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Caroline Fohlin
Thomas Gehrig
Tobias Brünner

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Caroline Fohlin*
Thomas Gehrig†
Tobias Brünner‡

ABSTRACT:

Despite reputedly widespread market manipulation and insider trading, we find surprisingly high liquidity and low transactions costs for actively traded securities on the NYSE between 1890 and 1910, decades before SEC regulation. Moreover, market makers behave largely as predicted in theory: stocks with liquid markets and competitive market makers (cross-trading at the rival Consolidated Exchange) trade with substantially lower quoted bid-ask spreads and with less anti-competitive behavior (price discreteness). Effective spreads, illiquidity, and volume all improve monotonically over time. Notably, the asymmetric information component of effective spreads increases in relative and absolute terms from 1900 to 1910.

* Johns Hopkins University. http://www.econ.jhu.edu/people/fohlin/index.html
† University of Freiburg and CEPR
‡ University of Freiburg

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LIQUIDITY AND COMPETITION IN UNREGULATED MARKETS

I. Introduction

Financial crises nearly always generate increased government involvement in the regulation of financial markets and institutions. The collapse of financial markets and myriad banks between 1929 and 1933, followed as it was by a slew of new federal regulation, remains the most significant example of the crisis-response pattern in the United States. While most would agree that resulting institutions like the Securities and Exchange Commission (SEC) have provided useful oversight and regulatory functions over the past 70 plus years, we actually know very little about the functioning of US financial markets prior to the onset of government regulation.

Thus, in this paper, we examine liquidity provision and transactions costs—key parameters of market performance—in the New York Stock Exchange between 1890 and 1910. Using a newly-gathered database of daily closing prices, quoted bid and ask prices and trading volume for all stocks traded on the exchange in those years, we calculate various measures of illiquidity and transactions costs, in order to estimate the quoted and effective costs of trading. In order to understand the sources of trading costs and market liquidity, we decompose the effective spread measures into asymmetric information and order-processing components, based on theoretical models of spread components. We then analyze the cross-sectional determinants of the quoted spreads and market liquidity, including the impact of simultaneous trading on the main competing exchange, the Consolidated Exchange.

Given the relatively early phase of development of equity trading in the NYSE, along with the rudimentary communications technology of the pre-WWI era, we expect to find high spreads by modern U.S. standards. Moreover, given the absence of regulation regarding insider trading, one might be tempted to expect a relatively high adverse selection component in quoted spreads and illiquid trading. At the same time, however, we expect that parallel trade on the Consolidated likely increased competition (even if it also decreased efficiency via market fragmentation) and therefore tightened spreads on the NYSE, particularly for stocks traded on both.

In fact, some of our hypotheses are borne out by the data, but there are many surprises. Indeed, for the most heavily traded stocks, trading costs are roughly comparable to those in developed markets at the end of the century. So we definitely have to revise our expectation that markets operated with dramatically higher trading costs at this time. Likewise we find that measures of market illiquidity for the highest volume stocks are comparable to the same measure for stocks traded at the NYSE at the end of the 20th century. In the cross sectional analysis, we confirm our hypothesis that stocks with liquid markets—those with a high number of trading days and large volume—trade at lower cost, and those with simultaneous Consolidated activity trade with significantly lower spreads. Over time, however, quoted spreads do not behave in line with other measures of market liquidity and trading costs: while quoted spreads increase from 1900 to 1910, effective transaction costs and market illiquidity decrease monotonically and trading volume of common stocks increases monotonically from 1890 to 1910. Preferred shares show a different volume pattern, with the more actively traded shares increasing in volume from 1890 to 1900 and then dropping off again by 1910. Also of note, the asymmetric information component of trading costs increases in relative and absolute terms from 1900 to 1910.

This study contributes to a growing line of research into the microstructure and performance of securities markets prior to government regulation. Few other works have investigated the historical development of transactions costs and liquidity in U.S. markets, particularly the NYSE. To our knowledge, the current paper is the first to study these phenomena for the NYSE using high-frequency historical data. Most closely related to our work is Jones (2002), which examines month-end quoted bid-ask spreads for the components of the

Dow Jones Industrial average between 1900 and 2000. Jones (2002) shows that transaction costs—he considers bid-ask spreads and commissions—explain a small part of the equity premium over this long period. Also, spreads seem to be good predictors for future returns. The purpose of that study is to follow very long-run movements in transactions costs. Due to the lower frequency of the data and the smaller sample (of mostly the largest firms), the results cannot readily be compared with those presented in the current paper. Moreover, our results suggest that quoted bid-ask spreads are not a good measure for comparing the relevant transaction costs over time. Rather measures of effective transaction costs or market illiquidity are more reliable.

Also related to our work, Brown et al. (forthcoming) argue that direct competition with the Consolidated Stock Exchange between 1885 and 1926 reduced transaction costs at the NYSE. While they identify the competition effect around structural breaks in the time domain, our cross-sectional regressions measure the competitive impact of firms being traded both at the NYSE and the Consolidated Stock Exchange. In this sense we can also measure the value of a "cross-listing" on both exchanges. As with Jones (2002), Brown et al. (forthcoming) rely on one trading day per year over an extended period for a small sample of stocks, as opposed to our daily data on the complete set of traded stocks. Additionally, we find that price clustering at whole and half dollar increments – a potential indication for non-competitive conduct – is less pronounced for securities traded on both exchanges both in 1900 and 1910.

Davis et al. (2007), focusing on capacity constraints and their softening after the seat sale of 1928, also produce quoted bid-ask spreads for a selected high and low volume days surrounding the sale. Mean spreads range from .65 to 1.69 percent: far lower than the estimates we produce for the full set of stocks traded in 1900/1910 but similar to the spreads on high volume stocks in these years. Their cross-sectional results, however, produce similar predictive factors as we find for the earlier period. Their study also has data insufficient to create the more extensive measures of effective transactions costs and market illiquidity that we use.

More similar from a methodological standpoint, Gehrig and Fohlin (2006) study trading costs in the Berlin Stock Exchange, using daily prices, for a similar time period (1880-1910). Due to the nature of trading in that market, however, the data are also quite different from the NYSE data: the Berlin market produced only one daily price quote and no reported bid-ask spreads. The results of that study indicate that estimated effective spreads in Berlin ranged between approximately 11 and 28 basis points, while round-trip transactions costs varied from 45 to 116 basis points. In both cases, the measures declined over time, but unlike the New York Exchange they were already fairly low by historical standards and certainly a lot lower than the average at the New York Stock Exchange at that time.

These findings are particularly interesting in comparison with recent developing markets (Lesmond, 2005). Our estimates indicate that NYSE illiquidity at the turn of the 20th century was roughly comparable to emerging stock markets of China, the Czech Republic and Mexico at the end of the 20th century.

The rest of the paper is organized as follows: the next section reviews the historical context of the New York Stock Exchange and key features of corporate finance practice in the pre-World War I era. Section III describes the theoretical underpinnings of various measures of transactions costs, while section IV introduces the newly created database on daily stock prices, volumes, and spreads. Section V presents the quoted and estimated effective spreads and their decompositions, and section VI investigates the cross-sectional determinants of quoted spreads. The final section concludes.

II. The Development of the NYSE before World War I

The New York Stock Exchange was created in 1792 when twenty four brokers and merchants signed the Buttonwood Agreement. At this time, five securities were traded on the exchange (nyse.com).[4] In the first half of the nineteenth century, government issues comprised the bulk of publicly traded securities. By 1860, the liberalization of incorporation law (Hickson and Turner, 2005) allowed for the creation of marketable securities to trade on organized exchanges. Within a few years, railroads began issuing securities for trading on the large public markets in order to satisfy their growing demands for capital. Around the 1880s, rail stocks made up a substantial majority of the trading on the NYSE. Listings and trading on the exchange grew rapidly, and the mix of securities changed, in the latter part of the nineteenth century and the first decades of the twentieth. While railroad securities remained important, they lost some market share around the turn of the twentieth century, as other sectors expanded more rapidly.[5] By 1910, "non-rails" outnumbered railroads on the NYSE for the first time since 1870 (Davis and Cull 1994). The value of securities listed on the exchange exceeded $26 billion (about $500 billion in 2005 terms).[6]

Rules and Regulation:

In the period of our study, the NYSE was owned by its members and largely self-regulated. Among the key regulations were those dealing 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

[4] See Michie (1986), p. 173 and Mulherin et al. (1991), p. 597, for surveys of the institutional development of the NYSE. See also Baskin (1988).

[5] Navin and Sears (1955) consider the 1880s the beginning of the shift to the widely-held industrial enterprise, particularly due to the "trust" movement in the processing industries. The main trusts created in the 1880s involved oil refining (Standard Oil), cotton oil refining, linseed oil refining, whiskey distilling, sugar refining, and lead smelting and refining. They also credit the heavy demand for trading in trust certificates with New York's rise to preeminent exchange during the late 1880s.

[6] Davis and Neal (1998) report a figure of 5.4 billion pounds, based on Michie (1987). The dollar values come from using the calculator provided by www.measuringworth.com.

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 $65,000 in 2005 values) and between $64,000 and $94,000 in 1910 (roughly $1-2 million in 2005 values).[7]

The Governing Committee of the exchange held ultimate responsibility for exchange operations and had the power to fine or even 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, 597-598). 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, 598-602).

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

External regulation of exchange operations or of listed corporations came much later, and corporate reporting law generally remained weak in the United States up until the Great Depression. Private incentives, particularly the desire to access outside funds from investors, encouraged more and more firms to disclose their balance sheets and income statements. In 1895, the NYSE began recommending that listed companies provide both a balance sheet and an income statement in annual reports to investors. Such reporting became mandatory in 1899 (nyse.com).[8] The content of these reports varied significantly in their breadth and accuracy, and accounting standards and auditing practices took many more decades to evolve into what would become the modern norm.

[7] Michie (1986, p. 175), presumably reported in nominal terms.
[8] See as well Archambault and Archambault (2005), who find that even as of 1915, listed companies—particularly industrials that were not already regulated by the government—were significantly more likely to report an income statement than unlisted companies. Similarly, listed companies were far more likely to report a balance sheet.

Organization of trading:

Though it started out operations using a call auction system, the NYSE moved to a continuous auction method in 1871.[9] Under this system, transactions occurred throughout the trading day at whatever terms could be agreed upon by the parties involved, with no guarantee of a single price.[10] While the continuous auction method eliminated the problem of overcrowding and the excessive time taken in the call auction, it created new problems of order imbalance—the brokers interested in trading a given security may not arrive simultaneously at the particular trading post for that security. In general, such random arrival reduces market liquidity, creating greater 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, hence the term 'specialist.' These specialists made a market in their stocks at a single trading post, and they traded on their own account as well as on behalf of their customers.

Competition from other Exchanges:

The NYSE's restrictive membership and listing rules led to the repeated rise of competitors from its inception.[11] The most significant competition came with the creation of the Consolidated

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[9] Kregel (1995, p. 464) gives a number of reasons relating to inefficiencies of the call auction. Kregel finds unconvincing Garbade and Silber's (1979) explanation for the shift to continuous trading—that the Civil War increased the arrival of new information to the market.
[10] See Kregel (1995) on the evolution of securities market organization in London and New York.
[11] See, for example, Garvey (1944).

Stock Exchange, formed out of the merger of several rival exchanges, in 1885. The Consolidated included 2,403 members—more than double the number of NYSE members—and many brokers also traded in the unorganized “curb” market. By 1908, the three exchanges contained 424 million shares of stock, over half of which (53.5 percent) were traded outside of the NYSE (Michie, 1986, 175-176).

Compounding the incentives to deal outside of the NYSE, the brokers of the New York Stock Exchange charged a fixed minimum commission of 1/8 percent on trades.[12] The Consolidated Stock Exchange, by contrast, charged a commission rate of 1/16, thus encouraging nonmembers of the NYSE to deal on the Consolidated using NYSE market prices (Michie, 1986, p. 178). By using the NYSE quotes, brokers of the Consolidated Exchange saved on the costs of creating a price discovery mechanism, and were thereby able to charge lower commissions than the NYSE (Mulherin et al., 1991, 608).

The NYSE worked continuously but not altogether successfully to eliminate its competition. It created an Unlisted Trading Department to trade in stocks of the Consolidated (Mulherin et al., 1991, 609), tried to remove tickers from the Consolidated Stock Exchange and from outside brokers, and later forbade phone links to the Consolidated Stock Exchange. The latter efforts failed, however, because brokers with legitimate access to the NYSE would trade at the Consolidated at NYSE prices (Michie, 1986, 178).[13] In 1896, dealing in differences between domestic exchanges was banned and in 1898 the exchange banned the transmission of continuous price quotes (Michie, 1986, 179).

The anti-competitive measures proved difficult to enforce, but they still limited transactions between the NYSE and other domestic exchanges and created price differentials.

[12] A loophole in the rule, however, allowed commissions of 1/32 percent (and often as low as 1/50 percent) on trades for members buying and selling from each other. This discount pertained to all partners of a member firm, and thus fostered the growth of large brokerage firms (Michie, 1986, 177-178). The original Buttonwood agreement stated a minimum commission of ¼ percent.

[13] For a detailed description of the legal battle for exchanges to control their quotes see Mulherin et al., 1991

The restrictive rules of the NYSE therefore limited the market in some securities, but simultaneously hindered access to current prices by traders in the Consolidated. As Michie (1986) points out, the "New York Stock Exchange covered only part of the New York market and prevented the remainder from operating as efficiently as possible."

Transactions Costs: Information and Competition

Trading in securities brought with it numerous costs, relating to both information asymmetries and order processing. Information discrepancies between insiders and outsiders raised costs that could be only partially offset by corporate reporting. The use of continuous trading created additional illiquidity risk, particularly in stocks with thin markets that often required specialists to hold inventories in order to make deals. Specialists required compensation for bearing these risks, and the resulting spreads added to overall transactions costs. Moreover, restricted memberships, minimum commission rates for brokers, and specialization in securities (effectively product differentiation) may have lessened competition and allowed some market power in the setting of spreads by specialists.

On the positive side, the innovations of the telegraph, ticker, and telephone lowered the costs associated with disseminating information and expanded the NYSE's geographical reach (Mulherin et al., 1991, 606). It also allowed competing markets to gain access to NYSE quotes and facilitated competition between the NYSE and other exchanges. These effects should have helped lower order processing costs. To the extent that the exchange limited the listing of issues judged to be too risky, the resulting selection bias should have mitigated the asymmetric information components of transactions costs.

III. Measuring Market Liquidity and Transactions Costs

The development of the microstructure of the New York Stock Exchange prior to World War I provides a unique real world experiment on the evolution of trading systems and associated market liquidity and transactions costs in an unregulated (or self-regulated) environment. Trading costs further reflect information about information asymmetries and market power. Together, these various measures, and their underlying explanatory factors, provide a wide-ranging picture of market functioning.

It is useful first to differentiate quoted spreads from effective spreads. While quoted spreads can be readily observed as raw data, effective spreads need to be estimated by statistical methods. Typically, effective spreads are more informative about real trading costs, because quoted prices often change soon after a transaction has taken place or because traders can actually negotiate to trade at prices between the quotes. When quotes change frequently during the day, the effective costs of a round-trip transaction is likely to be lower than the quoted spread at any point in time, because a hypothetical trader could take advantage of the option value of trading the second part of a round-trip transaction at a different more favorable points in time later. Also price improvements in form of bilateral agreements between traders and market makers are rather customary in so-called quote drive trading systems, (i.e. in trading systems based on market makers.)

Depending on the availability of empirical observations, estimated spreads can be decomposed into the various theoretical components, like information, inventory holding, and order processing cost. Since this decomposition of the underlying cost components is largely based on theoretical considerations, in the sequel we briefly outline the theoretical basis for the subsequent empirical analysis.

Quoted spreads

Market makers in an asset market receive as their compensation the difference between the price paid to sellers and the price obtained from buyers—the bid-ask spread. Empirically, the difference between quoted ask and bid prices, normalized by the midpoint of bid and ask prices of the asset, provides an estimate of the actual transaction cost. Transactions do not necessarily take place at quoted bid and ask prices, however, meaning that quoted spreads are not necessarily precise reflections of real transactions costs. Moreover, the quoted spread wraps up a range of different transactions costs: order processing expenses, inventory risk, asymmetric information, and potentially monopoly rents. A number of alternative methods have been devised to more accurately depict transactions costs and to allow decomposition of the spread into various components.

Realized Spreads and their Components

In order to estimate realized spreads, we use the method proposed by George et al. (1991). This method refines and extends the serial covariance measure proposed by Roll (1984). In that approach, for $r_{it} = p_{it} - p_{it-1}$ denoting the transactions return on a security *i* in period *t*, where p_{it} is the natural logarithm of the price of stock *i*, the Roll measure $s_i^R = 2\sqrt{-\operatorname{cov}(r_{it}, r_{it-1})}$ is an estimate of security *i*'s effective spread.[14] Since trades often take place at prices between the quoted bid and ask prices, the estimated effective spread is smaller than a quoted spread. The underlying idea of this estimator is that, in informationally efficient and stationary markets, variation in transactions prices results from the randomness of buy and sell orders plus positive transaction costs. In liquid markets with low transaction costs, successive individual orders have little impact on observed transaction prices. In thin markets, price effects of individual trades

[14] The transactions return is based on observed transactions prices. Transactions returns typically differ from true returns, because even in efficient markets transactions costs prevent arbitrage, when true returns and transactions returns are close enough.

may be more pronounced. If transaction costs are higher, the deviation of transaction prices from true fundamentals will not be immediately arbitraged, even in efficient markets. Therefore, the covariance of successive price changes provides information about market liquidity, and hence, effective transaction costs.[15] In liquid markets the covariance of successive prices will be low as long as the price changes are not caused by systematic factors such as new market information. And even new information will be reflected in prices immediately. In less liquid markets the covariance will be higher, both, because of a larger market impact of individual trades, and because information revelation is slower. The effective spread therefore arguably offers a better estimate of actual transaction costs than does the quoted spread.

The GKN measure corrects for positive autocorrelation in the expected returns, thereby overcoming the problem that the Roll measure often produces negative spread estimates. In the framework of George et al. (1991) the logarithm of transaction price at time *t* can be written as

$$p_{it} = m_{it} + \pi \frac{s_i}{2} q_{it} \ , \qquad (1)$$

where m_{it} is the logarithm of the true value of the asset at time *t*, π is the proportion of the quoted spread that is due to order-processing costs, s_i is the quoted spread and q_{it} is an indicator variable that equals 1 if the transaction at time *t* is at the ask price and -1 if the transaction is at the bid price. The true value of asset *i* consists of the expected return prior to transaction *t*, the asymmetric information component, which reflects information revealed by transaction *t,* and a white noise term. The logarithm of the bid price after transaction *t* is

$$b_{it} = m_{it} - \pi \frac{s_i}{2} \ . \qquad (2)$$

Subtracting the bid price from the transaction price and taking the first difference yields

$$r_{it}^{d} = p_{it} - b_{it} - (p_{it-1} - b_{it-1}) = \pi \frac{s_i}{2} (q_{it} - q_{it-1}) \ . \qquad (3)$$

[15] See Madhavan (2000) for a more technical survey on the empirical estimation of transaction costs.

Note that equation (3) does not depend on the true value m_{it} and hence any time series properties that the expected return $m_{it} - m_{it-1}$ may exhibit do not influence r_{it}^d. Taking the autocovariance of r_{it}^d yields the spread measure

$$s_i^{GKN} = 2\sqrt{-\text{cov}(r_{it}^d, r_{it-1}^d)} = \pi s_i \quad . \tag{4}$$

Using the spread measure s_i^{GKN} one can infer the proportion of the order processing component π by a cross-section regression of s_i on s_i^{GKN}:

$$s_i^{GKN} = \beta_0 + \beta_1 s_i + \varepsilon_i \quad . \tag{5}$$

According to equation (4) we expect $\hat{\beta}_0 = 0$ and $\hat{\beta}_1 = \pi$.

Since we do not have bid and ask quotes for the year 1890 to correct for the positive autocorrelation in expected returns we also employ another measure proposed by George et al. (1991). For this measure the returns of closing prices, r_{it}, are regressed on the expected return on the equal weighted market index $E(r_t^m \mid I_{t-1})$:

$$r_{it} = \gamma_0 + \gamma_1 E(r_t^m \mid I_{t-1}) + \eta_{it}$$

Then the Roll measure is applied to the residuals of this regression:

$$s_i^{GKN2} = 2\sqrt{-\text{cov}(\eta_{it}, \eta_{it-1})} \; .$$

Market Liquidity

Closely related to the cost of trading is the concept of market liquidity. While the spread itself is a widely used measure of market liquidity, it cannot reflect quantity reactions to changes in prices or spreads. Characterizing market liquidity in this manner requires alternative measures, three of which can be calculated with our historical data: i) the number of trade observations, ii) the trading volume, and iii) the Amihud illiquidity measure.[16] Asset pricing models have found the Amihud measure particularly useful (e.g. Amihud, 2002, Acharya and Pedersen, 2005, Pastor and Stambaugh, 2003).

The Amihud stock illiquidity measure can be defined as the average ratio of the daily absolute return to the absolute dollar volume on that day, i.e. $Aill_t^i = \sum_{t \in T} \frac{|r_t^i|}{vol_t^i}$, where T defines the averaging period (either monthly or annual). Economically, the illiquidity measure can be interpreted as the daily price impact caused by the respective order flow.

IV. Data

We test our hypotheses on liquidity, transactions costs, and spread components, using a new database containing the transaction data for all stocks listed on the New York Stock Exchange and reported in the New York Times for every trading day (Monday through Saturday) in the years 1890, 1900, and 1910. We gathered all data reported daily, including closing transaction prices, closing quoted bid and ask prices (only available in 1900 and 1910), and the number of shares sold for each stock each day.[17]

The original New York Times reports contained some errors. For some observations, errors were easily apparent, and we corrected them. For others, however, it was not as clear-cut. In these cases we adopted the following procedure: whenever the distance of a particular observation to the mean of the series exceeded eight times the standard deviation, we treated the entry as an erroneous datapoint (or at least an extreme outlier observation) and consequently deleted it.

[16] For a more extensive discussion of alternative measures of liquidity see Amihud (2002).
[17] The exchange operated every day but Sunday up until 1952, when the Saturday sessions ended. We also collected the closing price and days' volume for 1890, but because the NYT did not publish quoted bid and ask prices at that time, we cannot calculate quoted spreads or conduct the spread decomposition for 1890.

Comparing the data over the three points in time (Table 1), it is clear that the total number of traded NYSE securities changes only slightly over time, but the number of companies traded on the NSYE did change considerably from one decade to the next. The number of companies actually dropped between 1890 and 1900, from 231 to 190, before rebounding slightly to 200 in 1910.[18] While on the face of it, we might expect more shares to enter trading over time, the introduction of listing requirements in 1895/1896, particularly the obligation to publish annual reports made formal in 1899, likely depressed numbers. In addition, the crisis of 1893, the drying up of the new issues market from 1893 to 1897, and the beginnings of the merger wave in 1895, meant the exit of some existing companies and entry of fewer new ones. Due to an increase in issuance of preferred stocks, however, the number of securities (as opposed to companies) listed in the New York Times remained quite constant: 326 in 1890, 307 in 1900 and 332 in 1910. Between 1890 and 1900, preferred shares increased as a proportion of total listings from 23% to 35% and over the following ten years, their proportion relative to common stocks remained constant. Of these 1910 listings, only 185 (56%) were already traded in 1900, which also means that about 40 percent of the 1900 listings left the NYSE listings by 1910.

By certain measures, shares traded more actively over time, particularly in the early part of the period. For example, the average (median) number of trading days rose from 81 (31) per company in 1890 to 127 (96) in 1900. That number then fell back slightly to 117 (90) in 1910. The number of companies with at least 90 trading days followed a similar pattern, increasing from 110 in 1890 to 159 in 1900, and then rose slightly to 166 in 1910. While only 77 firms traded at least 150 days in 1890, 127 firms did so ten years later (down slightly to 124 firms in 1910).

[18] These figures are approximate, because the New York Times may have varied its reporting practices over time and (to a lesser extent) because we may have missed some firms that changed name or for which the New York Times changed its abbreviation of the name, and we failed to spot it. The abbreviations varied considerably, but we cleaned the data for this problem as best as possible.

Daily trading volumes follow a different pattern: the median number of shares traded dropped from 255 in 1890 to 83 in 1900 but then rebounded to 267 in 1910. But since trading days increased so much between 1890 and 1900, the total trading volume (in $) over the course of the year still rose. Based on averages, daily trading volume remained fairly constant at around 2,000 shares per day. In 1910, the daily averages covered a wider range, but the number of days traded increased. But while annual total shares increased significantly for 1910 median dollar volume fell. Average dollar volume increased by about two-thirds.

The high average volumes relative to medians come from a small number of heavy traders, such as Reading Railroad, which posted average sales of $14.6 million per day in 1910 (Table 2). The highest 20 trading volumes for each year reached well into the hundreds of millions annually, with daily averages ranging mostly between a half million and 1.5 million in 1900. The companies with the highest total trading volume change over the three years but three firms remained among the 20 most traded stocks in 1890, 1900 and 1910 (Union Pacific; Atchison, Topeka and Santa Fe; and Northern Pacific). One or two highly active shares exceed all others by a wide margin. American Sugar Refining topped the list in both 1890 and 1900, with nearly $1.6 billion of shares traded over 287 trading days in the latter year. The Reading held top place in 1910, with $4.3 billion of shares traded over 293 trading days. The second and third most traded stocks in 1910, Union Pacific and U.S. Steel, came in slightly behind, at $3.6 and $3.1 billion, respectively, over almost as many trading days. Below that, however, the annual volume drops off rather quickly, so that the tenth highest volume is about $250 million in 1910, for example. While the enormous railroads clearly dominated the top twenty in dollar volume, a few of the industrials and utilities—sugar, copper, steel, telephone, and gas—were in the same league.

V. Overall Market Liquidity and Transactions Costs

We add to this basic picture of market liquidity using quoted bid-ask spreads, a measure of the effective bid-ask spread (GKN) developed by George et al. (1991), and the Amihud (2002) illiquidity measure. Given the lack of bid and ask quotes for 1890, quoted spreads and GKN can only be calculated for 1900 and 1910. Therefore, we also calculate a second measure of the effective spread, proposed by George et al. (1991), that we denote as GKN2.

A first look at the data presents a somewhat mixed and even contradictory picture. Based on the GKN2 measure, effective trading costs fell dramatically from a sample-wide average of 3.8% in 1890 to 1.04% in 1900 and then further to 0.82% in 1910. Similarly, market illiquidity fell markedly over the three points in time. These patterns match well the path of increasing trading volume for common stocks but contradict the non-monotonic development of trading volume for preferred stocks. Also, quoted bid-ask spreads increased throughout from 1900 to 1910 for both common and preferred stocks alike. This is particularly true for mean spreads but also applies to median spreads. The average quoted spreads over the full sample as well as for most volume categories rose between 1900 and 1910, from about 2.4 percent in 1900 to almost 3 percent in 1910. Median spreads were significantly lower than averages but increased slightly for the full population, from 1.64 to 1.7 percent (Table 3).[19]

While improving communications technology could have lowered transactions costs, other factors seem to outweigh these potential cost reductions. In fact, our finding squares with Garvy (1944) and Brown et al. (forthcoming) who claim that after 1909 competition from the Consolidated Exchange declined. This loss of competitive pressure likely allowed brokers to raise costs. The population of securities clearly changed somewhat over the interval of our

[19] Note that Table 3 uses the average spread for each firm, thereby equally weighting all stocks. This method gives higher means and medians, since they give as much weight to light traders (with higher spreads) as heavy traders (with lower spreads).

observations, and newer listings carried higher spreads. Notably, however, the phenomenon of rising quoted spreads still appears among the subset of shares traded in both years (the average of which increased from 2 percent to 2.6 percent) and among the subset of shares traded on NYSE and the Consolidated (the average of which increased from 1.3 percent to 1.8 percent).

Preferred shares differ substantially from common stock, particularly in the voting and dividend rights attached to them. We may expect lower risk and therefore potentially narrower spreads on preferred shares. According to the GKN2 measure, in all three years preferred shares have lower effective spreads than common stocks although this difference is small in 1900. It should be noted, however, that this measure of effective spreads is noisy, and therefore a more rigorous analysis is deferred to quoted spreads and George et al. (1991)'s other measure of effective spreads. For 1900 we observe this phenomenon, with preferred shares averaging quoted spreads of a little more than 1.5 percent, while common stocks averaged nearly 2 percent (1.96)—a statistically very significant difference.[20] In 1910, however, the gap between common and preferred spreads disappeared almost entirely.

As is often the case in more recent data, effective spreads are lower than quoted spreads on average in 1900, but the difference is fairly small (2.27 versus 2.42).[21] In 1910, the GKN measure actually exceeds the average quoted spread by a small margin (3.04 versus 2.99). The estimates of the GKN spread (Table 3), like the quoted spreads, rose significantly between 1900 and 1910—from an average of 2.28 percent in 1900 to an average of 3.04 percent in 1910. As with the quoted spreads, the distribution of spreads is skewed, so that median effective spreads are lower, at 1.6 and 1.9, for the same years. Effective spreads also grew on average for the full

[20] Based on averages across the entire sample of spreads, rather than using the average within each stock, as reported in Table 3. Averaging across averages for each stock, the spreads are about 1.8 and 2.8 for preferred and common, respectively.

[21] We calculate the GKN measure for all companies for which the serial covariance of the returns of the bid prices could be computed based on at least 4 observations, i.e. where the number of observations of the second order difference of bid prices is greater or equal to 4. This condition leaves us with 203 firms in 1900 and 182 in 1910.

sample. As with quoted spreads, common stocks trade with higher effective spreads on average than do preferred shares (2.6 versus 1.8).

While the hypothesized relationship between transactions costs and the liquidity of the market for a given company's shares cannot be verified in the inter-temporal evolution of transactions prices, we check whether it is satisfied in the cross-section within a given year. Hence, we divide up the sample into thirds based on the average dollar volume of shares traded each day for the individual shares. Spreads and other characteristics of the stocks differ substantially depending on the average daily dollar volume traded. Those in the lowest volume tercile trade with the highest average spreads (both quoted and effective) and also have the lowest prices and highest return variance. Effective spreads are actually higher than the quoted bid-ask spreads for the most actively traded stocks A big portion of the increase in spreads between 1900 and 1910 shows up in the lowest volume tercile, where the GKN measure increased from an average (median) of 3.4 (2.8) to 4.6 (4.3). Among the most actively traded stocks, the median GKN measure increases from 0.9 to 1.2 percent. At the same time, the mean for this tercile rose from 1.3 to 1.8 percent. In other words, in the annual cross-sections, transaction costs relate monotonically negatively with trading volume for both common and preferred stocks.

The estimates for the actively traded stocks are comparable to recent estimates for the NYSE/AMEX exchanges. For example, Hasbrouck (2006) reports mean trading costs of about 1 percent and a median of .54-.61 depending on the specific measure in use for daily data from 1993-2005. Our estimated effective spreads for 1900 and 1910 are well below Lesmond's (2005) estimates for modern emerging markets. The 1890 estimates of the effective spread for high volume stocks of about 2.2% percent for the mean and 1.5% median are comparable to the estimates of the Roll measure for China (1991-2000), the Philippines (1987-2000), Portugal

(1988-2000) and Israel (1993-2000). This is another indication for the high degree of trading efficiency and liquidity in the early and unregulated New York Stock Exchange.

The spread premium for common over preferred shares also shows up most among the lightest traders, for whom average GKN spreads are nearly twice as high for common stocks as for preferred stocks in 1900. In fact, the reverse is true among the most active traders—common stocks trade at similar or even lower average GKN spreads (1.3 versus 1.7 in 1900); though medians are nearly identical.

In historical comparison the evolution of the Amihud illiquidity measure may be of particular interest. This measure decreased dramatically from a level of 19.8 in 1890 to 10.1 in 1900 to 5.0 in 1910 for common stocks and 10.8 (1890), 2.2 (1900) to 2.5 (1910) for preferreds. The corresponding numbers in the high volume tercile of common stocks, however, are significantly lower: 0.49 in 1890, 0.34 in 1900, and 0.31 in 1910. Surprisingly, those numbers compare directly with corresponding measures of market illiquidity in the most developed modern stock markets. Amihud (2002), for example, reports a cross-sectional mean of 0.34 for NYSE stocks in 1963-1996.[22] Thus, the 50 or so highest volume securities at the beginning of the century traded with illiquidity or transactions costs comparable to the average NYSE trading costs at the end of the century. Lesmond (2005) reports Amihud measures of 0.39 for China (1991-2000), 0.43 for the Czech Republic (1993-2000), and 0.46 for Mexico (1988-2000). By these measures, the most active NYSE stocks at the turn of the century appear slightly less illiquid than these modern emerging markets.

Spread components

We can learn even more about the sources of transactions costs and illiquidity by decomposing the effective spreads into an order processing and asymmetric information components using a

[22] Hasbrouck (2006) reports a mean of 0.36 (median of 0.07) on daily cross-sections AMEX/NYSE, 1993-2005.

cross section regression, based on equation (5). We evaluate this equation separately for common and preferred stocks and also by high and low volume (Table 4). For common stocks, we find that half of the effective spread comes from order processing costs in 1900, and that figure falls to about 17 percent in 1910. On the flip side, therefore, the asymmetric information component rises from 50 percent in 1900 to 83 percent in 1910. Even with the increase in dollar spreads between 1900 and 1910, the order processing component drops from about 44 cents to 41 cents. For preferred shares, we find an order processing component of 29 percent in 1900, and that figure jumps to 42 percent ten years later (in dollar terms, 33 to 74 cents). These patterns fit with the changes in trading volume: increasing for common stocks and decreasing for preferreds.

The spread decomposition also differs depending on trading volume, particularly for 1900. For stocks in the top half of the volume range, the spread is due almost entirely to order-processing costs. The order-processing component of spreads of firms in the lower half of the trading volume range is 46 percent in 1900 and 22 percent in 1910. The remainder, of course, is attributable to asymmetric information. In other words, asymmetric information costs contribute essentially nothing to the spreads for heavily traded stocks in 1900, while such costs make up half of trading costs for lighter traders in the same year and 80 percent for both high and low volume stocks in 1910.

This result contrasts with findings by George et al. (1991) and Stoll (1989) who find that although the size of the spread varies according to the liquidity of a stock, the composition of the spread does not. Since trading in stocks should have increasing returns to scale (e.g. due to fixed costs) we would expect a decrease not only in total spread but also in the order processing cost component as trading volume increases. However, the results show that asymmetric information costs essentially disappear as a component of transaction costs for highly traded stocks in 1900 but become much more important in 1910. The fact that the order processing component increases with volume suggests that spreads contain monopoly rents in 1900.

Also of note, the intercept in the estimation of equation (5) is positive. While $\hat{\beta}_0$ is positive and significant in both years, the estimates vary considerably. The generally positive constant implies that there is negative serial correlation in the adjusted returns even in the absence of a bid-ask spread. According to Harris (1990) this can be explained by price discreteness. Since stock prices are expressed as multiples of a minimum tick size there are rounding errors that increase the negative serial correlation of returns. The minimum tick size on the NYSE in 1900 and 1910 was $1/8. Figure 1 shows the frequency of quotes on the eight possible $-fractions. Assuming that the true value of the stock is a continuous variable we would expect quote prices to be equally distributed among the eight fractions. Figure 1, however, shows that in both years more than one half of all quotes are integers and around 20 percent end on half fractions. With more than 70 percent of all quotes being multiples of one half, market makers are clearly not exploiting the full range of the price grid. This does indeed lead to considerable rounding errors and a positive intercept in the above regressions.

Moreover, Christie and Schultz (1994) claim that avoiding odd eighth quotes is an indication for anticompetitive behavior on the part of the market makers. Following this interpretation we measure anti-competitiveness by the proportion of quotes that are multiples of one half. Table 5 reports the results of an OLS regression of this measure of anti-competitiveness on proxies for trading activity (volume and the number of trading days) and risk (variance and a dummy variable for preferred shares). In addition, we expect a positive relationship between the proportion of integer or half-integer quotes and the stock price since exploiting the full price grid is more important for reducing relative rounding errors on stocks with low prices. This effect is confirmed by our analysis; in both years, the coefficient of log(P) is highly significant and positive. But even after controlling for this effect, the proxies for trading activity are important;

both volume and the number of trading days relate negatively to price-discreteness. Price discreteness also increases with risk: Higher return variance significantly increases the mass on zero and one half price fractions in both years; and preferred shares, which are considered to be less risky than common shares, have a lower proportion of integer and half-integer quotes (the difference is significant for 1900). In other words, anti-competitive behavior appears to be more prevalent for less actively traded and more risky stocks. Another interpretation for this finding is that market makers do not explicitly quantify their costs but rather use a rule of thumb according to which they respond to uncertainty by rounding to the next integer or half-dollar price. We also find, however, that stocks cross-listed on the arch-rival Consolidated Exchange trade with significantly less price discreteness than those with NYSE-only trading. This finding supports the interpretation of price discreteness as an indicator of anti-competitive behavior.

VI. Explaining Transactions Costs and Market Liquidity

Spreads and liquidity measures vary considerably among stocks at any point in time, and the characteristics of securities, and of the trading process for them, may influence these costs. Thus, we also examine the cross sectional determinants of spreads and of the Amihud measure.

Factors Influencing Spreads (Cross-Sectional Variation)

According to the early view (Demsetz, 1968), market makers simply provide the service for immediacy. The competitive (realized) bid ask spread compensates for the cost of providing this service. According to this view the cross sectional variation can be captured by regressions of the form (Madhavan, 2000):

$$s_i = \beta_o + \beta_1 \ln(M_i) + \beta_2 \left(\frac{1}{p_i} \right) + \beta_3 \sigma_i + \beta_4 \ln(V_i) + \varepsilon_i ,$$

where s_i denotes security i's spread. M_i denotes market capitalization and proxies firm size, while $\frac{1}{p_i}$ is the inverse of the price as a proxy of the discreteness of price changes. The underlying riskiness of security *i* is measured by the volatility of past returns σ_i. Trading activity is measured by volume V_i. Studies of modern (i.e. post-WWII) markets reveal that volume, risk, price and firm size explain most of the variability of bid-ask spreads. Volume tends to reduce spreads since dealers can turn around inventories more quickly, reducing inventory risk. Risk typically increases spreads.

Modern market microstructure theory adds to the early view of cost components based on privileged (or inside) information and dealers' optimal inventory behavior. So, for a prominent example, Stoll (2003) delineates between two views—not mutually exclusive—of transactions costs as a reflection of a market maker's processing costs and inventory risk (using real resources) and as compensation for a market maker's losses to informed traders (not using real resources). Theoretical models of inventory risk, such as Stoll (1978), find that the proportional spread is an increasing function of dealer's risk aversion, the risk (i.e., variance) of the security being traded, and of the size of the transaction. Theories of information asymmetry (e.g., Glosten and Milgrom, 1985 and Kyle, 1985) indicate that the spread increases in the probability of encountering an informed trader as well as in the degree of uncertainty over asset value.

It is also worthwhile mentioning Dennert's (1993) work on competing market makers under adverse selection. While inside traders tend to camouflage their trades in each individual trade, they can exploit market fragmentation and submit trades almost simultaneously. Market makers will only realize the activity of insiders, when they find it difficult to sell off their position in the inter-dealer market. According to this model, volume increases when insiders are active. This increase correlates positively with the number of market makers in the security.

Hence, according to this theory, insiders will profit more from insider information in actively traded securities where relatively many market makers provide liquidity. This model predicts that skewness of volume correlates with insider activity.[23] An increase in (positive) skewness of volume would suggest a reduction of insider trading activity, and hence a reduction in adverse selection costs, implying a negative correlation between skewness and spreads.

Since inventory holding costs and information affect price dynamics differently, the two components can be identified if sufficiently rich data are available. Inventory holding costs imply mean reversion since dealers constantly trade back to their desired inventory position. Information has permanent effects on security prices since it affects a security's fundamental valuation. Glosten and Harris (1988) and Hasbrouck (1999) provide analyses of how the observed spreads can be decomposed into its components, when data are available on a high (intraday) frequency.

To summarize, the theoretical literature on transactions costs suggest that spreads vary in cross section, particularly with factors that indicate a stocks liquidity, risk, or information transparency. For example, the following factors should relate to spreads: in the positive direction, variance of returns and lumpiness of trading; in the negative direction, stock price, number of trading days, total trading volume, and proxies for information availability (such as firm size or age), as well as skewness of volume.

Several empirical studies support these models. In his survey of existing cross-sectional evidence, Stoll (2003) finds that fundamental values—share volume, return variance, price, number of trades and market value—nearly always relate very significantly to spreads in modern data. Trading volume is particularly informative: in both theory and practice, heavily traded stocks trade with lower costs. These stocks benefit from economies of scale in order processing,

[23] This prediction has largely been unexplored in empirical work so far. Madhavan, for example, does not refer at all to Dennert (1993). On the other hand, Dennert does not emphasize the empirical implications of his model.

significantly lower inventory holding costs and illiquidity risk to market makers, and possibly also from greater transparency of information regarding the underlying company and therefore lower asymmetric information costs. To the extent that they tend to also have more outside shareholders, the likelihood of encountering an insider is also reduced. If specialists retain market power even in high-volume stocks, however, we could anticipate little or no decline in the order processing component of the spread.

Table 6 sums up the testable implications of the various theories of factors influencing bid-ask spreads. Certain empirical variables proxy for more than one theoretical relationship. For example, trading volume and number of trading days provide an indication of the liquidity of a security's market and may also proxy for information availability; they may also relate inversely to the probability of a market maker encountering an insider trade. For some variables, such as trade size, individual transaction data are unavailable for the period of the study.

Hypotheses on historical average spreads and components

We set out several hypotheses based on the historical analysis. First, at the narrow level of the individual specialist, there seem to have been opportunities to set transactions costs above competitive levels due to the market power exercised, at least in some shares. At the broader level, the continuous market mechanism could have reinforced this tendency by splitting up orders into smaller lots (as opposed to aggregating the day's trades into larger ones) and thereby keeping order processing costs high. As communications technologies had advanced relatively far by 1900, order processing costs may have declined from their 19th century levels. Moreover, the NYSE maintained relatively tight listing standards, which should have mitigated asymmetric information costs. Still, we expect that the cost increasing factors dominate, so that we should find that average total transactions costs (realized spreads) for the full population of stocks in

1900 and 1910 exceed those calculated for the post-WWII period, particularly the last few decades of the 20th century. We hypothesize further that these relatively high costs stem both from a high order processing component and a somewhat higher adverse selection component.

In terms of the cross sectional variation in spreads, we expect that the theoretical models apply in the earlier stages of market development as they have in recent years. Thus, our hypotheses remain essentially the same as those posited in the literature.

Cross-Sectional Relationships

In this final section, we look at the cross-sectional determinants of bid-ask spreads and of the Amihud measure . While there is no single structural model of trading costs, the various theoretical models of spreads lead to a number of testable predictions, many of which are summarized in Table **6.** We use the following variables to explain average percentage spreads: average daily dollar volume (V), average price (P), variance of stock returns (Var) and the number of trading days (Days). This specification largely parallels Stoll (2000) and other studies surveyed by Madhavan (2000) and Stoll (2003), notably Demsetz (1968). Additionally, we include the skewness of daily trading volume, in order to attempt to proxy (inversely) for the lumpiness of trading, an indicator that relates to the frequency of large trades and therefore the likelihood of the market maker dealing with an informed insider.

For each year (1900 and 1910) and each stock type, common versus preferred, we run separate regressions based on monthly averages of our data.[24] Aggregating our data to a monthly frequency helps to eliminate the noise of daily data and still leaves a rich enough structure to allow for dynamic interactions between spread and liquidity measures and also the computation of return variance and volume skewness. Since transactions prices, volume and liquidity are

[24] Recall that the data sources available do not quote bid and ask prices for 1890, so we cannot estimate the quoted spread model for that year.

theoretically jointly determined, we only consider predetermined variables as regressors in order to reduce the impact of simultaneity on our parameter estimates.[25] Moreover, we use median regression to deal with outlier problems that are prevalent in our data set (see Figure 2).

As hypothesized, illiquidity relates positively with spreads, while trading volume (both measures) and the price level relate negatively with spreads (Table 7). These cross-sectional relationships hold for both common and preferred stocks in both years. Interestingly, the elasticity of spreads with respect to volume is the same for common and preferred stocks, about 2% in 1900 declining to 1.1% in 1910. The elasticity of spreads with respect to the price level, however, is twice for preferred relative to common stocks in both years. Less consistently, but in line with theory, risk has a positive impact on spreads. Skewness of trading volume on the other hand does not seem to systematically drive spreads.

Interestingly, we find a strong negative impact of cross-listing on the Consolidated Exchange, particularly for common stocks.[26] The cross-listing dummy measures the extent of the competitive pressure that the Consolidated Exchange exerted on New York Stock Exchange quoted spreads. This finding significantly strengthens the result of Brown et al. (forthcoming), who identify the competitive effect in the time domain around the emergence and the closure of the Consolidated Exchange. The evidence is less clear for preferred stocks; however, only few of those are dually traded. We also find that rail stocks tend to have tighter spreads. Rail stocks are generally traded on both exchanges in larger volumes. Hence, we may be picking up an additional effect of the competitive cross market trading in high-volume shares.

The determinants of illiquidity essentially are the same as those of quoted spreads. However, our results confirm that the Amihud measure aggregates those factors differently

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[25] We tested various cross-sectional regressions based on annual data and found ample evidence of simultaneity problems and parameter instability.

[26] Strictly speaking "cross-listing" really means trading on both exchanges, since the Consolidated Exchange did not have a formal listing procedure. In principle, any security could be traded there. In 1900, preferred shares have a negative cross-listing effect, but in 1910, the effect is reversed.

relative to the quoted spread. Still, volume has a negative impact on illiquidity, while the spreads and the price level consistently exert a positive impact on illiquidity. Rail companies have lower illiquidity only for their common stocks and only in 1900; otherwise the rail dummy is irrelevant for explaining illiquidity. Likewise the number of trading days only affects illiquidity of common stocks in 1900. Skewness of volume has no discernible impact.

The cross-listing dummy does not exert a systematic influence on liquidity. Statistically, it has a strong positive impact only in 1900 and a negative impact on preferred stocks in 1910. From a theoretical perspective two forces of dual trading are interacting in this case, leaving the aggregate effect unclear: dual trading tends to reduce liquidity in each market, while competition and lower trading costs tends to boost liquidity. In general, the net effect cannot be predicted without further information about market characteristics.

Overall, the cross-sectional results on the illiquidity measure accord well with those on the quoted spread. However, explanatory power is significantly higher for the spread regressions. Moreover, these results on a key historical market fall very much in line with similar cross-sectional analyses of established (e.g. Stoll, 2003) or emerging markets recently (Lesmond, 2005).[27] In this sense, we argue that the behavior of traders, and therefore the drivers of price discovery and liquidity, are already discernable in this unregulated regime and are quite comparable to those in tightly regulated modern markets.

VII. Conclusions

This paper contributes in several ways to the newly emerging line of research into the microstructure and performance of securities markets in the unregulated era. We provide the

[27] Our cross-sectional parameter estimates correspond reasonably well with Lesmond's (2005) estimates for modern emerging markets. While he can control for legal origin in his data set, in our historical analysis we can verify a strong negative influence of the quoted bid-ask spread.

first comprehensive daily measures of market illiquidity, quoted bid-ask spreads, and effective transactions costs for the pre-WWI NYSE; the last of which we decompose into order processing and asymmetric information components. We also analyze changes in these measures over time as well as the cross-sectional determinants at each point in time.

Most interestingly, we find that trading costs and measures of illiquidity were roughly comparable with modern-day rates for the most heavily traded securities. This finding demonstrates that even prior to the introduction of regulatory oversight, early securities markets did perform remarkably well. Moreover, the decomposition of the quoted bid-ask spread into order-processing and an adverse selection components suggests that adverse selection is not a significant component of trading costs in the earlier periods. While order processing costs did not vary much from 1900 to 1910 in absolute terms, their relative role declined. Moreover, we find evidence that quoted spreads did react to competitive pressure from rival markets, such as the Consolidated Exchange. NYSE securities that did not trade on the Consolidated exhibit a substantially larger probability of price-clustering, an indicator of non-competitive conduct. It is likely that the competitive reaction for dually-traded securities is largely driven by the order-processing component. On the other hand, fragmented trading should increase the adverse selection component. The analysis of the precise nature of competition between those early exchanges requires even more detailed data and, therefore, is left for future research.

Of methodological importance, we find different patterns in the various measures of trading costs and market liquidity. While we find that mean measures of market illiquidity, trading volume, and effective spreads all move together over time, quoted bid-ask spreads do not. Thus, the first three measures may provide a more accurate picture of market functioning at the aggregate level than do the quoted spreads. Cross-sectional analysis of the determinants of quoted spreads, however, indicate that this measures does help differentiate among individual stocks at a given point in time, reacting as expected to measures of trading volume, price, and risk. The measure also relates closely to illiquidity in cross section, and the determinants of the quoted spread are more robust.

Our analysis of the performance of the early New York securities markets suggests little cause for the regulatory intervention at least by that time. Based on our decomposition of quoted prices we find some evidence that informed trading was becoming a more serious component of trading costs from 1900 to 1910. Further research (and much more data collection) is needed to examine the pre-regulatory era completely. Our work suggests that market microstructure analysis based on historical cross-sectional trading data may prove useful to a scholarly analysis of the regulatory process that ultimately generated the various regulatory instruments such as insider trading restrictions and conduct regulation to ensure competitive pricing. Of particular use would be analysis of specific crises that prompted arguments leading to the foundation of the SEC.

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Table 1: Listings and Trading Activity on the New York Stock Exchange, 1890-1910

		1890	**1900**	**1910**
Number of companies in NYT		231	190	200
Number of issues by share type	Common	220	188	189
	Preferred	75	106	120
	(Other?)	31	13	23
Number of trading days for all stocks	Mean	81	127	117
	Median	31	96	90
	75th	138	240	214
	25th	4	17	18
	Stdev.	97	107	104
Number of companies with at least N trading days	N=90	110	159	166
	N=120	89	144	140
	N=150	77	127	124
Number of shares traded daily (by firm)	Mean	2,104.38	2,163.65	1,970.36
	Median	254.72	82.82	266.63
	Stdev.	10,097.64	4,974.77	9,998.53
Volume traded (dollars) annually	Mean	16,064,408	31,206,358	51,385,652
	Median	207,171.3	1,548,682.4	1,360,762
	Stdev.	79,452,821	118,011,694	347,853,198

Notes: In the first row, all issues for one company count as one company.

Table 2: The 20 Most Traded Stocks at the NYSE, 1890 - 1910

Panel A: 1890		**Volume traded ($)**	
Name	**No of obs.**	**Avg. volume ($)**	**Total volume ($)**
Sugar Ref. Co	280	2,197,006	615,161,680
Del., Lack & Western	291	1,925,099	560,203,809
Chicago, Mil. & St. Paul	292	1,160,432	338,846,144
Chicago, Rock Island & Pacific	292	772,939	225,698,276
Louis. & Nashville	292	752,132	219,622,427
Phil. & Reading	289	690,785	199,636,923
Union Pacific	292	651,819	190,331,206
Missouri Pacific	292	545,953	159,418,218
Atchison, Topeka and Santa Fe	292	524,884	153,266,216
Chicago, Bur. & Quincy	286	532,010	152,154,974
Northern Pacific pf.	288	437,604	126,029,981
Lake Shore	290	313,166	90,818,169
Chicago Gas Co.	179	435,223	77,904,828
C., C., C. & St. L.	288	230,523	66,390,653
Chicago & Northwestern	289	227,893	65,860,961
New York & New England	292	213,735	62,410,532
Oregon & Trans.	188	322,587	60,646,281
Western Union Telegraph	290	203,453	59,001,370
Chicago Gas Trust	112	417,904	46,805,214
Rich & W. P.e	292	144,878	42,304,376

Panel B: 1900		**Volume traded ($)**	
Name	**No of obs.**	**Avg. volume ($)**	**Total volume ($)**
American Sugar Ref. Co.	287	5,563,141	1,596,621,467
Brooklyn Rapid Tran.	290	1,700,663	493,192,270
Pennsylvania R. R.	288	1,627,078	468,598,464
American Tobacco	286	1,532,739	438,363,354
Chicago, Mil. & St. Paul	289	1,474,464	426,120,096
Atchison, Topeka and Santa Fe pf.	290	1,416,788	410,868,520
Union Pacific	291	1,355,106	394,335,846
Chicago, Bur. & Quincy	288	1,307,724	376,624,512
People's Gas, Chicago	288	1,260,107	362,910,816
Northern Pacific	289	1,028,360	297,196,040
Manhattan Elevated	254	944,303	239,852,911
Missouri Pacific	291	761,490	221,593,706
Reading 1st pf.	289	715,263	206,711,007
Met. Street Railway	285	724,258	206,413,644
Baltimore & Ohio	290	700,158	203,045,878
Southern Pacific	291	662,550	192,801,934
American Steel & Wire	288	625,523	180,150,624
New York Central	286	544,807	155,814,688
Federal Steel	290	507,879	147,284,881
Chicago, Rock Island & Pacific	287	495,239	142,133,593

Panel C: 1910	Volume traded ($)		
Name	**No of obs.**	**Avg. volumes ($)**	**Total volume ($)**
Reading	293	14,601,207	4,278,153,651
Union Pacific	291	11,544,421	3,359,426,511
U. S. Steel	292	10,447,567	3,050,689,564
Southern Pac.	292	2,827,583	825,654,236
Amalgamated Copper	291	2,002,704	582,786,864
Pennsylvania R. R.	292	1,782,215	520,406,780
American Smelt. & Ref	293	1,320,117	386,794,281
Chi., Mil. & St. Paul	292	1,224,725	357,619,700
Atch., Top. & S. F.	292	1,221,991	356,821,372
N. Y. Central	291	850,918	247,617,080
Chesapeake & Ohio	291	757,242	220,357,538
Consolidated Gas.	292	748,185	218,470,078
Northern Pacific	292	640,561	187,043,666
Rock Island Co	296	538,217	159,312,350
Brooklyn Rapid Tran	292	463,473	135,334,174
Great Northern pf.	289	447,186	129,236,667
Canadian Pacific	283	382,367	108,209,804
Lehigh Valley	27	3,897,035	105,219,945
Interborough-Met. pf.	293	297,480	87,161,523
American Tel. & Tel.	293	260,048	76,194,181

Table 3 (a): Effective Spreads and Liquidity in 1890

		Average daily volume ($)	# trading days	Avg. price	St. dev. returns	Amihud	GKN2 (%)
Preferred stocks:							
All	Mean	16339	130	58.98	0.038	10.77	2.18
	Median	8566	108	58.48	0.031	3.20	1.98
	Std. Dev.	30776	78	31.57	0.030	23.89	4.24
	Obs.	41	41	41	41	41	41
Low	Mean	2821	70	25.35	0.049	32.90	1.47
	Median	2625	56	25.63	0.048	10.53	2.83
	Std. Dev.	1200	37	11.32	0.020	45.09	5.48
	Obs.	9	9	9	9	9	9
Medium	Mean	9034	116	68.32	0.042	6.28	2.83
	Median	8283	106	64.38	0.032	3.41	1.75
	Std. Dev.	3153	55	30.21	0.036	5.74	4.61
	Obs.	22	22	22	22	22	22
High	Mean	44575	216	68.72	0.019	0.73	1.41
	Median	25598	235	74.46	0.019	0.67	1.55
	Std. Dev.	54645	82	27.14	0.011	0.46	1.26
	Obs.	10	10	10	10	10	10
Common stocks:							
All	Mean	88178	165	53.79	0.054	19.79	4.38
	Median	10300	162	35.27	0.032	2.85	1.81
	Std. Dev.	243801	91	46.52	0.179	57.47	22.47
	Obs.	116	116	116	116	116	116
Low	Mean	2928	98	33.18	0.099	50.01	8.13
	Median	3050	88	19.01	0.045	15.36	1.93
	Std. Dev.	1420	52	41.08	0.289	86.82	36.70
	Obs.	43	43	43	43	43	43
Medium	Mean	10894	149	56.16	0.030	4.12	2.13
	Median	10300	148	31.59	0.031	3.01	1.94
	Std. Dev.	3803	82	51.34	0.018	4.60	3.03
	Obs.	30	30	30	30	30	30
High	Mean	227348	245	72.74	0.026	0.49	2.20
	Median	68595	280	70.17	0.020	0.27	1.46
	Std. Dev.	362217	64	40.16	0.020	0.68	2.61
	Obs.	43	43	43	43	43	43

Table 3 (b): Quoted and Effective Spreads and Liquidity in 1900

		Average daily volume ($)	# of trading days	Avg. price	St. dev. of returns	Avg. spread	GKN	Amihud	GKN2 (%)
Preferred stocks:									
All	Mean	44814	168	69.55	0.021	0.018	0.018	2.23	0.94
	Median	13350	178	70.44	0.015	0.015	0.015	1.19	0.84
	Std. Dev.	131365	86	31.43	0.036	0.012	0.016	3.70	1.27
	Obs.	74	74	74	74	74	74	74	72
Low	Mean	6440	103	53.49	0.022	0.032	0.020	4.92	1.02
	Median	6900	94	49.38	0.021	0.034	0.021	3.39	1.54
	Std. Dev.	1853	46	31.26	0.009	0.011	0.010	4.60	1.66
	Obs.	17	17	17	17	17	17	17	17
Medium	Mean	15023	157	73.49	0.025	0.018	0.017	1.93	1.08
	Median	13200	164	75.26	0.017	0.015	0.015	1.22	0.86
	Std. Dev.	4619	79	32.35	0.049	0.007	0.011	3.51	1.30
	Obs.	39	39	39	39	39	39	39	37
High	Mean	145601	256	76.17	0.011	0.006	0.017	0.35	0.60
	Median	64905	273	73.07	0.011	0.006	0.009	0.26	0.68
	Std. Dev.	244514	56	25.37	0.004	0.003	0.027	0.32	0.61
	Obs.	18	18	18	18	18	18	18	18
Common stocks:									
All	Mean	152544	188	55.40	0.027	0.028	0.026	10.08	1.09
	Median	13000	211	36.55	0.022	0.017	0.019	1.60	0.95
	Std. Dev.	460846	92	48.20	0.019	0.029	0.022	33.07	2.18
	Obs.	129	129	129	129	129	129	129	125

Low	Mean	4292	128	26.22	0.040	0.052	0.039	23.86	2.05
	Median	3474	117	15.72	0.034	0.043	0.031	7.25	2.23
	Std. Dev.	2529	72	29.62	0.023	0.032	0.024	49.76	2.97
	Obs.	51	51	51	51	51	51	51	48
Medium	Mean	14806	189	57.10	0.021	0.019	0.023	2.32	0.76
	Median	13668	220	46.08	0.018	0.017	0.021	1.60	0.86
	Std. Dev.	4726	84	44.77	0.010	0.010	0.014	2.07	1.25
	Obs.	29	29	29	29	29	29	29	28
High	Mean	388365	250	84.76	0.017	0.007	0.013	0.34	0.35
	Median	142643	285	78.27	0.015	0.006	0.009	0.13	0.51
	Std. Dev.	689013	72	48.23	0.009	0.005	0.015	0.50	1.12
	Obs.	49	49	49	49	49	49	49	49

Table 3 (c): Quoted and Effective Spreads and Liquidity in 1910

		Average daily volume ($)	# of trading days	Avg. price	St. dev. of returns	Average spread	GKN measure	Amihud	GKN2 (%)
Preferred stocks:									
All	Mean	24427	144	75.77	0.021	0.030	0.031	2.45	0.54
	Median	11940	134	75.56	0.014	0.017	0.016	0.75	0.78
	Std. Dev.	45570	78	32.21	0.022	0.033	0.033	6.57	2.02
	Obs.	68	68	68	68	68	68	68	68
Low	Mean	7198	89	64.23	0.029	0.049	0.038	5.02	0.70
	Median	7298	88	68.42	0.016	0.035	0.034	1.67	1.06
	Std. Dev.	2403	47	28.56	0.031	0.043	0.030	9.75	2.50
	Obs.	28	28	28	28	28	28	28	28
Medium	Mean	15684	158	81.18	0.016	0.020	0.029	0.83	0.37
	Median	12900	155	75.29	0.014	0.016	0.015	0.61	0.89
	Std. Dev.	4346	61	31.89	0.010	0.014	0.040	0.64	1.94
	Obs.	27	27	27	27	27	27	27	27
High	Mean	79694	234	89.39	0.013	0.008	0.018	0.30	0.58
	Median	33125	253	95.68	0.009	0.008	0.015	0.24	0.45
	Std. Dev.	85831	67	34.31	0.007	0.003	0.015	0.21	0.64
	Obs.	13	13	13	13	13	13	13	13
Common stocks:									
All	Mean	332468	191	70.28	0.026	0.030	0.030	5.02	0.98
	Median	18172	209	58.37	0.020	0.017	0.021	0.80	0.80
	Std. Dev.	1560956	83	52.11	0.024	0.041	0.029	13.92	2.49
	Obs.	114	114	114	114	114	114	114	114

Low	Mean	4795	136	26.59	0.049	0.070	0.053	16.17	2.02
	Median	4156	128	20.78	0.039	0.054	0.048	8.03	2.48
	Std. Dev.	3132	68	22.36	0.033	0.060	0.034	22.94	4.31
	Obs.	32	32	32	32	32	32	32	32
Medium	Mean	15805	167	73.85	0.021	0.024	0.027	1.16	0.60
	Median	15175	175	63.84	0.022	0.020	0.020	1.01	1.06
	Std. Dev.	3854	71	52.84	0.007	0.013	0.026	0.66	1.27
	Obs.	34	34	34	34	34	34	34	34
High	Mean	775221	245	96.87	0.014	0.008	0.018	0.31	0.56
	Median	63328	272	100.99	0.012	0.008	0.012	0.15	0.53
	Std. Dev.	2347831	67	46.98	0.006	0.004	0.016	0.57	0.71
	Obs.	48	48	48	48	48	48	48	48

Table 4: Spread Decomposition Regression and the Implied Components

The dependent variable is the annually estimated spread. The independent variable is the average quoted spread. t-statistics are given in parentheses.

	C	Spread	R^2	Obs.	Avg. spread (%)	Order-processing cost component (%)	Asymmetric information component (%)	Avg. spread ($)	Order-processing cost component ($)	Asymmetric information component ($)
Common 1900	0.0116	0.5080	0.44	129	2.76	1.40	1.36	0.87	0.44	0.43
	(5.96)***	(7.55)***								
High	0.0064	0.9884	0.18	64	0.92	0.90	0.01	0.60	0.59	0.01
	(2.40)**	(4.84)***								
Low	0.0145	0.4605	0.38	65	4.57	2.10	2.46	1.14	0.53	0.62
	(3.97)***	(5.48)***								
Common 1910	0.0210	0.3073	0.19	114	3.00	0.92	2.08	1.33	0.41	0.92
	(4.26)***	(1.62)								
High	0.0169	0.2086	0.01	57	0.99	0.21	0.79	1.04	0.22	0.82
	(4.54)***	(0.79)								
Low	0.0300	0.2288	0.13	57	5.01	1.15	3.87	1.63	0.37	1.26
	(5.27)***	(2.84)***								
Preferred 1900	0.0127	0.2896	0.04	74	1.82	0.53	1.30	1.14	0.33	0.81
	(3.40)***	(1.92)*								
High	0.0101	0.5873	0.03	37	1.06	0.62	0.44	0.67	0.39	0.28
	(2.09)**	(2.22)**								
Low	0.0127	0.2679	0.06	37	2.59	0.69	1.89	1.61	0.43	1.18
	(2.80)***	(1.48)								
Preferred 1910	0.0182	0.4204	0.18	68	2.96	1.24	1.71	1.76	0.74	1.02
	(3.84)***	(5.09)***								
High	0.0260	-0.2442	0.01	34	1.40	0	1.75	1.20	0	1.20
	(2.93)***	(-0.47)								
Low	0.0192	0.4322	0.26	34	4.51	1.95	2.56	2.33	1.01	1.32
	(2.45)**	(3.33)***								

Table 5: Price Discreteness Regressions

Dependent variable is the proportion of quotes that are multiples of one half.

	Variable	Coefficient	Std. Error*	t-Statistic	Prob.
1900	*Intercept*	1.1626	0.0725	16.0253	0
	log(V)	-0.1086	0.0071	-15.2068	0
	Preferred	-0.0136	0.0169	-0.8076	0.4203
	log(Days)	-0.0433	0.0123	-3.5296	0.0005
	log(P)	0.2107	0.0119	17.6949	0
	Var	0.5653	0.5021	1.1259	0.2616
	Dummy(Consolidated)	-0.0878	0.0275	-3.1854	0.0017
	*Dummy(Consolidated)*Var*	62.7739	22.4289	2.7988	0.0056
	R-squared	0.7902	Observations:		203
	Variable	Coefficient	Std. Error*	t-Statistic	Prob.
1910	*Intercept*	1.2397	0.0946	13.1022	0
	log(V)	-0.0988	0.0099	-9.9885	0
	Preferred	-0.0196	0.0160	-1.2281	0.2211
	log(Days)	-0.0543	0.0138	-3.9422	0.0001
	log(P)	0.1797	0.0167	10.8057	0
	Var	4.6245	1.8659	2.4784	0.0141
	Dummy(Consolidated)	-0.0709	0.0288	-2.4646	0.0147
	*Dummy(Consolidated)*Var*	35.8994	17.3608	2.0678	0.0401
	R-squared	0.7812	Observations:		182

*White Heteroskedasticity-Consistent Standard Errors & Covariance

Table 6

Factors increasing spread	Available proxy variable	Expected relationship to spread
Fundamental risk of security returns	Variance of returns	Positive
	Preferred shares	Negative
Transaction size (inventory holding)	Daily or monthly volume/days traded (lumpiness)	Positive
	Skewness of volume	Negative
Illiquidity of market	Trading volume, stock price	Negative
Probability of informed trade	Number of trading days, total trading volume	Negative
	Transaction size (lumpiness)	Positive
	Skewness of volume	Negative
Lack of fundamental information availability	Firm size, age, information availability, preferred shares	Negative
Market power of specialists	Price discreteness	Positive

Table 7: Determinants of Average Spreads and the Amihud Liquidity Measure

This table presents the results of a least absolute deviations (LAD) estimation. All continuous variables are monthly averages. *Dummy(Rail)* equals 1 if the issuing firm was a rail company and zero otherwise. *Dummy(Consolidated)* equals 1 if more than 100 shares traded on the Consolidated on at least one of 12 randomly selected days and zero otherwise. The estimation corrects for heteroskedasticity in the error structure using the Huber sandwich standard errors and covariances. t-statistics are given in parentheses.

	Spread 1900		Spread 1910		Amihud 1900		Amihud 1910	
Indep. Variables	Common	Preferred	Common	Preferred	Common	Preferred	Common	Preferred
C	0.099	0.101	0.108	0.122	1.203	7.402	3.811	7.355
	(25.71)***	(15.65)***	(14.96)***	(13.52)***	(1.06)	(6.61)***	(3.64)***	(4.06)***
$\log(V_t)$	-0.002	-0.002	-0.001	-0.002	-0.227	-0.368	-0.024	-0.310
	(-8.83)***	(-5.65)***	(-3.46)***	(-2.45)**	(-2.40)**	(-7.30)***	(-0.58)	(-5.40)***
$\log(P_{t-1})$	-0.004	-0.008	-0.007	-0.011	-0.181	-0.661	-0.783	-0.958
	(-9.68)***	(-8.88)***	(-7.67)***	(-6.56)***	(-0.939)	(-3.89)***	(-6.26)***	(-2.55)**
Var_{t-1}	2.020	-0.139	0.520	3.985	316.322	106.138	429.648	128.597
	(2.20)**	(-0.87)	(10.80)***	(2.27)**	(0.31)	(0.53)	(2.84)***	(0.24)
Var_{t-1}^2	30.030	-0.058	-2.381	-320.562	-16031.23	1371.222	-1304.186	-71.045
	(0.86)	(-0.12)	(-15.55)***	(-3.65)***	(-0.14)	(0.21)	(-2.50)**	(-0.24)
$\log(Days_t)$	-0.016	-0.012	-0.019	-0.014	0.501	-0.059	-0.013	0.098
	(-15.07)***	(-7.73)***	(-8.86)***	(-9.00)***	(2.03)**	(-0.47)	(-0.07)	(0.83)
Dummy(Rail)	-0.001	-0.002	0.001	-0.001	0.222	0.014	0.066	-0.073
	(-2.93)***	(-3.05)***	(1.55)	(-1.64)	(2.11)**	(0.20)	(1.14)	(-1.01)
$Amihud_{t-1}$	0.0004	0.0004	0.0011	0.0008				
	(5.74)***	(3.13)***	(8.10)***	(16.79)***				
$Spread_{t-1}$					102.539	17.562	46.082	23.658
					(4.64)***	(5.38)***	(2.89)***	(10.66)***
$Skewness\ of\ Sales_{t-1}$	-0.001	0.000	0.000	0.000	-0.043	-0.021	-0.034	-0.007
	(-3.31)***	(-0.65)	(-0.35)	(0.16)	(-0.56)	(-0.38)	(-0.75)	(-0.15)
Dummy(Consolidated)	-0.0017	-0.002	-0.002	0.002	0.437	0.083	-0.185	0.069
	(-3.02)***	(-2.73)***	(-3.38)***	(1.63)	(3.25)***	(0.75)	(-2.10)**	(0.69)
No. of Observations	1215	725	1298	707	1148	691	1219	622
Pseudo R-squared	0.444	0.365	0.401	0.327	0.149	0.157	0.155	0.153
Adjusted R-squared	0.439	0.357	0.397	0.318	0.143	0.146	0.150	0.140

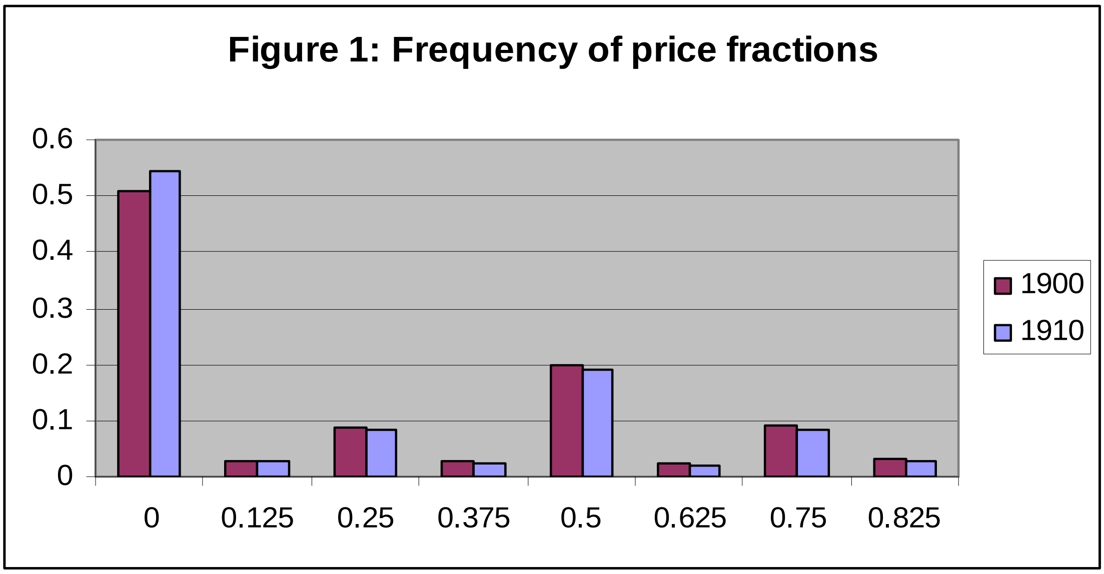
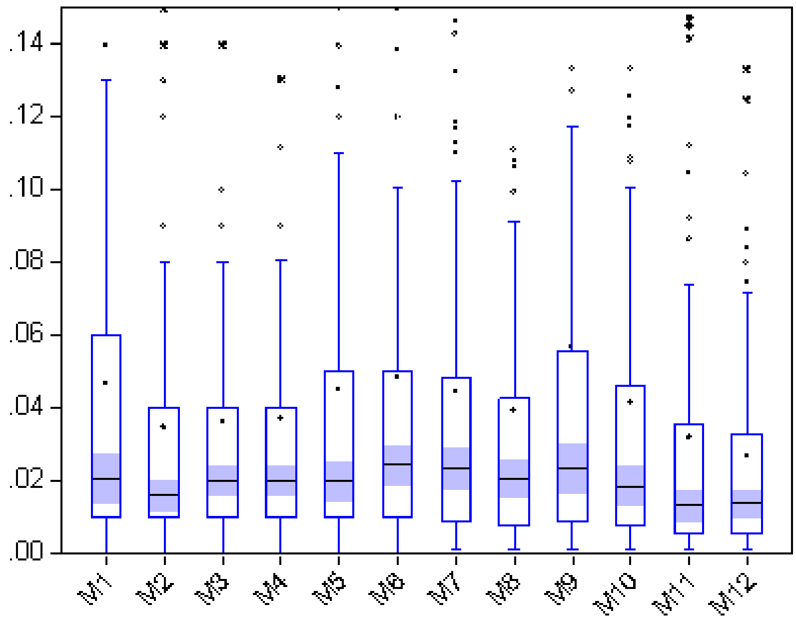


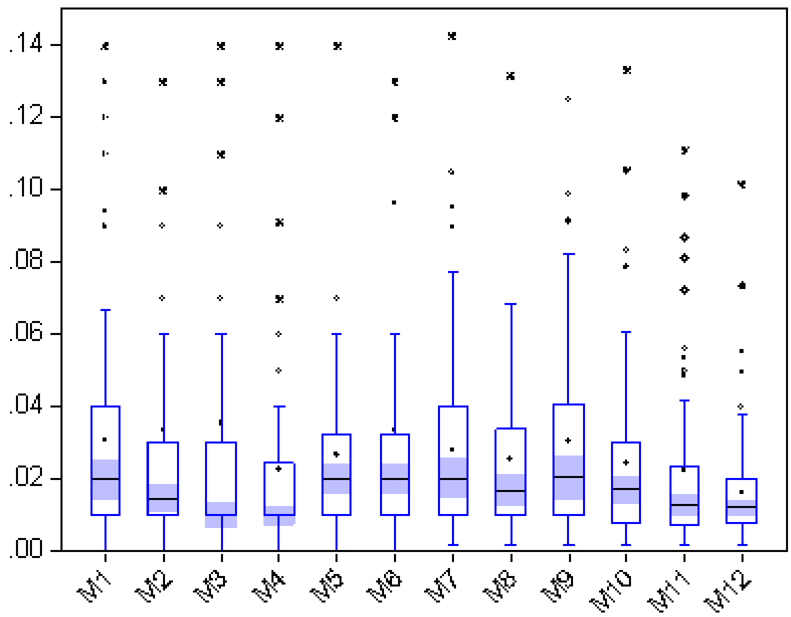
Figure 1: Frequency of price fractions
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.125
0.25
0.375
0.5
0.625
0.75
0.825
1900
1910

Figure 2: Boxplot graphs of the cross-section of monthly average spreads. The box contains the middle 50% of the data. The vertical line inside the box is the median and the black dot is the average. The shaded area gives the 95% confidence interval for the median. The whiskers show the highest or lowest value unless there are outliers in which case they extend up or down to 1.5 times the height of the box. Diamonds and stars denote near and far outliers, respectively. The graphs are cut off at 0.15.

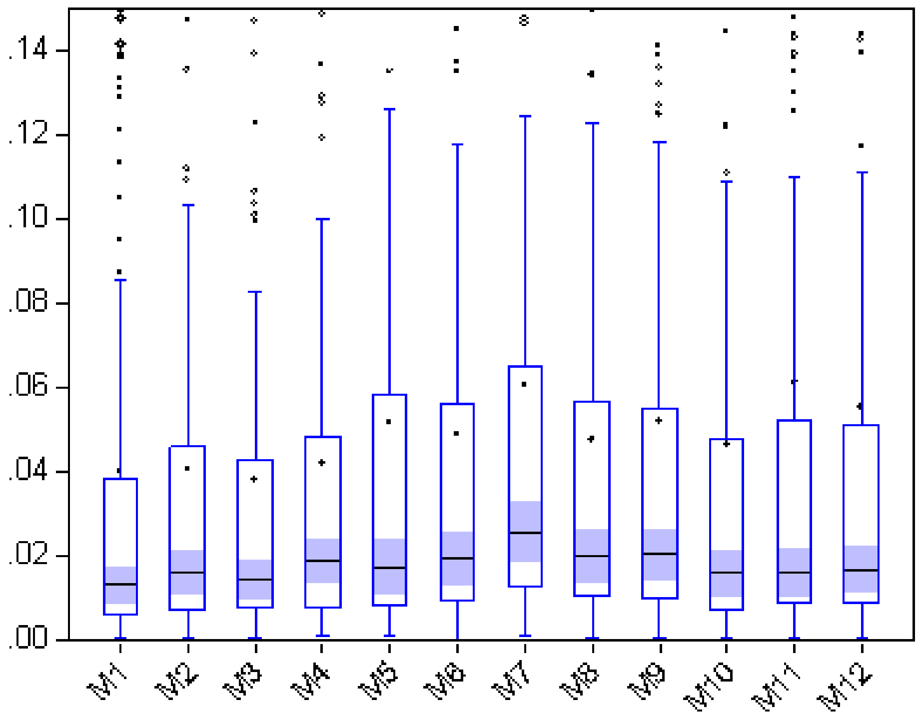
(a): Monthly average spreads of common stocks in 1900:



(b): Monthly average spreads of preferred stocks in 1900:



(c): Monthly average spreads of common stocks in 1910:



(d): Monthly average spreads of preferred stocks in 1910: