Rumors and Runs in Opaque Markets: Evidence from the Panic of 1907

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Abstract

Using a new daily dataset for all stocks traded on the New York Stock Exchange, we study the impact of information asymmetry during the liquidity freeze and market run of October 1907 - one of the most severe financial crises of the 20^{th} century. We estimate that the run on the market increased spreads from 0.5% to 3% during the peak of the crisis and, using a spread decomposition, we also demonstrate that fears of informed trading account for most of that deterioration of liquidity. Information costs rose most in the mining sector - the origin of the panic rumors - and in other sectors with poor track records of corporate reporting. In addition to wider spreads and tight money markets, we find other hallmarks of information-based illiquidity: trading volume dropped and price impact rose. Importantly, despite short-term cash infusions into the market, the market remained relatively illiquid for several months following the panic. Also market illiquidity enters positively in the cross section of stock returns. Moreover, we identify information risk as the main driver of illiquidity. Thus, our findings demonstrate how opaque markets can easily transmit an idiosyncratic rumor into a long-lasting, market-wide crisis. Our results also demonstrate the usefulness of illiquidity measures to alert market participants to impending market runs.

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1 Introduction

The Panic of 1907 marked the beginning of the end of unregulated capital markets and weak central monetary authority in the United States. Much like the global financial crisis of 2008, the episode set off an immediate outcry from the public followed by reactions from federal and state governments. While private initiatives - notably, the concerted effort organized by John Pierpont Morgan - contributed to resolving the crisis, the depth and duration of the crisis, and its after effects, provided central banking advocates the ammunition they needed to push through the Federal Reserve Act, and in the meantime the provision of emergency currency via the Aldrich-Vreeland Act[1] The crisis prompted the famous Money Trust hearings in Congress that led to the Clayton Antitrust Act, as well as a state level investigation in New York that ultimately led to tighter control over access to trading at the NYSE. These regulatory steps laid the foundation for the more far-reaching regulatory interventions, such as the U.S. Securities and Exchange Commission (SEC), that emerged during the Great Depression.[2]

Because it took place in an era of weak corporate governance law, highly variable accounting practices, and essentially no regulation of stock markets - all compounded by rudimentary information technology - traders faced a continual threat of informational contagion (e.g., Bernstein et al. (2014)) and difficulties in assessing counterparty risk (see Frydman et al. (2012)[3]). In the environment of October 1907, market participants could only see a general decline in market prices, combined with plummeting United Copper stock prices and the failure of a major brokerage house, followed by news of illiquidity and then runs on several associated banks and trust companies and spikes in short term borrowing (call money) rates. This series of events stirred panic across the board, because institutions and markets both were opaque and information was difficult to verify.

The Panic of 1907 provides an opportunity to understand better how information problems impact the financial system, via liquidity in both banks and markets. Most previous studies examine the panic at the aggregate level and at lower frequency and therefore cannot analyze microstructure effects-where the problem (and presumably, the solution) really lies. In contrast, we reveal a much more nuanced picture of the unfolding crisis by exploiting a new database of daily transaction, quotation, and volume data for all stocks traded on the NYSE from 1905 to 1910.[4] Based on this novel data set, we uncover a range

[1]Which would come into play in the summer of 1914 (Fohlin and Mozenter, 2016).
[2]This paper builds on an earlier study by Fohlin et al. (2008).
[3]See also Gorton (1988), Calomiris and Gorton (1991), and Moen and Tallman (1992) for earlier work.
[4]See Fohlin (2015) for more detail on the larger data collection project.

of new results on funding and market liquidity and their interaction with asset pricing.

We start, in the next two sections, by describing our data set and examining the details of the crisis and the economic and institutional context in which it unfolded. We demonstrate that the stock market (the NYSE) showed signs of deteriorating liquidity - rising bid-ask spreads and price impact measures and declining volume - starting in September of 1907, in advance of the most acute period of crisis. Moreover, the heightened illiquidity lasted until March 1908, several months after the run ended. Next, we explore, in Section 2, the role of funding illiquidity in causing stock market illiquidity (spreads) and demonstrate that funding illiquidity drives stock market illiquidity, but only during illiquidity spikes. We then move on (section 5) to test whether market illiquidity enters into asset pricing and confirm our expectation that bid-ask spread enters as a significant factor.

After establishing the general impact of the two forms of illiquidity, we dig a bit deeper, in section 6 , and test our hypothesis that opaqueness (information asymmetry) lay at the core of the problem. We undertake a decomposition of spreads and show that the adverse selection component accounts for the largest part of the spread and of the increase in spreads during the peak crisis months; then show that funding illiquidity also drives the three components. We show further that stocks with the worst information opaqueness - mining stocks, unlisted stocks, and stocks with the highest spreads pre-Panic - have the greatest illiquidity and adverse selection component during the panic. Finally, in section 6.5, we refine the initial asset pricing analysis to show that all three spread components are priced into returns. Section 7 concludes.

2 Data Collection

Understanding the 1907 financial crisis at a granular level, and connecting market illiquidity with funding illiquidity, requires high frequency data that has been, until now, unavailable to researchers. In order to provide this microstructure perspective, we use newly-gathered data on transaction prices (first, last, high and low), closing bid and ask quotations, and volumes (number of shares traded) for all stocks trading on the NYSE on every trading day from 1905 through 1910.[5] The markets were open Monday through Saturday during this period, making for roughly 300 trading days per year. The raw data come from the NYSE daily transactions table, printed the following day in the New York Times business pages. The newspaper images (Figure 6) are not machine readable, and

[5]The data constitute a portion of the new NYSE database for 1900-1925 created by and discussed in greater detail in Fohlin (2014), funded by grants from the U.S. National Science Foundation.

optical character recognition (OCR) proved infeasible, so the data were all entered by hand. Data were double entered and cross checked, and then all data were run through logical error checking to spot any potential typographical errors in the source or inserted during data entry. For example, we flagged cases violating rules such as positive spreads or high and low are the highest and lowest prices, respectively. We also checked any entries when bid-ask spread or daily return exceeded 10 percent. The database covers all stocks, common and preferred, as well as rights, warrants and other related equity securities. In the current analysis, we concentrate on common stock, since it is the most prevalent and actively traded class.

For every stock trading on the NYSE during the period, we gathered data on book value of common equity and par values of total capital on a semi-annual basis (with observations in January and July of each year) in order to re-weight portfolios. These data come from the New York Times weekly financial supplement and Moody's Manual of Investments. We excluded preferred stock data (following Fama and French (1993)).

In order to control for funding liquidity and riskless rates, we gathered both monthly U.S. call money rates and gold stock reserves (in billions of dollars) from the National Bureau of Economic Research Macro-history Database. Call money is short-term inter-bank lending, typically secured by gold or stocks. In the period we analyze, the call money rate represents the marginal cost of financing for stock purchases. Ellis Tallman kindly provided us with daily call money rates for the time period of September 23, 1907, to February 19, 1908.

1 provides descriptive statistics on the key variables: relative bid-ask spreads, number of shares traded, the highest price during a trading day, the respective lowest price, the last transaction price of the day[6], quasi volatility, and call money rates. The median percentage bid-ask spread over the period was one percent, though a number of high spread stocks pulled the average up to two percent. Likewise, the median stock traded only 700 shares in a given day, but the handful of large firms traded orders of magnitude more. Thus, around 7,000 shares traded per company on an average trading day. The highest price and the lowest price were on average \$75 with median values of \$55 and \$54, respectively. Call money rates were on average 5 percent during the panic period of 1907, with a median value of four percent. Table 2 reports descriptive statistics of the monthly variables used in our different analyses. It reports statistics for gold stock as well

[6]Note that the "last" price of the day could have taken place at the open. It is not necessarily a "closing" price in the sense of time, but rather the last transaction price of a given trading day.

as the three components of relative spreads: the adverse selection component, inventory holding component, and order processing component. The adverse selection component contributed on average the most to relative spreads (50 percent), whereas the inventory and order processing component contributed about 25 percent each. Median values are similar in size. Gold stock in the USA averaged 1.5 billion Dollars in 1905-1910. Finally, Table 3 reports descriptive statistics of capital stock data and the book-to-market ratio. As becomes clear from the book-to-market ratio, companies were on average undervalued with an average ratio of 3.71. Also the median value of this ratio shows that stocks were on average undervalued, with a median value of 1.79.

3 The Panic in Context

The basic facts of the Panic of 1907 are fairly clear. Stocks had been on a bull run for nearly two years, starting in late 1903, but weakness began to emerge in 1906. After considerable declines in the market in March and August 1907 (see Figure 1) the poor sentiment turned to panic in October of 1907. The bear market targeted mining stocks, dominated by copper, most heavily. The mining stocks had risen in excess of the broader bull market in 1905 and early 1906 and then dropped more dramatically during the crisis and recovered the least after the crisis ended in 1908 (see Figure 2).[7] Stock market liquidity measures, such as relative spreads and trading volume, highlight the progression of the crisis, transition to outright panic, and long duration of the recovery in the market: relative spreads started rising around March 1907, while trading volume dropped significantly (Figure 3). These trends accelerated in October 1907. While prices rebounded before the end of the year, spreads remained elevated and trading volume remained depressed and more variable until the following spring.

These patterns of market indicators over the 1907 crisis and recovery look a lot like a modern-day market boom-bust cycle. U.S. financial markets had achieved a significant level of development and integration, both national and international. Stock exchanges and banks operated in all corners of the country (and the world), and the New York Stock Exchange had risen to dominance among the U.S. exchanges. Excess funds flowed into New York, by then the clear financial center of the United States, from all over the country and from England, France, Germany, and elsewhere around the world.

In basic terms, the NYSE operated in 1907 much as it does today: a continuous auction mechanism, in which transactions occur throughout the trading day, with no guarantee of

[7] The contemporary/historical usage of "panic" is nowadays referred to as financial crisis.

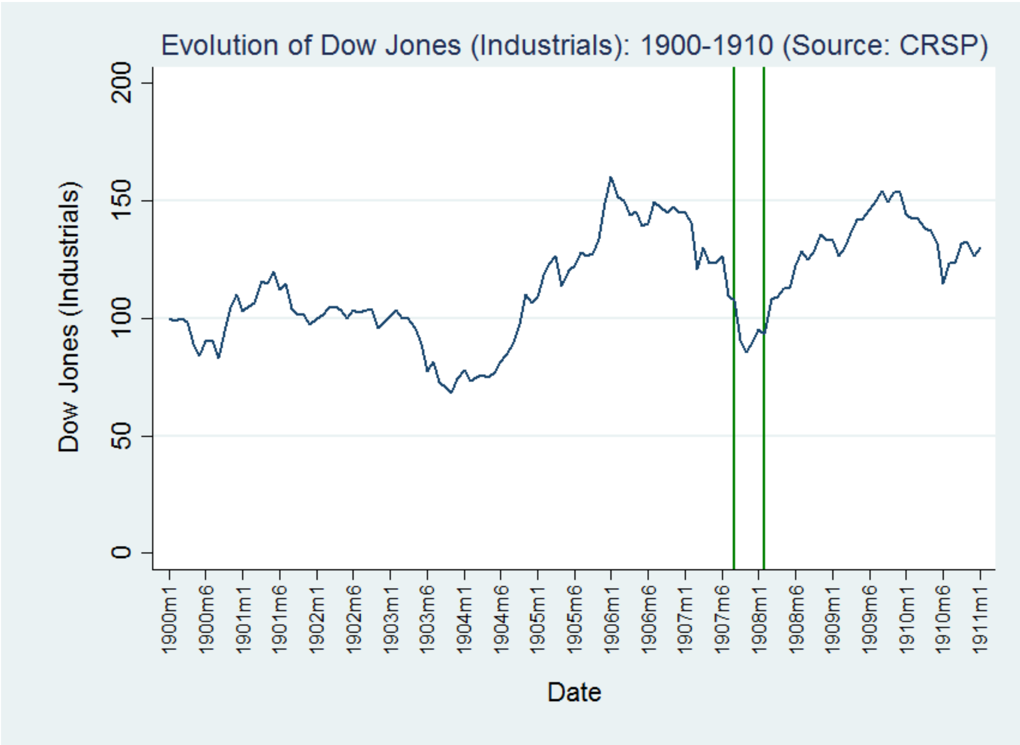

Figure 1: Evolution of Dow Jones Index: 1900-1910

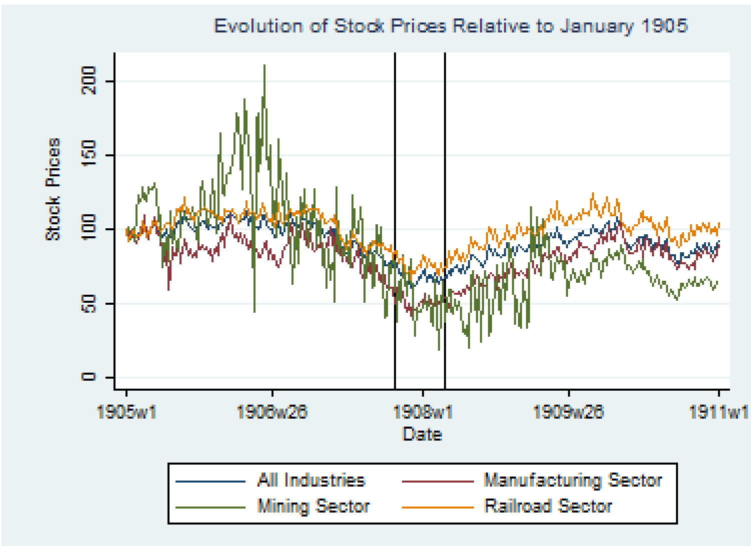

Figure 2: Stock Prices Relative to January 1905

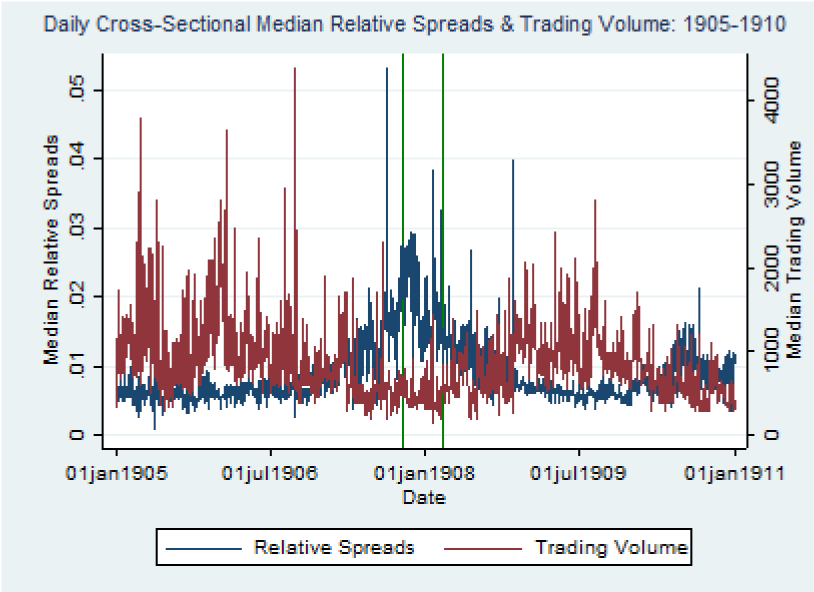

Figure 3: Median of Relative Spreads & Trading Volume: 1905-1910

a single price. Brokers traded on behalf of their customers and received set commissions as their payment, while specialists bought and sold shares in order to make markets in securities, and they received the bid-ask spread as their compensation. Specialists managed their trades at circular trading posts, equipped with telephones. The photograph in Figure 4, from Pearson's Magazine, depicts the trading floor in November of 1907, apparently shot covertly due to restrictions preventing photography of the trading floor at the time. Today's floor looks much the same, albeit with obvious modernization and technology (and fewer people).[8]

From its inception, and for most of its history, the NYSE was owned by its members and largely self-regulated. Among the key internal rules were those that dealt with membership. Joining the exchange was a costly venture: a new member had to pay a membership fee and then buy the seat of an existing member. The exchange had fixed the number of seats at 1,100 in 1879, so that the prices of seats varied with the market. Seat prices therefore varied considerably but grew fairly steadily and reached a local peak of \$95,000 in the year before the crisis.[9] Notably, seats sold for as little as \$51,000 in the panic year and the year following.[10] The Governing Committee of the exchange held ultimate responsibility for exchange operations and had the power to fine or even to expel members for infractions against exchange rules. The value of a member's seat worked as collateral

[8] See "Historical trading floor" or Figure 4

[9] In 2014 terms, equivalent to \$1.8 - \$2.5 million, depending on the deflator used.

[10] Davis and Gallman (2001), page 320.

Figure 4: **Historical Trading Floor**

in these cases or in the event of bankruptcy (Mulherin et al. (1991)). The courts upheld these powers as well as the exchanges' right to restrict trading solely to its members and to set other rules (Mulherin et al. (1991)).

The NYSE implemented relatively stringent listing standards and requirements, including registration of all shares (to prevent stock watering), minimum shareholder numbers, and a qualitative assessment of risk. Oil stocks, for example, could not be listed in their early years because they were deemed too risky.

Despite the similarities in organization (albeit with obvious technological innovations), financial markets circa 1907 differed considerably from today in their regulation. Weak (nearly non-existent) regulations over corporate governance and investor protections yielded persistent information opaqueness throughout the initial phases of development of the corporate economy and capital markets. In particular, corporate reporting law remained loose and vague in the United States until the Great Depression and the spate of disclosure regulations that followed.

Internal incentives and particularly the desire to access outside funds from investors encouraged a growing number of companies to publish their balance sheets and income statements, but the practice was far from widespread. The NYSE issued a recommendation in 1895 that listed companies provide both a balance sheet and an income statement in annual reports to investors. Such reporting then became mandatory in 1899. Still, the adherence to and enforcement of the rule remained weak for many years, and the content of these reports varied significantly in their extent and accuracy (Archambault and Archambault (2005) and Sivakumar and Waymire (1993)). In particular, companies in sectors subject to rate regulation saw the greatest incentive to publish their accounts, but their regulation also created incentives to manipulate their earnings statements (Archambault and Archambault (2011)). New laws and exchange rules requiring audited accounts developed only after the Panic of 1907 (Sivakumar and Waymire (1993) and Sivakumar and Waymire (2003)).

Thus, notably, the rapid financial development that funneled large amounts of capital into New York had taken place in spite of poor legal protection for investors and sparse, erratic, and often non-existent or erroneous information on corporate performance. This opaque information environment exacerbated the growing uncertainty over stock valuations in the months before the crisis, most particularly in the mining sector. We can see the role of information as we track the events over the days leading up to the panic. On October 16, 1907, the brokerage house of Otto Heinze was forced to close when he failed in his attempt to corner shares of the United Copper Company and pull a classic short squeeze. The manipulations in United Copper shares caused wild swings in the stock's price, but the price ultimately plummeted and left Otto in financial ruin.

Heinze's failure was only the beginning of the story. United Copper was partly owned by Otto's brother, the notorious copper magnate, F.A. (Augustus) Heinze.[11] The O. Heinze failure set off rumors that certain financial institutions had financed the failed short squeeze and therefore held unpayable debts from Otto Heinze. But Augustus was the key link in the rumor chain, as he had just a few months prior moved to Manhattan and taken an active interest in banking and finance - including Presidency of the Mercantile Bank and directorships at several other banks and trust companies.[12] Thus, as rumors spread about counterparties to Otto's brokerage firm, depositors ran on Mercantile National and on the trust companies with known ties to Heinze; first and foremost, the Knickerbocker Trust Company with $69 million in assets (Tallman and Moen (1990)). After the closure of Knickerbocker Trust Company on Tuesday, October 22nd, depositors rapidly began withdrawals from other trust companies.[13] As banks faced withdrawals,

[11]For extensive details, see the Smithsonian Magazine article from September 2012 and Chapter 6 of Parker and Whaples (2013).

[12]See the detailed reporting in the *Commercial and Financial Chronicle* in the weeks during and following the panic.

[13]Again, see the extensive details reported in the *Commercial and Financial Chronicle* as well as other

Figure 5: Price discovery process during the Panic of 1907

money became scarce, and rates on short-term loans spiked; thereby causing difficulties in financing stock market transactions. Falling stock prices set off margin calls and further sell-off in stocks to cover.

In an era in which investors learned price information by traveling to or phoning their brokers-who, in turn, relied on a stream of information printed onto ticker tape arriving via telegraph-the only way to learn news in real time was to appear in person. The now famous photograph in Harper's Weekly during the panic, gives an impression of what that "price discovery" process looked like (see Figure 5 from Harper's Weekly).
The extensive reporting in the *Commercial and Financial Chronicle* of the time as well as contemporary economists and numerous subsequent researchers point out that rumors - and the inability of investors to access and assess information - led to escalation into panic.[14] Market participants could observe the runs on trusts and banks that had close ties to the Heinze brothers, and they could learn - with some lag - about stock price declines, but they had no way of accurately evaluating in real time the fundamental values of either the financial institutions or the corporations whose stocks served as collateral on millions of dollars' worth of loans.

The crisis narrative of O.M.W. Sprague (Sprague (1910), page 246), an eminent economist

contemporary financial press.

[14]See Sprague (1908) and Sprague (1910) as well as the modern analyses of Frydman et al. (2012), Gorton (1988), Calomiris and Gorton (1991), and Moen and Tallman (1992).

of the time, clearly indicates that contemporaries well understood the importance of information and uncertainty, and how those problems led to a crisis of confidence, panic, and runs on banks and the stock market. Here, a brief excerpt from his extensive coverage:

> "After the August decline on the stock exchange a number of unfavorable events served to weaken confidence. The most important of these were the disclosures regarding the affairs of the New York street railway companies, which culminated in the appointment of receivers toward the end of September. There is, however, no evidence that distrust of the solvency of the banks either in New York or elsewhere had been excited. During the crisis distrust rapidly developed, but this was owing to causes similar to those which had produced the same effect in other crises and can be naturally accounted for by the events which marked its beginning.
>
> The initial episode of the crisis was, as has often happened in previous instances, insignificant enough. Copper was, as we have seen, the one branch of industry in which a positive decline had taken place. No time could possibly have been chosen so unfavorable for venturesome attempts at manipulation either of copper itself or of the shares of copper companies. It happened that the particular disaster which precipitated the crisis was a copper gamble, the outcome of which would ordinarily have had no public importance."

Sprague also emphasized the lack of lender of last resort facility for the "shadow banks" of the day, the trust companies, and the antagonistic relationship between these unchartered- and loosely regulated-trust companies and the more tightly regulated commercial banks. In particular, the required reserve ratios of national banks exceeded the reserves typically held by trusts, and that gap led to a competitive advantage for the trusts and an arguably self-defeating unwillingness to assist trusts in the face of the 1907 liquidity freeze. In this pre-Fed era, the Clearing House Association of New York, a private clearing house, acted as an emergency lender to its members in crisis times. The trusts were not part of this club (Tallman and Moen (2014)). Moen and Tallman (1992) point out that loans at trust companies contracted by 37% between August 22 and December 19, 1907. Loans at banks contracted by 19% during that same period.

The panic might have deepened if not for the rescue measures implemented in short order:

The Treasury Department's $25 million deposit in New York banks followed on October 24$^{\text{th}}$ by J. P. Morgan's now-famous bailout plan involving large sums of his own money and that of the city's top bankers. On October 26$^{\text{th}}$, the New York Clearing House Association issued Clearing House loan certificates for its member banks (Tallman and Moen (1990) and Tallman and Moen (2012)). To further calm the markets, treasury certificates were issued on November 19$^{\text{th}}$ and 20$^{\text{th}}$. Notably, as Rodgers and Payne (2012) find and as is described in Kindleberger and Aliber (2011), the announcement by the Bank of France that it would discount American commercial paper for gold Eagles held in the Bank's reserves ultimately seemed to have stopped the downward spiral of equity prices. According to Rodgers and Payne (2012), the Bank of France repeated its announcement between November 22 and December 7, 1907. The authors also conclude that the Bank of France actions signaled an ongoing ability to provide liquidity, and thereby a more enduring resolution of the crisis, in contrast to Courtelyou's and Morgan's temporary injections of funds.

Wilson and Rodgers (2011) point out that, in addition to the various policy responses, the structure of the U.S. capital markets proved to be beneficial for the economy during the Panic of 1907. For example, the payment system for bond transactions was not necessarily tied to banks. Hence, investors could continue to receive payments even with banks in trouble. Additionally, most bond indentures stipulated that coupon and principal payments had to be made in gold, which further explains why the Bank of France announcements proved so helpful in stabilizing the market.

This downturn displayed characteristics also observed in earlier financial crises (Moen and Tallman (1992)): interest rates increased, stock prices decreased sharply, output in the real economy fell significantly, and financial institutions suffered from deposit withdrawals (see Gorton (1988) and Kindleberger and Aliber (2011)). The resulting contraction of loans yielded significant negative consequences for the real sector (see Moen and Tallman (1992) and Bruner and Carr (2008)).

The Panic of 1907 marks an important turning point in the history of the U.S. financial system. The severity of the Panic of 1907 brought calls for reform of the financial system, with a particular focus on curbing potentially destabilizing activities in the stock markets and the need for a lender of last resort. Most of this first phase of activity focused on bank liquidity backstops. Consequently, on May 28, 1908, Congress passed the Aldrich-Vreeland Act that provided for emergency currency to infuse liquidity into the system when widespread insolvency threatened. Additionally, the Act introduced the National

Monetary Commission and charged it with investigating the Panic of 1907 and recommending measures to regulate capital markets and the banking system (Calomiris and Gorton (1991)). The Commission submitted its final report in 1912 and on December 23, 1913, Congress passed the Federal Reserve Act. Thus, the 1907 crisis stands as the last major crisis without an official institution to coordinate liquidity support in periods of financial distress, and ultimately the stimulus for the foundation of the Federal Reserve System.[15]

Politicians also held up the Panic of 1907 as an example of Wall Street excess and dishonesty and used it to motivate the famous Money Trust hearings in Congress. That investigation produced volumes of testimony by Wall Street insiders and led to the Clayton Antitrust Act. In New York, the Governor appointed a committee to study the crisis and recommend reforms to the financial markets. That investigation ultimately led to tighter control over access to trading at the NYSE. These regulatory steps made little inroads into the problem of information opaqueness that had exacerbated (if not outright caused) the crisis. The regulations did lay the foundation for more far-reaching interventions, such as the U.S. Securities and Exchange Commission (SEC), that emerged a few decades later.

4 Market Liquidity and Funding Liquidity during the Panic of 1907

The narrative of the Panic of 1907 points out the already fragile state of financial markets in the several months prior to the crisis, and general economic conditions had also weakened over the previous year. Odell and Weidenmier (2004) argue that the financial repercussions of the San Francisco earthquake in April of 1906 led to monetary stringency and made financial markets susceptible to a crisis. In the absence of a central bank, the setting of short-term borrowing rates was performed by the overnight call money market throughout our period of study. Funding liquidity issues therefore appear in the form of elevated call loan rates.

As Brunnermeier and Pedersen (2009) establish in a theoretical framework, in periods of crisis positive feedback effects between funding illiquidity and market illiquidity might amplify each other. In such situations, decreasing availability of funds increase margin

[15]We consider the situation in the summer of 1914, as an impending crisis, but one that was staved off in part due to the lessons of 1907 and the creation of a liquidity backstop in Aldrich-Vreeland. Fohlin and Mozenter (2015) provide an in-depth study of liquidity during the lead-up to the war and the several months following the reopening of the NYSE in December 1914.

requirements and haircuts on collateral, inducing fire-sales of the underlying assets and a widening of bid-ask spreads, reflecting higher inventory holding costs for market makers. As market liquidity dries up, margin calls and haircuts increase and reduce funding liquidity even further.

This mutually enhancing feedback between funding illiquidity and market illiquidity is particularly important in opaque markets with asymmetric information about assets' true valuations. If information is symmetric, margins and haircuts tend to be stabilizing towards a new equilibrium. Under asymmetric information, though, we expect increased correlation between funding illiquidity and market illiquidity, as well as an increase in commonality between asset returns, volatility and effective spreads–likely compounded by investors' flight to quality.

Li and Ma (2016) provide an explicit model of the feedback effect from funding illiquidity to market illiquidity for the case of banks, which typically are a prime example for opaque balance sheets. Their model provides a nice theoretical foundation for the 1907 Panic, which was triggered by a run on Knickerbocker Trust and subsequently on other trusts and banks as well.[16]

Since we cannot observe the margins and haircuts set by the exchanges during our period, we can only indirectly test this relationship between funding illiquidity and market illiquidity. Taking daily call money rates as our measure of funding illiquidity and spreads as the measure of market illiquidity, Figure 7 suggests that the co-movement between daily call money rates and relative spreads increased dramatically at the peak of the Panic in October 1907 with call money rates leading relative spreads by one day.[17] In other words, our measure of funding illiquidity seems to lead market illiquidity during these hectic two weeks. Afterwards - as before - we see a decoupling of funding liquidity and market liquidity and a convergence of market illiquidity to more normal levels despite the fact that funding liquidity spikes even higher toward the end of 1907.

To confirm this hypothesis, we compute correlations between call money rates and one-day-ahead relative spreads and then analyze the relationship in a more complete model of spreads. Focusing on one-day-ahead spreads we find that the correlation peaks between October 14 and November 1, 1907, with a correlation coefficient of 0.82. To be more pre-

[16]The trusts in the early twentieth century played a role to shadow banks about a hundred years later.

[17]Note that our sample of call money rates only covers the time period of September 23, 1907, to February 19, 1908. Hence, a complete analysis of the evolution of the different measures of liquidity and their interaction before, during and after the crisis is outside the scope of our analysis.

cise, the correlation between call money rates and one-day-ahead relative spreads reaches a maximum of 0.82 for the period from October 14 (Monday) - November 1 (Friday), 1907, while it attains only 0.46 before (September 23-October 11) and 0.32 after the crisis peak (November 4, 1907 - February 19,1908).[18] This is strong evidence that funding liquidity was a major driver of market liquidity particularly during the crisis.

To add further robustness to the correlation and graphical analyses, we estimate the following regressions for median relative spreads, the lowest quartile of relative spreads, and the highest (i.e., most illiquid) quartile of spreads:

$$\left.\begin{array}{l}\text{Relative Spreads}_{i,t,25thquantile}\\ \text{Relative Spreads}_{i,t,50thquantile}\\ \text{Relative Spreads}_{i,t,75thquantile}\end{array}\right\} \begin{array}{c} = a_i + \beta_1 CallMoneyRates_t + \beta_2 CallMoneyRates_{t-1} + \\ \beta_3 StockPrice_{i,t} + \beta_4 QuasiVolatility_{i,t} + \\ \beta_5 CallMoneyRates_t \cdot PanicHeight_t + \\ \beta_6 CallMoneyRates_{t-1} \cdot PanicHeight_t + \epsilon_{i,t} \end{array} \tag{1}$$

The regressors of this estimation include daily call money rates, daily stock prices, and daily quasi-volatility (where quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price). We furthermore include an interaction term of call money rates with an indicator for the "Height of Panic," which takes the value of one for dates between October 14, 1907 and November 1, 1907, and zero otherwise. As in the previous analyses, the daily sample currently covers September 23, 1907 to February 19, 1908. Currently only monthly data are available over the full 1905-1910 period, which is too low frequency to capture the changing relationship between funding liquidity and market liquidity in such a short window of time.

Table 4 shows the estimation results using the full panel and quantile regression. In line with the prior results, call money rates lead relative spreads throughout the crisis period. Across the entire distribution of spreads, we find funding liquidity (as measured by call money rates) leads market liquidity (as measured by spreads) by one day. The relation-

[18]These correlations relate to the minimum of the call money rates reported in the New York Times. Call money rates were reported in the Times for the open and close of the market. The correlations presented refer to the correlation between the lower value and relative spreads. Hence they measure the funding rates of the more creditworthy traders, though other rates could have prevailed during a given day. In midst of the turmoil at October 25$^{\text{th}}$ the lower of the quoted funding rates reached a level of 50 percent, significantly up from neighboring days. The number reported in the text excludes the observation of October 25$^{\text{th}}$. If one did, however calculate the autocorrelations for October 14 - October 24 and October 26 - November 1 the resulting values are 0.796 and 0.985.

ship proves strongest for median spreads and weakest for the most illiquid stocks.

During the height of the Panic, this relationship is amplified by feedback effects as described in Li and Ma (2016), with amplification being largest for the least liquid stocks. Moreover, the interaction effect is economically large; numerically it dominates the relatively weak baseline effect by an order of magnitude of 10. This finding further underscores the potentially tight connection between funding liquidity and market liquidity, in particular their potential to reinforce each other in a vicious cycle in periods of severe market stress. The Panic of 1907 set into motion just such an amplification mechanism, which only ended with concerted intervention led by Treasury Secretary Courtelyou, J.P. Morgan, John D. Rockefeller, and others in late October 1907.

While we only have daily call money rates for a short window for daily call money rates, we also explore the relationship between funding liquidity and market liquidity on the basis of monthly observations over the full sample, regressing relative spreads on call-money rates, a crisis dummy and an interaction term.

Our regressions confirm the result that funding illiquidity causes market illiquidity during the crisis (see Table 7). In fact, call money rates do not consistently affect spreads but only when interacted with the crisis period.

All of these results suggest that during the crisis margin requirements were destabilizing, and therefore, in line with Brunnermeier and Pedersen (2009), evidence in favor of asymmetric information among market participants.[19] Another striking result that matches their analysis is that commonality in asset returns shoots up in such periods.

5 Illiquidity as a Factor in Asset Pricing

We can further investigate how the markets handled the illiquidity shock by testing, a la Acharya and Pedersen (2005) and Pástor and Stambaugh (2003), whether the market priced in market illiquidity. In the now-standard fashion, we augment a Fama-French three factor model with a fourth liquidity factor, measured by relative bid-ask spreads.

In order to test this model, we first construct size and market-to-book factors using the procedure in Fama and French (1992).[20] We define Book-to-market as:

[19] Brunnermeier and Pedersen (2009) show that in the case of symmetric information, margins requirements tend to be stabilizing.

[20] Kenneth French's online database starts much later.

$$\text{Book-to-Market (B/M)} = \frac{\text{Total capital stock per month}}{(\frac{\text{Total capital stock per month}}{\text{Par value}}) * \text{Stock Price}} \tag{2}$$

We then break our entire sample of stocks into three book-to-market equity groups based on the breakpoints for the bottom 30% (Growth), middle 40% (Neutral), and top 30% (Value) of the ranked values of the book-to-market ratio. We furthermore sort our sample of stocks into size portfolios based on market equity. Market equity in our case is defined as:

$$\text{Market equity} = \left(\frac{\text{Total capital stock per month}}{\text{Par value}}\right) * \text{Stock Price} \tag{3}$$

We split the sample into two equal groups, Small and big (S and B), based on the median value of market capitalization. These sorts follows Fama and French (1992) as well as Fama and French (1993). The Fama/French factors are constructed using the six value-weight portfolios formed on size and book-to-market. SMB (Small minus Big) is the average return on the three small portfolios minus the average return on the three big portfolios:

$$\text{SMB} = \frac{1}{3}(\text{Small Value}+\text{Small Neutral}+\text{Small Growth}) - \frac{1}{3}(\text{Big Value}+\text{Big Neutral}+\text{Big Growth}) \tag{4}$$

HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios:

$$\text{HML} = \frac{1}{2}(\text{Small Value} + \text{Big Value}) - \frac{1}{2}(\text{Small Growth} + \text{Big Growth}) \tag{5}$$

Since there is no 3-month T-bill in the period of our study, we define the excess return $R^m - R^0$ relative to a zero-beta portfolio, using the gold flow rate (i.e., growth rate in the gold stock of the U.S. government). This rate correlates with the market return at only -0.01.[21]

Once we have our size and market-to-book factors, we follow a two-stage test procedure (Fama and MacBeth (1973)). In the first stage we estimate firm-specific regression coefficients ("Betas") for the market portfolio and spread. In this regression, $R_{i,t}$ is the firm-specific time-varying monthly return.[22] as i denotes the companies and t is a time-index (monthly). $R_t^m - R_t^0$ denotes the excess market return and "Spread" denotes our

[21]The market return is defined as the equally-weighted return of all stocks in our sample.

[22]Note that returns are calculated excluding ex-dividend dates as detailed information on firm-specific dividends is missing. We drop 0.6 percent of the entire dataset by excluding ex-dividend dates.

measure for illiquidity. We estimate the first stage as follows:

$$R_{i,t} - R_t^0 = \beta_{1,i} * (R_t^m - R_t^0) + \beta_{2,i} * Spread_{i,t} + \beta_{3,i} SMB + \beta_{4,i} HML + \epsilon_{i,t} \quad (6)$$

In the second stage, we regress the cross-section of average monthly expected returns on the estimated factor sensitivities of the first stage:

$$E[R_i - R^0] = \lambda_0 + \lambda_1 \widehat{\beta_{1,i}} + \lambda_2 \widehat{\beta_{2,i}} + \lambda_3 \widehat{\beta_{3,i}} + \lambda_4 \widehat{\beta_{4,i}} + \eta_i \quad (7)$$

The results of our asset pricing analysis (Table 5) indicate that liquidity risk is priced positively, such that investors expected and earned a liquidity premium very much in line with markets a century later. Moreover, in line with Chabot et al. (2014) we find negative contributions of the SMB and HML factors.[23]

6 Information and Opacity as the Main Drivers of Market Illiquidity

Thus far, we have assembled some of the key pieces of the 1907 puzzle - that funding illiquidity seems to have exacerbated market illiquidity during the peak weeks of the crisis, and that moreover, market investors priced in such illiquidity. What remains for us to determine is whether the core of the illiquidity problem lay - as we hypothesize - in the opaqueness of information in the market.

We start by reviewing theoretical work about the relation between opaqueness and price discovery. We then decompose bid-ask spreads into an information component and non-information components following Huang and Stoll (1997) to test the theory. We discuss alternative decompositions in section 7.

6.1 Opaqueness and Price Discovery

At the start of the panic, rumors about the solvency of banks and trusts, notably Knickerbocker Trust, spread widely, as evidenced by repeated commentaries to this effect published in the New York Times and other contemporary newspapers. The effects were

[23]We have different numbers of observations in each regression, because we exclude firms with too few observations to produce an R^2.

contained only after the liquidity infusions by Treasury Secretary Courtelyou, J.P. Morgan, and others, as well as the well-publicized examinations of the Mercantile by the New York Clearing House and the purging of the tainted Heinze interests there. The rumors of certain banks' involvement in the failed corner and potential insolvencies added to a general demoralization and uncertainty over economic conditions and the specific conditions in the mining sector. Despite public reassurances, fears about impending bank liquidations continued because of the general lack of information about financial institution balance sheets and the true state of their liquidity. Thus, opaqueness permitted rumors to reinforce the declining market and tight money conditions.

In his regard, Bernardo and Welch (2004) provide a theoretical framework which explains how rumor-based runs on financial markets can arise. In order to avoid the liquidation of shares at a bad "post-run" price, each investor may prefer selling shares today at the "in-run" price. If many investors fear alike, this in itself will cause a run on financial markets. Bernardo and Welch (2004) conclude that liquidity runs and crises are not necessarily caused by liquidity shocks per se, but instead by the fear of future liquidity shocks. Such fears are more likely the more opaque the economic environment. He and Manela (2014) show the same effect in a different framework. They study dynamic rumor-based runs on financial institutions with endogenous information acquisition. Agents who are unsure about banks' liquidity worry that other agents, who might have received even worse signals, withdraw before them. Hence, in order to front-run those agents with even worse signals, they start the run on the financial institution themselves. The fear of being too late increases the incentives to run. Thus, He and Manela (2014) and Bernardo and Welch (2004) offer an appropriate rationale for the happenings in the autumn of 1907. If these arguments hold, we should observe increased adverse selection risk as well as increased trading volume right after the failure of Heinze's stock corner. Both increased adverse selection risk and increased selling pressure should in turn drive up bid-ask spreads, making trading more expensive and traders reluctant to do so. At the same time, these theories imply a moderation of the runs once the concerns of market participants can be credibly resolved by (coordinated) market interventions.

Hellwig and Zhang (2012) establish a time-varying role of information during a crisis. They demonstrate that in the absence of intervention, markets tend to be more liquid at the onset of a crisis than towards the end. Specifically, they argue that the strategies over information gathering may depend on the liquidity in a given market. Strategic information acquisition may change across agents due to changing assets liquidity and valuation uncertainty about future states of the world. A vicious cycle can evolve in reaction to an unexpected event (i.e., in this case the failure of a stock corner) that leads to increased informational risk, which in turn leads to higher spreads, which again reinforces the trader's view that informational risk has indeed increased, and therefore spreads increase even more. The spiraling information problem freezes liquidity in the market, such that we should observe increasing illiquidity over the course of the crisis (also pointed out by Donaldson (1992)) as well as constantly increasing adverse selection risk for the cross section of companies. The Hellwig-Zhang model implies that outside interventions can stop such spirals, especially when independent information is generated.

To the extent that the interventions of J.P. Morgan, Secretary Courtelyou, and of the Clearing House reflected positive information about the solvency of the underlying firms (and the removal of Heinze interests at the Mercantile further committed to severing all ties to the failed Heinze brokerage house), it did reduce the need of market participants to produce costly information of their own. As described in Section 3, on October 24, 1907, J.P. Morgan - together with other wealthy individuals - pledged large sums of money in order to calm markets and restore confidence. With each new emergency to arise, trusted parties–the US Treasury, the New York Clearing House, J.P. Morgan, and other eminent financiers and industrialists–jumped in to assess the soundness of each institution in question, reveal that information publicly, and then to provide a backstop to "good" institutions suffering only temporary illiquidity. We expect that these interventions contributed critically to ending the liquidity freeze. Successful interventions should be reflected in declining spreads, increasing trading volume, and a reduction in overall informational risk as well as valuation uncertainty.

The theory further suggests that stocks with the most opaque financial reporting practices and those most prone to manipulations- such as naked short sales, corners, and short squeezes - suffer the most severe adverse selection effects. In these regards, mining stocks ranked among the worst, and it was therefore no accident that an unlisted copper company became the target of an attempted corner and short squeeze in 1907. The company in question, the United Copper Company, was incorporated in 1902 by F. Augustus Heinze, the brother of Otto Heinze and a copper magnate who had fought for years - largely against the Amalgamated Copper - to get access to lucrative copper mines in Butte, Montana. Otto Heinze also held stakes through United Copper Company in a number of other mining companies such as The Montana Ore Purchasing Company, The Nipper Consolidated Copper Company, The Minnie Healy Mining Company, The Corra Rock-Island Mining Company, and the The Belmont Mining Company.[24]

[24]See New York Times Article from April 29, 1902 regarding United Copper Company.

Furthermore, given the differing extent and thoroughness with which different industries published their accounting information (Archambault and Archambault (2005)), we conjecture that stocks in the more transparent sectors (e.g., utilities and railroad sector, which provided accounting information to the public in great detail) will exhibit lower informational risk than other sectors, such as manufacturing and mining, that published meager information on a sporadic basis. Transparency arguably mitigates potential for insider trading and adverse selection costs, assuming that insiders provide accurate information.[25]

That information asymmetry and adverse selection risk might not only differ across industries, but also across certain types of stocks is suggested by Hellwig and Zhang (2012). The authors show in an OTC-market setting that information acquisition may differ across liquid and illiquid markets. Chang (2012) goes a step further and demonstrates how limited market participation can arise as a result of informational frictions and how it then leads to distinct notions of illiquidity. In her theoretical framework she analyzes two types of informational frictions: sellers' private information about the quality of their assets and their private information of what motivates them to trade (e.g., different needs for liquidity). Her model endogenously generates and identifies the effects that adverse selection risk might have on transaction costs and volumes. In this environment, the trader who wants to sell her asset quickly is either trying to get rid of a low-quality asset, or simply has an urgent need for cash. If the other side of the transaction, the buyer, cannot differentiate between the two motives for trading, adverse selection risk will increase. This phenomenon should arise especially for illiquid stocks, as they are traded less frequently and market participants have more difficulty determining the fundamental value of the stock. Hence, we expect to find that adverse selection risk differs significantly between liquid and illiquid stocks. Moreover, we expect to find that adverse selection risk increases even more during crisis times. In a highly uncertain period, those problems might be disproportionately greater than in non-crisis times.

One means of offsetting some of the opaqueness is vetting by a trusted organization. Listing on the NYSE brought with it this sort of certification of quality, based on the exchange's listing requirements, which involved disclosure and examination of financial statements. The NYSE also maintained an "unlisted department" to trade in stocks that 1. could not meet NYSE listing requirements or 2. chose not to disclose the information required for an application for an official listing. Hence, since the NYSE did not impose

[25]We do note that transparency may be illusory in this period, as companies rarely produced audited accounts.

any disclosure rules on stocks trading in the unlisted department, less public information was available about these stocks, and consequently they presumably faced greater susceptibility to information shocks and rumors than stocks of companies that published more information. Episodes of heightened uncertainty may exacerbate such information problems. Thus, we expect that unlisted stocks are particularly vulnerable in a panic.

6.2 Decomposition of Bid-Ask Spreads

In order to analyze these questions, we decompose spreads into their three main components information risk, inventory holding risk and order processing costs. Information risk, equivalently adverse selection risk, captures the risk of market makers trading against better informed traders. Since market makers expect to lose money in trading with insiders, they protect themselves against losses by charging wider spreads. Inventory holding costs arise when market makers' exposure deviates from their optimal portfolios, while the order processing cost component compensates for technical costs of order handling plus rents due to market power.

We estimate these three cost components using the refinement of the Huang and Stoll (1997) spread decomposition of Gehrig and Haas (2015). The refinement insures that the three different cost components add up to 100% of the quoted bid-ask spreads.

In the model of Huang and Stoll (1997), the time frame consists of three separate and sequential events. Stock i's fundamental value, $V_{i,t}$, is unobservable on day t. The bid and ask quotes are set right after the fundamental stock value has been determined. $M_{i,t}$ denotes the quote midpoint and is calculated from the quotes that were posted by a market maker just before a transaction happened. $P_{i,t}$ denotes the respective transaction price. $Q_{i,t}$ denotes a trade direction indicator variable. It takes the value of 1 if the transaction price exceeds the midquote (i.e., if a transaction is buyer-initiated), and it takes the value of -1 if the transaction price is smaller than the midquote (i.e., if a transaction is seller-initiated). It equals zero if the transaction price is equal to the midquote.

Subsequent transactions and their respective transaction volumes are assumed to be serially correlated. The conditional expectation of the trade indicator variable Q_t at time *t-1* given Q_{t-2} is, therefore, shown to be:

$$E(Q_{i,t-1}|Q_{i,t-2}) = (1 - 2\pi_{i,t})Q_{i,t-2}. \tag{8}$$

where $\pi_{i,t}$ denotes the probability that the current trade is of opposite sign to the previous trade.

Huang and Stoll (1997) estimate equation 8 simultaneously with equation 9 in order to estimate the different cost components of the spread. In equation 9 $S_{i,t}$ denotes the equity bid-ask spread and $\alpha_{i,t}$ denotes the percentage of the spread that is associated with informational cost (i.e., adverse selection cost). From this equation it becomes obvious how adverse selection costs are measured, as $\alpha_{i,t}$ is the coefficient of the difference between what the actual trade turned out to be (i.e., $\frac{S_{i,t-1}}{2}Q_{i,t-1}$) and what a market participant expected the trade to be based on the previous trade (i.e., $\frac{S_{i,t-2}}{2}\mathbb{E}[Q_{i,t-1}|Q_{i,t-2}]$). Hence, $\alpha_{i,t}$, or informational costs, only arise if the current trade brings about a surprise relative to the previous trade. $\beta_{i,t}$, the percentage of the spread that is associated with inventory cost, is only measured with respect to the current trade and denotes the changes in the market maker's inventory holdings that she later might need to adjust. $\epsilon_{i,t}$ refers to a public information shock and is assumed to be serially uncorrelated.

$$\Delta M_{i,t} = (\alpha_{i,t} + \beta_{i,t})\frac{S_{i,t-1}}{2}Q_{i,t-1} - \alpha_{i,t}\frac{S_{i,t-2}}{2}(1 - 2\pi_{i,t})Q_{i,t-2} + \epsilon_{i,t}. \tag{9}$$

We estimate the parameters of equation 8 and 9, $\alpha_{i,t}$, $\beta_{i,t}$, and $\pi_{i,t}$, using the generalized method of moments (GMM) procedure outlined in Hansen and Singleton (1982) and Hansen (1982). The optimal weighting matrix is constructed using the method proposed in Wooldridge (2002). Under this procedure, the parameter estimates have to be chosen such that they minimize:

$$Q_N(\theta) = \left[N^{-1}\sum_{i=1}^{N} g(w_i,\theta)\right]' \widehat{\Lambda}^{-1}\left[N^{-1}\sum_{i=1}^{N} g(w_i,\theta)\right]. \tag{10}$$

Following the notation of Wooldridge (2002), θ is the vector of unknown coefficients. In this analysis, this vector includes the component for adverse selection risk ($\alpha_{i,t}$), the component for inventory holding risk ($\beta_{i,t}$), and the trade direction reversal probability ($\pi_{i,t}$). The order processing cost component is computed as the residual cost, after subtracting $\alpha_{i,t}$ and $\beta_{i,t}$ from one, since the three cost shares must add up to 100%. $g(w_i,\theta)$ is an (L x 1) vector of moment functions (or orthogonality conditions). These functions are non-linear and given by:

1. $g_1 = \left(Q_{i,t-1} - (1-2\pi_{i,t})Q_{i,t-2}\right) Q_{i,t-2}$
2. $g_2 = \left(Q_{i,t-1} - (1-2\pi_{i,t})Q_{i,t-2}\right) S_{i,t-1}$
3. $g_3 = \left(Q_{i,t-1} - (1-2\pi_{i,t})Q_{i,t-2}\right) S_{i,t-2}$
4. $g_4 = \left(\Delta M_{i,t} - (\alpha_{i,t}+\beta_{i,t})\frac{S_{i,t-1}}{2}Q_{i,t-1} + \alpha_{i,t}\frac{S_{i,t-2}}{2}(1-2\pi_{i,t})Q_{i,t-2}\right) S_{i,t-1}$

5. $g_5 = \left(\Delta M_{i,t} - (\alpha_{i,t} + \beta_{i,t})\frac{S_{i,t-1}}{2}Q_{i,t-1} + \alpha_{i,t}\frac{S_t i,t-2}{2}(1-2\pi_{i,t})Q_{i,t-2}\right) S_{i,t-2}$

6. $g_6 = \left(\Delta M_{i,t} - (\alpha_{i,t} + \beta_{i,t})\frac{S_{i,t-1}}{2}Q_{i,t-1} + \alpha_{i,t}\frac{S_{i,t-2}}{2}(1-2\pi_{i,t})Q_{i,t-2}\right)(Q_{i,t-1} - (1-2\pi)Q_{i,t-2})\,.$

$\widehat{\Lambda}$ is the optimal weighting matrix which is similarly determined following Wooldridge (2002):

$$\widehat{\Lambda} \equiv \frac{1}{N}\sum_{i=1}^{N}\left[g(w_i,\theta)\right]\left[g(w_i,\theta)\right]'\,. \tag{11}$$

For estimating consistency, we estimate adverse selection costs, inventory holding costs, and order processing costs on a monthly basis for all stocks having at least 15 daily observations in a given month. For each "stock-month" panel, we implement the GMM decomposition code in Matlab and obtain α and β coefficients for each month and stock. We then aggregate the estimation results across companies and time (i.e., over all months for the years of 1905 to 1910). Once that is finished we merge this dataset with a dataset of company-specific, end-of-month stock prices, relative spreads, opening prices, high and low prices as well as total number of shares traded of each month.

6.3 Adverse Selection Costs as the Main Driver of Illiquidity

In line with our expectations, we find that adverse selection costs contributed most to total spreads. In absolute (dollar) terms (Figures 8) adverse selection costs dominate transaction costs and thus contribute most to constraining liquidity in the market. During the panic, all three cost components roughly tripled: information costs rose from \$0.007 to \$0.02, inventory holding costs increased from \$0.003 to \$0.009, and order processing costs from \$0.004 to \$0.01. Hence, in line with our hypothesis, uncertainty and information asymmetry continued to play the greatest role in market illiquidity during the panic. In a sense, we also find support for Hellwig and Zhang (2012), that is, that the role of information changes from the onset of a crisis to the end. In the case of the Panic of 1907, we see an increase of informational costs from the onset of the Panic on. However, the real peak of rumor contagion is reached when the Panic is already evolving (i.e., late October 1907), not during the earlier phases of the increasingly severe bear market of August and September. This suggests that the spreading informational uncertainty (i.e., rumors) affected a large proportion of the market and ratcheted up during the crisis. Obviously, in the case of information produced and propagated through rumors, the process may create more noisy information–or misinformation–and thereby reduce market efficiency (Dang et al. (2010)).

To more rigorously test our hypotheses about market illiquidity and its changes during the panic, we estimate four separate sets of quantile regressions, for relative spreads and for each of the three estimated components of spread. We include indicators for the stages of the financial crisis, and control for price level and volatility, producing the following sets of regression equations:

$$\left.\begin{array}{r}\text{Relative Spreads}_{i,t,25thquantile}\\ \text{Relative Spreads}_{i,t,50thquantile}\\ \text{Relative Spreads}_{i,t,75thquantile}\end{array}\right\} \begin{array}{c}= \beta_0 + \beta_1 PanicHeight_t + \beta_2 Crisis_t +\\ \beta_3 StockPrice_{i,t} + \beta_4 QuasiVolatility_{i,t} + \epsilon_{i,t}\end{array} \tag{12}$$

$$\left.\begin{array}{r}\text{Adverse Selection Costs}_{i,t,25thquantile}\\ \text{Adverse Selection Costs}_{i,t,50thquantile}\\ \text{Adverse Selection Costs}_{i,t,75thquantile}\end{array}\right\} \begin{array}{c}= \beta_0 + \beta_1 Panic1907_t + \beta_2 CallMoneyRates_t +\\ \beta_3 CallMoneyRates_t * Panic1907_t +\\ \beta_4 StockPrice_{i,t} + \beta_4 QuasiVolatility_{i,t} + \epsilon_{i,t}\end{array} \tag{13}$$

$$\left.\begin{array}{r}\text{Inventory Holding Costs}_{i,t,25thquantile}\\ \text{Inventory Holding Costs}_{i,t,50thquantile}\\ \text{Inventory Holding Costs}_{i,t,75thquantile}\end{array}\right\} \begin{array}{c}= \beta_0 + \beta_1 Panic1907_t + \beta_2 CallMoneyRates_t +\\ \beta_3 CallMoneyRates_t * Panic1907_t +\\ \beta_4 StockPrice_{i,t} + \beta_4 QuasiVolatility_{i,t} + \epsilon_{i,t}\end{array} \tag{14}$$

$$\left.\begin{array}{r}\text{Order Processing Costs}_{i,t,25thquantile}\\ \text{Order Processing Costs}_{i,t,50thquantile}\\ \text{Order Processing Costs}_{i,t,75thquantile}\end{array}\right\} \begin{array}{c}= \beta_0 + \beta_1 Panic1907_t + \beta_2 CallMoneyRates_t +\\ \beta_3 CallMoneyRates_t * Panic1907_t +\\ \beta_4 StockPrice_{i,t} + \beta_4 QuasiVolatility_{i,t} + \epsilon_{i,t}\end{array} \tag{15}$$

The resulting estimates (see Tables 6 to 9) show that

6.4 Cross Sectional Evidence on Opaqueness and Market Illiquidity

In order to analyze in more detail how information opaqueness influenced illiquidity in the market, we divide the sample of stocks according to their different opaqueness levels. We expect that adverse selection risk was highest in the most opaque and rumor-ridden sectors (mining companies), among stocks that are ex ante traded with wider spreads, and for stocks that traded in the NYSE Unlisted department, where companies avoided the vetting process of official listing as well as NYSE disclosure rules.

First, we compare bid-ask spreads and the three cost factors by industry. As expected, the panic hurt the relatively opaque mining stocks' liquidity the most. Spreads of mining companies–whose stock returns also dropped the most during the bear market of 1907 (see Figure 2)–rose from about 2% before the crisis to about 5% during the height of the panic (Figures 10 to 12). The sharp rise in illiquidity results largely from adverse selection risk (Figures 13 to 15): adverse selection costs (in dollar-terms) triple from \$0.01 to \$0.03, the steepest increase across all industries. Most importantly, adverse selection costs remain high, even after rescue measures took place. This finding indicates that the rumor-based crisis infected mining stocks severely enough to persist over the longer term. Similarly, for the mining sector we find that inventory holding costs tripled from \$0.005 to \$0.015 as did order processing costs.

We also confirm our related hypothesis that stocks in the sectors that published accounting information on a regular basis (such as the railroad and utilities sectors), and whose accounting systems were relatively transparent due to federal regulatory burden, experience lower adverse selection costs compared to other industries, such as manufacturing. The railroad sector's informational costs averaged \$0.05 outside of the Panic period, compared to \$0.10 in the manufacturing sector. During the Panic period, informational cost rose to \$0.09 and \$0.15 for the railroad and manufacturing sectors, respectively. Relative transparency, therefore, yields lower adverse selection risk and increased stock market liquidity.

We further conjecture that, regardless of sector identity, illiquid or opaque (e.g. low volume, high price impact, or unlisted) stocks were affected disproportionally by informational costs. To test this presumption, we categorize the stocks as "liquid" if they fall into the lowest quartile of relative spreads and "illiquid" if they fall into the highest quartile of that distribution. As we predict, the most illiquid stocks experience significantly greater increases in informational costs, inventory costs, and order processing costs than liquid ones (Figure 16). All three spread components are more than three times larger for illiquid stocks than for liquid stocks. Furthermore, informational costs increased during the Panic of 1907 for illiquid stocks, whereas the other two cost types even declined slightly during the crisis. This suggests that illiquid stocks are particularly subject to adverse selection costs during a liquidity freeze.

We find similar results in comparing listed and unlisted companies: the latter get hit by informational costs more than the former (Figures 17). As we expect that unlisted stocks generally suffer more from higher informational costs due to the lack of certification and absence of disclosure rules, the adverse selection problems should intensify during a financial crisis. Information costs were especially elevated when rumors were most active in the last quarter of 1907. It also took longer for adverse selection risk to decrease in unlisted stocks compared to listed stocks.

Together, these results suggest that investments in companies that operated with greater transparency and liquidity–whether due to listing rules or regulatory requirements–indeed served as a hedge against adverse selection risk and especially so in times of heightened uncertainty.

6.5 Adverse Selection as a Factor in Asset Pricing

Now that we have a clear picture of the components of spread and the impact on these transactions costs stemming from opaqueness and illiquidity, we can assess the extent to which the various cost components enter into asset pricing decisions. We thus revisit the 3-factor Fama French model, but replace the relative spread with the three spread components: adverse selection costs, inventory management costs, and order processing costs.[26] Since the components of the spread decomposition exhibit a low degree of correlation with each other, they can be considered as largely independent contributing factors.

Key to our understanding of opaqueness-driven illiquidity, we find that the adverse selection (informational) risk factor is positive and statistically significant for excess returns (Table 10). The inventory management and order processing risk factors are insignificant.[27]

6.6 Robustness Tests

Since we have identified the adverse selection component as the only priced factor, we may check to what extent alternative measures of information risk accord with our finding. In particular we check the evolution of Kyle's Lambda as well as an adverse selection mea-

[26] This section otherwise follows the methodology outlined in Section 4.

[27] We have to note that we are using the company-specific microstructure cost factors as independent variables in all of the regressions, instead of differences between the highest and lowest quintile portfolio of the cost factors, because we are interested in the company-specific risk.

sure estimated from effective spreads (e.g., Hendershott et al. (2011)). We briefly describe the construction of those measures before using them in the above described asset pricing analysis to substitute for the original adverse selection component.

In order to measure Kyle's lambda, we exploit information entailed in the first price, i.e., the opening price. A benefit from using the opening price instead of the mid quote is that opening prices are less noisy because they are taken from the same day (whereas the mid quote is taken from the end of the day in order to construct the lambda measure. The mid-quote comes from the standing bid and ask quotes at the market close and is usually relatively wide, thus introducing noise into the estimation of informational risk. We hence suggest to instead working with the opening price here:

$$p_t = f_t + \lambda Q_t + \epsilon_t \tag{16}$$

where $lambda^{-1}$ is a measure of market depth. Taking first differences we get:

$$\Delta p_t = \Delta f_t + \lambda \Delta Q_t + \Delta \epsilon_t \tag{17}$$

We estimate lambda for both negative as well as positive order flow. The respective results can be found in Figure 18, in which it becomes clear that Lambda takes very small values.

We next estimate an adverse selection measure which was introduced by Hendershott et al. (2011) and also used in Menkveld and Zoican (2014). It is estimated from the effective spread as well as transactionprices p, mid quote m, and the trade direction indicator variable q.

$$ES = q_t \frac{m_{t+\Delta} - m_t}{m_t} + q_t \frac{p_t - m_{t+\Delta}}{m_t} \tag{18}$$

The first part of the sum captures the adverse selection component; the second part denotes the residual that cannot be explained by the adverse selection component. Delta denotes a time-increment (lead or lag). In the previously mentioned papers, which were using high frequency data, this time-increment was usually two to five minutes. Since we do not have such low latency data available, we have to work with a lag/lead of one day. The evolution of this proxy for informational risk can be found in Figure 19. As all the other measures of informational risk, it peaks shortly before as well as during the Panic months.

Obviously, all adverse selection risk measures reacted during the Panic of 1907. But are they also priced in the cross-section of stock returns as the adverse selection measure of

Huang and Stoll (1997)? Results of the asset pricing analysis using these types of adverse selection risk measures can be found in Table 10.

As becomes clear from the different robustness checks, other measures of adverse selection risk are not priced in all cases. This might be due to the fact that the Lambda measure takes on very small values that are almost not distinguishable from zero.

7 Conclusion

Our analysis offers several new insights into the role of information in financial markets, and in particular, how critical a role information transparency plays in mitigating adverse selection problems that destabilize markets. The period of our study, 1905-1910, surrounds one of the worst financial crises in over 100 years and provides a unique window on the performance of self-regulated asset markets operating under constrained information in the face of uncertainty shocks from unverifiable rumors.

We trace stock market illiquidity both to funding illiquidity during the peak of the crisis and more broadly demonstrate the liquidity premium demanded in the market. We then decompose equity bid-ask spreads into their underlying cost components and find that adverse selection costs play a dominant role in increasing transaction costs and thus contribute most to freezing liquidity. We find that all of our measures of liquidity show severe deterioration of market quality along with an increase in informational risk. Importantly, short-term cash infusions did not have a lasting effect on trading volume, even though the different risk factors recovered.

Our results demonstrate that an ostensibly short-run liquidity freeze happening in an opaque market setting can severely harm confidence in financial markets over extended periods, constraining liquidity far beyond the most acute phase of the panic. We show further that asymmetric information problems play out - as the theory suggests - in predictable cross-sectional variation in illiquidity. In particular, the liquidity crisis hit the mining sector most severely, because it lay at the heart of the crisis both in terms of illiquidity and heightened informational risk. The mining sector also ranked among the least transparent sectors of the economy and, along with many manufacturing enterprises, provided sparse information to investors. We find that these types of stocks suffered most from adverse selection costs, while the regulated and more transparent utilities and railroads suffered the least. Moreover, both extremely illiquid stocks as well as stocks traded in the NYSE's more opaque "unlisted" department also suffered significantly more during the Panic than well-certified (listed) and liquid stocks.

Finally, our analysis generates important insights for asset pricing. In particular, we show that it is possible to predict asset prices based on estimated components of bid-ask spreads. Informational costs incur risk premia above and beyond the standard market beta and Fama-French factors. Hence, the predictability of transaction costs and liquidity also implies predictability of asset prices. In this sense, asset prices are informationally efficient in, at most, a weak sense. Our findings demonstrate the first order relevance of liquidity components for asset pricing.

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8 Figures and Tables

Stock Quote 1 -- No Title
New York Times (1857-1922); Oct 18, 1907; ProQuest Historical Newspapers: The New York Times
pg. 12

NEW YORK STOCK EXCHANGE—Thursday, Oct. 17, 1907.

Total sales Oct. 17, 1907	875,153
From Jan. 1, 1907	166,946,447
Corresponding date last year	235,962,041

Closing. Bid.	Closing. Ask.	Sales.		First.	High.	Low.	Last.	†Net Change.
160	190	100	Adams Express	160	160	160	160	—5
15½	17	180	Allis-Chalmers	16	16	16	16	— ½
49⅝	49¾	128,550	*Amalgamated Cop	50⅜	50⅞	48⅝	49⅝	—1
13½	14½	200	Amer. Agricul. Chem	14	14	14	14	— ½
43¼	45	300	American Can pf	43½	43½	43⅝	43⅝	— ¼
25½	29	1,800	Amer. Car & Found	28½	29	28¼	28⅝	...
83⅝	87	500	Am. Car. & Foun. pf	84	85	83⅝	83⅝	—1⅜
29⅝	31	720	Amer. Cotton Oil	29½	29⅝	29	29⅝	— ⅜
185	195	10	American Express	195	195	195	195	...
4¼	5¼	810	*Amer. Grass Twine	4¼	4¼	4¼	4¼	— ¼
2⅝	3½	100	Am. Hide & Leather	2⅝	2⅝	2⅝	2⅝	— ⅛
27	30	10	Am. Ice Securities	30	30	30	30	...
7½	10	100	*Amer. Linseed	7½	7½	7½	7½	...
45½	46	400	*Amer. Locomotive	44⅝	45¼	44⅝	45¼	+ ¼
95	97	400	*Am. Locomotive pf	95	96⅝	95	96⅝	+3⅝
70¼	70⅝	69,000	*Am. Smelt. & Refin	71	71¼	68	70⅝	— ⅝
84½	85	11,890	Am. Smelt. & Ref. pf	85⅝	87	83½	85	—3
5½	6	100	Amer. Steel Foun	5⅝	5⅝	5⅝	5⅝	...
27	28	245	Amer. Steel Foun. pf	27	27	27	27	...
105	105½	3,350	*Amer. Sugar Ref	104½	105½	104½	105½	+ ½
70	75	1,374	Amer. Tobacco pf	74	74	70	70½	—4
79	79⅝	200	*Amer. Woolen pf	79⅝	79⅝	79⅝	79⅝	—1⅜
27⅝	28	8,700	*Anaconda Cop. Min	28	28⅝	27⅝	27⅝	— ⅝
80	80⅝	9,700	Atch., Top. & S. F.	79	80⅝	78⅝	80	+ ⅝
85⅛	87	800	Atch., Top. & S. F. pf	86	86	85½	85½	— ½
70	71½	500	Atlantic Coast Line	70⅝	70⅝	70⅝	70⅝	+ ⅛
85⅝	86	2,700	Baltimore & Ohio	86	86½	85½	86	+ ⅜
3½	4	1,200	*Balakalala Copper	3⅝	3⅝	3	3	— ⅝
4⅝	4⅞	300	*Batopilas Mining	4½	4⅝	4⅜	4⅞	— ⅛
41½	42	17,155	Brooklyn Rapid Tran	41½	42⅝	40	41½	+ ½
58	61	100	Canada Southern	58½	58½	58½	58½	— ½
157½	157⅞	2,100	Canadian Pacific	157¼	158	157¼	157⅝	+1⅝
14	14⅝	550	Central Leather Co	14⅝	14⅝	14⅝	14⅝	— ⅛
77	78	750	Cent. Leather Co. pf	77½	77½	77½	77½	— ½
29⅛	29¼	1,000	Chesapeake & Ohio	29⅝	29⅝	28½	29	...
7⅛	7½	800	Chi. Great Western	7½	7⅝	7⅛	7⅛	...
83	35	200	Chi. Gt. West pf., A	83½	84	83½	84	—1
9⅛	10¼	400	Chi. Gt. West. pf., B	9⅝	9⅝	9⅝	9⅝	— ⅜
113¼	113⅝	25,323	Chi., Mil. & St. Paul	113	114	112¼	113⅝	+ ⅝
140½	148	100	Chi., Mil. & St. P. pf	141	141	141	141	—1¼
125	127	100	*C., M. & S.P.pf.ctfs., 20 per cent. paid	125⅝	125½	125½	25½	— ½
140	141	1,000	Chi. & Northw	139⅝	140	139⅝	139¾	—1⅜
199	201	200	Chi. & Northw. pf	201	201	200	200	—4
150	170	10	C., St. P., M. & O. pf	160	160	160	160	...
1⅞	2	10	*Chi. Union Tr., t. r	2⅛	2⅛	2⅛	2⅛	...
15¼	16	1,850	Colorado Fuel & Iron	15⅛	15⅝	15⅛	15⅝	+ ⅝
19⅞	20½	2,400	Colorado Southern	19	20⅝	19	20⅝	+ ⅝
48	50	1,130	Col. Southern 1st pf	46⅝	48½	46⅝	48½	—1½
36⅝	37¼	700	Col. Southern 2d pf	36⅝	37	36⅝	37	—2
18	18½	200	Col. & H. C. & Iron	18	18	18	18	— ¼
87	88	1,425	Consolidated Gas	86	88	85½	87½	+1
10	10¼	2,200	Corn Products Ref	9½	10¼	9½	10⅛	+ ⅛
60	65	1,300	Corn Products Ref. pf	56⅝	60⅛	56⅝	60	+2⅝
147	150	1,000	Delaware & Hudson	145½	147½	145½	147½	...
19	20	400	Denver & Rio Grande	19½	20	19½	20	+ ⅝
38½	40	650	Detroit United Ry	35	39	35	39	+3
47	49	1,300	*Distillers Securities	46¾	47	46¾	47	+ ½

Figure 6: Example of Stock Quote from the New York Times (October 1907)

Table 1: Descriptive Statistics of Daily Data

Variables	Mean	Median	Std	Q25	Q75	Observations
Relative Bid-Ask Spread (1905-1910)	0.020	0.008	0.046	0.003	0.020	135.028
Number of Shares Traded (1905-1910)	7194	708	24195	200	3200	135.028
High Price (1905-1909)	75.38	55.00	61.88	28.25	112.38	109.795
Low Price (1905-1909)	74.54	54.00	61.51	11.25	27.75	109.805
Last Price (1905-1910)	74.38	55.00	60.25	28.75	111.38	135.028
Quasi Volatility (1905-1909)	0.016	0.009	0.045	0.00	0.020	109.647
Call Money Rates (Sep. 23, 07-Feb. 19, 08)	0.046	0.04	0.052	0.025	0.06	101

Table 2: Descriptive Statistics of Monthly Data

Variables	Mean	Median	Std	Q25	Q75	Observations
Gold Stock (Billion $)	1.50	1.61	0.17	1.34	1.64	72
Adverse Selection Component	0.49	0.51	0.20	0.44	0.56	1438
Inventory Holding Component	0.26	0.29	0.22	0.01	0.44	1438
Order Processing Component	0.25	0.15	0.27	0.04	0.39	1438

Table 3: Descriptive Statistics of Semi-Annual Data

Variables	Mean	Median	Std	Q25	Q75	Observations
Capital Stock	4.48e+07	2.14e+07	6.64e+07	1.25e+07	5.00e+07	1073
Book-to-Market Ratio	3.71	1.79	6.78	0.92	3.77	1073

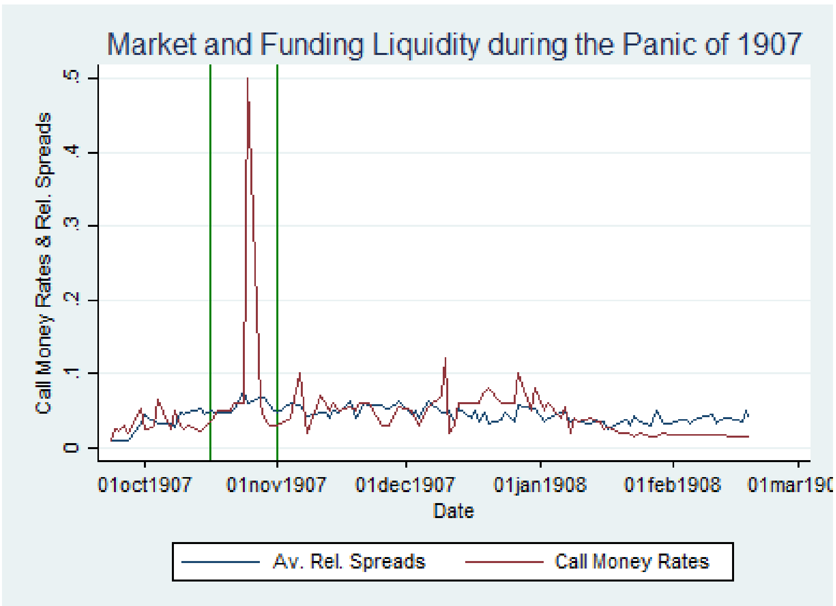


Figure 7: Market and Funding Liquidity During the Panic of 1907

Table 4: Call Money Rates and Relative Spreads During the Panic of 1907

This table reports the results of quantile regression of relative bid-ask spreads on lagged call money rates and controls for volatility, share price, and panic indicator variables. The sample includes the panel of all traded NYSE stocks at daily frequency from September 23, 1907 to February 19, 1908, and the table reports results for the 1st, 2nd, and 3rd quartiles. Relative bid-ask spread is the difference between ask and bid prices divided by the average of ask and bid prices. Quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price (note that we exclude observations for which quasi-volatility is zero). The "Height of Panic" indicator variable takes the value of one during the height of the 1907 Panic, namely from October 14, 1907, to November 1, 1907, and zero otherwise. "Crisis" denotes the remainder of the Panic of 1907, namely the period of November 2, 1907, to January 31, 1908. T-statistics use heteroskedasticity-adjusted standard errors and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Rel. Spread 1st quantile	Rel. Spread Median	Rel. Spread 4th qua
Call Money Rates	-0.011	-0.029	-0.027
	(-0.65)	(-0.66)	(-0.37)
L1.Call Money Rates	0.0099	0.11*	0.14**
	(0.43)	(1.72)	(2.14)
Call Money Rates x Height of Panic	0.0065	0.036	0.036
	(0.38)	(0.81)	(0.48)
L1.Call Rates x Height of Panic	0.057**	0.0054	0.16**
	(2.13)	(0.094)	(2.41)
Call Money Rates x Crisis	-0.0092	0.026	0.018
	(-0.48)	(0.63)	(0.23)
L1.Call Rates x Crisis	0.016	-0.069	-0.033
	(0.70)	(-1.21)	(-0.37)
Stock Price	-0.000067***	-0.000090***	-0.00014***
	(-2.80)	(-3.77)	(-4.06)
Quasi Volatility	0.043*	0.15***	0.32***
	(1.82)	(4.71)	(3.55)
Constant	0.0091***	0.014***	0.026***
	(4.76)	(5.89)	(4.58)
Observations	3,623	3,623	3,623
R-squared	0.058	0.071	0.073
FE	YES	YES	YES

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Asset Pricing with a Liquidity Factor

This table reports the results from the second stage regression estimation of the two-stage estimation procedure described in Section 4. The dependent variable is company specific excess returns. The explanatory variables include a market return beta, and the betas of the Fama-French factors, and a liquidity risk beta. The underlying time period covers the years of 1905 to 1910. The t-statistics are based on standard errors adjusted for heteroskedasticity and autocorrelation, and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	Company Excess Returns
Market Excess Return	-0.0025
	(-0.21)
SMB	$\mathbf{-0.0108}^{***}$
	(-4.36)
HML	$\mathbf{-0.0227}^{*}$
	(-1.84)
Relative Bid-Ask Spread	$\mathbf{0.00676}^{***}$
	(4.23)
Constant	$\mathbf{0.0185}^{*}$
	(1.61)
Adjusted R^2	0.69
Observations	190

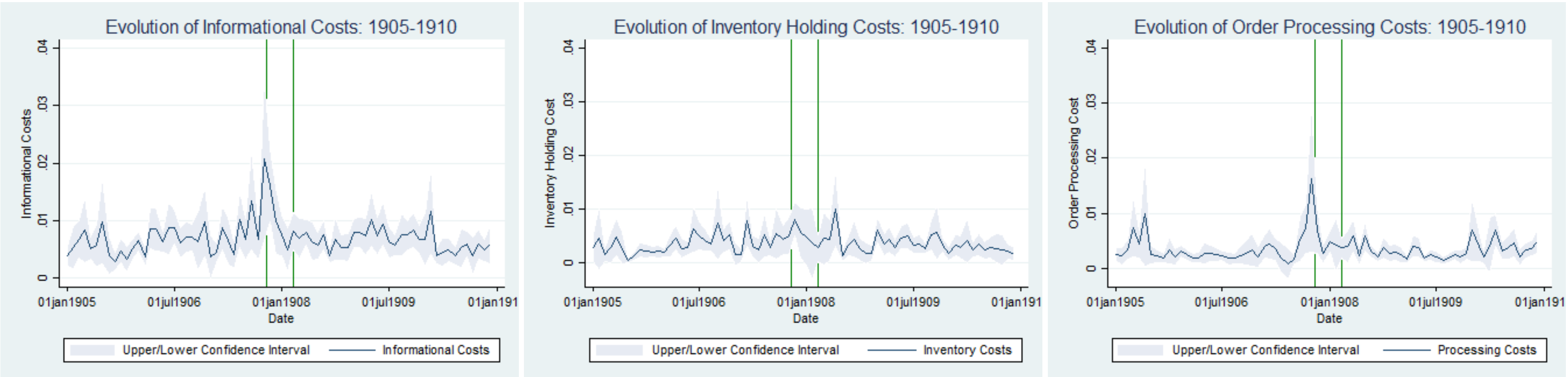


Figure 8: Informational Costs, Inventory Costs, and Order Processing Costs: 1905-1910

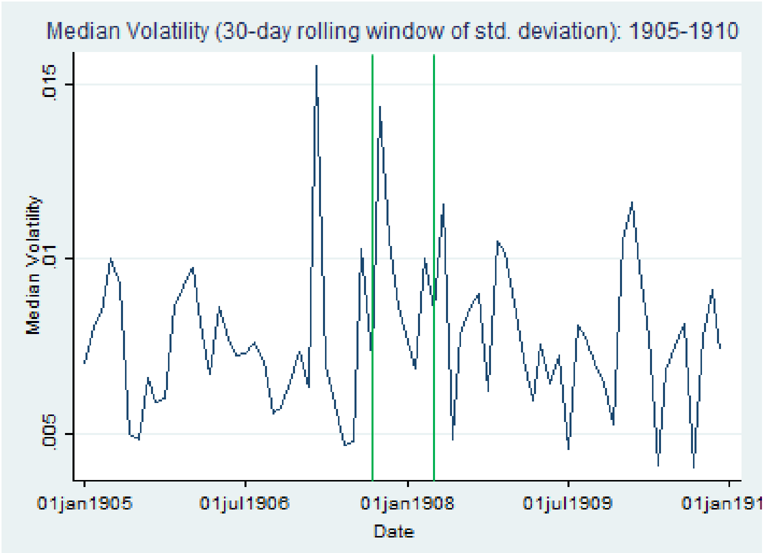


Figure 9: **Median Volatility: 1905-1910**

Table 6: Market Liquidity During the Panic of 1907

This table reports the results of quantile regression of relative bid-ask spreads on time indicator variables for the Panic period and controls for volatility, share price, and firm fixed effects. The sample includes the panel of all traded NYSE stocks at daily frequency from 1905 to 1909, and the table reports results for the 1st, 2nd, and 3rd quartiles. Relative bid-ask spread is the difference between ask and bid prices divided by the average of ask and bid prices. Quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price (note that we exclude observations for which quasi-volatility equals zero). The "Height of Panic" indicator variable takes the value of one during the height of the 1907 Panic, namely from October 14, 1907, to November 1, 1907, and zero otherwise. "Crisis" denotes the remainder of the Panic of 1907, namely the period of November 2, 1907, to January 31, 1908. T-statistics use heteroskedasticity-adjusted standard errors and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

VARIABLES	(1) Rel. Spread 1st quantile	(2) Rel. Spread Median	(3) Rel. Spread 4th quantile
Height of Panic	0.0040***	0.0094***	0.023***
	(3.97)	(9.51)	(7.47)
Crisis	0.0019***	0.0044***	0.012***
	(4.35)	(2.95)	(4.08)
Stock Price	-0.000023***	-0.000029***	-0.000041***
	(-4.83)	(-2.81)	(-5.31)
Quasi Volatility	0.024**	0.096***	0.26***
	(2.12)	(7.63)	(6.01)
Constant	0.0047***	0.0072***	0.012***
	(8.29)	(6.49)	(8.01)
Observations	81,156	81,156	81,156
R-squared	0.051	0.043	0.036
FE	YES	YES	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

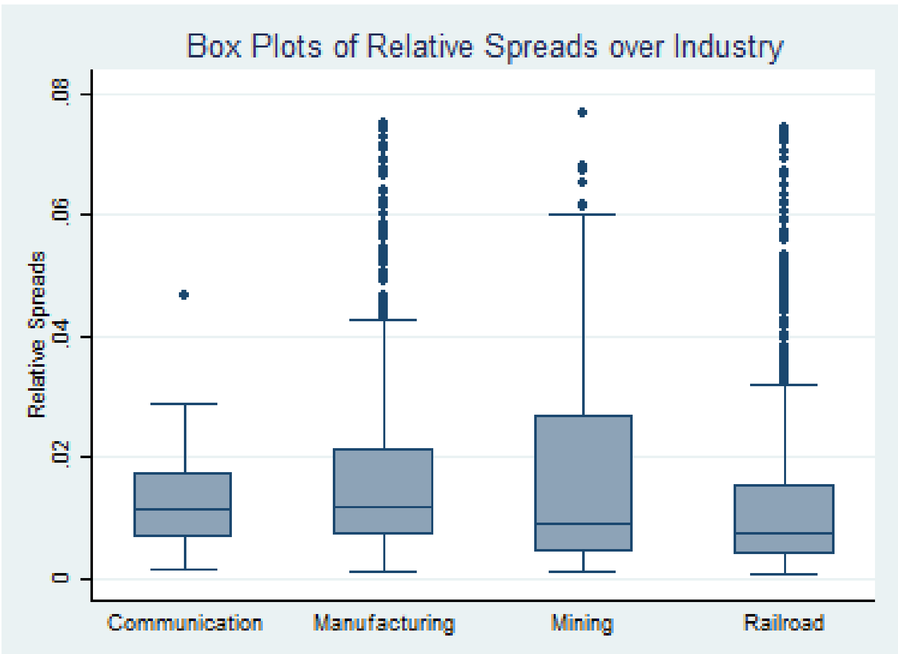


Figure 10: Box Plots of Relative Bid-Ask Spreads by Industry

Table 7: Determinants of Adverse Selection Costs (1905-1910, monthly frequency)

This table reports the results of quantile regressions of adverse selection costs on a time indicator variable for the Panic period (October 1907 to January 1908) and controls for monthly call money rates, end-of-month volatility, and end-of-month share prices. The sample includes the panel of all traded NYSE stocks at monthly frequency from 1905 to 1910, and the table reports results for the 1st, 2nd, and 3rd quartiles. Adverse selection costs are denoted in Dollar terms and represent the part of relative spreads that is due to informational risk. Quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price. T-statistics use heteroskedasticity-adjusted standard errors and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

VARIABLES	(1) ASCost 1st quantile	(2) ASCost Median	(3) ASCost 4th quantile
Panic of 1907	-0.0033	-0.025***	-0.039***
	(-0.58)	(-2.71)	(-2.76)
Call Money Rates	0.0013	**0.018****	**0.039***
	(0.32)	(1.98)	(1.90)
Panic of 1907 x Call Money Rates	0.095	**0.62*****	**0.90*****
	(0.72)	(2.82)	(2.84)
Stock Price	**-0.000013*****	**-0.000025*****	**-0.000043*****
	(-5.31)	(-5.06)	(-7.38)
Quasi Volatility	-0.013	**-0.040*****	-0.048
	(-1.49)	(-3.55)	(-1.23)
Constant	**0.0027*****	**0.0054*****	**0.011*****
	(8.04)	(7.78)	(7.17)
Observations	1,453	1,453	1,453
R-squared	0.054	0.060	0.060

Table 8: Determinants of Inventory Holding Costs (1905-1910, monthly frequency)

This table reports the results of quantile regressions of inventory holding costs on a time indicator variable for the Panic period (October 1907 to January 1908) and controls for monthly call money rates, end-of-month volatility, and end-of-month share prices. The sample includes the panel of all traded NYSE stocks at monthly frequency from 1905 to 1910, and the table reports results for the 1st, 2nd, and 3rd quartiles. Inventory holding costs are denoted in Dollar terms and represent the part of relative spreads that is due to inventory risk. Quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price. T-statistics use heteroskedasticity-adjusted standard errors and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

VARIABLES	(1) IHCost 1st quantile	(2) IHCost Median	(3) IHCost 4th quantile
Panic of 1907	-0.0034	**-0.0072*** **	-0.019
	(-1.36)	(-2.62)	(-0.72)
Call Money Rates	**0.0032** **	**0.012*** **	0.016
	(2.12)	(3.01)	(1.09)
Panic of 1907 x Call Money Rates	0.082	**0.17** **	0.46
	(1.40)	(2.57)	(0.78)
Stock Price	**-1.1e-06** **	**-8.3e-06*** **	**-0.000024*** **
	(-2.51)	(-4.01)	(-5.54)
Quasi Volatility	-0.0016	**-0.016*** **	-0.024
	(-0.97)	(-2.73)	(-1.01)
Constant	**0.00016** **	**0.0017*** **	**0.0061*** **
	(2.16)	(4.85)	(5.89)
Observations	1,453	1,453	1,453
R-squared	0.016	0.031	0.035

Table 9: Determinants of Order Processing Costs (1905-1910, monthly frequency)

This table reports the results of quantile regressions of order processing costs on a time indicator variable for the Panic period (October 1907 to January 1908) and controls for monthly call money rates, end-of-month volatility, and end-of-month share prices. The sample includes the panel of all traded NYSE stocks at monthly frequency from 1905 to 1910, and the table reports results for the 1st, 2nd, and 3rd quartiles. Order processing costs are denoted in Dollar terms and represent the part of relative spreads that is due to costs of processing orders and market power risk. Quasi-volatility is defined as the highest transaction price on a given day minus the lowest transaction price on that same day, divided by the last transaction price. T-statistics use heteroskedasticity-adjusted standard errors and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

VARIABLES	(1) OPCost 1st quantile	(2) OPCost Median	(3) OPCost 4th quantile
Panic of 1907	0.0039	-0.0053	**-0.013*** **
	(1.14)	(-0.39)	(-2.79)
Call Money Rates	-0.00040	-0.0038	0.0019
	(-0.33)	(-1.27)	(0.22)
Panic of 1907 x Call Money Rates	-0.076	0.15	**0.35*** **
	(-1.04)	(0.46)	(3.29)
Stock Price	**-1.9e-06*** **	**-6.0e-06*** **	**-0.000016*** **
	(-4.25)	(-5.51)	(-7.03)
Quasi Volatility	0.0024	0.0042	-0.0041
	(0.87)	(0.59)	(-0.30)
Constant	**0.00050*** **	**0.0017*** **	**0.0044*** **
	(6.13)	(8.11)	(8.86)
Observations	1,453	1,453	1,453
R-squared	0.021	0.061	0.059

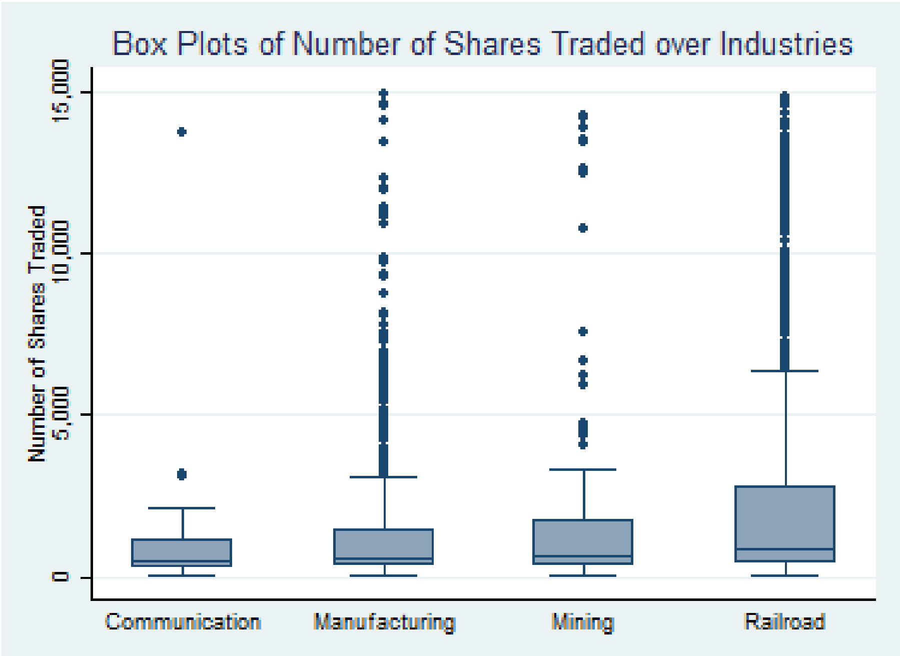


Figure 11: **Box Plots of Trading Volume by Industry**

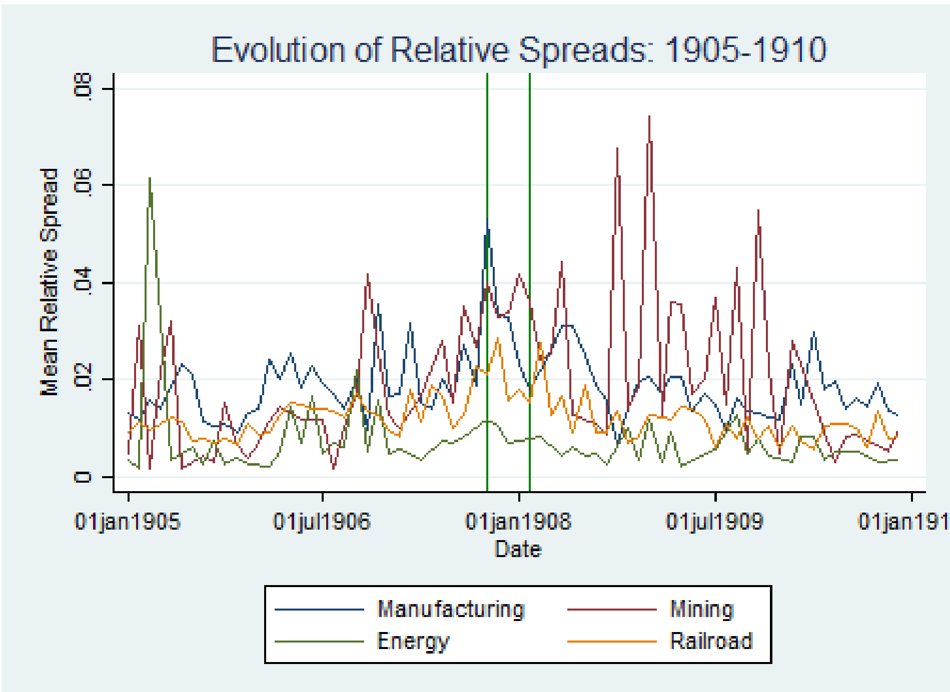


Figure 12: **Average Relative Industry Bid-Ask Spreads: 1905-1910**

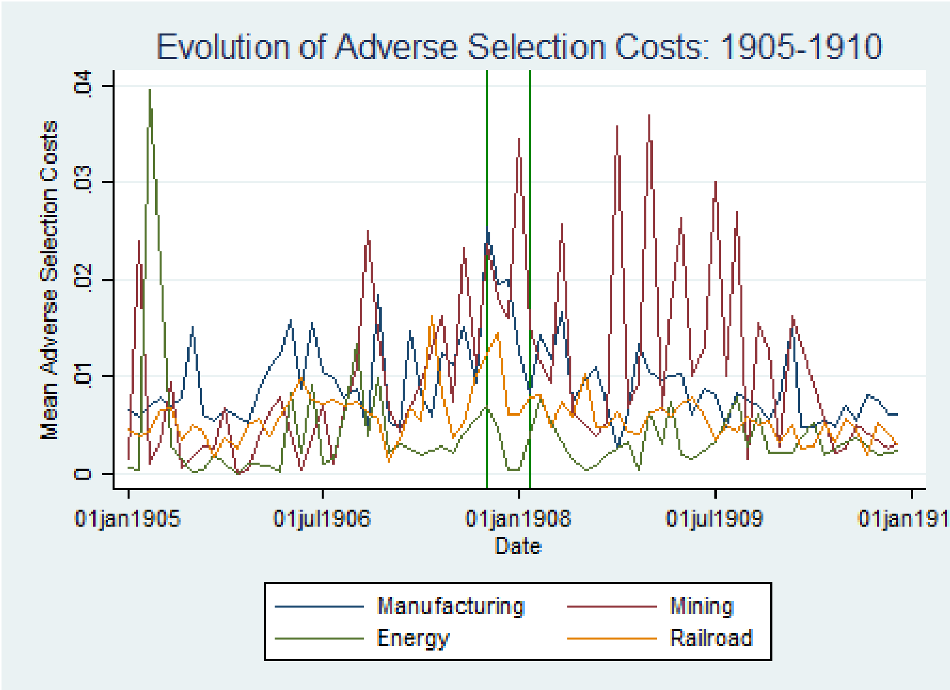


Figure 13: **Informational Costs across Industries: 1905-1910**

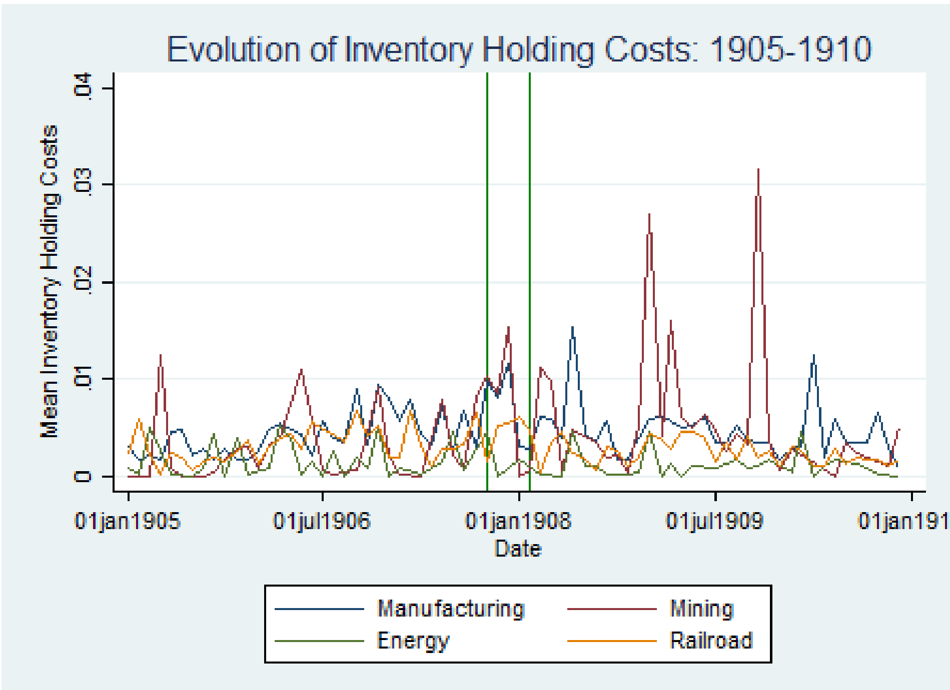


Figure 14: **Inventory Costs across Industries: 1905-1910**

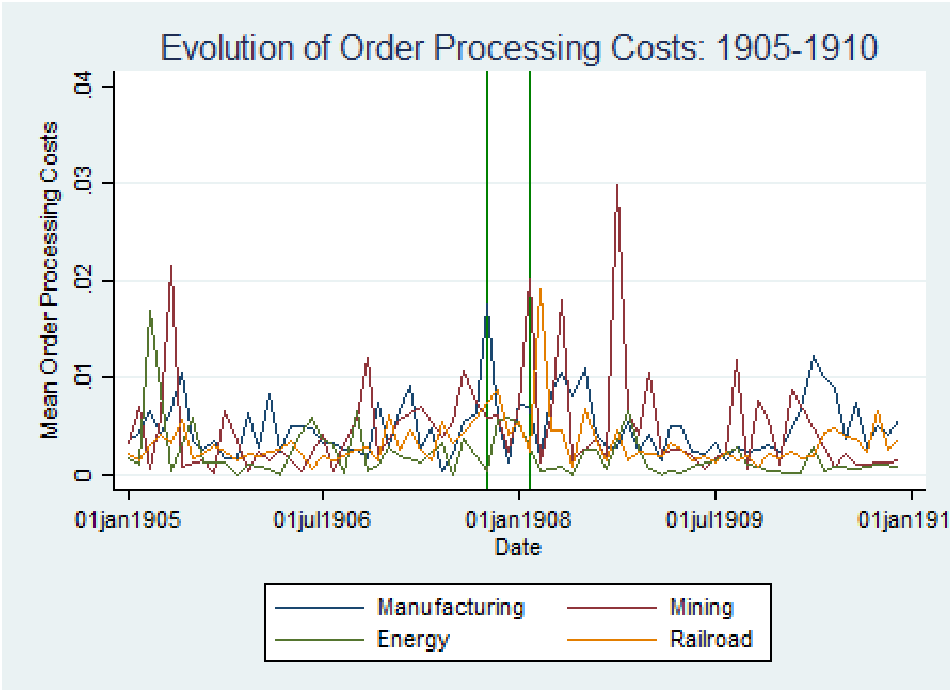


Figure 15: Order Processing Costs across Industries: 1905-1910

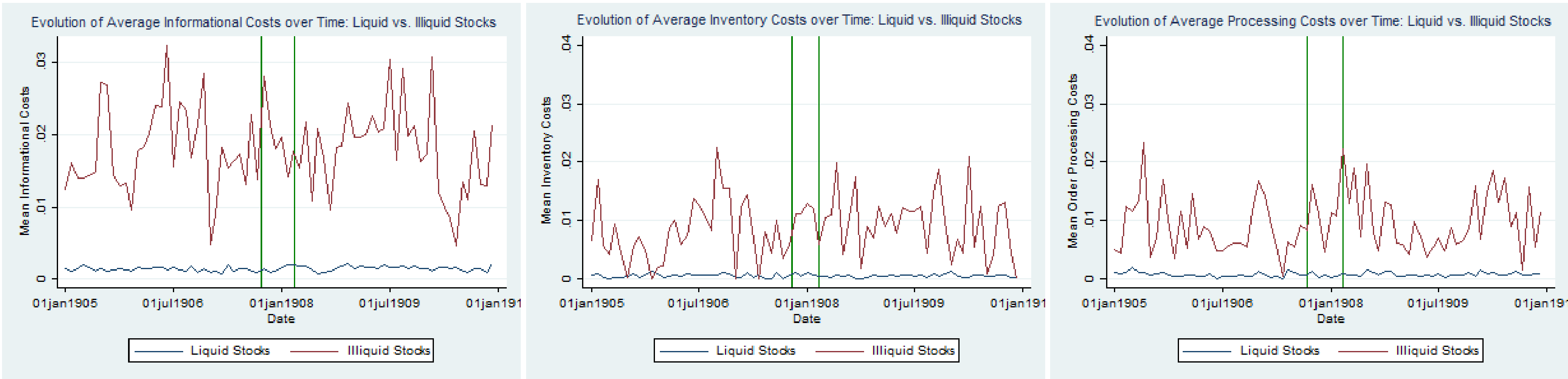


Figure 16: Informational Costs, Inventory Costs, and Order Processing Costs: Liquid vs. Illiquid Stocks

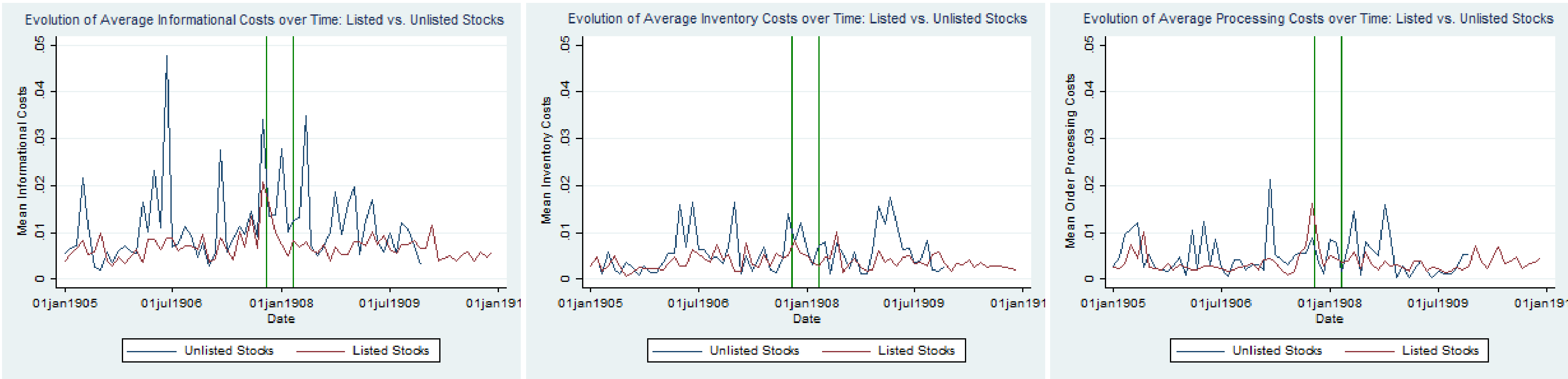
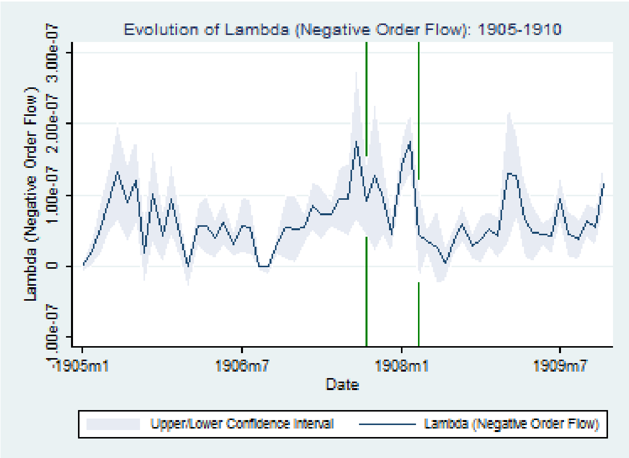


Figure 17: Infomational Costs, Inventory Costs, and Order Processing Costs: Listed vs. Unlisted Stocks

Table 10: Asset Pricing with Adverse Selection Risk

This table reports the results from the second stage regression estimation of the two-stage estimation procedure described in Section 4. The dependent variables are company specific average excess returns. The explanatory variables include a market return beta, adverse selection risk betas (measured according to Gehrig and Haas (2015), alternative measures of adverse selection risk betas (Kyle's lambda and the adverse selection measure of Hendershott et al. (2011))), an inventory holding risk beta, an order processing risk beta, and the the Fama-French factors betas, all of which were estimated in the first stage of the estimation procedure. The underlying time period covers the years of 1905 to 1910. The t-statistics are based on standard errors adjusted for heteroskedasticity and autocorrelation, and are reported in parentheses below the coefficient estimates. The symbols ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	Company Excess Returns	Company Excess Returns	Company Excess Returns
Market Excess Return (Gold Flow Rate)	**0.00532******	**0.013******)	**0.0223******
	(3.90)	(6.05)	(8.90)
SMB	$-$**0.000659****	0.000331	$-$0.00017
	($-$1.75)	(0.56)	($-$0.15)
HML	0.00153	**0.00645******	0.00415
	(1.02)	(4.21)	(0.99)
ASCost	**0.000274****	.	.
	(2.01)	.	.
IHCost	$-$0.000153	.	.
	($-$0.94)	.	.
OPCost	0.0000479	.	.
	(0.34)	.	.
Kyle's Lambda	.	**0.000000152****	.
	.	(1.90)	.
ASC (Hendershott et al. (2011))	.	.	**0.456******
	.	.	(4.80)
Adjusted R^2	0.19	0.22	0.69
Observations	127	167	159



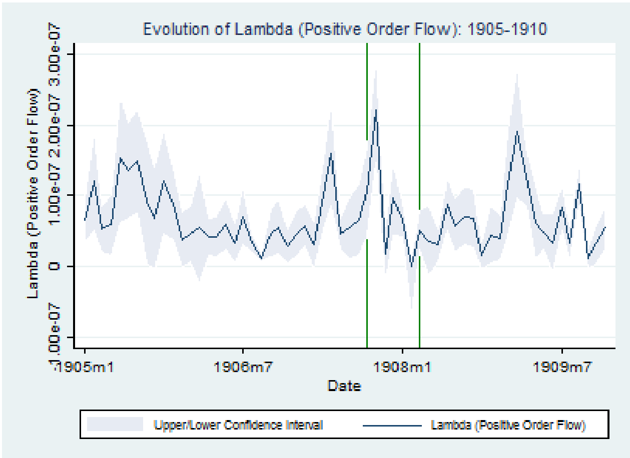


Figure 18: Evolution of Lambda for Negative and Positive Order Flow

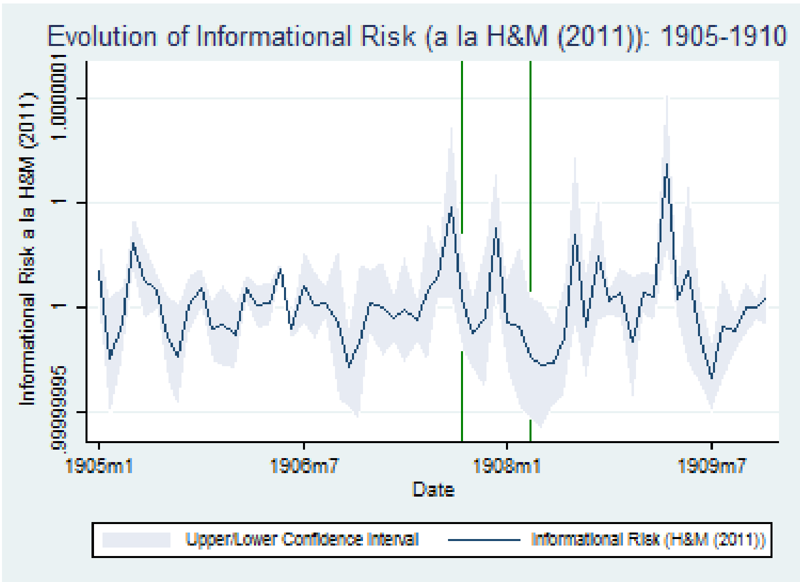


Figure 19: Evolution of Informational Risk according to Hendershott et al. (2011)

9 Online Appendix

Table 11: Descriptive Statistics of Betas of First Stage Regressions

Variables	**Mean**	**Median**	**Std**	**Q25**	**Q75**	**Observations**
Table 5, column 1						
Beta Spread	-0.475	-0.289	2.870	-0.961	-0.00477	187
Beta HML	3.269	-0.156	41.99	-0.571	0.352	187
Beta SMB	-3.363	0.443	39.81	-0.335	2.017	187
Beta Excess Market Return	-1.360	0.642	28.52	0.293	1.260	187
Table 5, column 2						
Beta Amihud	110,686	-253.9	8.628e+06	-12,807	2,002	187
Beta HML	-0.319	-0.198	4.387	-0.701	0.417	187
Beta SMB	0.669	0.885	9.476	-0.511	2.908	187
Beta Excess Market Return	0.949	0.788	2.032	0.428	1.326	187
Table 10, column 1						
Beta OPCost	0.408	0	37.99	-4.687	1.746	126
Beta IHCost	8.861	0	89.78	-3.254	3.365	126
Beta ASCost	-5.043	-0.812	51.23	-4.726	1.276	126
Beta HML	0.495	0	6.856	-0.700	0.859	126
Beta SMB	-2.694	0	20.72	-1.871	1.776	126
Beta Excess Market Return	1.487	0.828	3.340	0.387	1.869	126
Table 10, column 2						
Beta Kyle's Lambda	-1,749	-11.52	26,764	-607.0	33.95	166
Beta HML	-0.330	-0.233	3.922	-1.015	0.265	166
Beta SMB	0.797	0.856	12.24	-0.485	2.707	166
Beta Excess Market Return	1.212	0.967	2.180	0.537	1.532	166
Table 10, column 3						
Beta ASC (Hendershott et al. (2011))	-0.0548	-0.00707	0.750	-0.0142	0.0105	164
Beta HML	-0.835	-0.111	11.87	-0.494	0.171	164
Beta SMB	-0.331	0.153	7.505	-0.406	1.294	164
Beta Excess Market Return	2.543	0.908	19.38	0.557	1.339	164