia}\right)\left(\frac{1}{\lambda_o + \rho_o(\tau_d + \tau\tilde{p})^{-1}}\right) \tag{1.29}$$

$$c_o = \left(1 - \frac{\tau_{\tilde{p}}}{\lambda(\tau_d + \tau_{\tilde{p}})}\right)\left(\frac{1}{\lambda_o + \rho_o(\tau_d + \tau\tilde{p})^{-1}}\right) \tag{1.30}$$

The conditional moments are given by

$$E_i(d|s) = \overline{d} + \frac{\tau_\epsilon}{\tau_\epsilon + \tau_d}(s - \overline{d}) \tag{1.31}$$

$$Var_b(d|s) = (\tau_\epsilon + \tau_d)^{-1} \tag{1.32}$$

$$E_o(d|p) = \frac{\tau_{\tilde{p}}}{\tau_d}\tilde{p} + (1 - \frac{\tau_{\tilde{p}}}{\tau_d})\overline{d} \tag{1.33}$$

$$Var_u(d|p) = (\tau_d + \tau_{\tilde{p}})^{-1} \tag{1.34}$$

and the precision of the price signal is given by

$$\tau_{\tilde{p}} = \tau_\epsilon \frac{i^2 a^2 \tau_u}{i^2 a^2 \tau_u + \tau_\epsilon(1 + \gamma)} \tag{1.35}$$

and $\gamma = i^2\tau_u\alpha(\alpha\tau_z^{-1} + \frac{2}{i}\rho_{uz}(\sqrt{\tau_u\tau_z})^{-1})$.
A complete analytical solution of the system is rather involved. The next section will provide the intuition using numerical solutions.

1.6.3 Price volatility and price impact

This section shows how price impact and market volatility change when banks not only trade on their information, but also provide liquidity–services. I look at the case of a monopolistic informed trader and set $i = 1$.
Two important parameters influence a bank's decision to trade for informational reasons. ρ_z determines the correlation between a bank's market making demand and noise trading. α determines how strongly a bank reacts to noise trading. When a bank adds additional noise to the market, the effect on a bank's informational trading (and therefore the informativeness of prices) may be ambiguous. When the additional noise is negatively correlated with u and decreases overall noise $(u - \alpha z)$, a better informed bank is less able to hide its private information since less noise is reflected in prices. This restricts a bank's informational trading. However, if the correlation is low or the bank's reaction to noise trading is very strong, overall noise in the market increases due to the bank's market–making service. In this case, the bank can hide behind noise and trades more aggressive. Whether a bank's market–making demand increases or decreases informational trading depends therefore on the combination of α and ρ_z. How strong uninformed investors react to movements in prices also depends on the overall level of noise in the market. When a bank's market–making activity effectively decreases overall noise and price volatility, price fluctuations are more likely to reflect changes in fundamentals; uninformed traders will react less to fluctuations in prices. It is more risky to take on additional stocks and uninformed investors must be compensated by higher expected returns.

The interplay of these effect on price volatility and price impact can be seen in Figure 1.13. The figure plots price volatility and price impact in equilibrium as functions of α. The functions are plotted for different values of ρ_z, and the left panel shows price volatility as a function of α, the right panel shows price impact as a function of α. The bank is better able to decrease volatility for a large range of its taste parameter α if the negative correlation between u and z is stronger. But this decreases its incentives to trade on the basis of private information. The bank decreases its informational demand and uninformed traders react less to fluctuations in the price—the price impact of noise trading increases. In normal times, however, fluctuations due to noise trading are still low because overall noise, the difference between u and αz, is small. A problem arises if a bank is suddenly unable to provide its market–making services. In this case ,z is equal to zero, and a noise shock hits the market in its full size because liquidity provision is absent. As a result, prices react strongly. Other market participants are unaware of the real reason why banking demand is so low and attribute most of the price decline to a decline in fundamentals. Prices have to fall strongly since traders need to be compensated for the increase in risk with high expected returns.

What do these results mean in light of the German stock market before WW II? The decrease in price volatility rationalizes the findings of DeLong et al. (1990). Unlike the US market, excess volatility was not present on the German stock market. DeLong et al. (1990) already speculated that the low volatility is related to the banks' role in trading. The model shows that for a reasonable range of parameters, banks were able to provide liquidity to noise traders; they could reduce volatility because they were better informed. Yet this increased the price impact of noise shocks, and when a bank is suddenly unable to counteract noise trading, this effect becomes relevant. The shock to Danatbank's funding liquidity was such a situation. The model predicts that during the period when Danatbank is unable to provide marke–making services, price impact and price volatility are high. It can rationalize why Danatbank–connected stocks were more illiquid during May 1931. Prices awere mainly driven by noise trading, but for other investors to buy them, expected returns had to increase. In a repeated trading game, V-shaped price patterns were more likely to occur.

1.7 Conclusion

Although V-shaped price patterns came into the spotlight during the recent financial crisis, they are hardly novel. One explanation for the slow–movement of capital is limited funding liquidity. That hypothesis is difficult to test in today's markets, but this chapter provides a historical case study where a large, exogenous shock to a liquidity provider's balance sheet can be cleanly identified. Furthermore, in this particular context the role of liquidity providers is clearly assigned. One of them, the Danatbank, faced a major shock to its capacity to provide liquidity. I show that this shock directly affected the market liquidity of the stocks of firms connected to Danatbank. During the period of constrained intermediation capital, these stocks were highly likely to experience supply order book imbalances, and it is around these times that we observe V-shaped price patterns. The findings are rationalized by a model, which follows Kyle (1989), where informed traders exploit their informational advantage. Such traders also provide market–making services for a specific stock and thereby reduce the noise that prices reflect. At the same time price impact increases. When the market–making function cannot be performed, the effect of noise trading on prices increases and leads to sharp price declines.

The study provides a clear example of funding illiquidity causing market illiquidity. Of course, today's markets are different from the Berlin Stock Exchange during the interwar period. The rise of algorithmic trading, the emergence of several trading venues, and other differences limit the applicability of this study's quantitative results to the present. Even so, this chapter contributes to the discussion of whether funding liquidity is important for asset pricing by showing that such liquidity did matter in an institutional setting with universal banks and a well–developed stock exchange. The research reported here supplements the suggestive evidence from today's markets and provides further support for the view that liquidity providers' balance sheets can influence asset markets.

The study speaks also to the current debate over the dangers of universal banking. The Danatbank experienced a balance sheet shock because a creditor was in distress. Although not related to the bank's trading business, this shock led to illiquidity and price fluctuations on the stock market. Nowadays, JP Morgan Chase's CEO Jamie Dimon wants his bank to be "like Wal-Mart", [39] and Bank of America's CEO Brian Moynihan believes that universal banking is the "most important model there is because it gives consumers access to global information, capital markets, investment advice, and basic banking activities all in one place."[40] Neither CEO addresses the risks of these "financial supermarkets." The arguments in favor of the Glass-Steagall Act were based on conflicts of interest (Kroszner and Rajan 1994). When commercial banks are involved in securities trading, their financial advice might be driven by prospects of high profits for the investment department. As Glass-Steagall eroded, discussion about the dangers of universal banks was conspicuously absent. However, the recent financial crisis

[39] "America's Least Hated Banker." New York Times,1 December 2010

[40] Forbes.com (21 May 2012)

has brought it back to life. Reports on banking reform by Sir John Vickers[41] and Erkki Liikanen[42] suggest “ring-fencing” the deposit taking business of a universal bank. Others, like former Bank of England Governor Mervin King, go one step further. They advocate breaking up investment banking and deposit banking. The experience of Danatbank is one example of these concerns. This chapter shows that the arguments in favor of universal banking come with certain risks attached. Economies of scope and diversification are useful only as long as cash flows remains relatively uncorrelated. In the German stock market, banks traded actively in stocks of connected firms; hence payoffs from the investment business and corporate credit business were highly correlated. Private information is also often advanced as an argument in favor of large financial intermediaries. In the context in this chapter, private information enables the bank to reduce price volatility. Yet the presence of information asymmetries increases the price effect and restrains the activities of uninformed traders. This dynamic calls into question whether universal banking is actually welfare improving. Note also that the mixture of deposit taking, mortgage business, corporate loan business, and investment banking entails more risk that a bank’s funding liquidity will be constrained. A bank’s balance sheet can deteriorate for myriad reasons, any of which can lead to asset price fluctuations.

[41] *Independent Commission on Banking: Final Report* (September 2011)

[42] *High-Level Expert Group on Possible Reforms to the Structure of the EU Banking Sector* (October 2012)

1.8 Tables and Figures

Table 1.1: **A dealer's order book.** This table provides an example of a dealer's order book and the possibility of bank intervention. The previous day's price was 100. Maximizing volume, the price would drop to 90, still leaving a supply order imbalance at this price. Newspapers would quote a price of 90 and the existence of excess supply. A bank could step in between 90 and 100 to prevent a sharp price drop and eliminate order imbalances.

Price	Bid	Offer	Imbalance
w/o limit	5	50	45
100	10		35
90	15		20
50	20		0

Table 1.2: **Sample balancedness.** This table gives summary statistics and an overview of the composition of the sample. The sample is divided in two groups: firms connected to the Danatbank (Danat firms) and firms connected to other banks (Other firms). For each industry, the tables provides the number and percentage of firms within a group, and the median total book value. For firms in the finance industry, book values are not available. The differences in median book value are tested for statistical significance using a Wilcoxon rank sum test. None of the tests shows statistically significant differences between the two groups.

	Danat firms	Other firms	Difference
		Manufacturing	
No .of firms	19	37	-18
% in group sample	57.58	68.52	-10.94
Median book value (Mio RM)	34.1	52.4	-18.3
		Mining	
No. of firms	6	10	-4
% in group sample	18.18	18.52	-0.34
Median book value (Mio RM)	83.8	56.1	27.7
		Utilities	
No. of firms	4	5	-1
% in group sample	12.12	9.26	2.86
Median book value (Mio RM)	44.2	79.3	-35.1
		Finance	
No. of firms	4	0	4
% in group sample	12.12	0	12.12
Median book value (Mio RM)	n.a.	n.a.	
		Geographical location	
No. of firms located in Berlin	9	13	-4
% in group sample	26	24	2

Table 1.3: **Number of bank-firm connections.** This table provides an overview of how many firms in the sample are matched to one of the five big banks located in Berlin. A firm is connected to a bank when the latest equity issue before 1930 was done by this bank. A firm-bank connection is only established when the firm had at most two big underwriting banks. The big underwriting banks are the Berliner Handels Gesellschaft (BHG), Commerzbank (Commerz), Deutsche Bank und Discontogesellschaft (Deu-Dis), Darmstaedter und Nationalbank (Danatbank), and Dresdner Bank (Dresdner). Data to establish firm-bank connections comes from firm prospectuses and annual reports held at the German Federal Archives.

	BHG	Commerz	Deu-Dis	Danat	Dresdner
Firms	6	5	25	33	6

Table 1.4: **Price tags about order imbalances.** This table provides an overview of the possible price tags about order imbalances. The official stock price list printed in newspapers reported whether supply or demand order imbalances existed after the stock price had been set by the official market maker.

Abbreviation	Explanation
bz	no imbalances between demand and supply
bz B	supply was higher than demand
bz G	demand was higher than supply
B	supply was much higher than demand
G	demand was much higher than supply

Table 1.5: **Market illiquidity: Frequency of order book imbalances.** This table provides the average percentage of stocks having supply or demand order imbalances for a given bank-portfolio. A bank-portfolio consists of firms connected to the bank. Averages are taken over all firms and the time period between 1 November 1930 and 11 May 1931 (Before May 11) and between 11 May 1931 and 4 June 1931 (After May 11). Supply (demand) order imbalance is measured by a dummy which is one if the stock price list indicates supply (demand) order imbalances.

	Supply order imbalance		Demand order imbalance	
	Before May 11	After May 11	Before May 11	After May 11
BHG	0.09	0.11	0.21	0.14
Commerz	0.13	0.13	0.38	0.35
Deu-Dis	0.10	0.15	0.31	0.30
Danat	0.06	0.23	0.45	0.28
Dresdner	0.10	0.16	0.29	0.33

Table 1.6: **Baseline results.** This table provides the results for OLS regressions of the imbalance dummy as dependent variable on a set of dummy variables. The regression for the linear model is

$$Imbalance_{it} = \beta_1 \times Bank_i' + \beta_2 \times May_p + \beta_3 \times (May_p \times Bank_i') + \beta_4 X_{it} + \epsilon_{it}$$

$Imbalance_{it}$ is a dummy set to 1 if firm i has a supply order imbalance at day t and set to 0 otherwise. $Bank_i$ is a row vector including all bank dummies. In the specifications in Column (1), $Bank_i = Danat_i$, which is an indicator variable equal to 1 if firm i is connected to the Danatbank. In the other specifications, $Bank_i$ includes dummies for all five big banks. May_p is a dummy set to 1 after 11 May. The dummy varies over the periods $p \in \{BeforeMay, DuringMay\}$. The coefficients of interest are within the vector β_3. For the specification in column one, $\beta_3 = \beta_3^{Danat}$. For all other specifications $\beta_3 = (\beta_3^{BHG}, \beta_3^{Commerz}, \beta_3^{Deu-Dis}, \beta_3^{Danat}, \beta_3^{Dresdner})$. All standard errors are clustered at the firm level.

	(1)	(2)	(3)
May$\times Danat$	0.158***	0.167***	0.181***
	(0.0438)	(0.0470)	(0.0507)
May$\times BHG$		-0.0147	-0.0162
		(0.0319)	(0.0394)
May$\times Commerz$		-0.00133	-0.0131
		(0.0423)	(0.0553)
May$\times DeuDis$		0.0227	0.0300
		(0.0380)	(0.0386)
May$\times Dresdner$		0.0342	0.0410
		(0.0449)	(0.0441)
Time FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Size			Yes
Size$\times May$			Yes
N	15138	15138	15138
R^2	0.128	0.128	0.130

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Table 1.7: **Logit results.** This table provides the results for logit regressions of the imbalance dummy on a set of dummy variables. The dependent variable of the logit model is $Imbalance_{it}$, a dummy set to 1 if firm i has a supply order imbalance at day t. Independent variables are $Bank_i$, a dummy row vector including bank dummies. In the specification in Column (1), $Bank_i = Danat_i$, which is a dummy equal to 1 if firm i is connected to the Danatbank. In the other specifications, $Bank_i$ includes dummies for all five big banks. May_p is a dummy that is one after 11 May. The dummy varies over the periods $p \in \{BeforeMay, DuringMay\}$. The coefficients of interest are within the vector β_3. For the specification in column one, $\beta_3 = \beta_3^{Danat}$. For all other specifications $\beta_3 = (\beta_3^{BHG}, \beta_3^{Commerz}, \beta_3^{Deu-Dis}, \beta_3^{Danat}, \beta_3^{Dresdner})$. The same variable description applies for the non-linear regression results. All standard errors are clustered at the firm level.

	(1)	(2)	(3)
May$\times Danat$	1.662***	1.887***	2.029***
	(0.327)	(0.472)	(0.494)
May$\times BHG$		-0.269	-0.314
		(0.223)	(0.313)
May$\times Commerz$		0.0581	0.0172
		(0.470)	(0.485)
May$\times DeuDis$		0.472	0.501
		(0.443)	(0.466)
May$\times Dresdner$		0.180	0.219
		(0.367)	(0.391)
Time FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Size			Yes
Size$\times May$			Yes
N	14616	14616	14616
Pseudo R^2	0.158	0.159	0.159

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Table 1.8: **Danat-firms: Single underwriter vs. additional underwriters.** This table provides OLS results for regressions using the imbalance dummy as dependent variable:

$$Imbalance_{it} = \beta_1 OnlyDanat_i + \beta_2 May_p + \beta_3(May_p \times OnlyDanat_i) + \beta_4 X_{it} + \epsilon_{it}$$

$Imbalance_{it}$ is a dummy set to 1 if firm i has a supply order imbalance at day t. In Column (1), the dummy $OnlyDanat_i$ is equal to 1 if the Danatbank is the single underwriter of a given firm and is equal to 0 otherwise. Column (2) shows the results of the same regression, but using the variable $Danat+other_i$ instead of $OnlyDanat_i$ as explanatory variable. The variable $Danat+other$ is 1 if the Danatbank is part of an underwriter team of two or three big banks. All standard errors are clustered on the firm level.

	(1)	(2)	(3)
May$\times OnlyDanat$	0.166***		0.167***
	(0.0227)		(0.0289)
OnlyDanat	0.0173		0.0172
	(0.0260)		(0.0261)
May	-0.00886	0.109*	-0.00969
	(0.0626)	(0.0637)	(0.0665)
May$\times Danat + Other$		-0.117***	0.00140
		(0.0220)	(0.0275)
Danat+other		-0.0224	-0.000144
		(0.0259)	(0.0228)
N	9396	9396	9396
R^2	0.101	0.095	0.101

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Table 1.9: **Danat-firms: Imbalances and initial price level.** This table provides the results of OLS regressions of the imbalance dummy as dependent variable on price variables at the beginning of the sample:

$$Imbalance_{it} = \beta_1 Pricevar_i + \beta_2 May_p + \beta_3 (May_p \times Pricevar_i)$$

$Imbalance_{it}$ is a dummy set to 1 if firm i has a supply order imbalance at day t, $Pricevar_i$ is either the variable *Price above nom. value* or the variable *Price at* t_0. The variable *Price above nom. value* is a dummy equal to 1 if a firm had a price at the beginning of the sample that was above 100 percent and equal to 0 otherwise. The variable *Price at* t_0 is the price at the beginning of the sample. The sample is restricted to firms connected to the Danatbank. All standard errors are clustered on the firm level.

	(1)	(2)
Price above nom. value	0.0138*	
	(0.00752)	
May×(Price above nom. value)	-0.133*	
	(0.0727)	
May	0.151	0.227*
	(0.118)	(0.130)
Price at t_0		-0.00145***
		(0.0000520)
May×(Price at t_0)		-0.00131**
		(0.000503)
N	5742	5742
R^2	0.150	0.155

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Table 1.10: **Return co-movement.** This table provides the average β of firm-specific regressions of supply imbalances on bank-portfolio returns:

$$r_{it}^{exc} = \alpha + \beta r_{bt}^{exc}$$

r_{it}^{exc} are excess returns of firm i at time t and r_{bt}^{exc} are the excess returns of all other stocks connected to the same liquidity provider at day t. This regression is done for all firms i separately. All regressions are done for each firm once using the sample before 11 May 1931 and once using the sample after 11 May 1931. β's are then averaged across all firms connected to the same liquidity provider.

	β (Before May 11)	β (After May 11)
BHG	0.708	0.768
Commerz	0.595	0.362
Deu-Dis	0.934	0.815
Danat	0.774	0.983
All (except Danat)	0.964	0.917

Table 1.11: **Imbalances across variance quartiles.** This table provides the results for the following regression using the imbalance dummy as dependent variable:

$$Imbalance_{it} = \beta_1 May_p + \beta_2 X_{it} + \epsilon_{it}$$

$Imbalance_{it}$ is a dummy set to 1 if firm i has a supply order imbalance at day t. May_p is a dummy equal to 1 after 11 May. The dummy varies over the periods $p \in \{BeforeMay, DuringMay\}$. The sample changes across the columns: For each stock, the variance up to May 1931 is calculated using a Garch(1,1) model and taking the average over the conditional variances. Stocks are then sorted into quartiles according to their average conditional variance. Panel A provides the results for firms connected to the Danatbank, Panel B for other banks.

	(1) First quantile	(2) Second quantile	(3) Third quantile	(4) Fourth quantile
Panel A: Firms connected to the Danatbank				
May	0.154	0.0991**	0.101	0.319**
	(0.0885)	(0.0345)	(0.0555)	(0.102)
Constant	0.0434***	0.0329***	0.0585***	0.104***
	(0.00915)	(0.00357)	(0.00574)	(0.0106)
N	1566	1392	1392	1392
R^2	0.048	0.022	0.016	0.083
Panel B: Firms connected to other banks				
May	-0.00290	0.0166	0.0704**	-0.0460
	(0.0320)	(0.0274)	(0.0273)	(0.0567)
Constant	0.0902***	0.0646***	0.0884***	0.166***
	(0.00331)	(0.00283)	(0.00282)	(0.00587)
N	2436	2262	2436	2262
R^2	0.000	0.000	0.005	0.002

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Table 1.12: **Return predictions.** This table presents the results for predictive return regressions of excess returns as dependent variable on a liquidity provider dummy, May dummy, various lags of the supply or demand order imbalance dummy, and the interactions:

$$r_{it}^{exc} = \beta_1 Danat_i + \sum_{s=t-4}^{t-1} (\beta_{2,s}(Imbalance.X_{i,s}) + \beta_{3,s}(Imbalance.X_{i,s} \times Danat_i \times May_p)) + \beta_4 \times May_p$$

r_{it}^{exc} is the excess return of firm i at day t, $Danat_i$ is a dummy that is 1 if firm i is connected to the Danatbank, and May_t is 1 after 11 May. The dummy varies over the periods $p \in \{BeforeMay, DuringMay\}$. $Imbalance.X$ is a dummy for order imbalances, where X is equal to supply in the first specification and X is equal to demand in the second specification. For better readability not all coefficients are reported.

	(1)	(2)
	X=Supply	X=Demand
Imbalance.X$\times May \times Danat(t-1)$	-0.0191	0.0117
	(0.0207)	(0.0130)
Imbalance.X$\times May \times Danat(t-2)$	0.0249	-0.0156
	(0.0159)	(0.0122)
Imbalance.X$\times May \times Danat(t-3)$	0.0196	-0.00790
	(0.0190)	(0.0137)
Imbalance.X$\times May \times Danat(t-4)$	-0.0266*	0.00883
	(0.0155)	(0.0110)
Imbalance.X (t-1)	-0.00314	0.00572***
	(0.00236)	(0.00146)
Imbalance.X (t-2)	0.00135	-0.00160
	(0.00254)	(0.00137)
Imbalance.X (t-3)	-0.00172	0.000104
	(0.00220)	(0.00141)
Imbalance.X (t-4)	0.00152	-0.00224
	(0.00236)	(0.00141)
N	3639	3639
R^2	0.009	0.013

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Figure 1.2: **Order imbalances: Deutsche Bank vs. Danatbank firms.** This graph plots the average percentage of stocks with supply order imbalances for the current and the last two days between 1 November 1930 and 1 June 1931. Stocks are either from firms connected to the Deutsche Bank or firms connected to the Danatbank. The vertical line represents 11 May 1931.

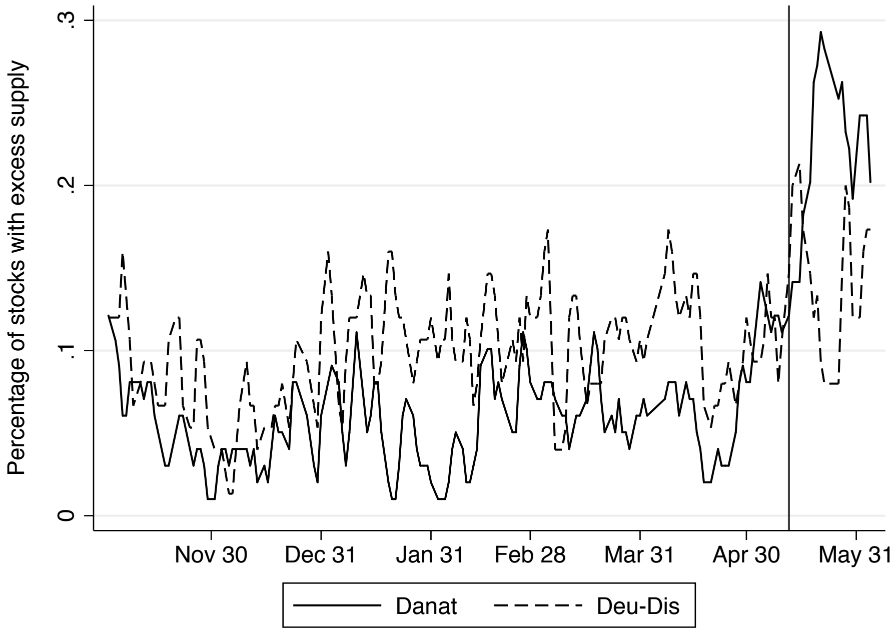


Figure 1.3: **Order imbalances: Placebo test.** This graph plots the coefficient of the interaction term of the following regressions:

$$Imbalance_{it} = \beta_1 Bank_i + \beta_2 Month_p + \beta_3 (Month_p \times Bank_i) + \beta_4 X_{it} + \epsilon_{it}$$

$Imbalance_{it}$ is a dummy that is 1 if firm i has a supply order imbalance at day t. $Bank_i$ is a dummy that is 1 if firm i is connected to the specific $Bank$. May_p is a dummy that is 1 after 11 May. The dummy varies over the periods $p \in \{BeforeMay, DuringMay\}$. The regression is performed for each combination of $Month \in \{Nov1930, \ldots, May1931\}$ and $Bank \in \{BHG, Commerz, Deu-Dis, Danat, Dresdner\}$. The graph plots β_3 for each bank–month combination.

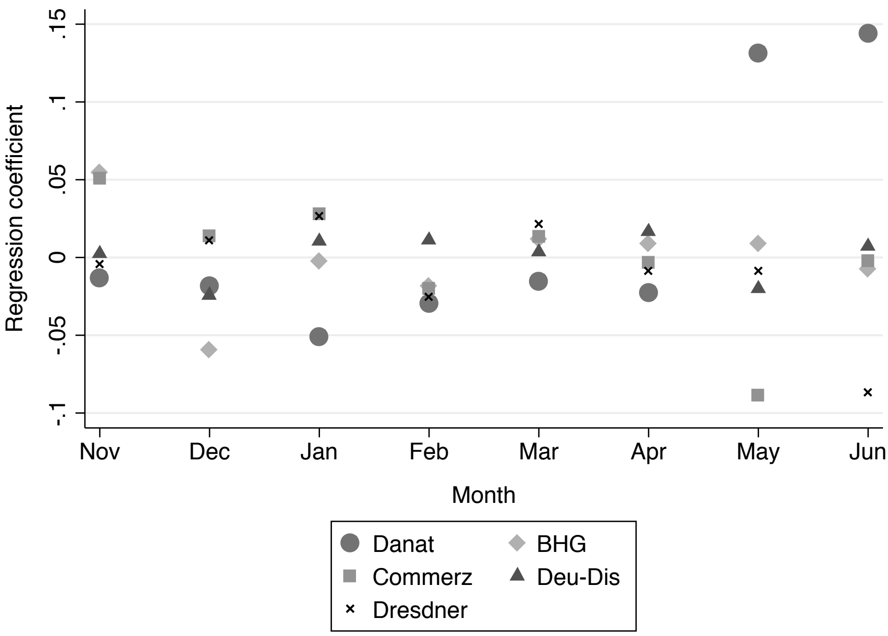


Figure 1.4: **News about Danatbank-firms.** This graph plots a news count for Danatbank–connected firms during a given month, performed using the *Vossische Zeitung*. The number of news items is shown as a ratio over the total number of Danatbank–firms in the sample.

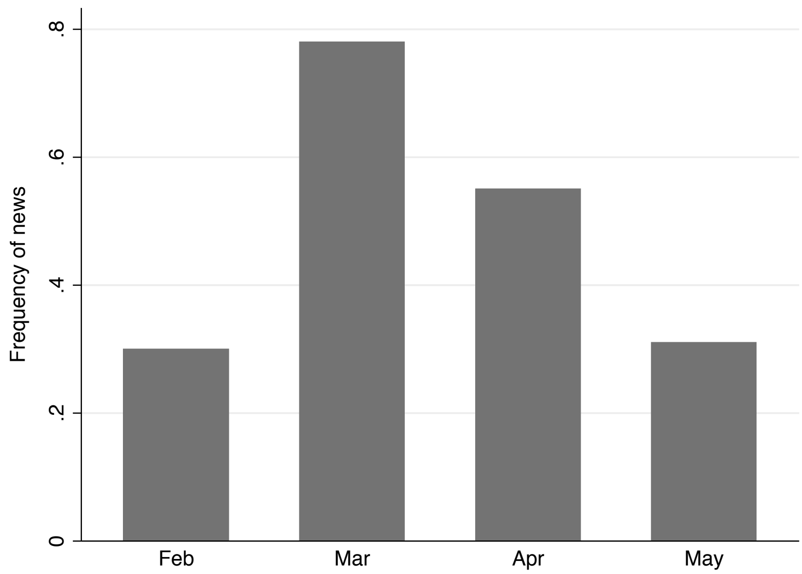


Figure 1.5: **Banks' stock prices.** This graph shows the evolution of the stock prices of the big Berlin banks between 1 February 1931–4 June 1931. Stock prices are normalized to 100 at 11 May 1931. Data is taken from the official stock price list published daily in the *Berliner Boersen Zeitung*. The vertical line represents 11 May 1931.

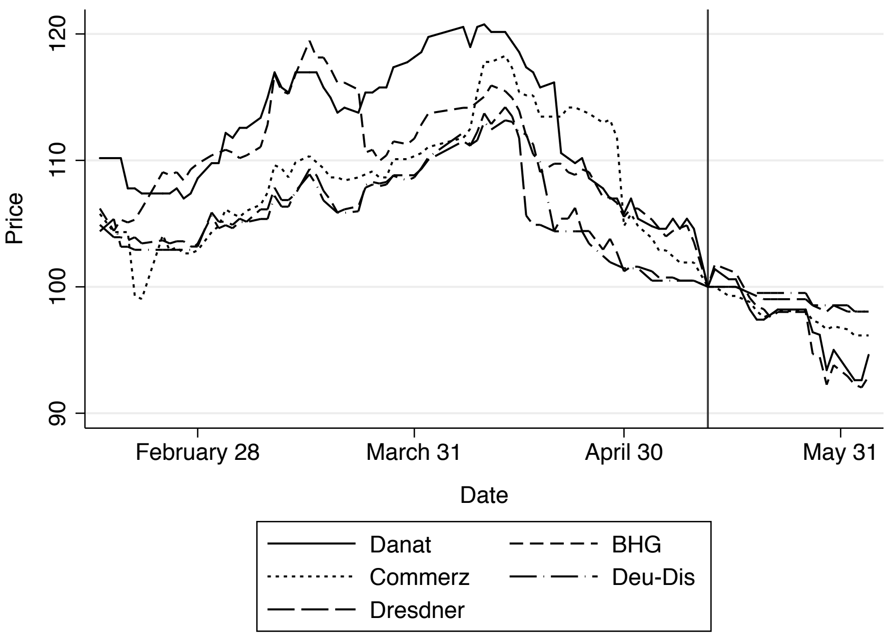


Figure 1.6: **Price indices.** This graph shows price indices for a portfolio of Danatbank firms and a portfolio of other firms. Daily portfolio returns are calculated as the average return across firms. The indices are normalized to 100 at 11 May 1931. The vertical line represents this date.

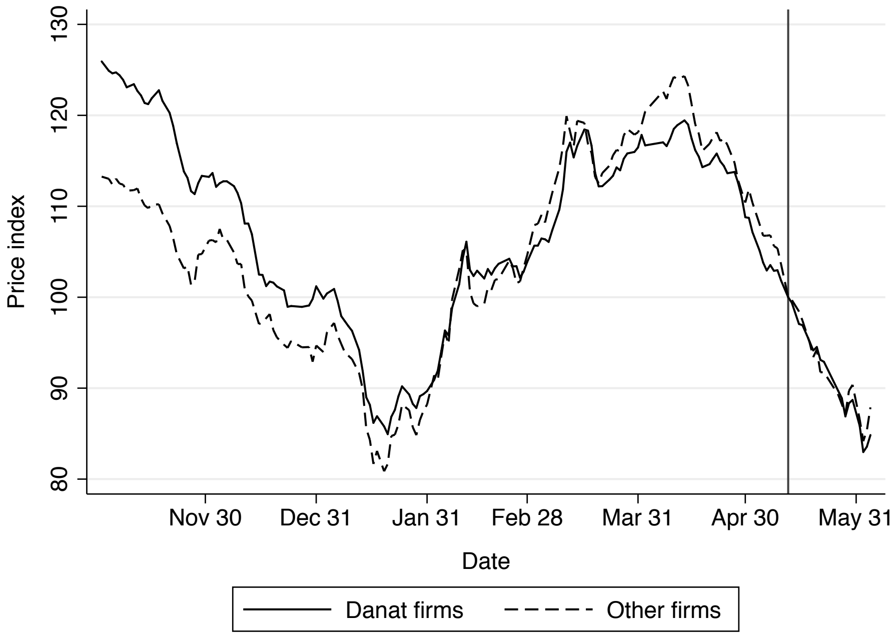


Figure 1.7: **Volatility.** This graph plots the average variance of firm-specific returns for firms connected to the Danatbank and for other firms. For each firm, the variances are calculated using a ten day rolling window. Then averages taken across firms, once across firms connected to the Danatbank and once across other firms. Values for a specific day refer to the center of the 10-day window. The vertical line represents 11 May 1931.

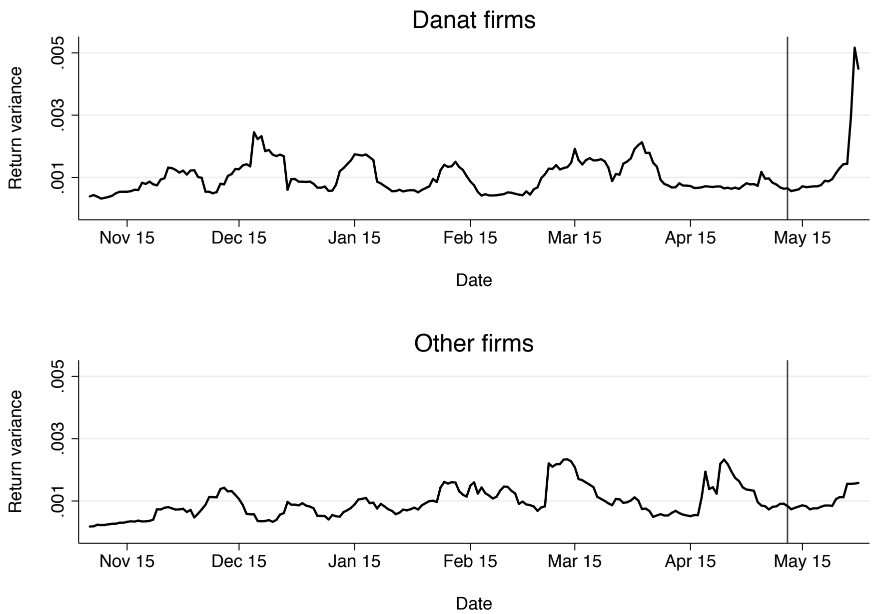


Figure 1.8: **Expected returns after order imbalances: General case.** This graph plots the coefficients from a regression of excess returns on several lags of the supply order imbalance dummy together with a 90 percent confidence interval.

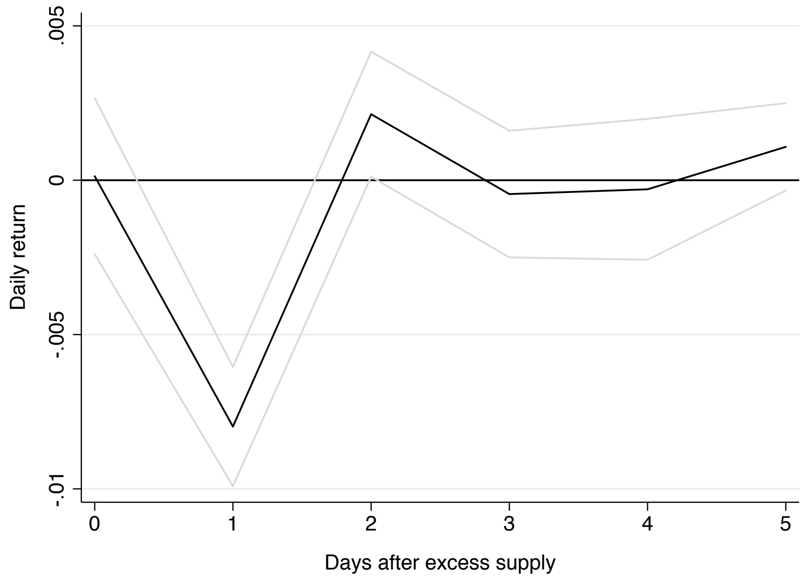


Figure 1.9: **Expected returns after order imbalances: Danatbank firms and other firms.** This graph plots the coefficients from a regression of excess returns on several lags of the supply order imbalance dummy together with a 90 percent confidence interval. The sample is split in firms connected to the Danatbank (upper panels) and firms connected to other liquidity providers (lower panels). For each sample, expected returns are shown for the period before May (1 November 1930–10 May 1931) and after 11 May (11 May 1931–4 June 1931).

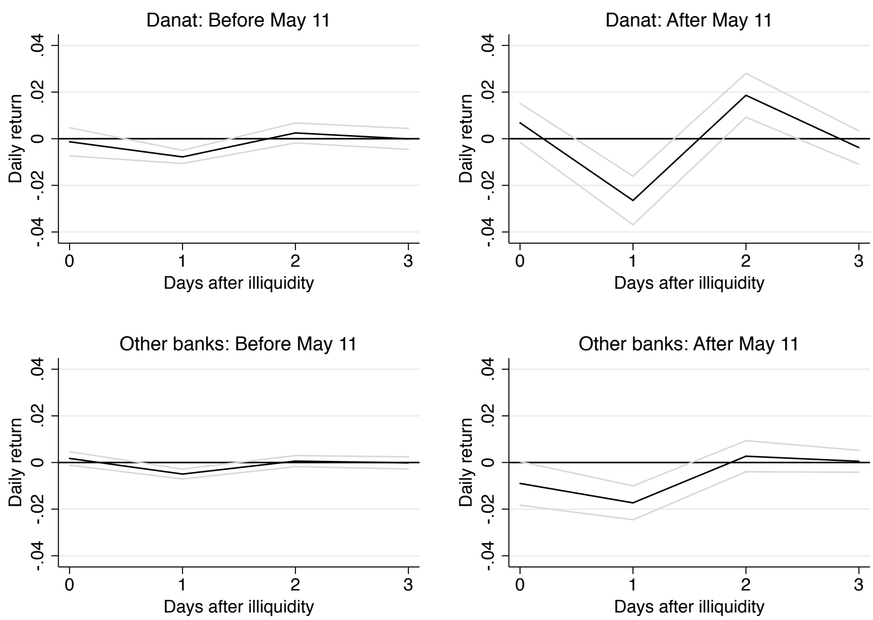


Figure 1.10: **Investing in illiquid stocks: Daily returns.** This figure plots the daily returns to a strategy that invests in stocks that saw a supply order imbalance the previous day. The weight of the stock in the daily portfolio is proportional to the decrease or increase in the stock: The larger the price change, the larger the weight of the stock in the portfolio.

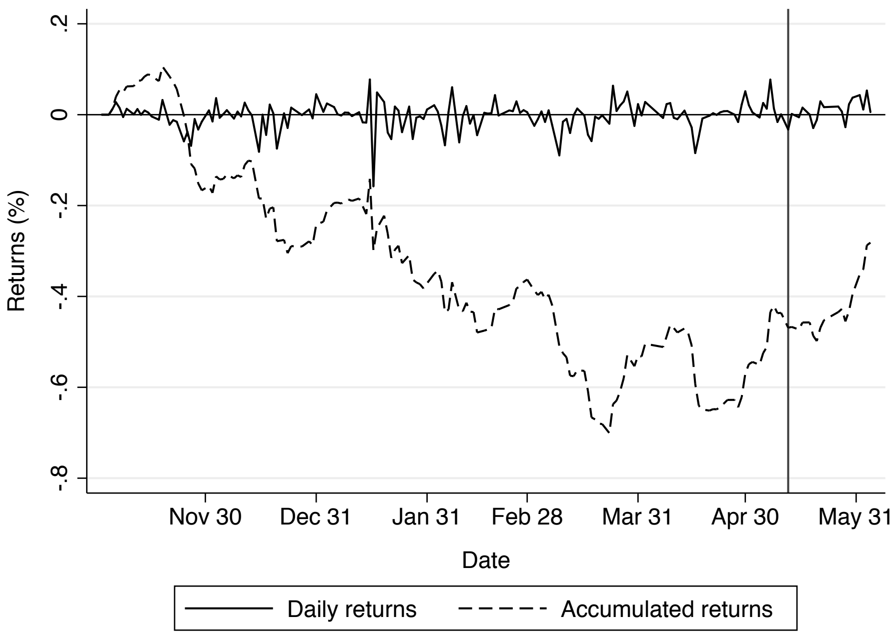


Figure 1.11: **Investing in illiquid stocks: Cumulative returns.** This figure plots the accumulated returns to a strategy that invests in stocks that saw a supply order imbalance the previous day. Stocks available for investment are grouped by liquidity provider. The weight of the stock in the daily portfolio is proportional to the decrease or increase in the stock: The larger the price change, the larger the weight of the stock in the portfolio.

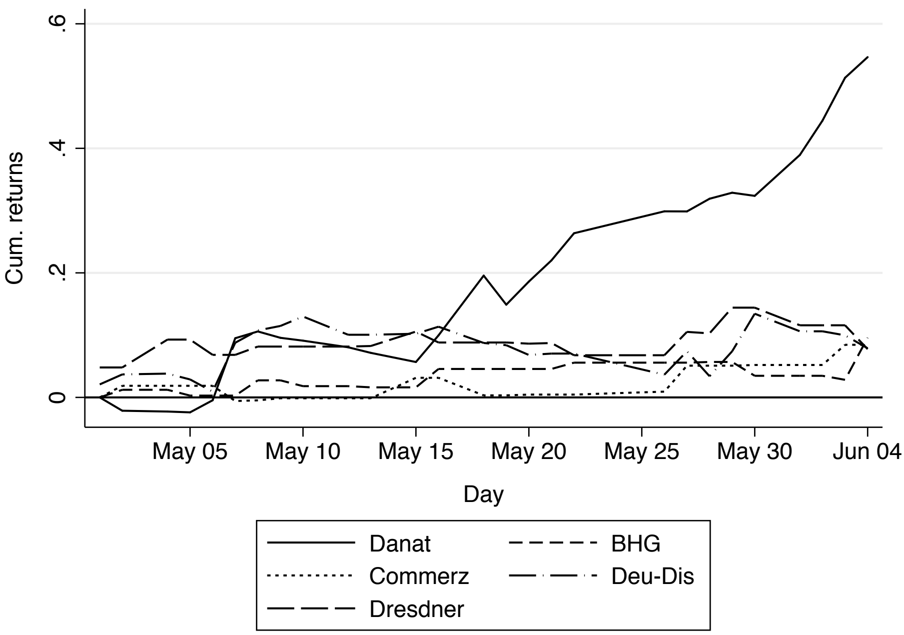


Figure 1.12: **Returns after order imbalances.** The graphs show the returns over the two days following a day with a supply order imbalance. Two-day returns are differentiated by the initial price drop at the time of the order imbalance. The x-axis shows the initial price drop when a supply order imbalance exists and the y-axis shows the two-day average return following this price drop. The figure shows that price reversals happened also for firms not connected to the Danatbank and also for Danatbank-firms before May. But on average, returns reversals are only observed for firms connected to the Danatbank during May 1931.

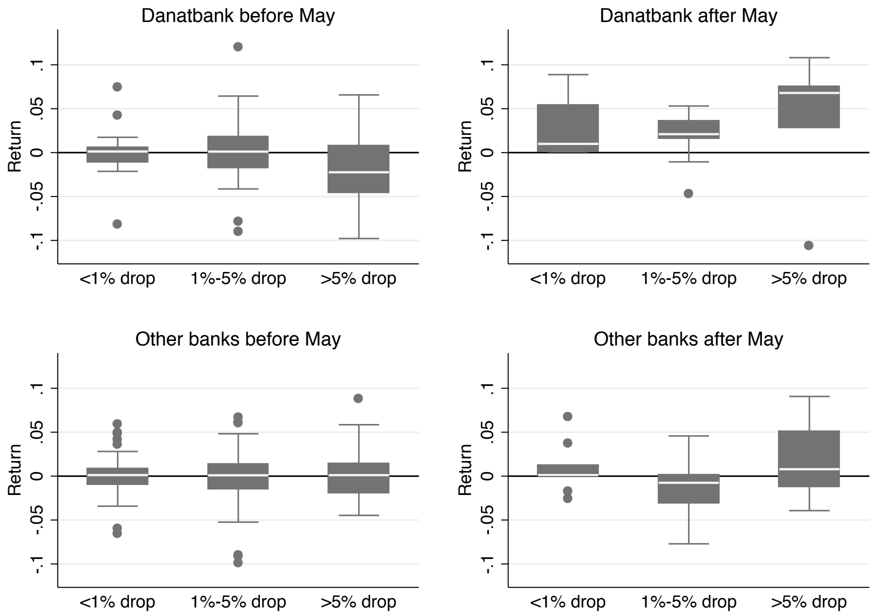
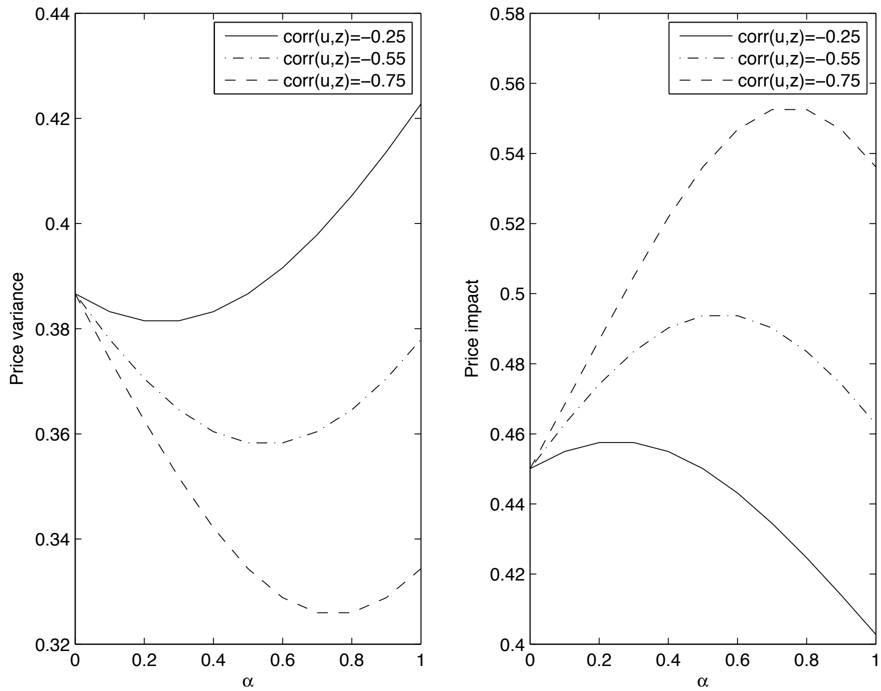


Figure 1.13: **Price variance and price impact.** These graphs plot the unconditional price variance and price impact. The first graph plots plots the price variance against α for different values of ρ_{uz}. The second graph plots plots price impact against α for different values of ρ_{uz}. The parameter values for the simulations are: $\tau_d = 1, \tau_u = 1, \tau_z = 1, \tau_\epsilon = 10, i = 1, o = 20, \rho_i = \rho_o = 2, \overline{d} = 1$.



1.9 Appendix A: Data sources

Stock prices:
Stock prices and order imbalance information are taken the evening issue of the *Berliner Boersen Zeitung*. Scans of the newspaper are held at the newspaper archive of the Staatsbibliothek Berlin.

IPO prospectuses:
IPO prospectuses and firms' balance sheets are held at the German Federal Archives in Berlin. Both are part of firm-specific files within the documents about the Berlin stock exchange (Signature R3103). I used the files R3103/300 to R3103/600.

Bank balance sheets:
Banks' balance sheets are held at the German Federal Archives in Berlin. I used the signatures R2501/1131 and R2501/1132.

Other data:
For background information and anecdotal data, I used scans of national newspapers held at the newspaper archive of the Staatsbibliothek Berlin. Information about the Berlin Stock Exchange can be found in several documents at the German Federal Archives in Berlin. These documents are mainly part of the signature R3103. I further used several statistical publications of the German Reich, all held at the Staatsbibliothek Berlin.

1.10 Appendix B: Excess returns

A classical correction of daily returns using the Fama-French factors (Fama and French 1993) is not possible for all the usual factors, because the data at hand do not provide a long time series on variables like book value. I correct for return factors in the following way:

- Market beta: I run simple time-series regressions separately for all firms i of returns on a constant and the returns of an unweighted portfolio holding all firms in my sample. This gives a firm's market beta β^M.

- I divide all stocks into 10 size classes. Within each size class I regress returns on the log of equity to obtain size betas β^{SIZE}.

- Finally, I regress returns on firm's market betas and size betas and use the residual as excess returns:

$$r_{it}^{exc} = r_{it} - \lambda_1 \beta_i^M - \lambda \beta_i^{SIZE} \tag{1.36}$$

Chapter 2

A MARGIN CALL GONE WRONG: CREDIT, STOCK PRICES,AND GERMANY'S BLACK FRIDAY 1927

2.1 Introduction

Leverage is often seen as villain in financial crises. Leverage of traders and financial intermediaries is procyclical and changes in credit are correlated with asset price movements (Adrian and Shin 2010). Further, leverage growth predicts excess returns in several asset classes (Adrian, Moench, and Shin 2010). In the recent crisis, sudden decreases in lending by financial intermediaries are regarded as one of the main culprits for fire sales and sharp increases in stock market volatility during 2008-2009 (Brunnermeier 2009). In frictionless markets, changes in lending to investors have no asset pricing implications. However, recent theories establish a direct link between changes in margin credit and stock price movements (Gromb and Vayanos 2002, Brunnermeier and Pedersen 2009). If investors cannot satisfy margin calls, a decrease in leverage may lead to fire sales. With downward-sloping asset demand, this induces price dislocations, which may reinforce further deleveraging.

There is growing support for the hypothesis that traders' and intermediaries' balance sheet conditions matter for asset pricing. Several empirical studies show a relationship between changes in margin credit and asset price movements. Broker-dealer leverage is a significant pricing factor for stock returns (Adrian, Etula, and Muir 2011). Changes in leverage of financial intermediaries are strongly correlated with stock market risk (Adrian and Shin 2010). However, it has proven difficult to establish a direct link between changes in credit and asset price movements. Leverage rarely varies exogenously; changes in credit are mostly endogenous decisions by financial intermediaries, other financiers, or investors. Further, when balance sheets are marked-to-market, changes in asset prices directly affect leverage.

In this chapter I examine a historical case study, where a large shock to margin credit led to disruptions in asset prices. Financial intermediaries differed in their exposure towards this shock. Employing these differences together with a strong bias in bank clients' portfolios towards firms connected to a certain bank, I show in a difference-in-differences framework that deleveraging had large asset pricing implications. During the weeks following the shock on margin credit, stocks affected by margin calls declined 50 percent more than other stocks. Affected stocks experienced negative cumulative returns of almost 400 percent (annualized). Further, return volatility of these stocks doubled. Connecting stocks directly with specific intermediaries and changes in their balance sheets, this chapter finds that mean daily returns were not affected by the cut in margin lending. However, a one standard deviation decrease in margin credit increased a stock's volatility by 0.22 standard deviations.

The historical setting is interwar Germany. During the mid-1920's, increasing stock market valuations went in lockstep with an increase in margin credit. Yet it were mainly the six large "Berlin banks" that enabled their clients to buy assets on credit. Margins could be as low as 10 percent. However, the rise of stock prices and margin credit drew the attention of the German central bank, the Reichsbank. Mostly for political reasons, its president, Hjalmar Schacht, campaigned against the banks' practices to constantly increase credit supply and to allow highly leveraged positions. This campaign culminated in the threat of the Reichsbank to cut short term funding for the Berlin banks. The threat was effective. On 12 May 1927, the Berlin banks issued a joint statement. Over the course of the following weeks, each bank would decrease their stock of margin credit by 25 percent while issuing margin calls towards their clients. The consequences were immediate – 13 May 1927 became known as Black Friday. The stock market declined by 13 percent. The large shock initiated by the Reichsbank trickled down to investors. During the following weeks, banks increased the margins of their clients' portfolios. As most investors could not satisfy the margin calls, fire sales occurred. However, at a given bank these fire sales were concentrated on a special set of firms – firms that had a close relationship to the bank. Using evidence from the German Federal Archives to establish these bank-firm connections, I show that stocks differed in their reaction to the deleveraging: A firm's stock price declined stronger and fluctuated more if the firm was connected to a bank that experienced a larger credit crunch.

Figure 2.1 summarizes the main result. The left panel shows two stock price indices, one index composed of firms connected to the large Berlin banks, and another index of firms with no connection to these banks. Both indices are normalized to 12 May 1927. At this day, the Berlin banks issued their joint statement and both indices declined. However, over the course of the following month "large bank"-stocks declined more than 12 percent, while other stocks dropped less than 8 percent. Further, volatility almost doubled for firms connected to the Berlin banks. This is shown in the right panel, which plots volatility indices for both groups of firms. Stocks more exposed to fire sales had more negative returns and experienced larger fluctuations. This causal impact of deleveraging on return volatility is robust to several criticisms. The result still holds when controlling for attributes such as the number of underwriters or firm size. An instrumental variable strategy further shows that reverse causality does not drive the results.

This study is related to several strands of the literature. Several theoretical papers establish a causal link between margin requirements and asset price behavior (Gromb and Vayanos 2002, Brunnermeier and Pedersen 2009). Recent empirical studies provide suggestive evidence for this link. Leverage is procyclical (Adrian and Shin 2010) and leverage growth has predictive power for excess returns (Adrian, Moench, and Shin 2010). I contribute to this literature by providing a clean empirical test that changes in margin credit led to increased volatility in interwar Germany. I further add to the literature on fire sales and price pressures. Coval and Stafford (2007) and other empirical studies show that in the short run, selling pressure leads to price dislocations. I complement these studies and add further evidence that an increase in selling volume leads to disturbances of asset prices. Historically, this study adds to the literature on stock markets in interwar Germany. I complement the study of Voth (2003) by providing a disaggregate look at the stock market crash in 1927.

The next section surveys the related literature. Section 2.3 describes the historical setting in more detail. It explains the economic situation as well as the banking industry in interwar Germany. Section 2.4 describes the data. Section 2.5 shows how the shock to margin lending affected stock price behavior. Section 2.6 refines the results. Section 2.7 concludes.

2.2 Related Literature

This study is related to several strands of the literature. It relates to the theoretical and empirical literature on margin credit and asset prices, commonality of returns, and the cyclicality of credit. Also, it adds to the literature on price pressure and asset fire sales. On the banking side, it adds to the literature on intermediary capital.

The connection between margin credit and asset prices received a lot of attention in the wake of the recent financial crisis. However, earlier theoretical papers already examined the causal effects of changes in margins on returns and volatility. In Gromb and Vayanos (2002) arbitrageurs cannot finance their arbitrage activity completely with own funds. Margin credit helps traders to pursue their investment strategies. In normal times, credit allows these traders to eliminate arbitrage opportunities and assets are traded at fair prices. Yet when margin constraints bind, arbitrageurs cannot eliminate price inefficiencies. Brunnermeier and Pedersen (2009) provide the microfoundations for binding margin constraints. In their model, financiers give credit to traders. The amount of credit depends on the volatility of assets and is determined by VaR constraints. When price volatility increases, financiers issue margin calls, which traders may be unable to satisfy. They are forced to sell their assets, which decreases asset prices and further diminishes a trader's wealth. Margin and wealth spirals occur. He and Krishnamurthy (2012) also develop a model where intermediary capital is scarce and relevant for asset pricing in crises times.

The importance of credit for asset prices is also stressed by several macroeconomic models. These theories focus mostly on the cyclical behavior of prices and credit to explain business cycle fluctuations. In Bernanke and Gertler (1989), asset prices influence the balance sheet capacity of borrowers. Kiyotaki and Moore (1997) show that collateral requirements change over the business cycle. These changes amplify shocks to the economy.

The relationship between credit or margin requirements and asset prices is the subject of various empirical studies. Earlier studies found no effect of changes in margin requirements on asset prices (Moore 1966, Officer 1973, Hsieh and Miller 1990). More recently, Adrian, Moench, and Shin (2010) find that leverage growth has predictive power for excess returns. Furthermore, Wall Street investment banks exhibit procyclical leverage (Adrian and Shin 2010). When asset prices and the corresponding balance sheet positions of banks rise, banks adjust their balance sheets and take on more debt – leverage increases. When asset prices decline, an opposite spiral emerges. Further, changes in leverage are correlated with increases in stock market risk.

These papers are related to a broader strand of the literature that investigates fire sales and price pressure. The theoretical literature on asset fire sales is large and summarized by Shleifer and Vishny (2011). Several empirical papers suggest that when traders have to exogenously unwind their positions, prices react. Coval and Stafford (2007) show that prices decrease when mutual funds sell large positions. Over the medium run, prices reverse course and recover. Mitchell and Pulvino (2012) look at several markets around the times of the Lehman Brothers bankruptcy. When investments banks cut their lending to hedge funds almost completely, these arbitrageurs were unable to follow their typical investment strategies. A large increase in the CDS-bond spread followed, the convertible securities market seemed mispriced, and merger arbitrage opportunities arose for merger target stocks. Hendershott and Menkveld (2013) look at price pressure in the short run and find dislocations of prices on a daily basis. Investigating differences in stock returns during times of high selling pressure, Blume, MacKinlay, and Terker (1989) show that stocks included in the S&P 500 declined stronger than other stocks during the 1987 crash. But these stocks also showed a stronger reversal, leading to higher volatility. Explanations for these differences range from institutional trading to behavioral reasons such as greater visibility. Greenwood and Thesmar (2011) use mutual fund data to show that stocks are more "fragile" if their ownership base is more concentrated. Individual liquidity shocks cannot be cancelled out when only a few investors own a specific stock. But even a diverse ownership base can lead to fragility, if several investors experience correlated liquidity shocks. Anton and Polk (2014) show that common ownership of stocks by mutual funds can explain return commonality in the cross-section.

Further, this chapter is related to the literature on intervention in asset markets. Most papers focus on intervention in foreign exchange markets. A classical reference on intervention by central banks is Bagehot (1873).

On the historical side, the study adds to the literature on German stock markets in the interwar period. Most literature on German stock markets investigates the period before WW I (Lehmann 2011, Burhop 2011). In one of the few studies on the interwar period, Voth (2003) looks at the Black Friday in an aggregate context. He claims that Schacht was wrong and the high stock price valuations in 1927 did not represent an asset price bubble. My study looks at the same episode, taking a disaggregate view on stocks and the banking sector. The next section explains this historical episode in more detail.

2.3 Historical background: The Black Friday of 1927 and the stock market in the interwar period

On the evening of 12 May 1927, the six largest German banks published the following statement:

> "The members of the union of Berlin banks and bankers (Stempelvereinigung) have come today to the agreement to slowly but noticeably decrease the funds available for stock purchases on credit. Therefore they will decrease the stock of margin credit until the middle of the month by 25 percent and further afterwards. Against clients they will act in the same way." [1]

One day later, the German stock market lost 13 percent. This section provides a short overview of how this communique came about. The first part looks at the economic situation and the evolution of the stock market during the interwar period. Parts 2 and 3 describe banking in Germany and the evolution of banks' balance sheets. Part 4 describes the Reichsbank's view on increasing stock valuations and banks' lending policies. The last part explains the strong connections between banks and firms before WW II in Germany.

[1] "Die Mitglieder der Vereinigung von Berliner Banken und Bankiers (Stempelvereinigung) sind heute untereinander übereingekommen, die zu Report- und Lombardzwecken und zur sonstigen Beleihung von Effekten gewährten Gelder allmählich, aber erheblich herabzusetzen. Sie werden deshalb zunächst die börsenmässige Report- und Termingeldhergabe bis zur Medio-Liquidation um 25 Prozent vermindern und an den darauffolgenden Terminen weitere Einschränkungen vornehmen. Der Kundschaft gegenüber wird im gleichen Sinne verfahren werden."

2.3.1 The economic situation of interwar Germany

Interwar Germany is often associated with political turmoil, austerity, and high unemployment. However, during the years after the hyperinflation, the outlook was far better. After 1924, the German economy began to recover. Chancellor Gustav Stresemann established a political and civic order, and a period of falling unemployment and increasing industrial production began. The "Golden Twenties" led to economic recovery, investment, and even a flourishing cultural scene. The recovery also affected the stock market. During the first years after the war, volume on the stock exchange had been low. Stock prices were at low levels and highly volatile, while interest rates were high and transactions in futures not allowed. As the outlook brightened, the high interest rates attracted foreign capital. In contrast to other central banks, the Reichsbank pursued a policy of high discount rates. Until February 1925, the discount rate was 10 percent and even during 1926 it still stood at 8 percent.[2] This policy was the main driver of foreign capital inflows. The American diplomat S.P. Gilbert saw these inflows even as a major cause of Germany's economic recovery. When interest rates started to decline and investors searched for higher yields, stock prices began to rise. A short recession during 1925 and the beginning of 1926 did not hinder this development and at the end of 1925, the aggregate stock market index stood at 99 percent (of its pre-WW I level). During 1926, it rose to 140 percent (November 1926) and even higher in 1927 (178 percent in April 1927).

The new confidence in stock markets increased the demand for margin credit. Already before WW I, margin credit was a major funding source for investors and a large part of banks' investment banking business. When an investor wanted to finance a trade, he had only to pay a fraction of the stock purchase with his own capital. A bank lent the rest and took the purchased securities as collateral. Investors were able to reach high levels of leverage; margin requirements could be as low as 10 percent. But during the period of hyperinflation, margin credit had come to a standstill and was a negligible part of banks' balance sheets. As the stock market recovered, margin credit slowly started to increase. Figure 2.2 shows the evolution of the stock market and margin credit between 1925 and 1928. During the bull market from 1926 to mid-1927, total margin credit increased from below 100 Million RM to almost 900 Million RM. However, not the whole banking industry participated in this rally. The six large Berlin banks

[2] Interest rates set by other central banks were between 4 to 5 percent

gave out most of this credit. At 31 October 1925, the total amount of margin credit was 303.5 Million RM. A third had been given out by the Berlin banks (101 Million RM). Total credit grew to 1413.9 Million RM (30 April 1927). As Table 2.1 shows, the largest fraction of credit was given out by the Berlin banks. In 1927, their share grew to 892 Million RM, while combined credit at other private banks was only 200 Million RM. During May and June, credit collapsed to 1035 Million RM overall and to 587 Million RM at the large banks.[3] In the baseline specifications, I will use these differences in deleveraging between Berlin banks and other banks. Stocks held by clients of Berlin banks experienced larger selling pressure. However, differences existed even among Berlin banks. The next section takes a closer look at these banks.

2.3.2 The Berlin banks

Individual bank balance sheets of the Berlin banks reflect the strong increase in margin credit. Deutsche Bank, the biggest bank in assets, increased its balance sheet position from 29.1 Million RM at the end of 1925 to 198.7 Million RM in April 1927. For most banks, margin credit was a substantial part of their assets at the height of the boom in early 1927. However, in May 1927 this came to a sudden stop as the six Berlin banks decreased their margin credit by 305 Million RM. This can be seen in Table 2.2, which describes the Berlin banks' balance sheets in April and July 1927.

While margin credit increased, other highly liquid positions on the banks' asset side deteriorated. An important measure of banks' liquidity was the ratio of cash and short-term assets at the central bank over short-term liabilities. The average of this ratio across the large banks was 5.58 percent at the end of 1912. After the hyperinflation it had already decreased to 3.21 percent. In February 1927, it reached its low at 2.59 percent. Liquidity increased after the intervention of the Reichsbank and short-term assets over short-term liabilities increased to 4.02 percent until the end of June 1927. The continuous decline in this liquidity ratio was mainly driven by a decrease in banks' cash positions. Before WW I, banks held 112.31 Million RM in cash. At the end of 1925, this position had fallen to 66.9 Million RM. Between February 1927 and June 1927 it increased again from 78.6 Million RM to 126.8 Million RM.

Low on cash, banks started to rely heavily on a different source of short-term

[3] Benning (1929), page 116

funding: Promissory notes. A promissory note is a promise of firm A to pay back a credit to firm B until a certain date. Firm B can use this promise to obtain cash at a bank. The bank takes over the promissory note, bearing the default risk of the debtor, firm A. Regularly, a bank was not the ultimate holder of a promissory note as it could redeem the note for cash at the central bank. The central bank accepted promissory notes from almost all industrial firms, which were the majority of the issuers.

The use of promissory notes by banks was inherently linked to margin credit. Investors used credit by banks to roll over their futures positions. At the Berlin stock exchange, futures were settled at the 15. and 30. of every month. If an investor was supposed to settle a long position at these dates, he often used bank credit. Banks took the bought stocks as collateral until the credit was due the following month. To obtain the liquidity needed to issue margin credits, banks redeemed promissory notes at the Reichsbank. This can be seen in Figure 2.3. The graph shows the evolution of promissory notes held by the Reichsbank. The series spikes twice a month, at the days when futures trades had to be settled. During the year before the Black Friday, promissory notes taken by the Reichsbank more than doubled. This reliability of banks on the Reichsbank made the large Berlin banks vulnerable.

Another source of vulnerability was the sudden stop in long-term foreign capital, which was initiated by the government. Up to the end of 1926, foreign owners of German bonds were not taxed by the German tax authority. But on 4 December 1926, the German government abolished this exemption – foreign holders of bonds had to pay German capital taxes. As a consequence, the inflow of long-term foreign capital declined from 137.9 Million RM (December 1926) to 13.7 Million RM (January 1927). Banks could no longer obtain long-term foreign funds and had to rely to an even greater extend on the central bank. The next section turn to this institution; an institution that criticized banks' lending policies and the evolution of the German stock market.

2.3.3 The Reichsbank and the shock to margin credit

The Reichsbank, and most prominently its president Hjalmar Schacht, had a specific position towards the stock market boom – the view that stocks were overvalued and that the high valuations were bad for the German economy. This view was based on three arguments (James 1986). First, Hjalmar Schacht believed that funds invested in the stock market would be unavailable for real investment.

Second, the surge in the stock market would attract too much short-term foreign capital, a source of instability and uncertainty. And third, in the eyes of Schacht stock market valuations were too high and irrational and did not reflect the state of the German economy.

Already contemporaries criticized the first argument. Before and after the stock market crash, commentators in newspapers, speeches, and dissertations noted that the stock market boom did not harm real investment (see for example Benning (1929)). Their main argument against Schacht was that one's stock purchase is another one's stock sell. This free capital could be invested in the real economy. Schacht was not convinced by this argumentation and claimed that most revenues from stock sales would flow into luxuries. However, national accounts of the German Reich do not show an increase in the consumption of luxuries.

The second argument, the fragile nature of short-term foreign capital, was more substantial. However, the Reichsbank itself and the government were the source of the increased instability. Because of high interest rates at the beginning of the recovery, Germany attracted foreign investors. Initially, foreign capital inflows were both short-term as well as long-term. But the abolishment of the preferential tax treatment for bonds in foreign currency led to a sudden standstill of long-term foreign capital flows. Further, the withdrawal of foreign funds depleted the Reichsbank's position in foreign exchange (Figure 2.4). In January 1927, reserves in foreign exchange dropped over 60 percent. New capital inflows were almost exclusively short term, and the Reichsbank was afraid of further withdrawals.

There was no consensus among contemporaries whether Germany experienced a stock market bubble. In the eyes of Hjalmar Schacht, stocks were overvalued. The state of the German economy would be far from good and the stock market would only reflect irrational exuberance. Further, high stock market valuations did not fit well into his political agenda. He advocated lower reparation payments and argued that the current level of payments restricted the German economy. On 8 May 1927, he wrote in the newspaper *Muenchner Neueste Nachrichten* that he disagrees with the "false image of the currently high stock prices at German exchanges, on which the opinion of supposedly regained German strength is mainly based." After months of arguing against high valuations, banks suggested to raise interest rates. Hjalmar Schacht did not commit to such a policy and instead focused on the large Berlin banks and their lending policies.[4] Looking at the level of the stock market, Voth (2003) argues that Hjalmar Schacht was already wrong in his premise of an existing stock market bubble.

The Reichsbank's position towards high stock market valuations together with the large banks' low short-run liquidity culminated in an unofficial threat. The Reichsbank warned the largest private banks: If the banks would not cut their margin lending by at least 25 percent, the Reichsbank would not redeem their promissory notes anymore. This threat was effective and on 12 May banks declared to cut their margin credit by 25 percent over the coming weeks. This large shock on credit had immediate consequences. On 13 May, later known as the "Black Friday", the whole stock market tumbled. The average decrease was 13 percent, but some stocks did far worse. In the following weeks, stocks declined further. The large shock on lending was transmitted to investors. The Berlin banks did not prolong the credit used to buy stocks and forced investors to liquidate their positions. Transaction tax revenues, a proxy for volume, increased during May and June, but dropped sharply afterwards.[5] Other German banks did cut their stock market credit on a much smaller scale. The empirical section will use these differences across banks. However, to establish a link between changes in margin credit and asset price movements, the margin cuts at the Berlin banks must affect different stocks than the margin cuts at other banks. The next section describes how I establish a relationship between banks and stocks.

2.3.4 Germany before WW II: Bank-firm connections and the stock market

The Economist described the German banking system in 1911 like this:

> "The German banks have a much wider sphere of action than our English deposit banks. Besides doing the same kind of business they are stock, bill, and exchange brokers and dealers, banker-merchants, trust, financial, and promoting companies, etc. What may be described as their chief merit and defect is their intimate connection with German industrial life...Not only have the banks promoted most of the industrial joint-stock companies, and retain

[4]Schacht could not be convinced that margin credit was still low compared to historical standards. At the end of 1910, the six Berlin banks had given out 1074.2 Mio RM of margin credit (Benning 1929)

[5]Benning (1929), page 146

> part of their share capital, but their managing directors remain members of the board of these companies..." *(The Economist, 21 October 1911)* [6]

German universal banks had very strong firm connections – a bank's CEO sat on the supervisory board of a firm, a bank was a firm's main creditor, and when a firm wanted to go public, its connected firm was the natural choice as underwriter. On the stock market, the connection between a firm and a bank did not end with a public equity offering. A bank held an inventory of stocks of connected firms and actively intervened in the stock market in case of order book imbalances. The bank therefore was a stock's main liquidity provider and soothed price fluctuations due to order imbalances. In his comparison between German and English banks, Weber (1915) summarizes this trading behavior of connected banks:

> "Sometimes the demand or supply of a few shares can lead to unreasonable price increases or decreases. Here it is the task of the bank, to put themselves between seller and buyer through taking on the demand or supply in order to establish a more balanced price setting. The underwriting bank can fulfill this task best, since it is mostly better informed about the true value of the shares." (*A. Weber 1915*)

Firms expected banks to provide this market-making service to see low volatility in their stocks. This made the stocks more attractive to investors, who still had the period of hyperinflation and large uncertainty in their minds and avoided highly risky investments. Banks also had a long-run gain from liquidity provision, since underwriter switching was less likely if stocks had lower volatility after their IPO (Lehmann 2011). When it came to investment advice to their clients, banks would strongly suggest to invest in firms they made markets in. These firms were backed by the same institution a client had picked in the first place. When in stocks connected to the same bank, clients also faced more liquid markets. Banks not only made markets at the Berlin stock exchange, but also matched trades internally.

Clients financed a large part of their stock purchases with margin credit. The

[6] While this quote stems from before WW I, it was valid until WW II. The *Wall Street Journal* wrote on 5 May 1931 that "Bank heads hold directorships in scores of companies, and the banks themselves retain holdings in shares they have issued".

lending bank took the purchased stocks as collateral. Since banks had better information in stocks of connected firms and also market power in these stocks, taking on stocks of connected firms as collateral was less risky than taking on other stocks. This informational advantage gave banks further incentives to bias their investment advice strongly towards affiliated firms.

This bias in clients' portfolios allows me to establish differences in selling pressure across stocks. Clients of the large Berlin banks held mostly stocks of firms affiliated with the Berlin banks. When these banks issued their margin calls, most of their clients could not satisfy them. They were forced to liquidate their investments and large amounts of stock came to the market. Short of cash, banks were in no position to intervene in the market on a large scale. Stocks not connected to the large Berlin banks did experience much lower selling pressure induced by margin calls. This is the main identifying assumption to establish a direct relationship between a cut in margin credit and asset price movements. The next section describes the data used to show this relationship.

2.4 Data and descriptive statistics

The main data are daily stock prices and underwriter prospectuses to establish bank-firm connections. I use two samples: the full sample and the single-underwriter sample. The full sample consists of daily stock prices for 147 firms between 1.2.1927 and 1.7.1927. Most of these firms had one or two large underwriters, while some firms had up to 6 Berlin banks as underwriters. Same parts of the analysis make use of a sub-sample, which consists of 98 firms that had a single underwriter. Prices are digitalized from newspaper scans of the *Berliner Börsen Zeitung*. Bank-firm connections are established with IPO and SEO prospectuses held at the German National Archives in Berlin. The archives hold firm-specific files of over 300 publicly listed firms before WW II and I select all firms still active in 1927. Bank balance sheet data are taken from the newspaper *Vossische Nachrichten*, which published banks' balance sheets for the Berlin banks every two months. Aggregate data (monthly stock market index, aggregate margin credit data for all big banks) are taken from the *Statistische Jahrbücher für das Deutsche Reich*.
Table 2.3 summarizes firms' characteristics. Most firms are from the manufacturing sector, although they differ in size. While the mean share capital in the lowest size quartile is 1.33 Million RM, the mean share capital is 108.63 Million

RM in the largest quartile. These differences are not perfectly reflected in the number of underwriters. Share capital and the number of underwriters are positively correlated, however, this correlation is far from perfect (0.5). The mean number of underwriters is below 1.5 for all but the biggest firms.

Table 2.4 summarizes firms with only one large underwriter. It provides mean and median share capital for each bank-specific portfolio. The largest portfolio in the sample is the Deutsche Bank portfolio. Most portfolios are similar in median share capital, with the Commerzbank being an exception. Mean share capital differs more and ranges from 11.95 Million RM for the BHG to almost 20 Million RM for the Danatbank portfolio.[7]

2.5 Margin credit and asset price behavior

When the Berlin banks were forced to change their lending policies, they issued margin calls to their clients. They did not roll-over the majority of stock market debt and increased margins, the proportions investors had to pay out of their own wealth. Most of their clients could not satisfy these margin calls. However, other banks were less affected as they were not subject to the threat of the Reichsbank. This section looks at the asset pricing implications of such a large change in lending policy. The first section shows that stocks affiliated with large banks became more volatile. The second part takes a closer look at this general result. The behavior of returns and volatility differed also across firm size and the number of underwriters.

2.5.1 Deleveraging and stock price movements: Summary statistics

After the Berlin banks had issued their joint statement, stocks experienced differences in selling pressure. This section provides a first glance at the consequences of these differences. It provides summary statistics for stocks that were connected to Berlin banks and other stocks.

Figure 2.1, already introduced in a previous section, shows that when the Berlin banks issued their margin calls, stocks of affiliated firms declined. Over

[7] While there were six big banks in 1927, balance sheet data are not available for the *Berliner Handels Gesellschaft*. This limits my single underwriter sample for most part of the analysis to the five banks *Commerzbank, Deutsche Bank, Discontogesellschaft, Darmstaedter-und Nationalbank (Danatbank)* and *Dresdner Bank*.

the following weeks, the stock price of a firm connected to a large underwriter declined on average more than 12 percent until the end of June. Firms that were not connected to a large underwriter were less affected. Such stocks declined on average only 8 percent. These differences in behavior did not occur immediately when the Berlin banks issued their statement. At 13 May, both groups declined equally. But over time, the differences became visible. Further, volatility spiked for affected firms. During the following two months, Berlin-bank-affiliated stocks were more volatile than other stocks.

These results can also be seen in Table 2.5. The table provides mean daily returns, the standard deviation of returns, mean firm-specific return volatility, and measures for order book imbalances before and after 12 May. Mean daily returns decline for both groups of firms after 12 May. Volatility declines for firms without a connection to Berlin banks. However, volatility almost doubles for firms connected to a large underwriter. As these banks cut their margin lending, asset prices of firms connected to them started to fluctuate. The next section will control for several factors that may influence this result and show that this basic finding is robust to several criticisms.

2.5.2 Baseline results

The simple descriptive statistics can neither account for differences across firms nor for differences across time. To properly address the question whether a change in lending policy had asset pricing implications, I use a difference-in-differences approach. The baseline specification is given by

$$y_{it} = \beta(Bank_i * May_t) + \gamma_{it} + \epsilon_{it} \tag{2.1}$$

y_{it} is the value of the dependent variable for firm i at time t. $Bank_i$ is a dummy that is 1 if firm i is connected to a large bank and 0 otherwise, May_t is a dummy that is 1 after the margin call at 12 May and 0 before, and γ_{it} is a vector if firm and time dummies to account for level differences. Table 2.6 reports the results for volatility and returns as dependent variables. The first two columns look at firm-specific return volatility. The regressions confirm the graphical evidence: Stocks connected to Berlin banks fluctuated more after 12 May. Compared to non-large bank firms before May 1927, volatility increases by 0.31 standard deviations. Using a regression without fixed effects, $var_{it} = \beta_1(Bank_i * May_t) + \beta_2 May_t + \beta_3 Bank_i + \epsilon_{it}$, β_1 has the largest impact on the outcome variable. Its standardized coefficient is 0.16, whereas the standardized coefficient for β_2 (β_3) is -0.02 (0.004). The increase in volatility is robust to including firm- and time fixed effects (column 2).

The stock price indices showed that stocks connected to large banks had lower cumulative returns during the weeks following 12 May. However, we cannot find a significant impact on daily returns. Not accounting for fixed effects, mean daily returns were -180 percent in annualized returns for the whole sample before May. The further decline in May is not significantly larger for firms connected to the Berlin banks.

Table 2.7 turns to order book imbalances. German newspapers did not report volume data or bid-ask spreads. They did, however, report the existence of order book imbalances. This information is used in Table 2.7. Columns 1 and 2 use an indicator for excess supply as dependent variable. This indicator is 1 if there existed a supply order imbalance for stock i at day t and 0 otherwise. Columns 3 and 4 employ a similar indicator to analyze demand order book imbalances. With respect to supply order imbalances, stocks did not differ according to their bank affiliation. However, there are significant differences in demand order book imbalances. Stocks connected to Berlin banks did have on average less demand imbalances. Further, during the crisis period, the decline in imbalances is significantly less pronounced than for other firms; the coefficient of the interaction term is positive. However, this result is driven by stocks of smaller firms. When observations are weighted by the size of firm share capital, the interaction term becomes insignificant (column 5).

The strong deleveraging of the Berlin banks had asset pricing implications. Stocks of affiliated firms fluctuated more as banks put pressure on their clients. However, even within the two groups, some firms experienced larger selling pressure than others. The next section addresses these additional differences.

2.5.3 Returns and volatility: Further differences across stocks

Given the same shock, selling pressure often differs across stocks. If demand is downward-sloping, these differences have asset pricing implications. Greenwood and Thesmar (2011) show that stocks are more fragile if their ownership base is either more concentrated or when liquidity shocks are correlated across investors. In these cases, selling pressure increases because liquidity shocks are less likely to cancel out across investors. The larger the affected fraction of a stock's ownership base, the larger is the price impact. For example, if several mutual funds experience the same shock, stocks commonly owned by several funds start to co-move (Anton and Polk 2014).

The previous section showed that selling pressure was larger for stocks affiliated with the Berlin banks. This section takes a closer look at the differences across stocks before and after 12 May 1927. Besides a large bank connection, which further characteristics determined the selling pressure after the margin calls? The first part of this section looks at firm size, while the second part looks at the number of underwriters. Both characteristics measure indirectly which proportion of stockholders was affected by the margin calls. The larger this proportion was, the more these stocks declined over the following weeks. Further, the impact on volatility increased as well.

Firm size

Firm size affects how widespread stocks are held. Stocks of larger firms are often assumed to be safer and to have smaller information asymmetries. The stock market in interwar Germany was no exception. Stocks of large companies like Siemens were widely held as safe investments. Even banks that did not act as underwriter for these firms often accepted them as collateral. Clients of Berlin banks held them in their portfolios even if the bank had no direct affiliation. Firm size therefore proxies for how many owners of a stock were affected by margin calls of the large banks. Larger firms experienced stronger selling pressure.

Figure 2.5 shows how returns and return volatility differed for firms of different size. Firm size is measured by share capital and the graph plots mean stock price indices and mean volatility indices for each size quartile. Looking at returns, the impact of the margin calls increases with firm size. On the day of the stock market crash, firms in the first size quartile decreased on average 2.26 percent. The same day, firms in the largest size quartile decreased 11.83 percent. These differences persisted over time. One month after the announcement of the Berlin banks, small firms had declined on overage 8.32 percent since 12 May. The largest firms had experienced a mean cumulative return of 15.04 percent.

Not only did stocks of large firms decline stronger, they also fluctuated more. The second panel of Figure 2.5 shows mean firm-specific return variance for the four size quartiles. Before 12 May, a commonly known characteristic can be seen: Larger firms are more stable; smaller firms fluctuate more. However, this finding turns after 12 May. At the onset of the crisis, stocks of large firms start to fluctuate heavily. Mean volatility for larger firms doubles in the period after

12 May compared to the weeks before. Mean volatility for firms in the first size percentile decreases slightly from 0.001 to 0.0009.

After 12 May, large firms lost their characteristic as safer investments. Although their "ownership base was disperse", in the words of Greenwood and Thesmar (2011), most owners were affected by the Berlin banks' margin calls. As a consequence, these stocks reacted sharper on impact and fluctuated stronger during the crisis period. The next section turns to another proxy for the impact of the margin call on stockholders.

Number of large underwriters

The previous section argued that larger firms were used more often as collateral because they were considered to be safer investments. This observation is not specific to interwar Germany and even applies to todays markets. However, other characteristics exist to proxy the impact of the margin call on stockholders. One characteristic is specific to the close bank firm connections in pre-WW II Germany: the number of large underwriters. The fraction of stockholders connected to a large bank increased if a firm had more than one large underwriter. Figure 2.6 plots stock price and volatility indices depending on the number of large underwriters. Looking at the returns directly after 12 May, no large differences can be observed. On impact, stocks connected to no large underwriter had the same negative returns as stocks connected to one or more underwriters. During May and June 1927, however, differences emerged. As large underwriter banks started to send out their margin calls to individual investors, prices of stocks connected to these banks slipped. One month after the shock, prices had declined on average 14 percent for firms with two or more large underwriters. During the same period, firms with no large underwriters saw negative returns of only 7.3 percent. Further, after the Reichsbank's intervention volatility was increasing in the number of underwriters (right panel).

Firm size and the number of underwriters both allow us to proxy the fraction of the ownership base hit by margin calls. However, these measures are correlated. Although the correlation is far from perfect, the two graphs just described may still pick up the same mechanism.[8] Larger firms had more underwriters; the number of underwriters may only reflect this fact. Can each characteristic on its own explain differences in asset price behavior? To disentangle the effects, I run

[8]In the sample, firm size and the number of underwriters have a correlation coefficient of 0.5.

the following regression:

$$y_{it} = \beta May_t * Charac_i + \gamma_{it} + \epsilon_{it} \tag{2.2}$$

where y_{it} is either the return or return volatility of stock i at day t. Volatility is the variance of returns measured over the period $t - 5$ to t. May_t is a dummy that is one after 12 May 1927 and 0 otherwise and γ is a vector of controls that includes firm dummies and a constant. $Charac_i$ describes a firm characteristic, which can be a vector of size dummies, or a vector of underwriter dummies. Table 2.8 reports the results. The effects of size and the number of underwriters on returns and volatility are estimated alone or jointly (columns 3 and 6). Whereas Figures 2.5 and 2.6 showed cumulative returns, daily returns did not significantly differ across firm size or the number of underwriters after 12 May. The exception were the largest firms. However, volatility was strongly influenced by firm size or the number of underwriters. Volatility was significantly larger for firms in size quartile 3 and 4 during May and June 1927 (column 4). The same holds true for firms with one or more large underwriters (column 5). Estimated jointly, both effects have explanatory power. Nevertheless, the coefficients for firm size decrease only slightly, whereas decreases in the underwriter coefficients are more pronounced.

This section showed that the behavior of stocks differed along several dimensions. The initial argument used only differences across stocks based on whether they were connected to a large bank or not. Additionally, firm size and the number of underwriters can explain part of the behavior of asset prices after 12 May 1927. Both characteristics are proxies for the fraction of the ownership base affected by the credit squeeze. However, so far we have only looked at stock-specific characteristics. I cannot rule out that these characteristics are further correlated with other, unobservable variables that affected selling pressure. To address this problem, the next section turns to the intermediaries themselves. It investigates whether differences in lending policies affected asset prices and which balance sheet positions can explain lower returns or higher volatility. Linking changes in margin credit directly to asset price behavior shows that the results obtained in the baseline regressions are not driven by other differences between large bank firms and other firms.

2.6 Balance sheets and asset price behavior

Aggregate intermediary balance sheet variables have strong predictive power for excess returns (Adrian, Moench, and Shin 2010). This section links asset price behavior directly to changes in margin credit at individual banks. The first part shows that stocks fluctuated more if they were connected to a bank that sharply cut its margin lending. Part 2 turns to order book imbalances. The last part shows that the baseline results are robust to the problem of reverse causality.

2.6.1 Margin credit, returns, and volatility

The analysis so far showed that a contraction in credit led to higher volatility in interwar Germany. The baseline results use the differences between two groups of firms: Firms connected to large underwriter banks and firms with no connection to these banks. Differences in asset price behavior are then attributed to different deleveraging between Berlin banks and other banks. Berlin banks had to change their lending policies and stocks related to these banks became more volatile. However, other characteristics influenced returns and volatility as well; Berlin bank related firms may be inherently different from other firms. This section turns to a more homogeneous sample: Firms that are affiliated with a single Berlin bank. To identify how margin credit affected asset prices, I now use only differences in lending policies between the Berlin banks. For example, Diskonto Gesellschaft decreased its margin credit by 41.56 percent during May and June. In the same period, Commerzbank cut its credit by only 15.63 percent. In terms of absolute decrease, Deutsche Bank experienced the largest decline – 67.29 Million RM. Did these differences induce different asset price behavior for affiliated firms?

Table 2.9 provides a first look at the single underwriter sample. It reports the results of the following regression:

$$y_{ibt} = \beta May_t + \alpha + \epsilon_{ibt} \tag{2.3}$$

where y_{ibt} is the daily stock returns of stock i connected to bank b at day t in the upper panel of the table. In the lower panel the dependent variable is return volatility. May is a dummy that is 1 after 12 May and 0 otherwise. The regression is estimated for each bank-portfolio b separately.

Daily returns were only significantly lower during May for firms connected to Deutsche Bank. For all stocks, volatility was higher during May and June than before. However, the increase in volatility differs across bank-portfolios. Stocks connected to the Commerzbank saw the lowest increase in volatility. The shock of 12 May had a much larger impact on stocks connected to Deutsche Bank and Diskonto Bank. The strength of the coefficients correlates with the level of deleveraging a bank experienced.

A panel framework can address this hypothesis properly. It allows us to control for differences across bank portfolios and common factors. Further, since each stock is connected to a single bank, the change in credit can be directly used in the regressions. The specification is given by

$$y_{ibt} = \beta_1 May_p * Credit_{bp} + \gamma + \epsilon_{ibt} \tag{2.4}$$

and the results are reported in Table 2.10. y_{bit} is either daily returns or volatility. $Credit_{bp}$ is specific for bank b during period p, which are bi-monthly intervals. $Credit_{bp}$ is either the total amount of margin credit outstanding by bank b during p (columns 1 and 3) or the absolute change in margin credit (columns 2 and 4). γ includes several controls. All regressions control for firm- and time-fixed effects.

As in the larger sample, daily returns did not change significantly across firms connected to different banks (columns 1 and 2). Neither the level of credit nor its change had a significant impact on returns. Volatility, however, was significantly affected by banks' credit policies (columns 3 and 4). Over the whole sample, the overall level of stock market credit had a negative impact on return volatility. A one standard deviation increase in the level of stock market credit decreased a stock's return volatility by 0.25 standard deviations. This effect was not significantly different after 12 May. The impact of a change in the level of credit did have a significant impact on return volatility during the crisis period (column 4). A negative change in the level of credit led to larger volatility. During May and June, a stock saw a 0.22 standard deviation increase in volatility if the change of credit decreased by one standard deviation on the affiliated bank's balance sheet.

2.6.2 Credit and order book imbalances

The volume on the Berlin stock exchange increased sharply during May and June 1927.[9] So far we saw that the increase in volume did not lead to significantly

[9] No direct volume data is available. However, income from monthly transaction taxes increased during May and June 1927.

higher order book imbalances. However, when comparing only non-Berlin bank firms with Berlin bank firms, we may average out differences within the latter group. Table 2.11 shows the frequencies of order book imbalances before and after 12 May for each bank-specific portfolio. The table provides a more detailed view on the behavior of order book imbalances. Excess supply decreased for firms connected to banks with small decreases in margin credit (Commerzbank, Dresdner Bank). If a firm was affiliated to banks with large credit cuts, the frequency of excess supply increased (Deutsche Bank, Danatbank). These differences across banks are confirmed in Table 2.12. Instead of returns or volatility, the frequency of order book imbalances is now used as dependent variable. The overall level of margin credit had a negative impact on the frequency of supply order imbalances and a positive impact on demand order imbalances. During the large deleveraging of some banks, however, the relationship changes. Stocks connected to more active lenders were more likely to be in excess supply. Further, the absolute change in margin credit had a significant impact on the probability of excess supply during the crisis period (column 2).

This section refined the baseline results and confirmed the negative impact of changes in margin credit on return volatility. But, even in the absence of mark-to-market, the results may still be prone to problems of reverse causality. Higher asset prices could have influenced banks lending decisions. The next section addresses this criticism.

2.6.3 IV strategy

When intermediaries account for their assets in real time (mark-to-market), changes in asset prices and changes in margin credit may reinforce each other (Brunnermeier and Pedersen 2009). A decrease in prices can lead to a further tightening of credit constraints and additional fire sales may follow. In the context of 1927 Germany, the problem of real time accounting is not present. Nevertheless, rising asset prices may still have influenced banks' lending decisions. The previous results may be biased due to the problem of reverse causality. Further, the previous section used daily returns, whereas banks' balance sheet variables vary at a lower frequency. Within a given two-month balance sheet period, we do not exactly know when the decrease in credit occurred.

I address the latter problem by aggregating all variables on a bi-monthly basis. The following analysis uses mean daily returns and mean firm-specific volatility as dependent variables. Means are taken over the periods where balance sheet variables change.

To address the problem of reverse causality, I use the Reichsbank's threat against the Berlin banks in a two-stage least squares specification. Berlin banks were heavily dependent on promissory notes. Each bank held a large portfolio of such notes. In times of liquidity needs, they could redeem these claims at the Reichsbank in return for cash. However, the Reichsbank's willingness to redeem large amounts of promissory notes started to decrease during the run-up to the crisis. Although never stated officially, historians agree that Schacht started to threaten private banks: Not cutting margin lending would come at the price of not having access to the Reichsbank's liquidity. The threat worked. I will instrument the absolute change in margin credit during balance sheet period s by the level of a bank's promissory notes portfolio in period $s-1$. Further, the interaction term of change in margin credit with the May dummy is instrumented by the interaction of the lagged promissory portfolio and the May dummy. For this to be a valid instrument, the level of a bank's promissory notes portfolio cannot influence future asset price movements of affiliated firms except through the Reichsbank's threat. Each bank held promissory notes of a large spectrum of industrial firms. While the previous owners of these notes were mainly bank-affiliated firms, the debtors were not. It is therefore reasonable to assume that a portfolio composed of debts of different firms did not directly influence future asset price movements of bank-affiliated firms.

The first stage regressions are given by

$$Change_{bs} = \beta_1 Notes_{b,s-1} + \beta_2 Notes_{b,s-1} * May_s + \gamma_{bs} + \epsilon_{ibs} \tag{2.5}$$

$$Change_{bs} * May_s = \beta_3 Notes_{b,s-1} + \beta_4 Notes_{b,s-1} * May_s + \gamma_{bs} + \epsilon_{ibs} \tag{2.6}$$

$$\tag{2.7}$$

where $Change_{bs}$ is the change in bank b's margin lending during the bi-monthly period s and $Notes_{b,s-1}$ is the stock of promissory notes of bank b during period $s-1$. The vector γ_{ibs} includes time fixed-effects and bank fixed effects. The instruments are relevant. β_1 in the first regression has a t-statistic of 9.68 and the coefficient on the interaction term in the second regression, β_4, has a t-statistic of -21.21. In both regressions the null hypothesis of an F-test about the relevance of the instruments can be easily rejected.

The results for the second stage are obtained by the regression

$$var_{ibs} = \beta_1 \widehat{Change}_{bs} + \beta_2 (\widehat{Change_{bs} * May_s}) + \gamma_{ibs} + \epsilon_{ibs} \tag{2.8}$$

where $\widehat{Change}_{bs}$ and $\widehat{Change_{bs}} * May_s$ are obtained in the first-stage. Table 2.13 reports the results. In the first column, daily stock returns are the dependent variable in the second stage. The results obtained in the OLS regressions are confirmed – changes in margin credit did not significantly affect daily returns. Further, larger negative changes in May did not have a significant influence neither. Turning to volatility (Column 2), both coefficients of interest are significant. The absolute change in margin credit had a positive effect on volatility. But during the downturn in May, a large unwinding of credit increased volatility as well.

This section showed that the results obtained using OLS are robust to the critique of reverse causality. Using the threat of the Reichsbank against the Berlin banks as an instrument, changes in margin credit still significantly affect return volatility.

2.7 Conclusion

Do tighter lending standards induce fire sales, price dislocations, and worsen financial crises (Gromb and Vayanos 2002, Brunnermeier and Pedersen 2009)? This chapter provides a historical case study where a large change in lending standards induced stock market volatility. When the German central bank forced some banks to size down their margin lending, stocks connected to the affected banks declined significantly more than other stocks during the following weeks. Return volatility of these stocks doubled.

In the absence of marking-to-market, this study is a lower bound of the impact of deleveraging on asset prices. However, this historical case cannot answer the severeness of second round effects, asset price spirals, and margin spirals. The recent crisis has shown the importance of a more detailed knowledge of these issues, for academics as well as policy makers. Further quantitative studies can guide regulation regarding capital buffers and intermediaries' balance sheet capacity.

Before being appointed as head of the Federal Reserve, Janet Yellen said that "it is important for the Fed, as hard as it is, to try to detect asset bubbles when they are forming."[10] Yet the experience of 1927 shows that more research is

[10] *Wall Street Journal*, 14 November 2013

needed to understand the interaction of asset market intervention, bank balance sheets, and macroeconomic outcomes. Adrian, Moench, and Shin (2010) provide first insights in the co-movement of banks' balance sheets and macroeconomic dynamics. The results presented here show the importance of a financial sector in quantitative macroeconomic models. Adopting regulators' and policy makers' toolkit to incorporate a financial sector poses a challenge for future research. An emerging literature takes on this challenge (see, for example, Brunnermeier and Sannikov (2014)) and future research in this direction will be important to avoid the mistakes of 1927.

2.8 Tables and Figures

Table 2.1: **Balance sheets: Berlin banks and other banks.** This table provides an overview of various bank balance sheet variables and their change between 30 April 1927 and 30 June 1927. The table reports values of promissory notes, the total stock portfolio, stock market credit, and share capital. All values are aggregated and differentiated whether banks belong to the Berlin banks or not.

	30.4.1927	30.6.1927	Change May-July 1927
Berlin banks			
Promissory notes	1461.8	1418.8	-43
Stock portfolio	108.8	107	-1.8
Stock market credit	892.7	587	-305.7
Share capital	527	527	0
No of banks	6	6	
Other private banks			
Promissory notes	375.4	351.4	-24
Stock portfolio	124.5	136.6	12.1
Stock market credit	200.5	148.4	-52.1
Share capital	390.6	391.2	0.6
No of banks	80	75	

Table 2.2: **Banks' balance sheets.** This table provides an overview of various bank balance sheet variables at different points in time. The table reports on the asset side the stock of promissory notes, the value of the stock portfolio, and stock market credit. On the liabilities side, share capital is reported. Liquidity is the ratio of short-term assets over short-term liabilities.

				Change (in percent)	
	30.4.1925	30.4.1927	30.6.1927	30.4.25-30.4.27	30.4.27-30.6.27
Deutsche Bank					
Promissory notes	320.76	410.38	167.52	27.94	-59.18
Stock portfolio	12.88	28.88	26.95	124.22	-6.68
Stock market credit	3.03	198.7	131.41	6457.76	-33.87
Share capital	150	150	150	0.00	0.00
Liquidity	0.039	0.045	0.047	16.34	4.92
Disconto Gesellschaft					
Promissory notes	149.56	248	275.06	65.82	10.91
Stock portfolio	5.18	10	10.22	93.05	2.20
Stock market credit	0.73	113.68	66.43	15472.60	-41.56
Share capital	100	135	135	35.00	0.00
Liquidity	0.020	0.038	0.034	92.03	-10.80
Dresdner Bank					
Promissory notes	198.39	291.52	262.8	46.94	-9.85
Stock portfolio	12.36	26.09	25.47	111.08	-2.38
Stock market credit	13.22	171.1	115.12	1194.25	-32.72
Share capital	78	100	100	28.21	0.00
Liquidity	0.032	0.020	0.036	-37.42	79.63
Danatbank					
Promissory notes	203.8	268.15	270.94	31.58	1.04
Stock portfolio	18.24	19.64	22.13	7.68	12.68
Stock market credit	16.55	182.89	123.8	1005.08	-32.31
Share capital	60	60	60	0.00	0.00
Liquidity	0.031	0.027	0.034	-12.08	23.53
Commerzbank					
Promissory notes	106.33	169.34	165.9	59.26	-2.03
Stock portfolio	14.91	15.83	15.42	6.17	-2.59
Stock market credit	27.56	155.68	131.35	464.88	-15.63
Share capital	42	60	60	42.86	0.00
Liquidity	0.030	0.018	0.038	-38.16	106.37

Table 2.3: **Descriptive statistics (Full sample).** This table provides descriptive statistics related to firms' share capital. For the total sample as well as for each share capital quartile the table provides the mean, the standard deviation, and the median capital. The table also states the mean number of large underwriters for the total sample as well as for each size quartile.

	Total	Size quartiles			
		1st	2nd	3rd	4th
Share capital					
Mean	31.88	1.33	4.57	13.85	108.63
St.Dev.	114.19	0.50	1.64	4.95	213.23
Median	7.50	1.30	4.32	12.68	50.00
No. of underwriter					
Mean	1.41	0.97	1.22	1.44	2.00
N	145	37	36	36	36

Table 2.4: **Descriptive statistics (Single underwriter sample).**This table provides the mean and median share capital and its standard deviation for firms within a bank-specific portfolio. A firm is connected to a bank if the bank is the single underwriter.

	(1)	(2)	(3)	(4)	(5)	(6)
	BHG	Commerz	Deutsche	Diskonto	Danat	Dresdner
Share capital						
Mean	11.95	15.72	16.01	13.79	19.82	15.42
Stan.Dev.	11.91	24.25	21.64	14.74	26.54	33.86
Median	9.20	2.50	7.50	7.55	7.50	6.00
N	3	13	27	16	19	21

Table 2.5: **Summary statistics before and after margin call.** This table provides summary statistics of the main variables. The variables are differentiated along two dimensions: Whether a firm is connected to a large Berlin bank (*Large bank*) or not (*No large bank*) and whether the period is before or after the margin call. The period before the margin call is from February until 12 May, the period after the margin call is from 13 May until 28 June. The statistics provided are mean daily returns, the standard deviation of daily returns within the large bank or non-large bank sample during the given period, mean volatility (where firm-specific volatility is measured as the variance of returns in a 5 day rolling window), mean supply order book imbalances (*Excess supply*), and mean demand order book imbalances (*Excess demand*).

		Before margin call	After margin call
Returns			
	Large bank	-0.0005	-0.0037
	No large bank	-0.0029	-0.0055
Returns, St.Dev			
	Large bank	0.026	0.041
	No large bank	0.028	0.032
Volatility			
	Large bank	0.00072	0.00138
	No large bank	0.00068	0.00056
Excess Supply			
	Large bank	0.13	0.12
	No large bank	0.12	0.1
Excess Demand			
	Large bank	0.36	0.3
	No large bank	0.43	0.26

Table 2.6: **Baseline regression: Variance and returns.** This table provides the results for the following regression: $y_{it} = \beta(Bank_i * May_t) + \gamma_{it} + \epsilon_{it}$, where y_{it} is the value of the dependent variable for firm i at time t. $Bank_i$ is a dummy that is 1 if firm i is connected to a large Berlin bank and 0 otherwise, May_t is a dummy that is 1 after the margin call at 12 May (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927), and γ_{it} is a vector of firm and time dummies. The dependent variables are the return variance calculated as the variance of returns in a 5 day rolling window in columns 1 and 2, and daily returns in columns 3 and 4. Robust standard errors are reported.

	(1) Variance	(2) Variance	(3) Returns	(4) Returns
May*Bank	0.000778***	0.000684***	-0.000620	-0.00141
	(0.000103)	(0.0000963)	(0.00321)	(0.00314)
May	-0.000117		-0.00260	
	(0.0000880)		(0.00310)	
Bank	0.0000442		0.00236	
	(0.0000628)		(0.00174)	
Constant	0.000681***	0.00120***	-0.00292*	0.0127**
	(0.0000591)	(0.000256)	(0.00170)	(0.00566)
Firm FE	No	Yes	No	Yes
Time FE	No	Yes	No	Yes
N	11273	11273	9107	9107
R^2	0.020	0.230	0.002	0.277

Table 2.7: **Baseline regression: Order book imbalances.** This table provides the results for the following regression: $y_{it} = \beta(Bank_i * May_t) + \gamma_{it} + \epsilon_{it}$, where y_{it} is the value of the dependent variable for firm i at time t. $Bank_i$ is a dummy that is 1 if firm i is connected to a large Berlin bank and 0 otherwise, May_t is a dummy that is 1 after the margin call at 12 May (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927), and γ_{it} is a vector of firm and time dummies. The dependent variables are a dummy that is 1 if excess supply existed and 0 otherwise (columns 1 and 2), and a dummy that is 1 if excess demand existed and 0 otherwise (columns 3 and 4). Robust standard errors are reported.

	(1) ExcSupply	(2) ExcSupply	(3) ExcDemand	(4) ExcDemand	(5) ExcDemand
May*Bank	0.0101	0.0101	0.108***	0.108***	-0.00137
	(0.0239)	(0.0230)	(0.0357)	(0.0334)	(0.0765)
May	-0.0214		-0.168***		
	(0.0228)		(0.0343)		
Bank	0.0161		-0.0694***		
	(0.0176)		(0.0266)		
Constant	0.120***	0.0704	0.433***	-0.0756	-0.0146
	(0.0168)	(0.0527)	(0.0256)	(0.0586)	(0.0955)
Firm FE	No	Yes	No	Yes	Yes
Time FE	No	Yes	No	Yes	Yes
N	9996	9996	9996	9996	9860
R^2	0.001	0.126	0.006	0.214	0.229

Table 2.8: **Firm size and number of underwriters.** This table provides the results for the following regression: $y_{it} = \beta May_p * Charac_i + \gamma_{ipt} + \epsilon_{it}$ where y_{it} is the return of stock i at day t or return volatility measured over the period $t-5$ to t. May_p is a dummy that is 1 after 12 May 1927 (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927) and γ is a vector of controls that includes firm dummies and a constant. $Charac_i$ describes a firm characteristic. This variable is either a dummy for each firm size quartile (*Size 1,2,3,4*) or a vector of dummies whether firm i has 0, 1, or more large underwriters (*1UW, 2+UW*).

	Returns	Returns	Returns	Volatility	Volatility	Volatility
May*Size 2	0.000979		0.00129	0.000225		0.000170
	(0.00145)		(0.00160)	(0.000240)		(0.000258)
May*Size 3	0.00141		0.00167	0.00112***		0.00106***
	(0.00156)		(0.00167)	(0.000365)		(0.000378)
May*Size 4	0.00248*		0.00264*	0.000779***		0.000689***
	(0.00141)		(0.00154)	(0.000242)		(0.000257)
May* 1 UW		-0.00185	-0.00258		0.000601***	0.000304
		(0.00176)	(0.00196)		(0.000165)	(0.000230)
May*2+ UW		-0.000232	-0.00138		0.000909***	0.000512**
		(0.00172)	(0.00185)		(0.000177)	(0.000249)
Constant	-0.0234***	-0.0268***	-0.0243***	0.00179***	0.000980***	0.00249***
	(0.00293)	(0.00241)	(0.00297)	(0.000268)	(0.000227)	(0.000278)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	8970	9107	8970	11106	11273	11106
R^2	0.276	0.277	0.277	0.236	0.230	0.237

Table 2.9: **Bank-specific regressions: Returns and volatility.** This table provides the results for estimating the regression $y_{ibt} = \beta May_t + \alpha + \epsilon_{ibt}$, where y_{ibt} is the daily stock return of stock i connected to bank b at day t in the upper panel of the table. In the lower panel the dependent variable is return volatility measured as average firm-specific return variance (5 day rolling window). May is a dummy that is 1 after 12 May (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927). The regression is estimated for each bank-portfolio b separately. Standardized coefficients are reported.

	(1) Commerz	(2) Deutsche	(3) Diskonto	(4) Danat	(5) Dresdner
Returns					
May	-0.039	-0.057**	-0.011	-0.054	-0.027
	(0.00253)	(0.00187)	(0.00230)	(0.00200)	(0.00191)
N	968	2026	1003	1307	1665
R^2	0.010	0.025	0.010	0.010	0.023
Variance					
May	0.036*	0.161***	0.174***	0.147***	0.106***
	(0.000133)	(0.000164)	(0.0000898)	(0.0000852)	(0.000103)
N	1174	2451	1248	1597	2011
R^2	0.174	0.109	0.144	0.109	0.142

Table 2.10: **Credit and stock prices.** This table provides the results for the regression $y_{ibt} = \beta_1 CredMeasure_{bs} + \beta_2 CredMeasure_{bs} * May_p + \gamma_{ibt}$, where y_{ibt} is the return of stock i connected to bank b at day t (columns 1 and 2) or return variance (columns 3 and 4). May_p is a dummy that is 1 after 12 May (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927). The variable $CredMeasure_{bs}$ is the level of margin lending by bank b during the bi-monthly period s in columns 1 and 3 and the absolute change of credit in columns 2 and 4. Robust standard errors are reported.

	(1)	(2)	(3)	(4)
	Returns	Returns	Volatility	Volatility
Credit	0.0000234		-0.0000145***	
	(0.0000508)		(0.00000353)	
May*Credit	-0.0000497		0.00000119	
	(0.0000344)		(0.00000195)	
Credit Change		-0.0000116		0.00000517
		(0.0000867)		(0.00000603)
May*(Credit Change)		0.0000743		-0.0000192***
		(0.0000832)		(0.00000629)
Constant	-0.0220***	-0.0205***	0.00272***	0.00105***
	(0.00498)	(0.00629)	(0.000498)	(0.000236)
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	6969	6969	8481	8481
R^2	0.247	0.247	0.210	0.210

Table 2.11: **Order book imbalances.** This table provides the frequency of order book imbalances. Order book imbalances are measured by the price tags quoted in the official stock price list.

Bank	Exc.supply		Exc.Demand	
	Before 12 May	After 12 May	Before 12 May	After 12 May
Commerz	0.13	0.12	0.25	0.31
Deutsche	0.12	0.21	0.40	0.31
Diskonto	0.13	0.11	0.31	0.36
Danat	0.11	0.14	0.28	0.31
Dresdner	0.13	0.12	0.33	0.36

Table 2.12: **Credit and order book imbalances.** This table provides the results for the regression $y_{ibt} = \beta_1 CredMeasure_{bs} + \beta_2 CredMeasure_{bs} * May_p + \gamma_{ibt}$, where y_{ibt} is excess supply or excess demand of stock i connected to bank b at day t. May_p is a dummy that is 1 after 12 May (13 May 1927-30 July 1927) and 0 before (1 February 1927-12 May 1927). The variable $CredMeasure_{bs}$ is the level of margin lending by bank b during the bi-monthly period s in columns 1 and 3 and the absolute change of credit in columns 2 and 4. Robust standard errors are reported.

	(1) ExcSupply	(2) ExcSupply	(3) ExcDemand	(4) ExcDemand
Credit	-0.00160***		0.00291***	
	(0.000431)		(0.000552)	
May*Credit	0.000969***		-0.000951**	
	(0.000303)		(0.000401)	
Credit Change		-0.000490		0.00261**
		(0.000864)		(0.00114)
May*(Credit Change)		-0.00207***		0.00158
		(0.000763)		(0.000979)
Constant	0.269***	-0.00340	0.186*	0.676***
	(0.0826)	(0.0352)	(0.109)	(0.0585)
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	10584	10584	10584	10584
R^2	0.099	0.099	0.216	0.215

Table 2.13: **IV results.** This table provides the results for the second stage regression $y_{ibs} = \beta_1 abs.CreditChange_{bs} + \beta_2 abs.CreditChange_{bs} * May_s + \gamma_{ibs}$, where y_{ibs} is the daily return of stock i connected to bank b during the bi-monthly period s (column 1) or return volatility (column 2). May_p is a dummy that is 1 for May and June. The variable $abs.CreditChange_{bs}$ is instrumented by $Prom.notes_{b,s-1}$, which is the level of promissory notes of bank b during the previous period. The interaction term $abs.CreditChange_{bs} * May_s$ is instrumented by $Prom.notes_{b,s-1} * May_s$. The instruments are relevant and the first-stage t-statistics are 9.68 and -21.21, respectively.

	(1) Returns	(2) Volatility
abs.CreditChange	-0.0000461	0.0000916*
	(0.000276)	(0.0000535)
May*(abs.CreditChange)	0.0000622	-0.0000832**
	(0.000210)	(0.0000393)
Constant	0.00181	0.00108
	(0.00844)	(0.000829)
Firm FE	Yes	Yes
Balancedate FE	Yes	Yes
N	267	264
R^2	0.611	0.550

Figure 2.1: **Returns and volatility.** This figure plots stock price indices and return volatility for two groups of firms. The "Non large banks" group is composed of firms that do not have a connection to a large Berlin bank. The "large bank" group is composed of firms that have a connection to at least one large Berlin bank. All stock price indices are normalized to 100 at 12 May 1927. Volatility is calculated as the average firm-specific return variance using a 5 day rolling window.

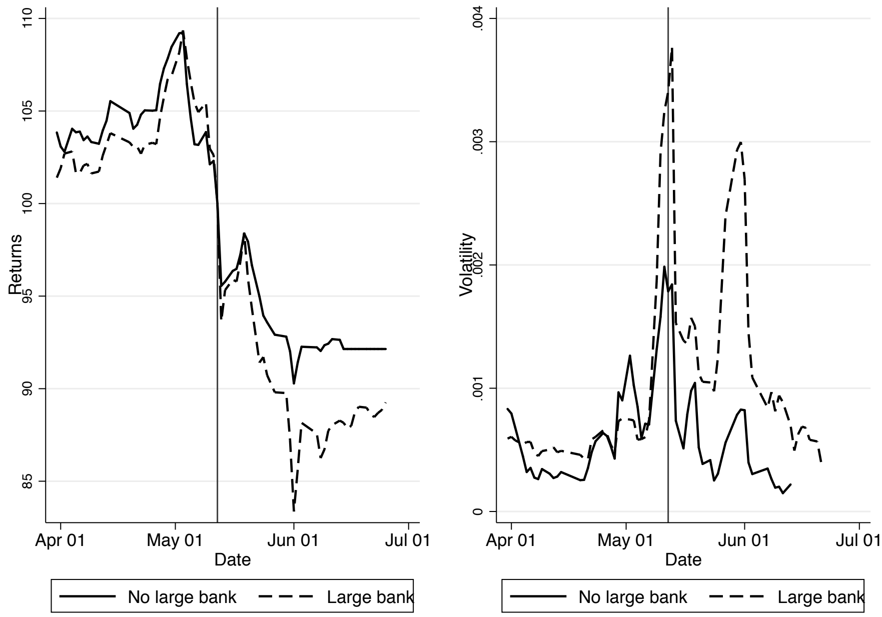


Figure 2.2: **Stock market credit and the overall stock market.** This figure plots a stock market index and the overall position of banks' margin lending between January 1925 and January 1928. The vertical line represents 12 May 1927. The aggregate data are taken from the statistical yearbooks of the German Reich.

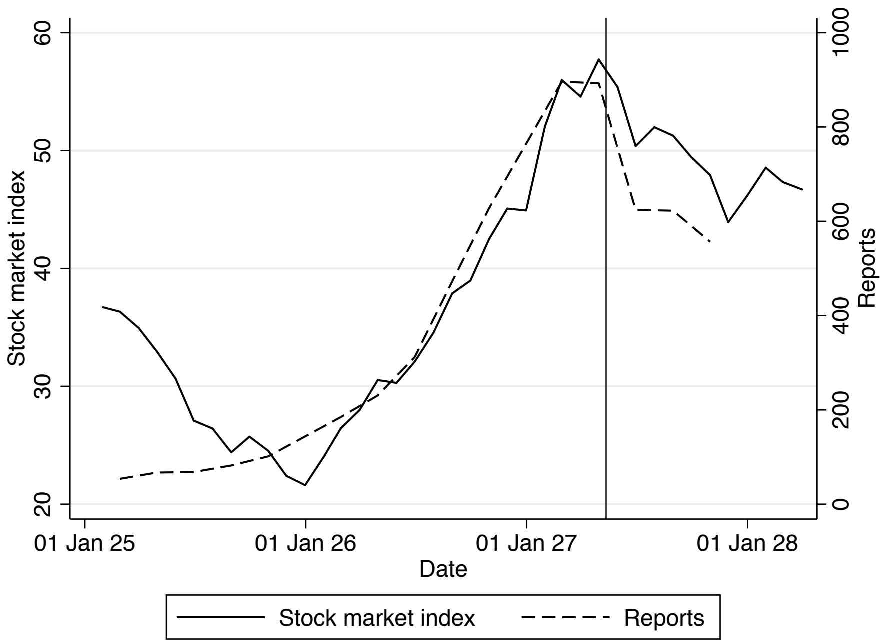


Figure 2.3: **The Reichsbank's promissory notes portfolio.** This figure plots the evolution of the promissory notes held by the Reichsbank between January 1926 and July 1928. The vertical line marks 12 May 1927. No data are available between November 1927 and March 1928. The data are taken from the statistical yearbooks of the German Reich.

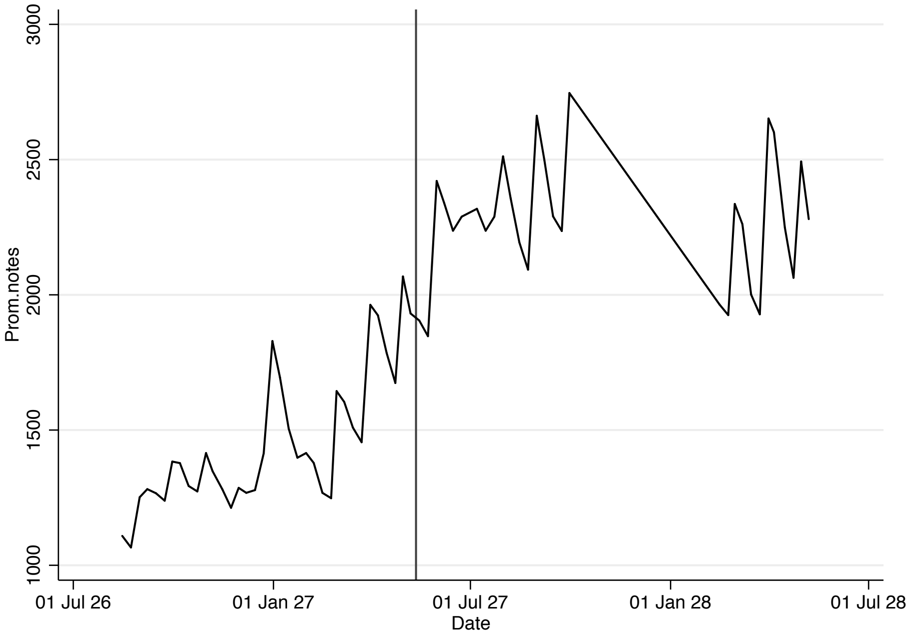


Figure 2.4: **The Reichsbank's foreign exchange.** This graph shows the evolution of the foreign exchange in the hands of the Reichsbank as stated in the Reichsbank's balance sheets. The vertical line marks 12 May 1927. No data are available between November 1927 and March 1928. The data are taken from the statistical yearbooks of the German Reich.

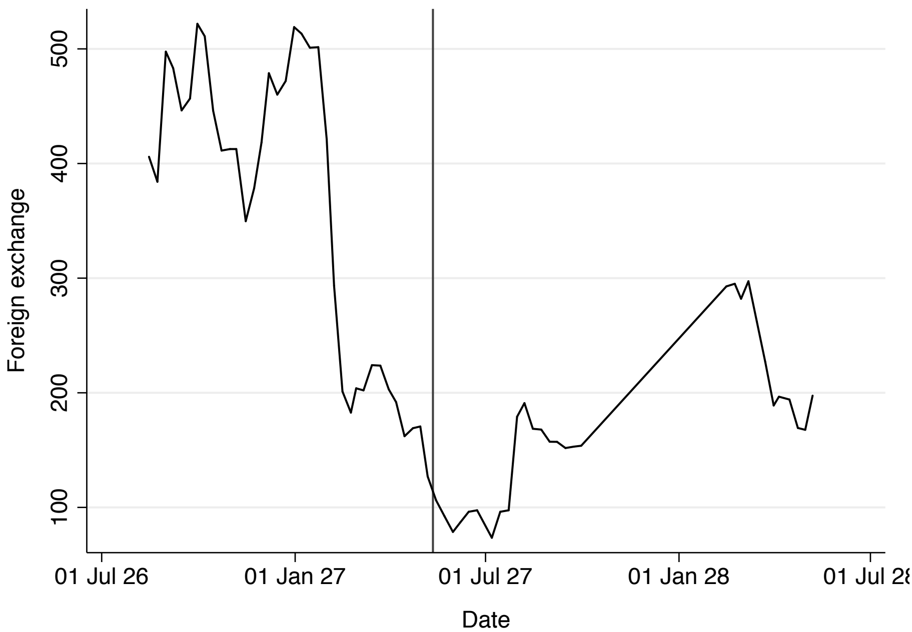


Figure 2.5: **Differences by size.** This figure plots stock price indices and return volatility for firm size quartiles. Firm size is measured by share capital. All stock price indices are normalized to 100 at 12 May 1927. Volatility is calculated as the average firm-specific return variance using a 5 day rolling window.

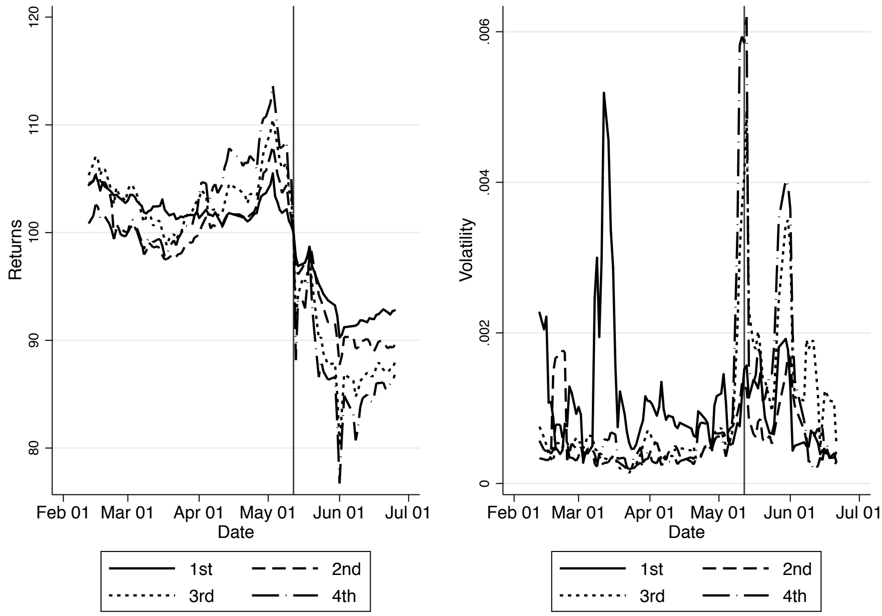
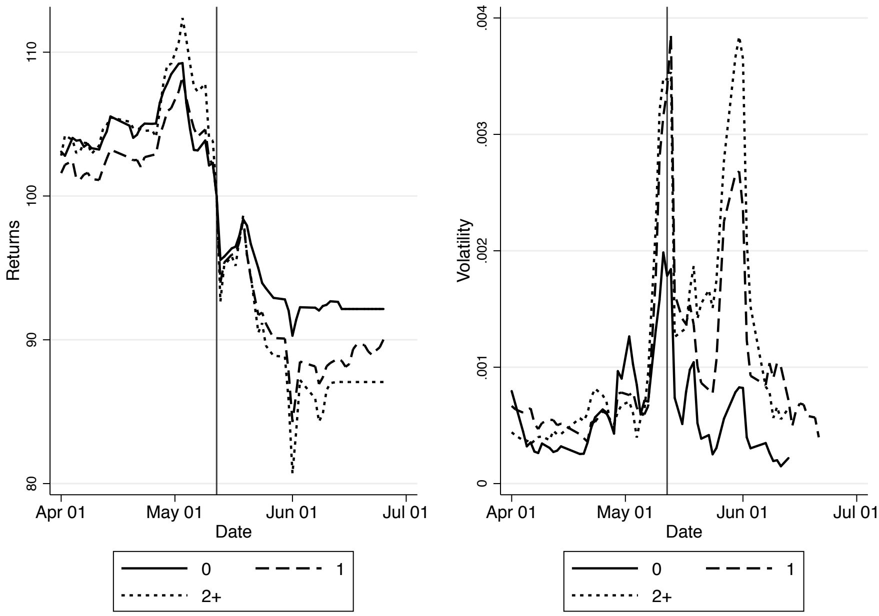


Figure 2.6: **Differnces by number of underwriters.** This figure plots stock price indices and return volatility for different number of large underwriter banks. The index of underwriter banks is 0 if a firm has no large underwriter, 1 if it has one large underwriter, or 2 if it has two or more large underwriters. All stock price indices are normalized to 100 at 12 May 1927. Volatility is calculated as the average firm-specific return variance using a 5 day rolling window.



Chapter 3

CONSUMING WITHOUT CAPITAL: THE BLESSINGS OF GOVERNMENT DEBT IN 18TH CENTURY ENGLAND

3.1 Introduction

Bloody wars and a highly indebted government - this combination helped the English middle class in the eighteenth century to consume as they never did before. Around 1700, England started to finance wars with debt. Hand in hand with this Financial Revolution went a Consumer Revolution. The middle class increased its possessions, and luxuries trickled down from the upper class. However, increasing consumption might seem at odds with the common view of economic historians on England. During this period, England experienced low investment in physical capital, a low capital stock per worker, low output growth, and a low degree of specialization. In this chapter I show that these two views of England do not necessarily contradict each other. A Consumer Revolution was indeed possible in an environment that did not look very promising. In the presence of financial constraints, it was the invention of government debt that enabled the English middle class to increase their consumption. I provide evidence for the presence of severe financial constraints; English investors had no means to save their wealth efficiently. These constraints effected the ways individuals behaved and consumed. The Financial Revolution gave individuals a store of value – government debt. Being able to transfer wealth over time, the set of feasible allocations expanded. Consumption bundles unavailable before became affordable. This chapter therefore challenges the view of deVries (2008), who sees consumer behavior at that time "... detached from constraining economic and social forces."

The eighteenth century is the subject of a large literature. It is of special interest because of the emergence of the Industrial Revolution. Opinions differ about the conditions of the English economy in the running up to the Industrial Revolution. They cover the whole spectrum from overly optimistic to completely pessimistic. In terms of growth rates and capital accumulation, a widely accepted view is that the situation did not look very promising for England. However, during the same period, England emerged as a stable country after the Glorious Revolution of 1688. This emergence of stable institutions and a credible government made debt financing of wars possible. North and Weingast (1989) see this innovation as a major step towards economic development. Yet the growing national debt is mostly seen as problematic, even when a clear answer has still not emerged, whether government debt crowded out private investment.[1]

Looking at the demand side, the picture of eighteenth century England spurs greater optimism. In an influential book, McKendrick, Brewer, and Plumb (1983) propose that England experienced a major change in consumption patterns. The middle class acquired more consumption goods and accumulated luxuries. Studies of inventories around this time show an increase in household possessions. Luxury goods like china or clocks became commonplace in middle class households. Almost neglected in the economics literature, sociologists nowadays widely accept the existence of a Consumer Revolution.

Nevertheless, the causes of this increase in consumption levels and the change in consumption patterns are still subject to speculation. Most explanations propose changes in tastes or changes in the social perception of consumption; something must have changed in the minds of the English people. While this may explain the change in the composition of a typical consumption basket, it does not explain the increased levels in consumption. Such an increase is only feasible if wealth increases as well – a stark contrast to the above mentioned low

[1]See WIlliamson (1984) for a favorable argument for the crowding out hypothesis and Clark (2001a) for a negative assessment

growth rates of wages. However, wages and prices of agricultural goods, the focus of economic historians, are only one part of total income. During the eighteenth century, capital gains increasingly contributed to total income (Holderness 1976). Most of these gains were derived from government debt, new investment vehicles that cannot be neglected after the Financial Revolution. Before, capital markets were imperfect, and capital could not be allocated efficiently in the presence of asymmetric information. Consumers could hardly channel their savings to entrepreneurs. To transfer wealth over time, they relied on inefficient storing technologies. The government's need to finance its wars was a blessing for consumers. It provided them with a safer, more efficient way of storing their wealth. This increase in efficiency made higher consumption possible, while the capital stock did not increase; rates of investment in physical capital staid low. Therefore, the Financial Revolution is the missing link between two seemingly orthogonal views on England in the eighteenth century – pessimistic indicators of economic development on the one side, and an increase in the number and quantity of goods in households on the other side.

This chapter is based on the literature about financial constraints and rational bubbles. Financial frictions are assumed to be a common feature in todays capital markets. They act as an explanation for various macroeconomic events. One main friction in financial markets is asymmetric information. In the presence of asymmetric information, entrepreneurs may not be able to obtain sufficient credit to invest at an efficient scale. In its most extreme form, entrepreneurs have no access to outside financing and must rely entirely on internal funds.[2]

The literature on rational bubbles and the effects of missing stores of value started out with Samuelson (1958). In a simple overlapping generations model, the introduction of an unproductive asset can be welfare enhancing when consumers lack a store of value. In earlier articles, this result depends on the assumption of dynamic inefficiency (Tirole 1985). However, Martin and Ventura (2012) shows that this condition does not need to hold if financial frictions are present – an economy can experience positive welfare effects by the introduction of an unproductive asset even when it is dynamically efficient in the sense of Diamond (1965). Rational bubbles can arise and crowd out inefficient investments

[2]The literature on financial frictions is large and still growing. See, for example, Tirole (2005) for the effects of credit market imperfections on corporate finance. Bernanke and Gertler (1989) is a classical model for the effects on the macroeconomy and Matsuyama (2002) for an application to International Economics and Economic Growth

while boosting consumption. In contrast to these models, which are concerned with the emergence of bubbles, this chapter is mainly about government debt. However, in a standard Diamond-Model government debt and rational bubbles are perfect substitutes. Further theoretical evidence for the substitutability of government debt and bubbles is given by Kraay and Ventura (2005) and Farhi and Tirole (2012).

The structure of this chapter is as follows: In the following section I lay out the economic and social situation in eighteenth century England. Section 3.3 describes the introduction and evolution of government debt, the Financial Revolution. Section 3.4 unifies the two contradictory views. I present anecdotal evidence on the existence of financial constraints and the linkages between the Financial and the Consumer Revolution. The last section concludes.

3.2 Eighteenth-century England: Two tales of one country

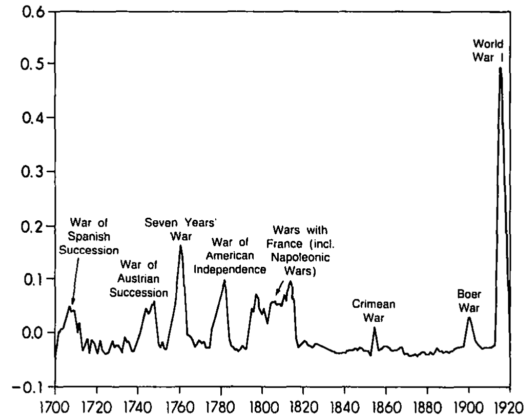
Asking about living standards in eighteenth century England, one may receive the answer that "it depends." The first part of this section summarizes the more pessimistic outlook of stagnant wages and low output growth. The second part turns another, more optimistic view on England. This view stresses an increasing number of consumption goods. Luxuries trickled down to middle class households and consumption of non-durables rose sharply.

3.2.1 The economic situation

Economic growth in England during the eighteenth century was "modest at best" (WIlliamson 1984). Refining the results of Deane and Cole (1962), Crafts (1983) estimates an annual growth rate of output per capita between 1700 and 1760 of 0.31 percent. Between 1760 and 1800, growth even declined to 0.01 percent according to Crafts (1983). Agricultural real wages were low and stagnant; the take-off of wages is never dated before 1790 (see, for example, Clark (2001b)). Even the decline in agricultural food prices during the first half of the eighteenth century did not lead to a major increase of wages relative to agricultural products.

Additional statistics deliver the same negative impression. Neoclassical growth models always stress the importance of two things: capital accumulation and total factor productivity growth. According to these measures, England's situation seemed hopeless. Productivity growth was near zero (Clark 2001b) and investment rates were low. Crafts (1983) estimates that only four percent of GDP were used as gross domestic investment. And although the investment ratio increased after 1760, most of the higher levels of investment were attributed to the increase in the rate of population growth.

Figure 3.1: **Military spending.** This figure shows the ratio of Real Military Spending to Trend Real GNP.



Source: Barro (1987)

Apart from a stagnating economy, the eighteenth century was also characterized by England constantly fighting wars. Starting in 1696 with the war against France, public expenditure on war financing increased to levels never seen before. The war of the Spanish Succession was followed by a short period of peace, during which the government was mainly concerned about repaying outstanding loans. After 1740, the need for money increased again – wars became more frequent and their costs rose steadily. Figure 3.1, taken from Barro (1987), shows the evolution of government spending on wars. The rapid increase in the number of wars, their costs, and the public expenditure on military has received a lot of attention in the literature. It is often seen as one cause of the low growth in England. Barro (1987) argues that the government crowded out investments and restricted growth opportunities (before Barro, Ashton (1955) had put this argument forward as well). WIlliamson (1984) writes that wars "almost certainly worsened the economic status of labor" and that "the same may perhaps be said of industrialization, capital formation, and export expansion." He estimates an English savings rate of 18 percent, with a large proportion going into the financing of costly wars. However, a significant effect of government debt on private investment is questioned by several authors. Clark (2001a) claims that if crowding out was present, private returns should have increased. The data do not show such a pattern, and Clark (2001a) concludes that government debt had no negative effect on private investment.[3] However, in the presence of credit rationing price data can be misleading (Temin and Voth 2005). Using evidence from Hoare's bank, Temin and Voth (2005) conclude that the credit market in England did clear through quantity rather than through prices.

Further, no consensus exists about the impact of taxation on English growth. Beckett and Turner (1990) describe the pattern of taxation. The real per capita tax burden rose sharply after the French war in 1693. After 1700, the burden of direct taxes declined and after 1713, no clear evidence can be found that higher taxes went together with higher levels of debt.

England's situation did not look promising. Low growth, low wages, hardly any increase in productivity, and a rapidly increasing debt burden from endless wars – living standards must have been low and people should have been mostly concerned about keeping consumption above subsistence level. Turning to consumption, the next section describes a different scenario – one in which the middle class enjoyed large welfare gains because of increased consumption levels.

3.2.2 A "Nation of Shoppers"

There is another view on England in the eighteenth century – the view that the middle class experienced an increase in consumption and that luxuries trickled down from the upper class. Contemporary observers and social historians suggest that "there was a Consumer Revolution in eighteenth-century England" (McKendrick, Brewer, and Plumb 1983). Inspired by McKendrick's work, sociologists began to look closer at the demand side. They conclude that before the

[3] Several other authors also examined this connection. See Mirowski (1981), Mokyr (1987), Quinn (2001)

Industrial Revolution, England experienced yet another revolution: The Consumer Revolution. After 1700, peoples' consumption behavior shifted notably. Consumer durables were exchanged for non-durables and households held more valuable goods. During the second half of the eighteenth century, this trend even strengthened. Former luxury products found their way into the possessions of the middle-class; consumption of products like tobacco and tea increased at a large scale (see, for example, Shammas (1993)).

While consumption of luxuries increased, products of the mass production type played the largest role in the Consumer Revolution. Schumpeter (1960) and Deane and Cole (1962) report that the export of manufactured goods accounted only for a small proportion of total manufactured goods. The remainder was absorbed by the English population. Home goods saw major changes in demand as well. Eversley (1967) recognizes that per capita consumption of these goods increased from £10 at the end of the seventeenth century to £40 in 1801. People stocked up on clothing and on different kinds of hardware like pottery, furniture, or silver. Table 3.1 shows the evolution of the possession of selected consumer items for the first quarter of the eighteenth century. It stresses the overall trend of increased possessions of consumer goods.

People also bought different kinds of food. Shammas (1993) notes that non-European groceries were adopted on a large scale. Table 3.2 shows the increase in the import of tea as an example of a non-durable good. Another example is provided by Table 3.3, which shows the increase in consumption per capital of sugar and tea. After 1725, inventory data become harder to track, but authors like Weatherill (1988) suggest that the same pattern of growth can be seen for the whole first half of the eighteenth century.

What drove this increase in consumerism? The literature on the evolution of commercialization during the eighteenth century is large.[4] However, even authors such as McKendrick lack a proper explanation for why consumption has increased exactly during that time. For McKendrick, the prerequisites of a Consumer Revolution were present before, albeit at a smaller scale. Therefore changes in tastes (deVries 1994) and character types (Campbell 1993) are regarded as the main factors that influenced changes in consumption.[5]

[4] See for example the articles in Brewer and Porter (1993)

[5] In the literature it is often stressed that the English society was marked by high social mobility and an increasing acceptance of consumption. The huge impact of Mandeville's (1714) "Fable of the bees" and later on the emergence of authors like Adam Smith can be seen as evidence for that.

Table 3.1: **Frequencies of ownership of selected household goods.** This table provides the frequencies of ownership of certain household goods as an example of the increased number of possessions over time. Data come from household inventories.

Year	No. of inventories	Saucepans (%)	Earthenware (%)	Clocks (%)
1695	497	8	34	14
1705	520	11	36	20
1715	455	17	47	33
1725	390	23	57	34
		Pictures (%)	Window curtains (%)	Utensils for hot drinks (%)
1695	497	9	11	1
1705	520	14	12	2
1715	455	24	19	7
1725	390	21	21	15

Source: Weatherill (1988)

If large changes in tastes and preferences occurred, the share of consumption should have changed. However, until 1750 the proportion of consumption in wealth staid constant. It was the overall level of consumption that increased steeply. Several authors document an increase in wealth, prosperity and therefore living standards. Shammas (1993) notes that mean wealth in East London rose from £72 in 1661 to £1293 in 1720. This trend was also present in other parts of England. More detailed data on an increase in household income are hard to find; most evidence comes from diary entries of contemporaries. Nevertheless, the anecdotal evidence suggests an increase in the overall income of the middle-class.

McKendrick, Brewer, and Plumb (1983) summarize the rise of consumerism in the following way:

> These characteristics - the closely stratified nature of English society, the striving for vertical social mobility, the emulative spending bread by social emulation, the compulsive power of fashion begotten by social competition - combined with the widespread ability to spend (offered by new levels of prosperity) to produce an unprecedented propensity to consume: unprecedented in the depth to which it penetrated the lower reaches of society and unprecedented in its

Table 3.2: **Tea imports for home consumption.** This table provides the tea imports for home consumption in England and Wales. The numbers are annual averages for 1700-1799.

Years	Tea in legal lb. per capita
1700-09	0.01
1710-19	0.05
1720-29	0.10
1730-39	0.17
1740-49	0.29
1750-59	0.49
1760-69	0.81
1770-79	0.70
1780-89	1.26
1790-99	2.00

Source: Shammas (1993)

impact on the economy.

The picture of eighteenth century England is therefore a story of two conflicting views. On the one hand, economic historians stress low wage growth and almost no capital accumulation. On the other hand, sociologists are amazed by the increase in consumption and luxury. England emerged as a "nation of Shoppers." deVries (1994) provides one explanation to combine the facts. Aware of the contradiction, he introduces yet another revolution: the Industrious Revolution. A change in tastes led to changes in consumer demand and changes on the demand side. Only after the shift in tastes was fully realized, the supply side's answer was the Industrial Revolution.

Can changes in tastes explain the whole puzzle? Holderness (1976) is not convinced by theories that look only at psychological factors or changes in prices. "But neither price nor emulation can fully explain changes in the structure of demand up to the Industrial Revolution." Is there another link between the low growth rates, high savings rates, slow capital accumulation, and the Consumer Revolution that can rationalize these events? In the next section I argue that the missing link was the introduction of government debt. In the presence of financial frictions, capital could not be channeled from consumers to productive entrepreneurs. Consumers lacked a store of value; a void that was finally filled by

Table 3.3: **Consumption of selected goods** This table provides the per capita consumption of sugar and tea in England during the eighteenth century.

Year	Sugar	Year	Tea
1700-09	2.6 kg	1722	0.28 kg
1720-29	5.0 kg	1750-59	0.50 kg
1750-59	7.5 kg	1784-86	0.61 kg
1770-79	10.6 kg	1805-06	0.79 kg

Source: deVries (2008)

government debt. In deVries' terms, the "industrial dimension" and the "social dimension" had to be accompanied by a financial dimension. This dimension is described in the next section.

3.3 The Missing Link: The Financial Revolution

During the eighteenth century, a modern financial system emerged in England. Institutions like the Bank of England and the London Stock Exchange were created, and new financial instruments enabled the government to borrow long-term.[6] This section describes the evolution of national debt before and after the Financial Revolution.

Before 1650, government debt hardly existed in England – it was risky, illiquid, and not accepted by the public. To finance their expenditures, kings borrowed from goldsmiths and defaulted on their debts from time to time. "The total picture [of government financing] prior to 1700 was best described as chaotic" (Kindleberger 1993). Developments in actuarial science allowed the French and Dutch governments to test the grounds of government borrowing. However, no country developed such an efficient system of national debt as England. The Glorious Revolution provided the institutional framework for reliable lending to the government. New political institutions evolved, and the government enhanced its credibility (North and Weingast 1989). Before the Glorious Revolution, North and Weingast (1989) describe the incentives of the crown as those of an "extended household". The Glorious Revolution introduced rules that constrained

[6] Dickson (1967) is the classical reference for the emergence of government debt in England. He also coined the term "Financial Revolution" that I adopt here.

the government's behavior and that brought the government's and the public's incentives closer together. The government could borrow at a larger scale; less money had to be raised through taxation. As its credibility increased, the government's costs of borrowing declined. During the course of the eighteenth century, borrowing costs never reached the level of the French wars during the 1690's.[7]

By 1740, England had a highly developed financial system with a liquid market in long-term government bonds. Nevertheless, the road to financial development was not free of crises and setbacks. At the beginning of the century, long-term borrowing was not common. The government financed its war against France mainly through taxes and customs as well as short-term loans at the Bank of England. Interest on these loans was high (between 6 per cent and 8.7 per cent). Further, the issuance of loan contracts was not properly managed by the government and resulted often in financial crises. It was a period of trial and error. The success of a government loan issue depended also on the expectations of the public. In 1704, Montague became Chancellor of the Exchequer, with Godolphin as Lord Treasurer. Together they restored the public's faith in national debt. This faith increased further when the newly founded Bank of England took over the issuance of government debt. Once established, not even the bursting of the South Sea bubble and the crisis during the aftermath could destroy the public's trust in government securities. Demand for government debt grew constantly, and after some years of peace, the English government could finance wars at even lower rates of interest than before the South Sea bubble. During the first decades of the century, the government was able to place increasingly higher debt issues in the market – national debt increased from £1 Million in 1689 to £900 Million in 1817. At the same time, interest rates declined and the government could raise funds at only three per cent in 1740 (Table 3.4).

3.4 Putting the pieces together: National debt and the Consumer Revolution

How did the two revolutions interact? This section puts the pieces previously described together. In the first part, a simple model of overlapping generations provides the theoretical foundations of the argument. The second part describes

[7]For the evolution of interest rates during the eighteenth century, see Sylla and Homer (1996)

Table 3.4: **British National Debt.** This table shows the evolution of British National debt between 1697 and 1815.

Year	Debt in Mio. £	Annual Interest Charge in Mio. £	War
1697	14.5	1.2	End of Nine Years' War
1702	12.8	1.2	
1714	36.2	3.1	War of the Spanish Succession
1739	46.4	2.0	
1748	75.4	3.1	War of the Austrian Succession
1757	77.8	2.7	
1763	132.1	5.0	Seven Years' War
1776	130.5	4.8	
1781	187.8	7.3	American War of Independence
1786	243.2	9.5	Forth Anglo-Dutch War
1793	244.7	9.5	
1802	523.3	19.5	Napoleonic War
1815	834.3	31.4	Napoleonic War

Source: Hargreaves (1930)

anecdotal evidence of the model's predictions. Government debt provided a store of value for English investors, making the Financial Revolution a prerequisite for the Consumer Revolution.

3.4.1 Government debt and Financial constraints: A simple model

Government debt not only enabled England to fight wars, it also gave consumers a means of savings. The effects of this new investment opportunity are analyzed in a simple overlapping generations model. The model shows that the level of consumption increases, whereas the economies capital stock won't grow when the government issues debt.

The argument is not new. Already contemporaries such as Colquhoun (1815) noted the positive role of government debt. Ashton (1955) states:

> Even the long-dates securities had some effect on the volume of purchasing power. For the fact that any holder could dispose of them through stock dealers and so obtain cash (though at the expense of cash holdings of others) meant that men were less concerned than

their fathers had been to keep quantities of coin, bullion, and plate locked up in safe or buried in their orchards and gardens.

But why did investors purchase government securities? Interest rates on government bonds declined during the eighteenth century, dropping to 3 percent around 1740. Compared with estimates of the marginal return on capital of 10 percent (Holderness 1976), bonds seemed a rather bad investment. This comparison, however, holds only if investors had equal access to all investment opportunities. Most studies on the behavior of interest rates in England and on the crowding out hypothesis are based on the assumption of frictionless capital markets. They assume that private investments and government bonds were substitutes for consumers. However, financial frictions provide a rationale why English investors were eager to invest in government bonds. If asymmetric information is high, pledgeable income of entrepreneurs is too low to raise outside funds for new investments. Even if entrepreneurs would be willing to pay a higher cost of capital, equilibrium on the credit market is not established through the price of capital, but through the quantity of credit available. Under these circumstances, interest rates may be misleading. Low interest rates are compatible with a low capital stock even if the production function exhibits decreasing returns to capital. Investors can only turn to inefficient investments. The model describes such a situation. The introduction of government debt helps investors to avoid inefficient projects. Government securities enable them to transfer their wealth more efficiently over time.

The model is based on Martin and Ventura (2012).[8] There is a continuum of individuals with mass 1 that live for two periods, young and old. When young, individuals inelastically supply one unit of labor. There are three types of individuals: Craftsmen (c), friends of the craftsmen (f), and savers (s). The total population consists of a fraction λ_s of savers, a fraction λ_f of friends of craftsmen, and $(1 - \lambda_s - \lambda_f)$ craftsmen. Let me call the fraction of savers and friends λ, so $\lambda \equiv \lambda_s + \lambda_f$.

Individuals care only about consumption when old. The expected utility of the young generation at time t is given by

$$U_t = c_{t+1} \tag{3.1}$$

[8] Whereas the model of Ventura is about rational bubbles, this model is about government bonds.

Each period, output is produced with capital and labor according to the following production function

$$Y_t = L_t + K_t \tag{3.2}$$

The labor market is perfectly competitive and labor is paid its marginal product. The wage w is equal to one.

Capital can be produced through investment projects. These projects are the only way to transfer income from one period to another. Craftsmen have direct access to an investment technology where they can invest one unit of the final good when young. When old, the project returns R^c, with $R^c > 1$. The problem in this economy is that the only store of value are investment projects run by craftsmen. Savers and friends need to give their income to craftsmen and receive some return when old. This gives rise to a principal-agent problem. Investors have to pay some monitoring cost to make sure that the craftsmen do not "take the money and run".[9] Monitoring is easier for the friends of the craftsmen; their costs of monitoring are lower. Friends of craftsmen will receive a return $R^f = (1-\gamma_f)R^c$ and savers a return $R^s = (1-\gamma_s)R^c$. I make the following parameter assumptions:

Assumption 1

$$R^c > 1$$
$$R^f \leq 1$$
$$R^s < R^f$$

For simplicity, I assume that $R^f = 1$.

Total savings in this economy are given by $S_t = w_t = 1$. Consumption of the different types and aggregate consumption (which is equal to the total capital stock) are given by:

$$C_t^c = R^c \tag{3.3}$$
$$C_t^f = R^f = 1 \tag{3.4}$$
$$C_t^s = R^s \tag{3.5}$$
$$C_t = R^c(1 - \lambda_f\gamma_f - \lambda_s\gamma_s) \tag{3.6}$$

[9]The model is not a model about monitoring costs. They are one way to introduce financial frictions, but other ways are available. For an overview see Tirole (2005)

Now a market for one period government bonds is introduced. So far, the stock of government bonds was zero. However, in period $t = 0$ the government needs to finance a war. It sets up a financial market where it can issue bonds. The interest that the government has to pay on its bonds depends on the amount it wants to borrow in period t, b_0.

Assumption 2

$$\lambda_s < b_0 \leq \lambda$$

This assumption pins down the interest rate the government has to pay. Since $R^f = 1$, the interest on government bonds, R, is equal to 1. Given this interest rate, the government has no need in future periods to introduce taxes to finance bond repayments. It can finance its expenses every period by simply rolling over its debt.

Total savings are still one, whereas the capital stock has declined to $(1 - b_0)$. Consumption is now given by

$$C_t^c = R^c \tag{3.7}$$

$$C_t^f = R^f = 1 \tag{3.8}$$

$$C_t^s = 1 \tag{3.9}$$

$$C_t = R^c(1 - \lambda) + \lambda \tag{3.10}$$

Government bonds crowd out inefficient investment and increase total consumption.

This equilibrium is not the first best equilibrium. In such an equilibrium, everyone earns the same return as the craftsmen. However, government bonds eliminate at least some inefficiencies in the economy. Young savers and friends of craftsmen now have a second vehicle to transfer their savings to their old age: government bonds. Future young generations will always prefer to buy government bonds. The government can use the proceeds from new issues to pay back their debt to the old generation.

The assumption of a zero net interest rate can be relaxed. Under certain circumstances the government has still no need to introduce taxes. The additional assumption needed is that the economy grows at a rate at least as high as the rate of interest. At first sight, this assumption might seem unrealistic. Overall population growth was low. But population growth rates for England are misleading, at least for the first half of the eighteenth century. It is more reasonable to look at the high growth rates of London's population, since most bondholders were situated there. As financial markets developed (during the second half of the eighteenth century), the demographic change in England was on its way and population growth increased. Therefore the assumption of dynamic inefficiency seems defendable. With this simple theoretical framework in mind, I now turn to the case of England in the eighteenth century.

3.4.2 Government debt and financial constraints: Evidence from eighteenth-century England

In an ideal world, what evidence would be needed to test the model's predictions? Statistics of national accounts would be the major source of evidence. With data on consumption, savings, investment, and government spending, we would suspect an increase in savings at the wake of the eighteenth century. This increase in savings would be accompanied by a decrease in investments. As soon as government bonds start paying out, consumption would increase. We should see a situation comparable to the convergence to the golden rule level in a dynamically inefficient economy.

However, history ties our hands. No detailed data on English national accounts are available. I will therefore provide indirect evidence on why the Financial Revolution was the missing link between low growth and a Consumer Revolution.

One building block of the model are financial frictions. In the case of England, several authors have mentioned their existence. Starting with Adam Smith, credit markets in England have been characterized by the presence of asymmetric information. Ashton (1955) questioned the usefulness of interest rates as prices that cleared the market and Temin and Voth (2005) present further evidence on credit rationing. Asymmetric information and usury limits on interest rates prohibited market clearing prices.

One should mention that there is a slight difference between credit rationing and financial frictions induced by asymmetric information. Credit rationing is an equilibrium, in which the price is just above a fixed price that can be charged (here the usury limits). Lenders supply the amount of credit they are willing to sell at this fixed price and the market clears by quantity. If the government seeks financing, it has to provide at least the usury limit interest rate to obtain financing. But throughout the eighteenth century, the English government could often finance their bonds at much lower rates. Ruling out a high risk premium, financial frictions and asymmetric information can help to explain this situation. In a standard model of asymmetric information between borrowers and lenders, there is a difference between the expected return of the borrower and the income he can pledge to finance his project. The difference arises for example because of the presence of the risk of expropriation or the possibility of managers to extract private benefits. If the wedge is too high, entrepreneurs are unable to find outside financing; the market interest rate does not reflect the return to capital. In such a setting, market interest rates do not reflect the return an investor has to be paid to make him indifferent between investing in different projects. Therefore the government could finance its wars by interest rates lower than the usury limit.

Further evidence of financial frictions can be found when we look at how firms financed themselves. Kindleberger (1993) notes that "capital to start most enterprises came from an individual, his family, friends, neighbors, in very informal ways. Growth came usually from retained earnings." But not only the supply side of capital was distorted, there were frictions on the demand side as well. "Middle-class entrepreneurs in small firms were reluctant to get involved with outside funds for fear that the family's ownership might be diluted and even lost" (Kindleberger 1993).

Financial frictions laid the ground for people's appetite for government bonds. Who were these investors that purchased government bonds? As opposed to todays large influence and market share of institutional investors, the biggest share of government bonds was held by small investors. They came mostly from the middle class: Traders, merchants, and other people from the middle class invested in the new instruments. Suspicious at the beginning and investing only small sums, their demand was nonetheless high. When the first long-term loan, the Tontine, was issued in 1693, it was oversubscribed after only 10 days. At later issues, the government could place almost any desired amount in the market. The sums invested by individuals increased over time as confidence in and experience with this new instrument rose.

Looking at the ownership structure of government bond holders, the huge proportion of women stands out. For example, 18 percent of the Tontine's subscribers were women. This proportion staid high in the following issues. Women were not only important investors, they also played an important role in the evolution of consumption. The vast increase in goods occurred mainly within the household, at that time the domain of women. They were the driving force behind the evolution of fashion. Women's spending on clothing increased during the eighteenth century and their possession of hats, dresses, shoes, and other fashionable items grew on a large scale. Government debt helped to afford this increase.

A further argument is of geographical nature. London was of major importance for eighteenth century England. With the exception of Paris, no other city compared in size to England's capital. London's population increased from 200.000 inhabitants in 1600 to 900.000 in 1800. In 1750, 11 per cent of the English population lived in London. Wrigley (1967) notes that these statistics only look at net migration to London. Taking gross migration into account, he suggests that at least a sixth of the English population "had at some stage... in there lives direct experience of life in the great city." Being the biggest city in Europe had a large impact on the behavior of its citizens and on economic development. People moved from "traditional" behavior to being more "rational" individuals (Wrigley 1967). Specialization and innovation were fostered by the concentration of mostly young people.

London not only influenced its own citizens. It was the "shopwindow for the whole country" (McKendrick, Brewer, and Plumb 1983). It set trends, introduced the latest fashion, and influenced the lifestyle and structure of the society. London's evolution as the consumption capital of England was matched by London becoming England's financial centre. The Bank of England's foundation as the government's bank and debt manager marked the Financial Revolution's take-off. Since capital markets were not perfectly integrated until 1770 (Buchinsky and Polak 1993), most of the government debt was held in London. In 1737, between 25.000 and 40.000 people in London held stocks in government bonds (Dickson 1967). The number of government stock accounts in 1757 was 59.000.[10]

A closer look at the episode of the South Sea Bubble delivers additional evidence that people needed a store of value. In the simple model outlined above, government bonds are perfectly substitutable with a rational bubble. As long as returns are high enough, people are willing to invest in seemingly worthless slips of paper. Such a situation arose in England around 1720. The South Sea Company bought government debt in exchange for stocks. 30.000 creditors were affected by the government's proposal. Expectations about the rate of return were

[10]Note that the number of accounts does not equal the number of owners of government debt. People often collaborated and formed groups of investors, holding only a single account. Therefore the number of people owning government bonds is likely to be much higher.

at least as high as bond returns and people were willing to hold stocks instead of bonds. Expectations on the return of the bubble were even larger than the return of investments in physical capital. When investors agreed to exchange national debt holdings for stocks in the South Sea Company, a period of debt reduction began. National debt continued to decline even some time after the burst of the bubble. Eventually, bond issues picked up again after 1726, with a more rapid expansion after the end of a period of peace in 1740. Interest rates increased and ruled out further bubbles. Investors only used government debt as a vehicle for their savings.

The previous sections showed that the upper and middle class were largely involved in the Financial Revolution. But does this also hold for the Consumer Revolution? McKendrick, Brewer, and Plumb (1983) and others state the importance of the rich. Their increased spending on luxuries led to improvements in production and a decline in prices. The rich took the lead and the increase in the consumption of goods trickled down.[11] A boom in luxurious houses started and personal expenditures rose to often extraordinary levels. For example, the personal expenditure of Robert Walpole was about £90.000 between 1714 and 1719 (Holderness 1976). At the same time, the upper class held a growing share of government debt. The increase in their debt holdings coincides with the increase in consumption spending. Earnings on stocks became an important part of income and so the rich were the first ones to enjoy the blessings of the government's need to finance wars.

The growing importance of financial assets for the middle- and upper class is further documented by records of bequests. Table 3.5 shows the evolution of the composition of bequests in Worcestershire at two points in time. At the beginning of the eighteenth century, financial assets constituted only 12 percent of total bequests. Only 20 years later, their share had risen to 18 percent, whereas the share of specific goods in bequests had declined. The increase in households' possessions of consumption goods was not just an accumulation of goods from parents and relatives. It was made possible because financial assets provided a liquid and efficient store of value.

The availability of an efficient vehicle of saving has to be accompanied by liquidity. Investors not only have to be able to buy government bonds, they also have to be able to sell them at short notice. Several authors have played down the

[11]For a theoretical description of this effect, see Matsuyama (2002)

Table 3.5: **Composition of Bequests.** This table shows the composition of bequests found in inventories from Worcestershire.

	1669-70	1720-21
Financial assets (in %)	11.9	17.6
Specific goods (in %)	67.9	61.5

Source: Shammas (1993)

role public liquidity played in England. They argue that a large part of the government debt was held abroad, whereas taxes had to be paid by English citizens. This argument is in contrast with the data. The main part of debt was held by English citizens. This large ownership base and an established secondary market made government bonds a highly liquid asset.

However, foreign ownership cannot be neglected. Did English debt also increase foreigners' consumption baskets? Especially the Dutch invested in English government debt. In 1790, Dutch foreign assets were worth between 500 million and 650 million florins (£30 million to £37), out of which 150 million to 200 million florins were loans issued by foreign borrowers on the Amsterdam market (Riley 1980). It seems reasonable to assume that people in Amsterdam had the same lack of a store of value as people in London. They welcomed the availability of English government debt. Together with the introduction of English debt in foreign markets came a change in the ownership structure of financial assets in Amsterdam. McCants (2007b) finds that financial assets expanded to the middle-class during the eighteenth century in Amsterdam. She notes that "even though small by the standards of the 18th century high finance, theses assets were clearly capable of making a difference in the economic lives of their holders." As in England, the increase in available assets for the middle-class went in line with a "well-documented consumer revolution taking place at the same time" (McCants 2007a). This consumer revolution was smaller and less significant, but nevertheless noticeable. Data for this episode are scarce, but anecdotal evidence further strengthens the claim that government debt can enhance consumption (see, for example, McCants (2007a)). In the Netherlands as well as in England, the consumer revolution went in line with the introduction of government debt. However, in contrast to England, the system of constant borrowing from the public could not be sustained in the Netherlands. The consumer revolution was suppressed by the break-down of public finances and the credibility of the government. The introduction of English government debt provided a new start for the Dutch consumer revolution.

3.5 Conclusion

Low investment rates, low output growth, and an increase in consumption - this is the situation during the eighteenth century in England. This chapter combines these opposing views. I propose that the missing link between low growth and the Consumer Revolution was the introduction of government debt in the presence of financial constraints. Whereas “the stocking in the matress continued to serve European peasants as savings banks” (Holderness 1976), the English government provided an efficient store of value. The Glorious Revolution put the necessary constraints on the government to make the commitment to repay credible. Consumers noticed this shift in credibility and government debt became a liquid financial asset. Because financial frictions prohibited the channeling of funds from consumers to entrepreneurs, the government did not need to pay an interest rate as high as the private returns. Consumers were able to transfer wealth more efficiently across periods. The gain from this increase in efficiency could be spent on consumption. This line of reasoning resolves the puzzling facts of low capital accumulation and the appearance of a Consumer Revolution in eighteenth century England.

Because of limited data availability the evidence presented here is rather indirect. Detailed knowledge of national accounts could provide more direct evidence. However, the facts concerning consumption behavior, the ownership structure of government debt holders, and the importance of London provide support for my hypothesis. The presence of credit constraints is documented by contemporaries like Adam Smith as well as in recent research (Temin and Voth 2005).

Government debt was not the only factor driving economic and sociological changes in England. The situation in England was too complex and no single channel can explain everything. The Financial Revolution changed not only the way governments could finance their expenditures. It also laid the foundations for better working credit markets, the emergence of the London Stock exchange, and peoples’ interest in investing in stocks. Changes in peoples’ tastes and views on consumption also played a role. Especially in London, consumers tried to “keep up with the Joneses.” This may have changed their attitude towards work and their willingness to adapt innovations. Taking all this into account, this chapter provides a new channel of why England was such a special case in the eighteenth century. It provides a novel view and brings several contradicting facts in line with modern economic theory.

What conclusions can we draw from this episode in history for todays functioning of capital markets and the efficient allocation of capital? First of all, in the words of Douglas North, “institutions matter.” It is institutions that give incentives to the government to honor their debts. Before the Glorious Revolution, such incentives did not exist in England. The introduction of constraints on the government provides a rare example of a political economy case study. A government or politician that seeks to maximize his own utility faces a trade-off in the need for financial resources: One possibility is to be unconstrained, but funds have to be raised through taxation (which involves some costs of forcing consumers not to evade taxes). The government can also give up some of its power. By introducing institutions that make commitment to repay debt credible, funds can by raised at lower costs.

A second implication is the positive impact of government debt on welfare under certain circumstances. England’s financial system was emerging, but still not fully developed. People lacked proper investment choices. Under such circumstances, government debt can increase consumption. The long run effects of this policy might be unclear as the stock of physical capital stays constant. However, once a institutions and developed financial markets are in place, capital accumulation and economic growth might follow (Kose, Prasad, Rogoff, and Wei 2006).

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