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Liquidty Freezes and Market Runs; Evidencefrom the Panic of 1907

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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$^{\text{th}}$ 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, we find that the market remained relatively illiquid for several months following the panic. We go on to show that rising illiquidity enters negatively in the cross section of stock returns. 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.

JEL classification: G00, G14, N00, N2

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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 recent global financial crisis, the severity and duration of the after effects set off an immediate outcry from the public and reactions from federal and state governments. While private initiatives - the concerted effort organized by John Pierpont Morgan - ultimately contributed to resolving the crisis, it 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 (which would come into play in the summer of 1914). The episode 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 interventions such as the U.S. Securities and Exchange Commission (SEC) that emerged much later. [1]

We study this episode, as it provides one of the best examples of a financial crisis based on rumors and information asymmetry rather than economic fundamentals (Frydman et al. (2012) [1]). 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. Thus, the 1907 panic allows us unique insights into the price discovery process and the role of information during crises, within a comparatively opaque market environment.

While many previous researchers have examined the panic at the aggregate level, we are able to offer a much richer view 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.[2] We uncover a range of new results. First, the stock market (the NYSE) showed signs of deteriorating liquidity - rising bid-ask spreads and Amihud price impact measures - starting in September of 1907, in advance of the most acute period of crisis. The heightened illiquidity also lasted until March 1908, several months after the run ended. Notably, our spread decompositions show that adverse selection risk - the result of asymmetric information - accounts for the greatest part of this illiquidity problem. As we predict, the effects are most pronounced in the most opaque market segments. The

[1] This paper builds on an earlier study by Fohlin et al. (2008).

[1] See also Gorton (1988), Calomiris and Gorton (1991), and Moen and Tallman (1992) for earlier work on this.

[2] See Fohlin (2014) for more detail on the larger data collection project.

mining sector, the target of the stock manipulations that led to the Panic in the first place, also operated with some of the least transparent accounting and governance procedures. In addtion, we relate stock market illiquidity with interest rates in the money market (call loans), the primary source of funding for stock transactions.

In a final set of tests, we show that it is possible to predict the cross section of stock returns based on estimated microstructure cost factors and that the role of liquidity intensifies during the crisis. The fact that we can predict asset prices with liquidity measures demonstrates the first order importance of microstructure cost factors for stock returns.

The remainder of the paper is organized as follows. Section 2 describes the trading environment in 1905 to 1910 and Section 3 describes the exact line of events of the Panic of 1907. Section 4 outlines the hypotheses that underlie this research. Section 5 describes in detail the data that we are using for our analyses, while Section 6 explains the methodology. Sections 7 and 8 present the results of the transaction cost analysis and of asset pricing, respectively. Section 9 concludes.

2 The New York Stock Exchange in 1905-1910

In the period analyzed in our study, the NYSE was owned by its members and largely self-regulated. Among the key regulations 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. These prices ranged between \$4,000 and \$4,500 in 1870 (approximately \$125,000 in 2013 terms) and between \$64,000 and \$94,000 in 1910 (roughly \$1.5-2.5 million in 2013). 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 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. External regulation of exchange operations or of listed corporations was set in place much later. Corporate reporting law generally remained vague in the United States until after the Great Depression. Internal incentives and particularly the desire to access outside funds from investors encouraged

a growing number of companies to disclose their balance sheets and income statements. Following this movement, the NYSE began to recommend in 1895 that listed companies should 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)).

The NYSE operated a continuous auction market during this period; having converted from the call auction method in 1871, due to space and time constraints. The system functioned much like a modern continuous market, in which transactions occurred throughout the trading day at whatever terms could be agreed upon by the parties involved, with no guarantee of a single price. While the continuous auction method eliminated the problem of overcrowding and the excessive time taken in each call auction, it created a new problem: order imbalance. In general, random arrival reduces market liquidity, creating greater chance of order imbalance and price volatility compared to a call auction (Kregel (1995)). The evolution of the trading method led to the creation of two distinct types of intermediaries. The first type, brokers, traded on behalf of their customers and received set commissions as their payment. The others, jobbers, bought and sold shares in order to make markets in securities, and they received the spread between bid and ask prices as their compensation. The increasing number and sophistication of jobbers then encouraged their specialization in particular stocks.

3 The Panic of 1907

In light of the recent global financial crisis, the panic that hit the U.S. financial system in the fourth quarter of 1907 has gained renewed interest among economists (Frydman et al. (2012) and Bordo and Haubrich (2010)). The "Panic of 1907" came on top of a slowing economy and displayed typical features also observed in earlier financial crises (Moen and Tallman (1992)): interest rates spiked, stock prices decreased sharply, output in the real economy fell, and financial institutions suffered from deposit withdrawals (see Gorton (1988) and Kindleberger and Aliber (2011)).

The Panic began on October 16, 1907, with the failure of the brokerage firm of Otto

Heinze. Heinze's brokerage house was forced to close when he attempted to corner shares of "The United Copper Company" and pull a classic "short squeeze". The manipulations caused wild swings in the price of United Copper, but the price ultimately plummeted and forced Otto into financial ruin. United Copper was owned by Otto's brother, the notorious copper magnate, F.A. (Augustus) Heinze.[3] The 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.[4] 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 (Bruner and Carr (2008)). After the closure of Knickerbocker Trust Company on Tuesday, October 22nd, depositors rapidly began withdrawals from other trust companies.[5]

As this summary of events and the extensive reporting in the Commercial and Financial Chronicle of the time as well as numerous other researchers point out such as Frydman et al. (2012), Gorton (1988), Calomiris and Gorton (1991), and Moen and Tallman (1992), this panic was purely rumor-based. Market participants could observe the runs on trusts and banks that had close ties to the Heinze brothers, but they had no way of accurately evaluating the fundamental values of either the financial institutions or the corporations whose stocks served as collateral on millions of dollars' worth of loans. Though the panic began without any basis in fundamentals, the resulting runs forced liquidations at financial institutions and yielded significant negative consequences for the real sector. 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 biggest problem for trusts was their lack of access to the Clearing House Association of New York, a private clearing house that also acted as an emergency lender to its members in crisis times. The trusts simply were not part of this club (Tallman and Moen (2014)). Hence, as suggested by Moen and Tallman (1992) and Bruner and Carr (2008), the main mechanism through which this panic spread to the real sector was a contraction of loans.

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

[3]For extensive details, see the Smithsonian Magazine article from September 2012.

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

[5]Again, see the extensive details reported in the Commercial and Financial Chronicle.

October 24th 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 26th, the New York Clearing House Association issued Clearing House loan certificates for its member banks (Tallman and Moen (1990)). To further calm down markets, treasury certificates were issued on November 19th and 20th. 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 in contrast to Morgan's temporary injection of funds, and thereby provided a more enduring resolution of the crisis.

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.

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 to backstop the banking system. Consequently, on May 28, 1908, Congress passed the "Aldrich-Vreeland Act" that permitted banks to coordinate during crisis episodes and 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)). Most of those reports pointed out the need for an official lender of last resort. The Commission submitted its final report in 1912 and on December 23, 1913, Congress passed the Federal Reserve Act.

4 Rumor-based Liquidity Freezes

The Panic of 1907 features a range of asymmetric information problems, including lack of transparency and informed trading by certain market participants (for example, those involved in the stock corner) and a highly uncertain general environment due to the dissemination of rumors about financial institutions' insolvency. The theoretical literature

offers a variety of models that capture most of these elements of financial crises that we can use to derive testable hypotheses for this particular episode.

Bernardo and Welch (2004) offer a theoretical framework which explains how rumor-based runs on financial *markets* may come about. 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 think alike, this in itself will cause a run on financial markets. Based on this intuition and the underlying model, 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. 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.

The initial impetus for the Panic resulted from the failure of a short squeeze via a stock corner. However, since the participants in that stock corner were highly connected people in the business world of 1907, rumors and fears about impending liquidations of interconnected companies and financial institutions, spurred investors to sell their shares immediately in order to avoid coming in last. If this line of arguments holds true, 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.

Hellwig and Zhang (2012) show that the role of information changes during a crisis. They demonstrate that markets tend to be more liquid at the onset of a crises 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 may 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.

These theories do not address the impact that liquidity interventions might have on the vicious cycle of increased informational risk and freezing liquidity. 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. We expect that this intervention as well as other measures put in place by the Clearing House Association and the Treasury significantly contributed to ending the liquidity freeze. This should be reflected in declining spreads, increasing trading volume, and a reduction in overall informational risk as well as valuation uncertainty.

On the timing of events, Gorton (1988) is able to classify the business cycle of 1907/8 rather precisely from May 1907 to July 1908, the Panic, however, to October 1907 only. Using a unique dataset on both the bond and stock market, Tallman and Moen (2014) provide empirical evidence for both asset markets that the serious financial distress already started prior to the suspension of Knickerbocker Trust and hence prior to what Gorton (1988) classifies as the 1907 Panic.

Moving beyond the timing of historical crises, Calomiris and Gorton (1991) theoretically and empirically review two competing views on how bank runs can possibly emerge: random withdrawals vs. "asymmetric information" runs, where panics are caused by depositor revisions in the perceived risk of a bank when they are uninformed about the health of a bank and receive adverse news about the state of the economy. By reviewing a large set of bank crises, they find that banks' self-regulation used to be quite effective in mitigating bank panics. They furthermore are able to show that the banking environment used to be opaque and hence informationally risky, but that this has changed with the changing business models of banks and the ability to sell loans on the open market.

Kyle and Obizhaeva (2012) turn the focus of why panics and crashes emerge to whether they are predictable. By comparing price declines in stock markets with predictions from a market microstructure invariance measure, they are able to show that early warning systems are actually feasible and that those can be easily implemented.

Due to data restrictions, none of these papers is able to empirically evaluate changes in the intensity of a crisis and its roots (fundamental changes vs. information-based panic). We help fill this gap in the literature by tracking changes in informational risk closely and thereby provide evidence of how crises in *stock markets* can form based on panics rather than fundamentals. To our knowledge, we are the first to do so (compare Goldstein (2010)).

To be specific, we conjecture and then later test the following hypothesis:

Hypothesis 1: Adverse selection risk drives illiquidity during a rumor-based panic, in particular, during the Panic of 1907.

We further expect to find the most severe adverse selection effects in stocks that have the least transparency regarding their financial performance and in which stocks are most prone to manipulations, such as naked short sales, corners and short squeezes. Mining stocks ranked among the worst in this regard, and it was the failed corner on the United Copper Company that lay at the center of the panic. 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. According to an article of the New York Times of April 29, 1902, 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.[6] So based on the wide-spread connections of the Heinze brothers in the mining sector we conjecture the following hypothesis:

Hypothesis 2: In the historical context of this panic, the effect of adverse selection is particularly strong in the mining sector.

Based on the differing extent and thoroughness with which different industries published their accounting information (Archambault and Archambault (2005)), we furthermore expect stocks in the more transparent sectors (e.g., utilities and railroad sector, which provided accounting information to the public in great detail) to suffer from 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.[7]

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

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

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

needs for liquidity). Her model thereby is able to endogenously generate and identify 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. 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. Thus, we expect to find the following hypothesis to hold:

Hypothesis 3a: Adverse selection risk affects illiquid stocks more than liquid stocks.

Listing on the NYSE brought with it a certification of quality, based on the exchange's listing requirements, which involved a vetting process and disclosure of financial statements. As a way to ward off competitors, the NYSE also maintained an "unlisted department" to trade in stocks that 1. could not meet NYSE listing requirements or 2. chose not to report the information required for an application for an official listing. Hence, since the NYSE did not impose 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 for which more information was available publicly. Moreover, episodes of heightened uncertainty may exacerbate such information problems. Thus, we expect that unlisted stocks are particularly vulnerable to rumors:

Hypothesis 3b: Adverse selection risk affects unlisted stocks more than listed stocks.

5 Data

We use newly-gathered data on daily transations, quotations, and volumes for all stocks trading on the NYSE during 1905 through 1910.[8] We checked the data thoroughly for pos-

[8]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. The raw data come from the NYSE listings printed each day in the New York Times, via the Proquest digital archive. The images are not machine readable, and Optical Character Recognition (OCR) methods proved infeasible, so the data were all entered by hand. An earlier paper provided some initial cleaning and analysis of the 1900 and 1910 waves of the data, and we proceed generally in line with that earlier

sible transcription mistakes and standardized the many variations on each firm's name.[9] We then implemented a thorough automated search for potential errors, based on inconsistencies across variables (e.g., "high" price that is not the highest price for the day or ask prices exceed the respective bid prices). We hypothesized that it is not possible for the closing bid and ask prices to deviate from the last trading price by a large amount and therefore dropped observations for which the bid or ask deviated from the last price by more than $10. The number of observations dropped by this procedure, range from five to 70 observations depending on the respective year.

We next compute bid-ask spreads, the mid-quotes , and a trade direction indicator variable. The trade direction indicator indicates whether the last transaction was a buy (+1), a sell (-1), or not determinable (0). We calculated this variable by comparing the last trading price with the respective mid-price (similar to Lee and Ready (1991)). If the last transaction price exceeds the respective mid-price, the trade indicator variable takes a value of +1. If the mid-price exceeds the transaction price, the trade indicator variable takes a value of -1 and zero in all other cases.

An important variable that we use for our liquidity analyses refers to monthly U.S. call money rates. This data comes from the National Bureau of Economic Research Macrohistory Database and is denoted in percent. We furthermore include monthly data for gold stock reserves in our subsequent analyses which also comes from the National Bureau of Economic Research Macrohistory Database and is denoted in billions of Dollars. To investigate differences between liquid and illiquid companies, we create an indicator variable that takes the value of one if a stock was in the first quantile of the spread distribution and zero otherwise. In order to control for the size of companies, we furthermore generate a dummy variable that takes the value of one if a company was in the first quantile of the trading volume distribution and zero otherwise. Descriptive statistics can be found in Table 1 for the full sample and Table 2 for the Panic of 1907. Table 2 shows the severe impact of the Panic: spreads and call money rates increase on average and in all quantiles. Respectively, trading volume drops during the crisis. Gold stock reserves increase over the course of the Panic which confirms Rodgers and Payne (2012).

6 Methodology

In order to estimate informational costs, inventory costs, order handling costs, and their respective contribution to the bid-ask spreads on the highest frequency possible (i.e.,

work Gehrig and Fohlin (2006).

[9] In a typical year the raw data contained around 1,100 different stock names, of which some 80 percent were duplicates. For example, "Am. B. Su. Co."; "Am. Beet S. Co."; "Am. Beet Sug. Co."; "Am. Beet Sugar" all refer to the company: American Beet Sugar.

monthly), we apply Gehrig and Haas (2015)'s refinement of the Huang and Stoll (1997) spread decomposition. The refinement insures that the three different cost components add up to a 100% of the quoted bid-ask spreads. We review the methods briefly and refer the reader to the detailed description in Gehrig and Haas (2015).

In the model of Huang and Stoll (1997), the time frame consists of three separate and sequential events. The stock's fundamental value, V_t, is unobserveable. The bid and ask quotes are set right after the fundamental stock value has been determined. M_t denotes the quote midpoint and is calculated from the quotes that were posted by a market maker just before a transaction happened. P_t denotes the respective transaction price. As described in section 3, Q_t denotes the trade direction indicator variable. It takes the value of 1 if the transaction price exceeds the midquote, and it takes the value of -1 if the transaction price is smaller than the midquote. It equals zero if the transaction price is equal to the midquote.

Trade flows 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:

$$E(Q_{t-1}|Q_{t-2}) = (1 - 2\pi)Q_{t-2}. \tag{1}$$

where π denotes the probability that the current trade is of opposite sign to the previous trade.

Huang and Stoll (1997) estimate equation 1 simultaneously with equation 2 in order to estimate the different cost components of the spread. In equation 2 S_t denotes the equity bid-ask spread and α denotes the percentage of the spread that is associated with informational cost (i.e., adverse selection cost). As can be seen α is assigned to the difference of what the actual trade turned out to be (i.e., $\frac{S_{t-1}}{2}Q_{t-1}$) and what the market maker expected the trade to be based on the previous trade (i.e., $\frac{S_{t-2}}{2}\mathbb{E}[Q_{t-1}|Q_{t-2}]$). Hence, α, or informational costs, only arise if the current trade brings about a surprise relative to the previous trade. β, the percentage of the spread that is associated with inventory cost, on the other hand is assigned to the current trade and denotes the changes in the market maker's inventory holdings that she later might need to adjust. ϵ_t refers to a public information shock. It is assumed to be serially uncorrelated.

$$\Delta M_t = (\alpha + \beta)\frac{S_{t-1}}{2}Q_{t-1} - \alpha\frac{S_{t-2}}{2}(1 - 2\pi)Q_{t-2} + \epsilon_t. \tag{2}$$

With equation 1 and 2, we have arrived at the equations that we use for our estimation procedure. The parameters of equation 1 and 2, α, β, and π, are estimated 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:

$$Q_N(\theta) = \left[N^{-1} \sum_{i=1}^{N} g(w_i, \theta) \right]' \widehat{\Lambda}^{-1} \left[N^{-1} \sum_{i=1}^{N} g(w_i, \theta) \right]. \tag{3}$$

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 (α), the component for inventory holding risk (β), and the trade direction reversal probability (π). The order processing cost component is computed by subtracting α and β from one. This is because those three components represent costs, which have to add up to 100% or one. $g(w_i, \theta)$ is an (L x 1) vector of moment functions (or orthogonality conditions). These functions are non-linear and given by:

1. $g_1 = (Q_{t-1} - (1 - 2\pi)Q_{t-2})\, Q_{t-2}$
2. $g_2 = (Q_{t-1} - (1 - 2\pi)Q_{t-2})\, S_{t-1}$
3. $g_3 = (Q_{t-1} - (1 - 2\pi)Q_{t-2})\, S_{t-2}$
4. $g_4 = \left(\Delta M_t - (\alpha + \beta)\frac{S_{t-1}}{2} Q_{t-1} + \alpha \frac{S_{t-2}}{2}(1 - 2\pi)Q_{t-2} \right) S_{t-1}$
5. $g_5 = \left(\Delta M_t - (\alpha + \beta)\frac{S_{t-1}}{2} Q_{t-1} + \alpha \frac{S_t t-2}{2}(1 - 2\pi)Q_{t-2} \right) S_{t-2}$
6. $g_6 = \left(\Delta M_t - (\alpha + \beta)\frac{S_{t-1}}{2} Q_{t-1} + \alpha \frac{S_{t-2}}{2}(1 - 2\pi)Q_{t-2} \right) (Q_{t-1} - (1 - 2\pi)Q_{t-2})\,.$

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

$$\widehat{\Lambda} \equiv \frac{1}{N} \sum_{i=1}^{N} [g(w_i, \theta)]\, [g(w_i, \theta)]'\,. \tag{4}$$

7 Results

7.1 Informational Risk and Liquidity Freezes

We start this section by graphically analyzing whether it was the risk of informed trading that drove the wedge between bid and ask prices after the unexpected failure of the stock corner of Heinze. The spread decomposition based on the method of Section 6 demonstrates significant variation in the relative weights of adverse selection costs, inventory

costs, and order processing costs as contributors to overall transaction costs (Figure 3). The informational cost appears as the dominant cost factor. During the crisis, informational cost and inventory cost components comprise the largest shares: together they make up 75% of bid-ask spreads, and they intensified during the panic. In particular, during the third and fourth quarters of 1907 and first quarter of 1908 informational costs and inventory costs increased to about 85% of the overall spread; an increase of about 10% compared to normal times.

When plotting the absolute cost components in Dollar-terms (Figures 6) it becomes apparent that adverse selection costs dominate transaction costs and thus contribute most to constraining liquidity in the market. During the panic information costs increased steeply from \$0.007 to \$0.02, while inventory holding costs increased from \$0.003 to \$0.009 and order processing costs from \$0.004 to \$0.01. Hence, the cost decomposition supports the view that uncertainty and information asymmetry - namely rumors - drove the 1907 crisis. This finding accords well with our hypothesis, based on theoretical models of rumor-based market runs (He and Manela (2014) and Bernardo and Welch (2004)). In a sense, we also find similar results to what Hellwig and Zhang (2012) predict, 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., October 1907), not at the very beginning of it. This suggests that the spreading informational risks (i.e., rumors) affected the whole stock market and worked contagiously during the crisis. Obviously, in the case of information production through fear and rumors, information production may reduce market efficiency (Dang et al. (2010)).

Alternative liquidity measures bolster our results on different risk factors. In particular, volume (measured as the daily number of shares traded), transaction costs (measured as relative bid-ask spreads), and price sensitivity associated with one additional unit of trading volume (measured as the Amihud-ratio, which is the ratio of the absolute return for a stock ($|r_t|$) to trading volume in monetary terms over a day (see Amihud (2002)) all demonstrate the liquidity freeze phenomenon (see Figures 9 to 12). The number of shares traded on an average trading day dropped from about 3000 shares per day to about 200 shares; spreads more than tripled from about 0.5% before the crisis to about 2.5% during the Panic; and the Amihud illiquidity measure also more than doubled indicating severe illiquidity during the Panic of 1907. Especially interesting is the evolution of daily number of shares traded during the Panic of 1907 (Figure 11): they increase sharply once informational costs increase. This suggests that traders - because of the increased informational risk they were facing and the spreading fear and rumors - increased their trading activity in order to front-run other traders and to be on the "safe side". However, once

J.P. Morgan intervened on October 24th, 1907, stock markets calmed down: the number of shares traded per day decreased to pre-crisis levels as did informational costs and order processing costs. This suggests that his measures actually helped to stop the "liquidity freeze" in the stock market. Importantly, the cash injection only had short-term effect on trading volume. About two months after the intervention of J.P. Morgan and his colleagues, the number of shares traded *decreased* sharply (i.e., severely below pre-crisis levels) and stayed on a depressed level for about a year (Figure 10). Thus, even though the risk factors that influence the behavior of market makers returned to their pre-crisis levels, the uncertainty that stymies traders persisted much longer. This indicates that a rumor-based liquidity crisis can severely destroy traders' confidence in markets, thereby freezing liquidity far beyond the actual Panic period. Box plots of relative bid-ask spreads, the number of shares traded, and the Amihud illiquidity measure (Figures 13 to 15) elaborate further on the means and medians, indicating growing dispersion of each measure as well.

We confirm these graphical results in panel regression analyses of spreads and their components (Table 3). Here, the dependent variables (i.e., k) are 1. relative bid-ask spreads (column 2), defined as the difference between ask and bid prices divided by the average of ask and bid prices; 2. informational costs (column 3), defined as the adverse selection component times the relative bid-ask spread, 3. inventory costs (column 4), defined as the inventory holding component times the relative bid-ask spread, and 4. order processing costs (column 5), defined as the order processing component times the relative bid-ask spread. We regress each dependent variable on a crisis indicator and monthly call money rates from the National Bureau of Economic Research Macrohistory Database. The crisis indicator takes the value of one if the time period equals the third or fourth quarter of 1907 or the first quarter of 1908 and zero otherwise. We base the timing of the crisis on both past literature and our own analysis of volatility. Papers such as Frydman et al. (2012) and Bordo and Haubrich (2010) date the panic to exactly this time period. Our own statistical analysis of volatility over time falls in line with the literature, indicating that volatility rose sharply at the end of the third quarter of 1907 and then began a decline that lasted until March 1908 (Figure 2). Volatility in this case is measured as a 30-day rolling window of the standard deviation of stock returns. 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. To assess the impact of call money rates on market liquidity specifically during the Panic of 1907, we furthermore include an interaction term of both the crisis indicator variable and call money rates. The exact econometric model thereby looks as follows:

$$Y_{k,i,t} = \beta_0 + \beta_1 Crisis_t + \beta_2 CallMoney_t + \beta_3 Crisis_t \cdot CallMoney_t + \beta_2 X_{j,i,t} + FE_i + TE_t + \epsilon_{i,t} \quad (5)$$

Where:

- $Y_{k,i,t}$: Dependent variables k:
  - Relative Bid-Ask Spreads of company i
  - Adverse Selection Costs of company i
  - Inventory Holding Costs of company i
  - Order Processing Costs of company i
- $X_{j,i,t}$: Control variables j:
  - Liquidity indicator variable (highly liquid vs. illiquid stocks)
  - Size indicator variable (large vs. small stocks based on number of shares traded)
- FE: Firm fixed effects
- TE: Time fixed effects

The resulting estimates show that relative spreads and most components (except for order processing costs) relate positively and significantly with call money rates. This indicates that indeed call money rates drove liquidity as well as informational costs and inventory holding costs. This result is also economically significant: an increase in call money rates by one percent leads to an increase in relative spreads by 0.2%. The effect of call money rates on market liquidity is amplified during the Panic of 1907, for which we find a strongly statistically significant and positive relationship between call money rates and relative spreads. This amplification during the crisis, however, does not hold for all transaction costs equally. Informational costs are not statistically significantly affected, whereas order processing costs are. They tend to increase during the Panic of 1907 when call money rates were rising as well. Fading liquidity obviously reduces transactions demand and, hence, increases market power, potentially due to the exit of dealers.

Thus, call money rates, reflecting money market liquidity, drove a substantial part of stock market liquidity during this period and did so all the more during the panic episode of late 1907 and early 1908. We therefore interpret the Panic of 1907 as a liquidity crisis. Call money rates also relate especially robustly with informational costs and inventory holding costs; highlighting the channel linking call money rates to spreads. [10]

[10] The crisis indicator variable is omitted in this regression due to collinearity with the interaction term.

In order to confirm that the findings of call money rates on liquidity are robust across different liquidity dimensions and also hold in a less latent frequency, we perform a similar regression analysis but with *daily* data (Table 4). Specifically, we regress different measures of liquidity on daily call money rates and a crisis indicator variable. [11] In order to exploit the daily call money rates, we use correspondingly high frequency liquidity measures: daily relative bid-ask spreads (column 2), defined as the difference between ask and bid prices divided by the average of ask and bid prices, daily trading volume (column 3), defined as the number of shares traded per day, the daily Amihud Ratio (column 4), defined as the ratio of the absolute return for a stock ($|r_t|$) to trading volume in monetary terms over a day (see Amihud (2002)), and quasi-volatility (column 5), defined as the day's highest price minus its lowest price divided by the last price of that day. The regressors include an indicator for the crisis period of October 16, 1907 (the day of the stock corner failure) to January 21, 1908 to daily call loan rates. Call Money Rates $\times$ Crisis denotes an interaction term of both the crisis indicator variable and call money rates. We also include lagged dependent variables in each regression specification to account for autocorrelation in the dependent variables. The daily call loan rate data covers September 30, 1907, to February 19, 1908, which therefore sets the period of our regressions.

In line with our monthly results, all three of our daily liquidity measures relate positively and statistically significantly with the call loan rates, confirming that money markets played a key role in transaction costs (see Table 4). Moreover, rising call money rates during the crisis led to significant deterioration of liquidity (higher spreads and price impact, and lower volume) compared to normal times.

To confirm that these findings are robust and attributable specifically to call money rates, we assess the underlying factors moving call money rates and whether those factors simultaneously drive market liquidity. In particular, we regress call money rates on the level of U.S. gold stock reserves, our crisis indicator variable, and an interaction term of the crisis indicator variable and the level of gold stock reserves. The monthly data for gold stock reserves comes from the National Bureau of Economic Research Macrohistory Database and is denoted in billions of Dollars. Call money rates show a strong inverse correlation with the level of gold stock reserves (Table 5). Call rates also rose significantly during the Panic of 1907, however, this effect was partly offset by gold imports during the crisis: the interaction term between the crisis indicator variable and the level of gold stock in the economy is negative and statistically significant, suggesting that as the level of gold stock rose towards 1908 (as described by Rodgers and Payne (2012)), call

[11] The daily data of U.S. call money rates was kindly provided to us by Ellis Tallman, who also uses this proprietary dataset in his recent paper Tallman and Moen (2014).

money rates decreased and helped relieve the tight liquidity conditions of the crisis period. Interestingly, rising gold stocks do not directly ameliorate illiquidity in the stock market; including that variable in the models of Table 3 yields insignificant results. Rather, call money rates capture the impact of gold flows completely. Hence, we confirm Rodgers and Payne (2012)'s finding that the rising level of gold stock helped to end the crisis. But it did so via call money rates and did not directly improve stock market liquidity.

7.2 The Mining Sector at the Heart of the Crisis

In order to analyze our second hypothesis, that adverse selection risk hit worst in the most opaque and rumor-ridden sector (mining companies), we compare relative bid-ask spreads and the different cost factors by industry. Indeed, the panic hurt mining stocks' liquidity the most. Spreads of mining companies rose from about 2% before the crisis to about 5% during the Panic of 1907 (Figures 17 to 19). This sharp rise in illiquidity results entirely from adverse selection risk (Figures 20 to 22): 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 endure over the longer term. The other two cost types show less significant increases during the Panic of 1907.

The other sectors do experience higher adverse selection costs as well, which supports our hypothesis that informational risk was an important driver of this overall liquidity freeze. But all other industries react *after* the mining sector which suggests that the mining sector - due to the connections of the Heinze brothers, and the overall opacity of the sector and its activities - was really at the heart of this Panic.

We also confirm our related hypothesis that stocks in the sectors that published accounting information on a relatively frequent basis (such as the railroad and utilities sectors), do indeed experience lower adverse selection costs compared to other industries, such as manufacturing. Relative transparency, therefore, turns out to be beneficial in terms of lower adverse selection risk and increased stock market liquidity.

7.3 The Informational Advantage

Our third hypotheses conjectured that illiquid (e.g. low volume, high price impact, or unlisted) stocks were affected disproportionally more by informational risk than liquid stocks. To test our hypothesis, we divide the cross section of companies into two subsamples: a "liquid" one and an "illiquid" one. We define liquid stocks as those falling into the lowest quartile of relative spreads and illiquid stocks as those falling in the highest quar-

tile of that distribution. As we predict, the most illiquid stocks experience significantly greater increases in informational costs, inventory costs, and order processing costs than liquidity ones (Figure 7) All three spread components are more than three times as large 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 risk during a liquidity freeze. These results are robust to using different types of liquidity measures, such as number of shares traded or the Amihud illiquidity measure.

We find similar results in comparing listed and unlisted companies: the latter get hit by higher informational costs than do the former (Figures 8). 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. This implies that investments in listed companies that had to publish accounting information, indeed served as a hedge against adverse selection risk and especially so in times of heightened uncertainty. This lends robustness both to our sector analyses, in which we showed that companies from sectors that published on average more than other sectors were subject to less adverse selection risk, and to our illiquidity results from Hypothesis 3a.

8 Asset Pricing Implications

As the previous analysis demonstrates, asymmetric information and other market frictions drive up transaction costs. But we also want to assess whether these cost factors also matter for asset pricing in opaque markets. That liquidity risk in itself matters for stock returns has been thereby already been shown for modern markets by Pástor and Stambaugh (2003) and Acharya and Pedersen (2005). Thus, we now go depper into the microstructure of liquidity risk and analyze the relationship between each of the three main contributors to transaction costs and the securities' asset prices. In order to do so, we estimate a panel regression of the logarithm of monthly stock prices ($Log(P_{i,t})$) on a market return (i.e., the equally-weighted average of returns of all companies in our sample), a risk-free rate (i.e., the "10-Year Treasury Constant Maturity Rate" from Schiller (2000)), a market risk premium (i.e., equally-weighted average returns minus the 10-year Treasury constant maturity rate), monthly adverse selection costs, monthly inventory holding costs, and monthly order processing costs. We have to acknowledge that our

variable for the market return is an imperfect proxy as it does not deal with changes in the market portfolio, and none of the underlying returns is dividend adjusted. The time period covers the years of 1905 to 1910. We include an indicator variable called "$\text{Dummy}_{\text{Crisis}}$" and interact this indicator variable with the three cost types. This way we can analyze the relation of those cost types to stock prices during the crisis. Specifically, we estimate the following regression:

$$\begin{aligned} Log(P_{i,t}) = \beta_0 &+ \beta_1 Return_{Market_t} + \beta_2 MarketRiskPremium_t + \beta_3 ASCost_{i,t} + \beta_4 IHCost_{i,t} \\ &+ \beta_5 OPCost_{i,t} + \beta_6 Dummy_{Crisis} + \beta_7 ASCost_{i,t} \cdot Dummy_{Crisis} \\ &+ \beta_8 IHCost_{i,t} \cdot Dummy_{Crisis} + \beta_9 OPCost_{i,t} \cdot Dummy_{Crisis} + \epsilon_{i,t} \end{aligned} \tag{6}$$

Since neither the company specific stock price processes nor the adverse selection cost, inventory holding cost, and order processing cost processes are stationary, we difference the data as follows:

$$\begin{aligned} \Delta Log(P_{i,t}) = \beta_0 &+ \beta_1 Return_{Market_t} + \beta_2 MarketRiskPremium_t + \beta_3 \Delta ASCost_{i,t} + \beta_4 \Delta IHCost_{i,t} \\ &+ \beta_5 \Delta OPCost_{i,t} + \beta_6 Dummy_{Crisis} + \beta_7 \Delta ASCost_{i,t} \cdot Dummy_{Crisis} \\ &+ \beta_8 \Delta IHCost_{i,t} \cdot Dummy_{Crisis} + \beta_9 \Delta OPCost_{i,t} \cdot Dummy_{Crisis} + \epsilon_{i,t} \end{aligned} \tag{7}$$

We find that the individual stock returns are positively and statistically significantly related with the market return (i.e., the equally-weighted average of returns of our sample companies) as (the firm-specific) Beta (i.e., β_1) is positive and statistically significant. Hence, an increase in the average return of the whole stock market is associated with an increase in individual stock prices from *t-1* to *t*.[12] Relating this equally-weighted market return to the risk-free rate does not render a statistically significant relation with individual stock prices. $\Delta ASCost$ is significantly and negatively related to $\Delta Log(P_{i,t})$, meaning that an increase in the absolute adverse selection cost from *t-1* to *t*, decreases the average cross-sectional return from *t-1* to *t* by 11.02% (Table 6). The same holds true for both inventory holding costs and order processing costs. An increase from *t-1* to *t* lowers the average cross-sectional return by 10.21% and 9.93%, respectively. We do not find significantly different effects of adverse selection costs and order processing costs during the panic months. Inventory holding costs, however, do negatively affect

[12]This finding is robust to using the "Real S&P Composite Stock Price Index" of Schiller (2000) as the market return.

returns: an increase from *t-1* to *t* during the panic lowers average cross-sectional returns by 18.73%. Thus, the inventory cost effect is heightened during the panic.

Overall, we find strong evidence of predictability of asset returns based on market microstructure information embodied in transactions costs over and above market returns (i.e., systemic risk). In fact, all three drivers of liquidity risk relate significantly to asset prices. This finding holds both before and after the crisis and is even intensified during the crisis, suggesting that microstructure information - such as the evolution of informational risk and inventory risk over time - is particularly valuable in crisis periods. Summarizing these analyses, we conclude that insofar as transaction costs can be predicted, liquidity factors, and, hence, in line with Pástor and Stambaugh (2003) and Acharya and Pedersen (2005), asset prices can be predicted. This highlights the first order importance of microstructure cost factors for asset pricing. [13]

9 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, surrounding one of the worst financial crises in over 100 years, provides a unique window on the performance of asset markets operating under constrained information in the face of uncertainty shocks from unverifiable rumors.

By decomposing equity bid-ask spreads into their underlying cost components , we find that the Huang and Stoll decomposition procedure provides a powerful tool to analyze price formation over the course of a crisis. Specifically, we 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 a rumor-based liquidity crisis 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 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

[13] We estimated the same analysis for the relative components but do not display the results here for conciseness reasons.

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. Moreoever, both extremely illiquid stocks as well as stocks traded in the NYSE's 'unlisted' department-and therefore avoided the official listing requirements of the NYSE-also suffered significantly more during the Panic than well-certified and liquid stocks.

Finally, our analysis also generates insights for asset pricing. In particular, we show that it is possible to predict asset prices based on estimated components of bid-ask spreads. Outside of the peak months of the Panic of 1907, an increase in any of the estimated cost components (i.e., informational costs, inventory holding costs, and order handling costs) leads to a significant decrease of average cross-sectional returns. Hence, the predictability of transaction costs and liquidity also implies a certain degree of predictability of asset prices. In this sense, asset prices are informationally efficient in, at most, a weak sense. Our findings hence demonstrate the first order relevance of microstructure cost components for asset pricing.

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10 Appendix

Variables	Mean	Median	Std	Q25	Q75	Observations
Relative Bid-Ask Spread	0.015	0.001	0.016	0.005	0.019	1438
Trading Volume NYSE	5854	1049	17400	505	3244	1438
Call Money Rates	3.69	3.37	1.57	2.46	5.24	72
Gold Stock (Billion $)	1.50	1.62	0.17	1.33	1.65	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 1: Descriptive Statistics: 1905-1910

Variables	Mean	Median	Std	Q25	Q75	Observations
Relative Bid-Ask Spread	0.02	0.02	0.02	0.01	0.03	136
Trading Volume NYSE	4990	869	19570	465	2637	136
Call Money Rates	4.42	4.56	0.85	4.05	5.00	7
Gold Stock (Billion $)	1.58	1.61	0.06	1.56	1.63	7
Adverse Selection Component	0.44	0.50	0.24	0.29	0.56	136
Inventory Holding Component	0.21	0.08	0.29	0.00	0.41	136
Order Processing Component	0.36	0.24	0.34	0.06	0.63	136

Table 2: Descriptive Statistics: The Panic of 1907

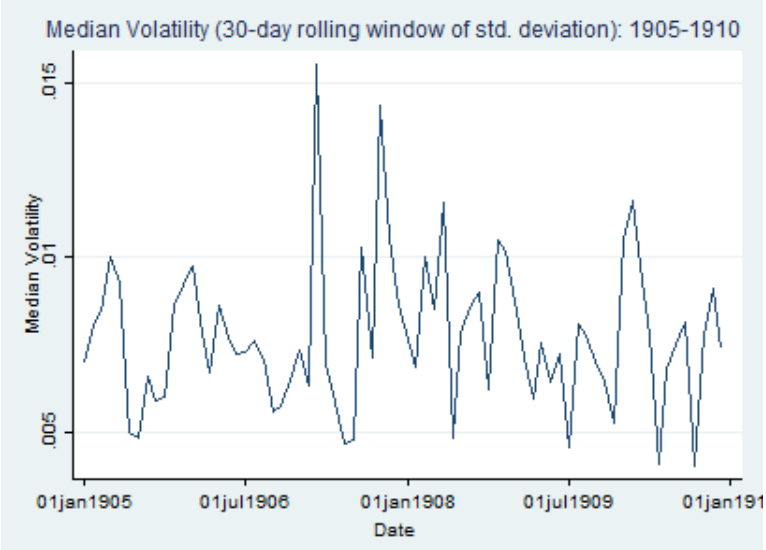

Figure 1: Median Volatility: 1905-1910

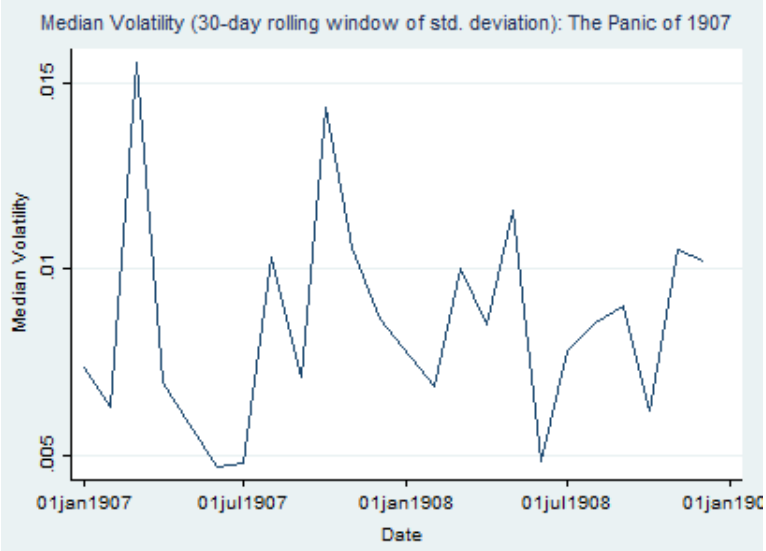

Figure 2: Median Volatility: 1907 and 1908

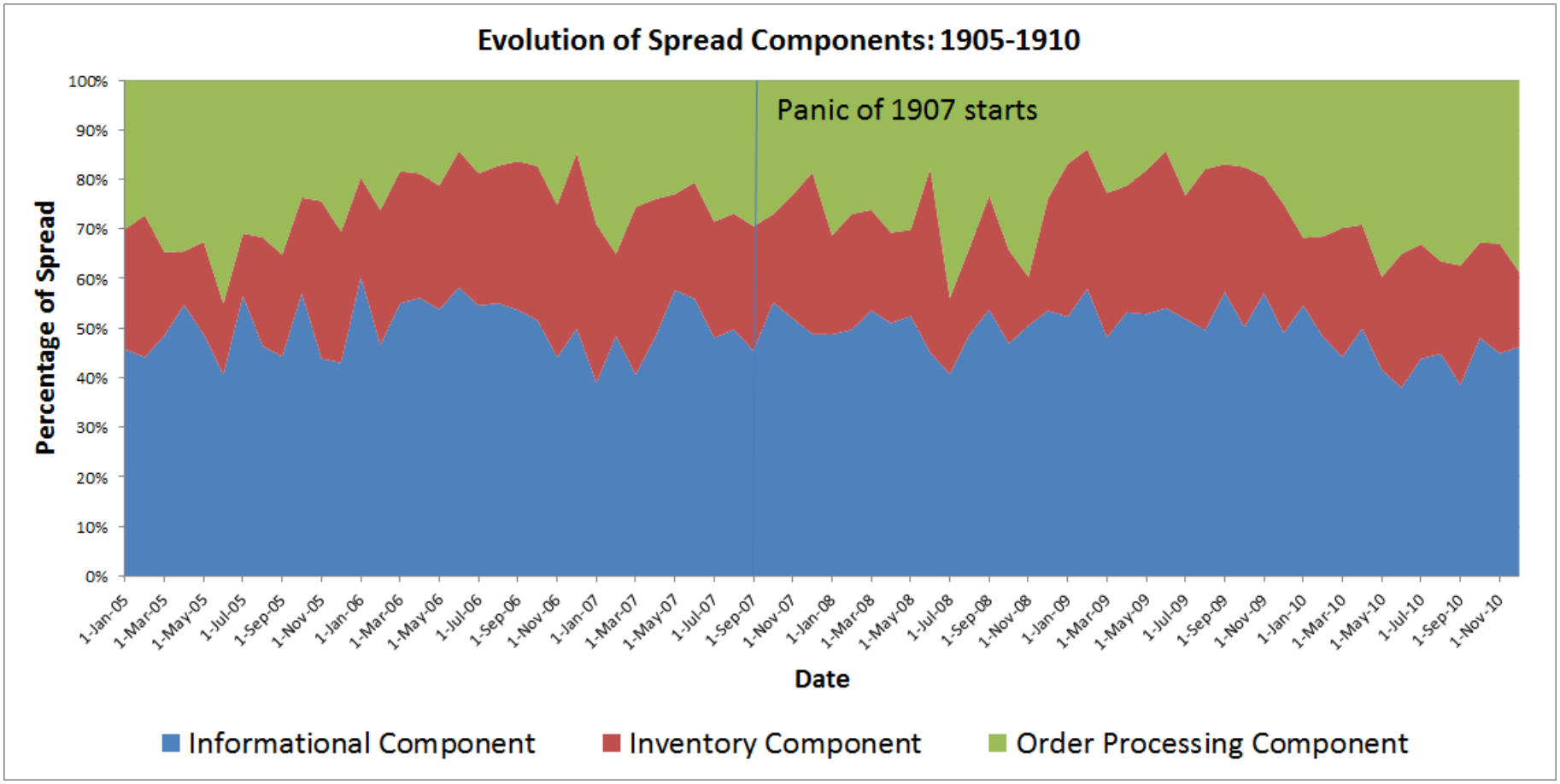

Figure 3: Average Cost Components (as Percentage of Bid-Ask Spreads): 1905-1910

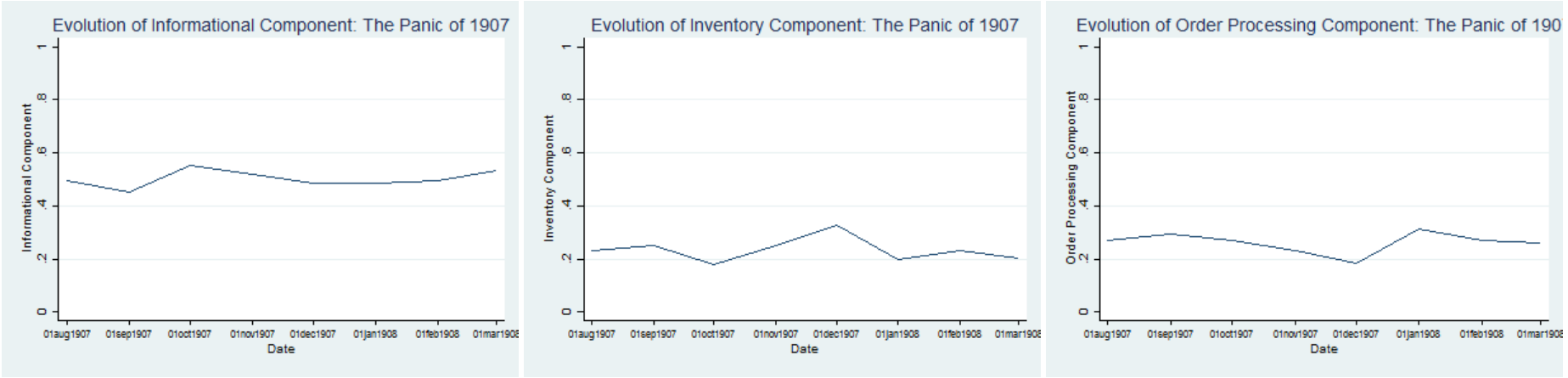

Figure 4: Infomational Component, Inventory Component, and Order Processing Component: The Panic of 1907

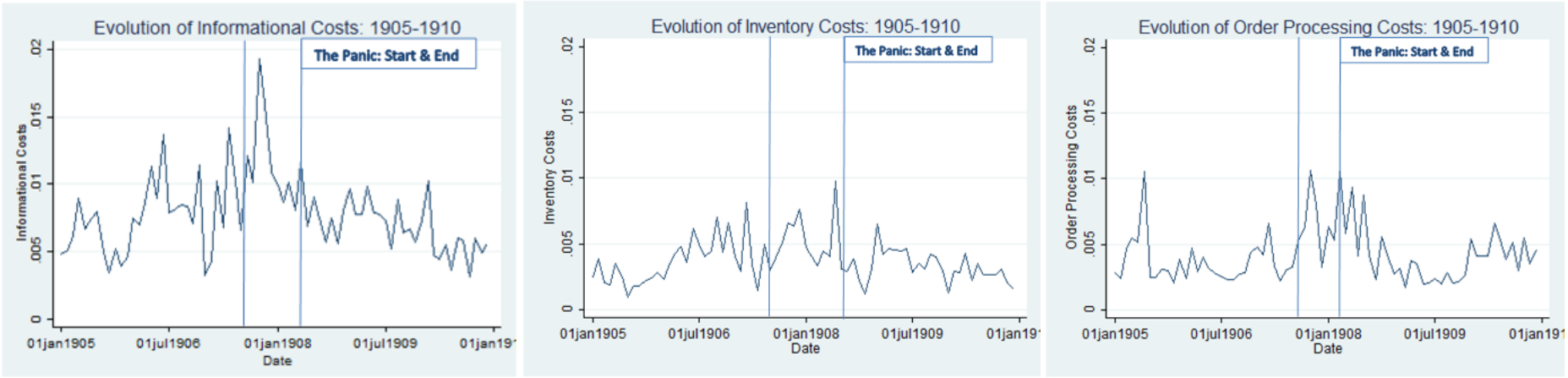

Figure 5: Informational Costs, Inventory Costs, and Order Processing Costs: 1905-1910

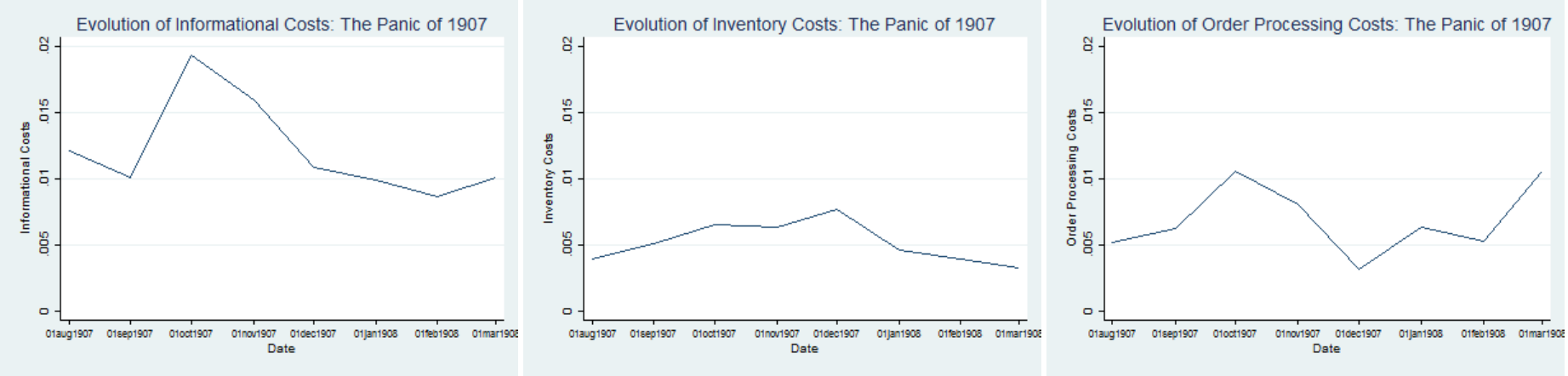

Figure 6: Informational Costs, Inventory Costs, and Order Processing Costs: The Panic of 1907

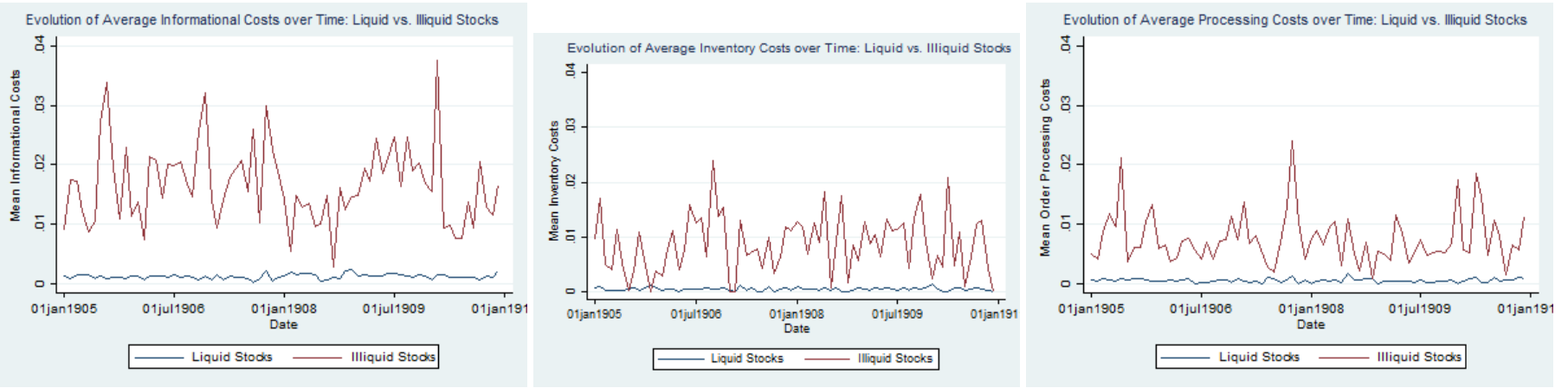

Figure 7: Informational Costs, Inventory Costs, and Order Processing Costs: Liquid vs. Illiquid Stocks

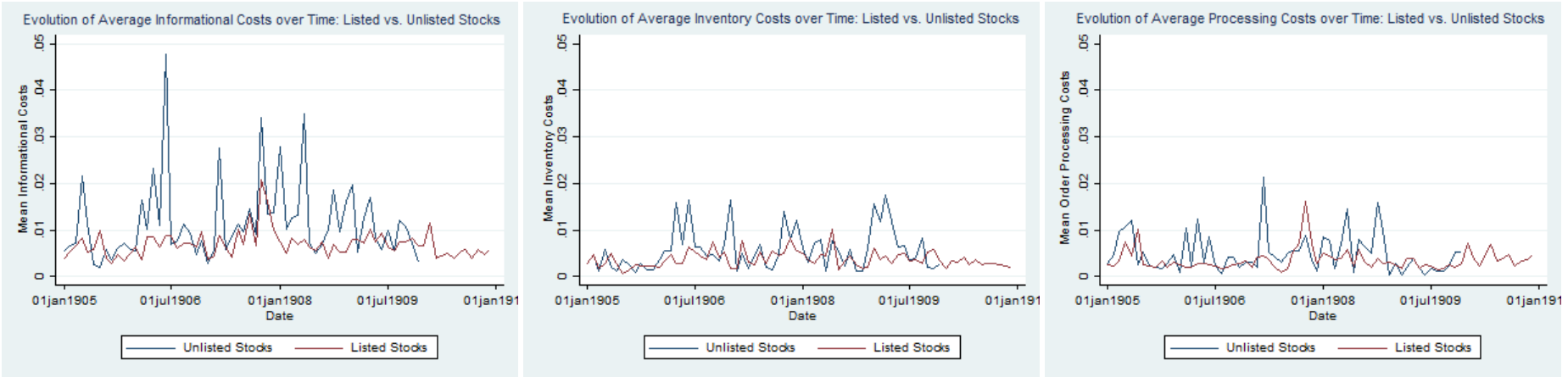

Figure 8: Infomational Costs, Inventory Costs, and Order Processing Costs: Listed vs. Unlisted Stocks

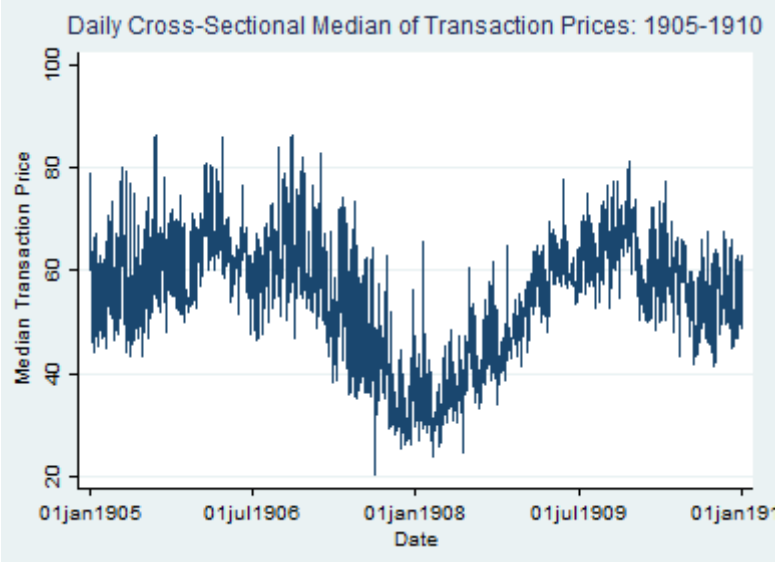

Figure 9: **Daily Cross-Sectional Median Transaction Prices: 1905-1910**

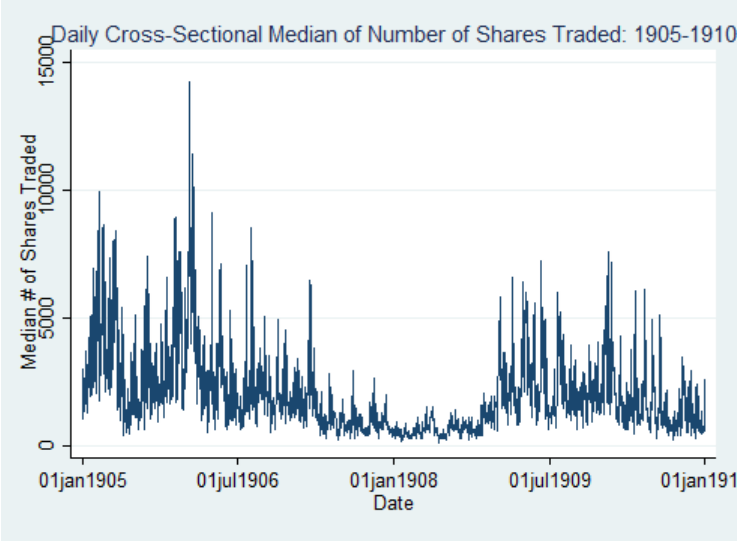

Figure 10: **Daily Cross-Sectional Median Number of Shares Traded: 1905-1910**

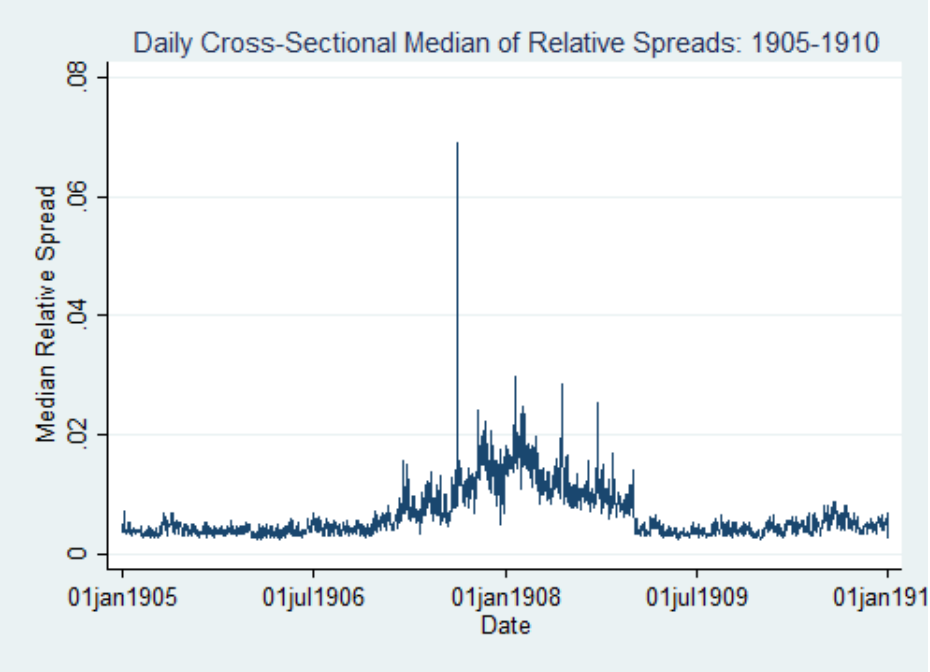

Figure 11: **Daily Cross-Sectional Median Relative Bid-Ask Spreads: 1905-1910**

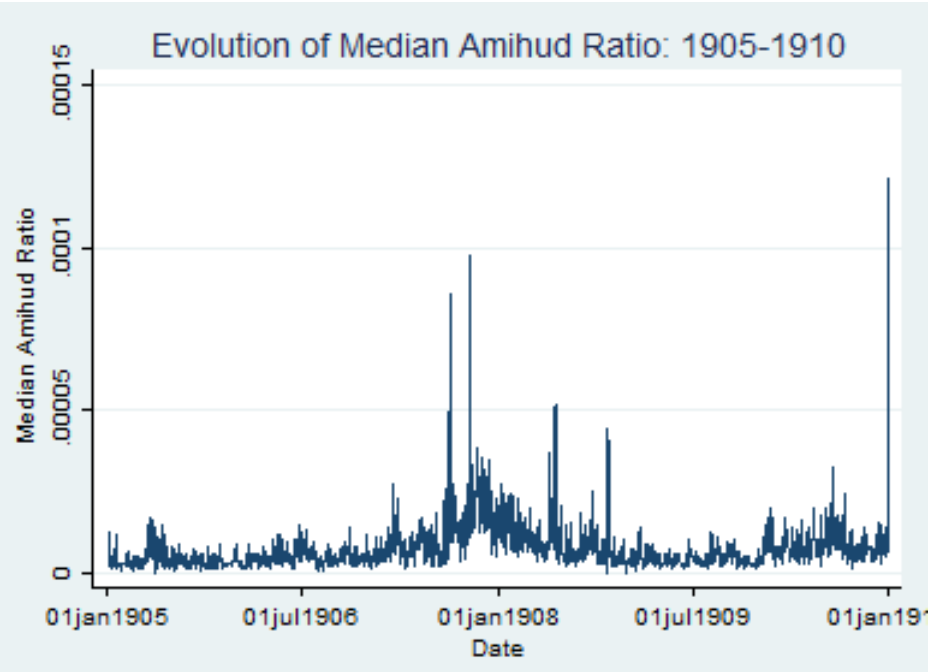

Figure 12: **Daily Cross-Sectional Median Amihud Ratio: 1905-1910**

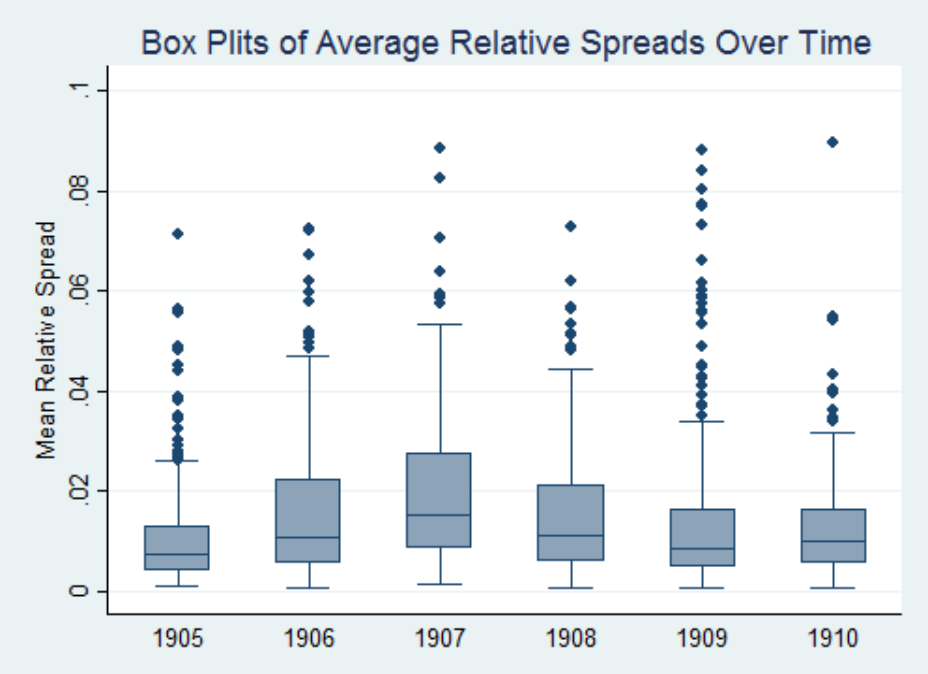

Figure 13: **Box Plots of Average Relative Bid-Ask Spreads: 1905-1910**

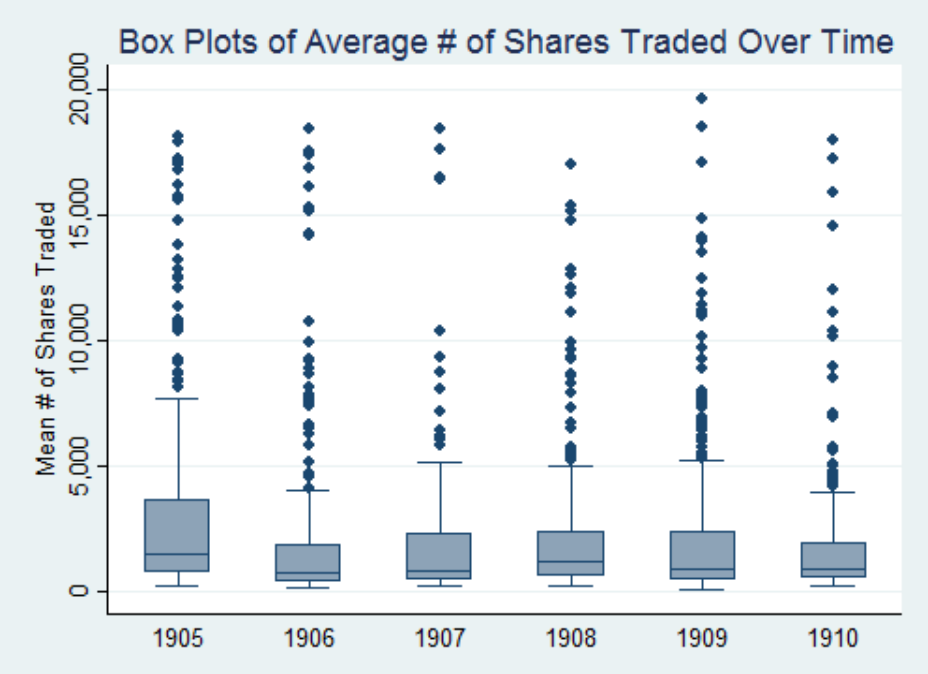

Figure 14: **Box Plots of Average Trading Volume: 1905-1910**

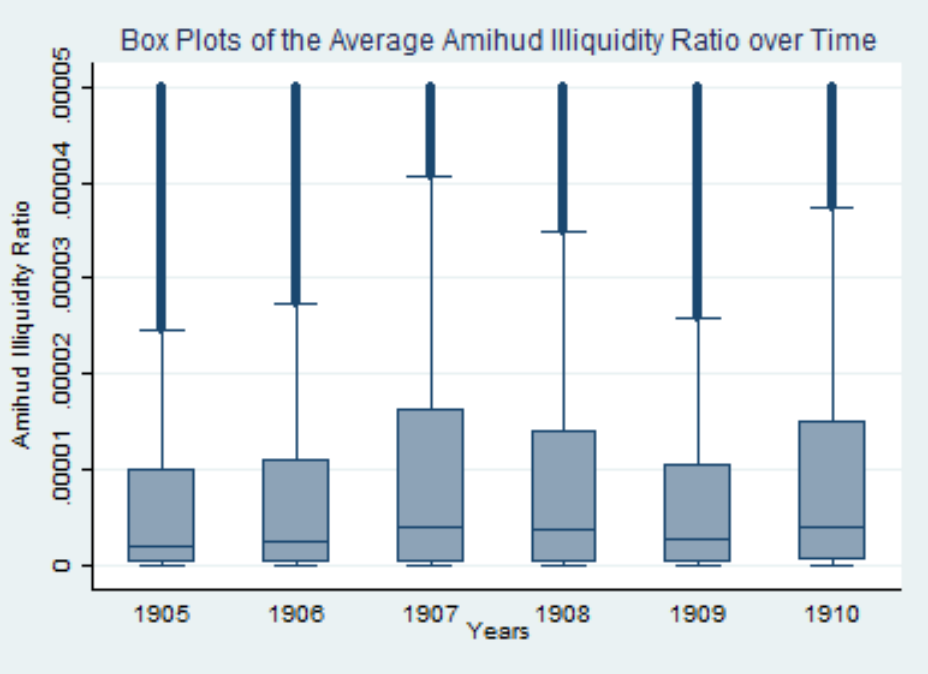

Figure 15: **Box Plots of the Average Amihud Illiquidity Measure: 1905-1910**

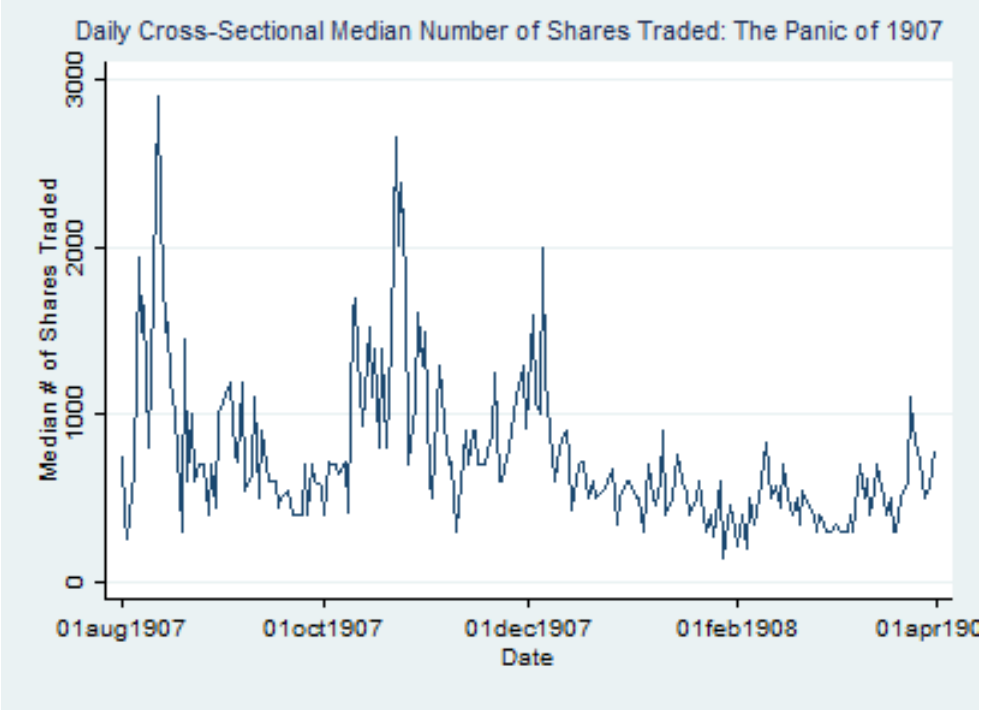

Figure 16: **Daily Cross-Sectional Median Number of Shares Traded: The Panic of 1907**

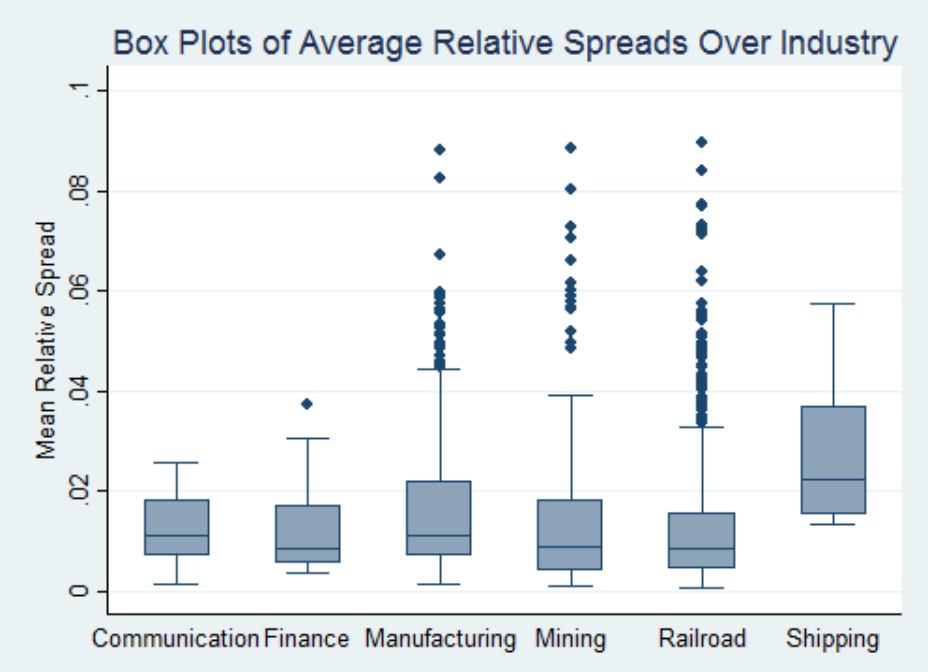

Figure 17: **Box Plots of Average Relative Bid-Ask Spreads per Industry**

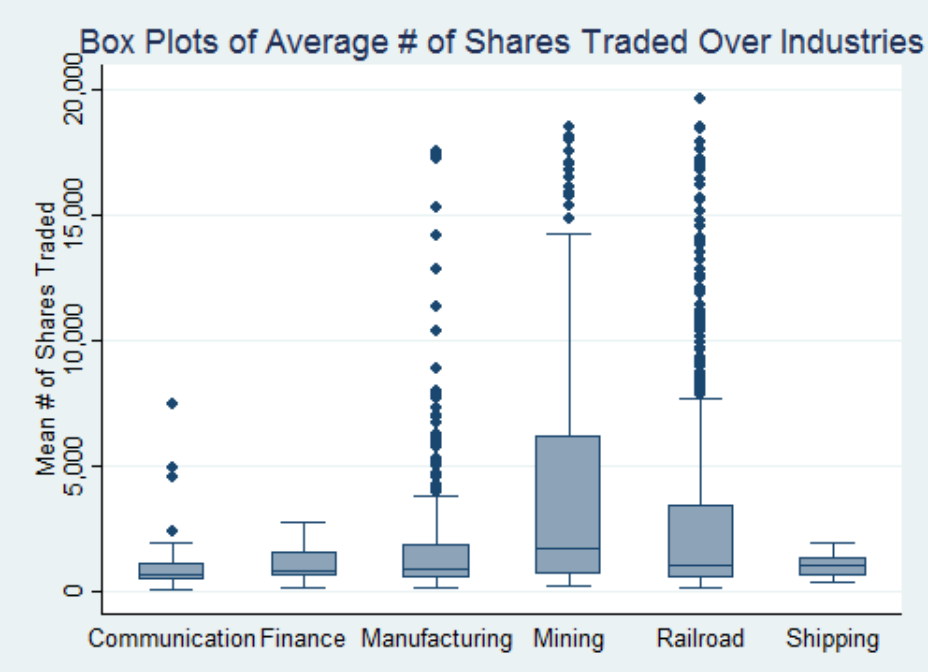

Figure 18: **Box Plots of Average Trading Volume Per Industry**

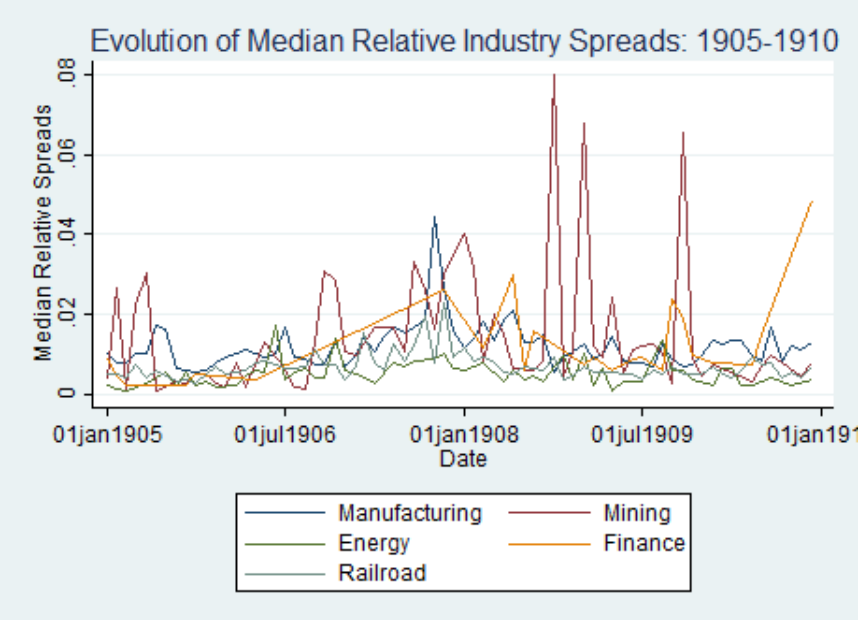

Figure 19: **Average Relative Industry Bid-Ask Spreads: 1905-1910**

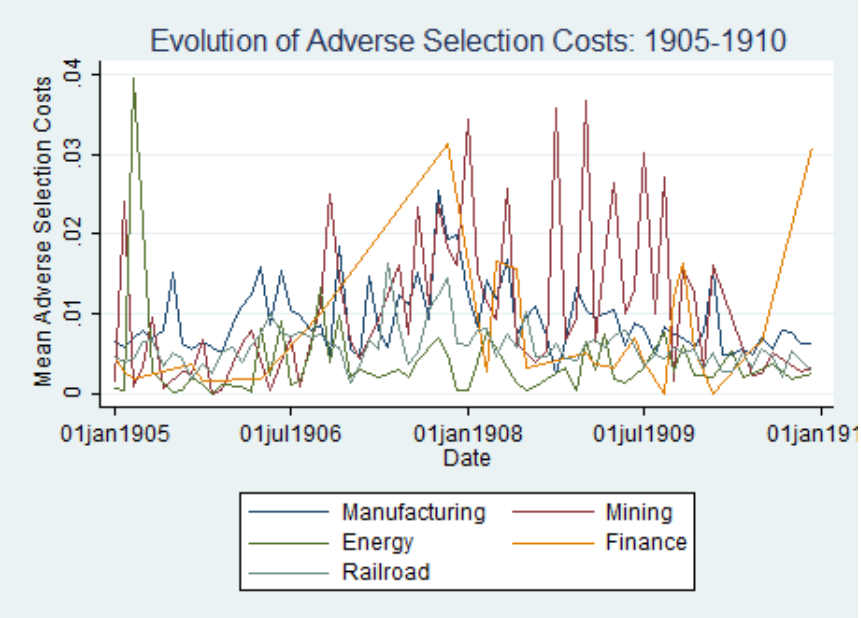

Figure 20: **Informational Costs across Industries: 1905-1910**

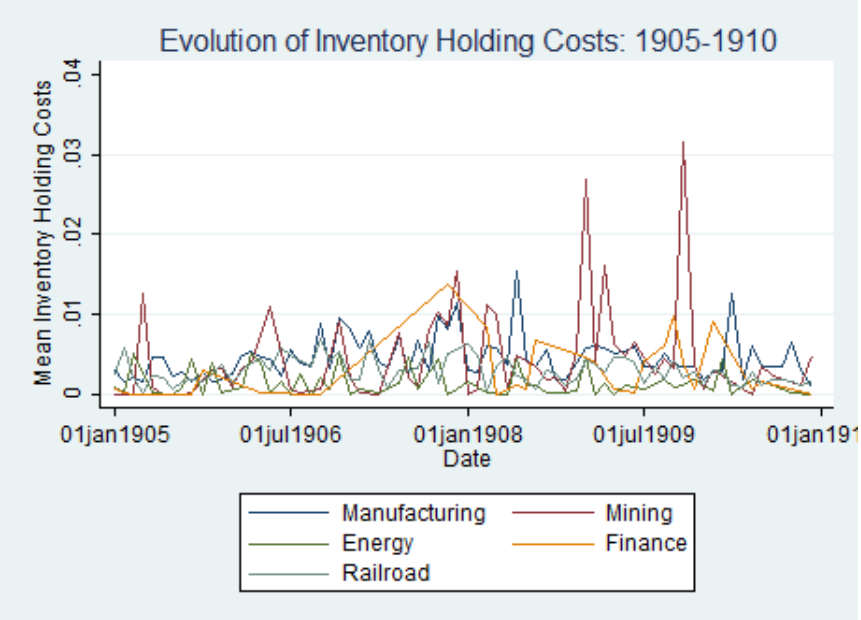

Figure 21: **Inventory Costs across Industries: 1905-1910**

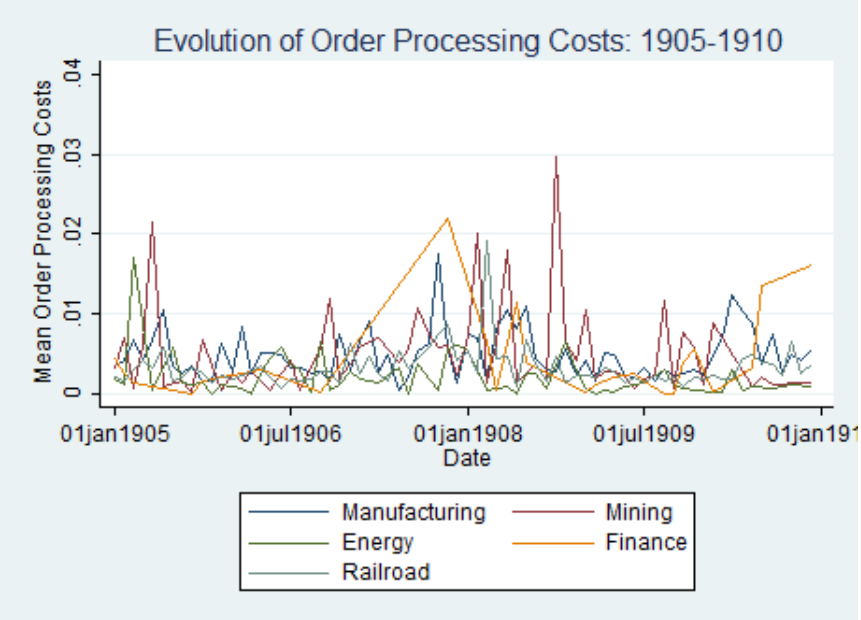

Figure 22: **Order Processing Costs across Industries: 1905-1910**

Regression Analyses for the Panic of 1907

This table reports the results from panel regression estimations. The dependent variables are relative bid-ask spreads (column 2), defined as the difference between ask and bid prices divided by the average of ask and bid prices, informational costs (column 3), defined as the adverse selection component times the relative bid-ask spread, inventory costs (column 4), defined as the inventory holding component times the relative bid-ask spread, and processing costs (column 5), defined as the order processing component times the relative bid-ask spread. The regressors include a dummy variable that indicates crisis times and which takes the value of one if the the time period equals the third or fourth quarter of 1907 or the first quarter of 1908 and zero otherwise. A second regressor refers to monthly U.S. call money rates. This data comes from the National Bureau of Economic Research Macrohistory Database and is denoted in percent. Call Money Rates × Crisis denotes an interaction term of both the crisis indicator variable and call money rates. Controls include the following variables: trading volume; a dummy variable that indicates whether a stock was rather liquid and, hence, takes the value of one if a stock was in the first quantile of the liquidity distribution and zero otherwise; an interaction term between the crisis dummy and the liquidity dummy; a dummy variable that takes the value of one if a company was in the first quantile of the size distribution of companies and zero otherwise; an interaction term between the crisis dummy and the size dummy. The dataset consists of U.S. companies listed at the New York Stock Exchange for the period from 1905 to 1910. The t-statistics are based on standard errors adjusted for heteroskedasticity and within-firm/year clustering (see Petersen (2009)), 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	Relative Spread	AS Costs	IH Costs	OP Costs
Crisis	.	.	.	.
	.	.	.	.
Call Money Rates	**0.002****	**0.002****	**0.001***	−0.0002
	(2.93)	(3.21)	(1.82)	(−0.82)
Call Money Rates × Crisis	**0.002****	0.003	0.003	**0.001****
	(2.62)	(0.61)	(0.81)	(3.38)
Fixed effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Within R^2	0.19	0.11	0.05	0.08
Observations	2891	2891	2891	2891

t-statistics in parentheses based on HAC standard errors

Table 3

Regression Analyses for the Panic of 1907: Daily Rates

This table reports the results from panel regression estimations. The dependent variables are daily relative bid-ask spreads (column 2), defined as the difference between ask and bid prices divided by the average of ask and bid prices, daily trading volume (column 3), defined as the number of shares traded per day, the daily Amihud Ratio (column 4), defined as the ratio of the absolute return for a stock ($|r_t|$) to trading volume in monetary terms over a day (see Amihud (2002)), and quasi-volatility (column 5), defined as the daily high prices minus daily low prices divided by the last price of that day. The regressors include a dummy variable that indicates crisis times and which takes the value of one if the time period equals October 16, 1907 (the day of the stock corner failure) to January 21, 1908, and zero otherwise. A second regressor refers to monthly U.S. call money rates. This data comes from the National Bureau of Economic Research Macrohistory Database and is denoted in percent. Call Money Rates × Crisis denotes an interaction term of both the crisis indicator variable and call money rates. The time period that this daily sample covers is September 30, 1907, to February 19, 1908. The t-statistics are based on standard errors adjusted for heteroskedasticity, 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	Relative Spread	Trading Volume	Amihud Ratio	Quasi-Volatility
Crisis	−0.002	**−364.44*****	0.00001	**−0.002*****
	(−1.04)	(−3.48)	(−0.91)	(−3.73)
Call Money Rates	**0.001*****	**8.82***	−0.00000001	**−0.0001*****
	(5.99)	(2.49)	(−0.02)	(4.49)
Call Money Rates × Crisis	**0.001***	**52.29*****	−0.000004	**0.0002***
	(2.00)	(3.22)	(−0.01)	(2.48)
Lagged Spreads	**0.41****	.	.	.
	(54.30)	.	.	.
Lagged Trading Volume	.	**0.89*****	.	.
	.	(20.16)	.	.
Lagged Amihud Ratio	.	.	**0.99*****	.
	.	.	(64.86)	.
Lagged Quasi-Volatility	.	.	.	**0.98*****
	.	.	.	(282.97)
Fixed effects	Yes	Yes	Yes	Yes
Time effects	No	No	No	No
Controls	No	No	No	No
Within R^2	0.48	0.80	0.15	0.87
Observations	3654	3654	3654	3654

t-statistics in parentheses based on robust standard errors

Table 4

Regression Analyses for the Determinants of Call Money Rates

This table reports the results from a panel regression estimation. The dependent variable are monthly call money rates (column 2). This data comes from the National Bureau of Economic Research Macrohistory Database, is denoted in percent, and covers the period of 1905 to 1910. Call Money Rates are regressed on the level of U.S. gold stock, a crisis indicator variable, and an interaction term of both a crisis indicator variable and the level of gold stock. The crisis indicator variable takes the value of one if the the time period equals the third or fourth quarter of 1907 or the first quarter of 1908 and zero otherwise. The monthly data for gold stock comes from the National Bureau of Economic Research Macrohistory Database and is denoted in billions of Dollars. The t-statistics are based on standard errors adjusted for heteroskedasticity and within-firm/year clustering (see Petersen (2009)), 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	Call Money Rates
Gold Stock	$\mathbf{-6.04}^{***}$
	(-28.81)
Crisis	$\mathbf{12.59}^{***}$
	(18.58)
Gold Stock $\times$Crisis	$\mathbf{-7.16}^{***}$
	(-16.44)
Fixed effects	Yes
Time effects	Yes
Controls	No
Within R^2	0.41
Observations	2891

t-statistics in parentheses
based on HAC standard errors

Table 5

Regression Analyses for Asset Pricing Implications

This table reports the results from the panel regression estimation. The dependent variable is the monthly logarithmized stock price. The explanatory variables include a market return (i.e., the equally-weighted average of returns of all companies in our sample), a risk-free rate (i.e., the "10-Year Treasury Constant Maturity Rate" from Schiller (2000)), a market risk premium (i.e., equally-weighted average returns minus the 10-year Treasury constant maturity rate), monthly adverse selection costs, monthly inventory holding costs, and monthly order processing costs. The time period covers the years of 1905 to 1910. We include an indicator variable called "$\text{Dummy}_{\text{Crisis}}$". This indicator takes the value of one if the time period equals the third or fourth quarter of 1907 or the first quarter of 1908 and zero otherwise. In order to isolate effects on stock prices, we interact this indicator variable with the three cost types. The t-statistics are based on standard errors adjusted for heteroskedasticity and within-firm/year clustering (see Petersen (2009)), 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	Δ Log Price
Market Return	$\mathbf{0.57}^{**}$
	(3.22)
Market Risk Premium	0.02
	(1.11)
$\text{Dummy}_{\text{Crisis}}$	$\mathbf{-0.11}^{***}$
	(-4.47)
Δ ASCosts	$\mathbf{-10.95}^{***}$
	(-5.05)
Δ IHCosts	$\mathbf{-9.99}^{***}$
	(-6.31)
Δ OPCosts	$\mathbf{-8.96}^{***}$
	(-4.12)
$\text{Dummy}_{\text{Crisis}}$ * Δ ASCosts	1.71
	(0.58)
$\text{Dummy}_{\text{Crisis}}$ * Δ IHCosts	$\mathbf{-19.09}^{**}$
	(-3.36)
$\text{Dummy}_{\text{Crisis}}$ * Δ OPCosts	0.94
	(0.31)
Fixed effects	Yes
Time effects	Yes
Controls	No
Within R^2	0.42
Observations	1748

t-statistics in parentheses based on HAC standard errors

Table 6