Counterparty Risk and the Establishment of the NYSE Clearinghouse

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Abstract

The recent financial crisis suggests that counterparty risk in markets without multilateral net settlement through a centralized clearing party (CCP) may pose a threat to financial stability. We study the effect of clearing on counterparty risk by examining a unique historical experiment, the establishment of a clearinghouse on the New York Stock Exchange (NYSE) in 1892. During this period, the largest NYSE stocks were also listed on the Consolidated Stock Exchange (CSE), which already had a clearinghouse netting trades. Using identical securities on the CSE as a control, we find that the introduction of netting on the NYSE reduced the average counterparty risk premium by 24bps and volatility by 26-42bps. Prior to clearing, shocks to overnight lending rates reduced the value of stocks on the NYSE, relative to identical stocks on the CSE, but this was no longer true after the establishment of clearing. We also show that at least ½ of the average reduction in counterparty risk is driven by a reduction in contagion risk through spillovers in the trader network. Our results indicate that clearing can cause a significant improvement in market stability and value through a reduction in network contagion and the counterparty risk premium.

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"For more than a century, financial stability has depended on the resilience under stress of clearinghouses and other parts of the financial infrastructure. As we rely even more heavily on these institutions in the United States and around the world, we must do all that we can to ensure their resilience, even as our financial system continues to evolve rapidly and in ways that we cannot fully predict."

– Federal Reserve Chairman Ben Bernanke April 4, 2011

1 Introduction

The recent financial crisis has brought to the forefront concerns about the role of counterparty risk in the stability of the financial system. Over the counter (OTC) securities, which include credit default swaps (CDS), interest rate swaps, and foreign exchange, are not required to engage in multilateral net settlement through a centralized clearing party (CCP). Instead, OTC asset markets often rely on bilateral netting and ad-hoc margin requirements. These OTC markets are sizable, and despite a reduction in volume following the financial crisis, the total gross exposures even after bilateral netting were more than $3.5 trillion as of June 2010[1]. Under bilateral netting, traders are exposed to additional counterparty risk through spillovers and contagion in the trading network. This follows because when one trader defaults, this can cause a second trader to default as well, possibly setting off a cascade which causes numerous defaults.

When new CDS contracts engage in multilateral netting, however, Cecchetti et al. (2009) estimate gross notional exposures are reduced by approximately 90 percent, reducing, at least theoretically, not only the possibility of an initial default, but also counterparty risk arising from contagion. Policy makers have responded to concerns about both default risk and contagion by passing the Dodd-Frank Act, which requires

[1] Bank for International Settlements

centralized clearing of many OTC derivatives, and substantially increases counterparty risk-based capital requirements for banks via Basel III.

Despite the response of policy makers, academic studies are unclear on the effects of multilateral clearing on asset value and stability . Duffie and Zhu (2010) is one of a growing number of theoretical papers that demonstrate that a single party clearing all derivative products should reduce counterparty risk, *ceterus paribus*, leading to lower volatility and higher asset value. Menkveld, et al. (2013), however, point out though that if the introduction of centralized clearing causes increases in collateral and margin requirements then the effect of funding and market liquidity on asset prices makes the response of prices theoretically ambiguous (see e.g. Acharya and Pedersen 2005, Brunnermier and Pedersen 2009, Garleanu and Pedersen 2011). Hence, identifying the effects of the introduction of multilateral netting is inevitably an empirical question.

Empirical identification of the effect of clearing on asset prices is challenging however. This is because asset markets rarely alter methods of settlement and when they do, the introduction is generally driven by events that violate the exclusion restriction on asset prices, such as financial crises. For example, the introduction of a CPP for equities in Nordic countries in 2009 was driven by the collapse of Lehman Brothers in the fall of 2008 and the resulting financial crisis (Menkveld, et al. 2013). Similarly the beginning of multilateral net settlement through a clearinghouse on the New York Stock Exchange (NYSE) in 1892 was driven by a variety of factors, most notably financial panics in the early 1890s (McSherry and Wilson 2013).

Fortunately, history provides an experiment to study the effects of a clearinghouse and netting on counterparty risk. During the late 19th and early 20th century, the

Consolidated Stock Exchange (CSE) was a major exchange that competed head-to-head with the Big Board, traded many NYSE listed securities, and averaged more than a 50 percent share in those securities it did trade during the 1890s. Located diagonally across the street from the NYSE, the CSE netted stock trades through a clearinghouse. Using dual-listed security prices on the CSE as a control, we can cleanly identify the casual effect on asset prices of the introduction of multilateral net settlement through a clearinghouse in a way that is difficult to replicate with modern data.

We find that the introduction of netting on the NYSE reduces the average counterparty risk premium by 24bps. The empirical analysis suggests that clearing increases rather than reduces equity values. This is also consistent with the findings in McSherry et al. (2013), who document a decline in broker defaults on the NYSE after the introduction of clearing. Because brokers had to fund positions overnight, daily borrowing rates were a major determinant of counterparty risk. Prior to the introduction of clearing, a one standard deviation (3.7 percentage point) increase in the overnight collateralized borrowing rate for brokers, also known as the call loan rate, is associated with an 8bp decline in the value of a stock on the NYSE relative to the identical security on the CSE. After the introduction of clearing, shocks to the call loan rate no longer affected prices on the NYSE relative to the CSE suggesting a decline in the volatility of NYSE prices. Consistent with this prediction, we find that the monthly volatility of the NYSE relative price falls 26-42bps after the introduction of clearing. We also contribute to the literature by using the staggered introduction of clearing on the NYSE to show that at least half of the average reduction in counterparty risk is driven by a reduction in contagion risk through spillovers in the trader network. Finally, we run a series of robustness tests to demonstrate that our results are driven by changes in counterparty risk coming from the introduction of clearing, rather than changes in asynchronous trading, market liquidity, or financial crises

In Section 2 we begin with a brief background on the introduction of clearing on the NYSE. In Section 3 we describe the data used in the project. In Section 4 we present the empirical methodology and predictions. Section 5 contains the empirical results. Section 6 concludes.

2 Historical and Institutional Background

2.1 Counterparty Risks on the NYSE Prior to Clearing

Like OTC derivatives today, , NYSE equities settled on a bilateral rather than a multilateral basis prior to the introduction of a clearinghouse in 1892. In the absence of multilateral netting, brokers are required to write and receive checks/securities for every transaction. To illustrate, consider the hypothetical set of transactions in Example 1.

Example 1. A visual representation of bilateral trades between three brokers.

Broker A sells 100 shares of stock for $10,000 ($100/share) to broker B and later in the day B sells 100 shares to C for $10,100. In the absence of multilateral netting broker C owes a check to broker B for $10,100 and broker B would owe a check to broker A for $10,000 resulting in $20,100 of checks and 200 shares of stock being transferred. There are direct counterparty risks since, for example, if broker B defaults (and has no wealth) broker A loses $10,000, but there is also a possibility of large spillovers causing contagion counterparty risk throughout the trading network. For example if broker C defaults (and has no wealth) broker B loses $10,100. If in turn this pushes broker B into default (and again has no wealth) then A loses $10,000. As we add more brokers into the network the chain of defaults can continue to grow. Depending on how interconnected the trading network is, the spillover from contagion could be a substantial component of total counterparty risk. If we could eliminate counterparty risk for a security A, it should also reduce the counterparty risk of a security B even if it is unrelated because there is less chance of a broker, or brokers he is trading with, defaulting on his positions. For clarity we will refer to the counterparty risk caused by network spillovers as *contagion risk* and the remaining as *direct counterparty risk*.

At the time the NYSE clearinghouse was introduced, securities traded on the NYSE settled at time T+1, which meant all brokers were required to deliver gross checks/securities from trades by the next day at 2:15pm, and brokers engaged in transactions with numerous other brokers throughout the day, so they rarely had enough assets on hand to pay every single transaction. Banks were forced to extend significant credit and day loans to brokers, typically using stock as collateral, to enable them to fulfill their daily contracts. This practice was called overcertification since banks endorsed checks which certified an amount greater than the balance in the broker's account[2], effectively providing short-term leverage to brokers to finance their daily positions. This bears a very strong similarity to modern broker-dealers who use the repo market and asset-backed commercial paper to provide short-term financing for trades in

[2] While technically illegal overcertification was endemic during the period and use by most brokers and banks to finance their overnight positions.

the OTC markets. McSherry and Wilson (2013) find that leverage, measured as the value of certified checks divided by total capital, for 9 “broker banks” increased from 1.4 to 9.0 from 1875 to 1882 with anecdotal evidence suggesting even higher leverage ratios in the 1890s. By comparison for a broad sample of banks from 2000-2009 find an average leverage of 12.4, where leverage is defined as the value of total assets divided by total equity (Kalemli-Ozcan et al. 2012).

Just as short-term collateralized financing rates in the modern period are set by repo rates, the overnight collateralized borrowing rate to buy and sell securities on margin, also known as the call loan rate in the late nineteenth and early twentieth century, could fluctuate wildly depending on the market environment. Although the call loan rate was usually close to longer-term borrowing rates, call loan rates were prone to seasonal increases during the harvest months and tended to sky-rocket during the numerous banking panics during this period (Miron 1986, Bernstein et al. 2010). For example during the Panic of 1907 the call loan rate reached a daily annualized value of 125% (Moen and Tallman 2003).

The volatility of funding costs to finance overnight positions led to substantial broker default and counterparty risk prior to the introduction of clearing. McSherry et al. (2013), citing Michie (1986), succinctly summarize the counterparty risk problems on the NYSE:

> “The daily settlement system tended to exaggerate crises. The short time before payment was due meant that it was difficult for either bankers or brokers to take measures to avoid crisis. Any tightening of the money available on the call-loan market had an immediate and all-embracing impact, since almost all borrowings were for day-to-day money. If stocks could not be immediately liquidated, or if prices dropped to the extent that loans were no longer covered, the brokers would be unable to repay the banks. For example, in 1890, when Decker, Howell & Co. failed, the Bank of North America had to suspend operations, leading to a general restriction of credit.”

Contemporary researchers, such as Sprague in 1903, also blamed the immediacy of the liquidity requirements inherent in the NYSE system of daily settlement for broker failures; which tended to spike during periods of financial tumult. He also noted that during periods of panic buyers could walk away from buy orders, leaving brokers with losses and potential defaults on overcertified checks. Anticipating this outcome, Wall Street banks and trust companies that normally participated in overcertification might withdraw the privilege extended to brokers. This is exactly what happened in the Panic of 1873 when banks suspended overcertification to NYSE brokers leading to a suspension of trading for nine days and 57 broker failures (Eames, 1894). By early 1892, R. L. Edwards, the President of the Bank of the State of New York, threatened that certification for brokers would be cut unless decisive action was taken to lessen the strain on bank lending and clerks, causing NYSE President Francis L. Eames to finally push for the creation of the New York Stock Exchange Clearing House in May (Pratt 1909).

2.2 Timing of Introduction of Clearing on the NYSE

On May 17th, 1892 the New York Stock Exchange began to test clearing by introducing multilateral netting for 4 firms. The decision to introduce clearing was driven by the financial panics of the early 1890s, concerns that banks would restrict overcertificaton again, and evidence on the effectiveness of multilateral netting already used on the Consolidated Stock Exchange[3]. That some of the same stocks were already cleared on the Consolidated Exchange allows us to disentangle the effects of economic events from the effects of clearing on counterparty risk. As indicated in the clearinghouse

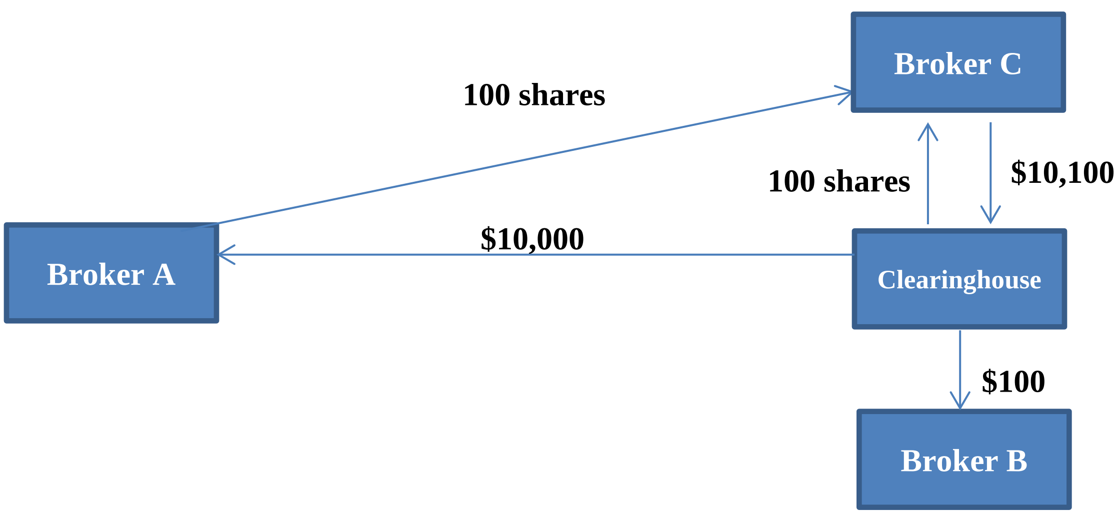
[3] Meeker (1922) also documents that without multilateral netting, it would have been physically impossible to maintain daily settlement. If, however, physical constraints were the main reason for the introduction of multilateral netting, a perhaps more plausible response would have been to increase the settlement period.

meeting minutes, the NYSE had pre-scheduled meeting dates and decided "the list of stocks to be cleared will be enlarged as members become familiar with the clearing system." Since having some NYSE stocks clearing had spillover benefits through a reduction in contagion risk for the remainder, the staged and independent timing of the introduction multilateral netting for different securities allows separate identification of contagion and direct counterparty risk. The NYSE continued to have meetings and clear additional stocks throughout the 1890s, although by the end of 1893 most of the major securities were clearing[4].

2.3 Reduced Counterparty Risk after Clearing

To understand the benefits of the introduction of clearing on the NYSE, we examine multilateral netting between three brokers.. The hypothetical set of transactions are shown in Example 2.

Example 2. A visual representation of multilateral netting between three brokers.



[4] For example, by the end of 1893 more than 80% of all Dow Jones stocks were clearing.

Each transaction a broker made was recorded on the broker's clearance sheet for a given day. In our example, A's clearance sheet had a single sale, C's clearing sheet had a single purchase, and B's clearance sheet had a purchase and a sale. It is at this stage that netting occured – and here, netting occured only for B. B bought 100 shares for $10,000 and A sold the same amount for $10,100[5]. The purchase and sale were netted out and B received the difference of $100. Broker A had a balance to deliver 100 shares valued at $10,000 and C had a balance to deliver of $10,100. Therefore, A wrote a draft on the Clearing House of $10,000; B wrote a draft for $200, and C wrote a check to the Clearing House of $10,200. By 10:00 a.m. the next day, the Clearing House returned a complete statement to each firm, specifying to whom a delivery must be made by 2:15 p.m. that day (here A delivered to C). Creditors to the Clearing House received checks for their remaining balances by noon, which were then deposited in the bank (American Bankers Association 1910)[6].

In the case of gross bilateral clearing there were $20,100 worth of checks and 200 shares which could be defaulted on, but after multilateral netting there were only $10,100 worth of checks and 100 shares to be transferred. There was reduction in direct counterparty risks since with multilateral netting, if broker B defaulted (and had no wealth) broker A lost nothing. There was also a reduction in spillovers causing contagion counterparty risk throughout the trading network. For example, if broker C defaulted (and had no wealth) broker A lost $10,100 and if broker A defaulted (and had no wealth)

[5] This simple example overlooks one complication. In reality, delivery prices were not simply what one paid or sold his or her shares for, but were instead determined by the Clearing House. At the end of each day, representatives set an arbitrary price based on the quotation of the last day's sales, which was then announced over the ticker (Pratt 1909).

[6] These exact times may have varied throughout the years, but they provide a rough picture of the daily operations of the Clearing House.

broker B lost only $100. With multilateral netting as we add more brokers into the network the chain of defaults does not grow, as it might with bilateral netting. Therefore the introduction of multilateral netting causes a reduction in both contagion and direct counterparty risk[7].

It may not be surprising then that in the years immediately following its implementation in 1892, the Clearing House proved wildly successful in reducing the counterparty risk on the NYSE. In the post-Clearing House period (i.e. between 1892 and 1920), it has been estimated that the demand for day loans from certifying banks decreased by nearly 65 percent, and 90 percent of all checks were eliminated (Pratt 1909). On average, transactions in securities valued at $25 million necessitated only $5 million to change hands. In one case, 204,000 shares, valued at $12.5 million were settled by a payment of only $10,000 (Meeker 1922). The reduction in counterparty risk was immediately apparent during the crisis of 1893. NYSE president Frances Eames noted that

> "Bank officers have expressed the opinion that, during the Panic of 1893, failures in the Stock Exchange would have been vastly more numerous had there been no clearing system in operation…it was thought by some that, without the clearing system, the panic of that summer [1893] would have necessitated the closing of the Exchange" (statements by Frances Eames in 1894 and 1896)

Consistent with the contemporaneous accounts McSherry et al. (2013) hand-collect NYSE broker defaults from 1879-1908 and find that even though trading volumes and call loan rate spikes were higher after the introduction of the clearinghouse, the average number of broker defaults declined from 1.96/month to 0.58/month.

[7] These reductions can be substantial and result just from multilateral netting by the clearinghouse without any novation – that is, no risk-taking by the clearinghouse itself. This is consistent with the introduction of clearing on the NYSE in 1892 since novation would not be introduced until the 1920s.

2.4 Consolidated Stock Exchange: An Ideal Control

The Consolidated Stock Exchange, also known as the "little board," was established in New York City in1885 with 2,403 members as a direct competitor with the NYSE, also known as the "big board" (Michie 1986). Many of the stocks listed on the NYSE also actively traded on the CSE and although there was less trading volume and market liquidity for those stocks on the CSE, it still averaged a respectable 23 percent market share (Brown et al. 2008) over its 40-year history. While the NYSE waited until 1892 to introduce clearing, the CSE began multilateral net settlement in 1886. As noted by McSherry and Wilson (2013) , one of the motivations for the NYSE introducing clearing was that by introducing clearing the CSE had "reduced financing needs and also lowered counterparty risk and broker defaults." In addition they note that:

> "When the stringency came [in the panic of 1890 and 1891], many failures resulted from the impossibility of procuring the necessary loans. On the other hand, on the Consolidated Stock Exchange of New York, the failures were comparatively few… This difference was ascribed solely to the fact that one institution attempted to carry on its business by old fashioned methods, while the other was equipped with a modern clearing system. The explanation is easily accepted with the comparative ease with which the Stock Exchange has weathered similar troubles since the clearing house was adopted."

We hand-collected information on broker defaults from the Annual Reports of the CSE and find that consistent with the contemporaneous accounts the CSE clearinghouse was successful in minimizing counterparty risk. We find that losses from broker defaults were less than 0.03% in 1893, a year that included one of the most severe financial panics in American history.

Therefore, prices on the CSE for NYSE-CSE dual-listed stocks provide an almost ideal control for the price response on the NYSE to the introduction of clearing. This is why the introduction of clearing on the NYSE can be used to identify the casual effects of multilateral netting. In addition to having cross-listed securities, we also benefit from the close proximity of the two exchanges[8]. Since the two exchanges were diagonally across the street from each other, arbitrageurs could effectively prevent price discrepancies between the two exchanges not caused by "real differences" such as market liquidity or counterparty risk premia. Nelson (1907) dedicates an entire chapter to the "expertise" of arbitrageurs on the Consolidated who were, he felt, only exceeded in their expertise by the arbitrageurs on the NYSE. Another benefit of their proximity is that both exchanges paid in the same currency. Cross-listed securities in markets quoted in different currencies are confounded by the need to convert currencies using OTC FX markets. Normally this is not problematic, but since these markets are OTC, during times of financial distress, FX swaps may also include potentially significant counterparty risk. For example, Levich (2011) shows that immediately following the Lehman bankruptcy covered interest rate parity in the highly liquid FX swap GBP/USD deviated from no arbitrage conditions (in the absence of counterparty risk) by hundreds of basis points.

3 Data Description

3.1 Security Market Data

We focus our empirical analysis on common stocks in the Dow Jones Indices using monthly data from September 1886 – December 1925 since these securities

[8] Another benefit than the ones listed here is that since both exchanges were in the same time zone daily data on opening and closing prices are easily comparable. From May 21, 1887 to Sept. 29, 1952 on the NYSE, trading hours were: Monday-Friday 10 a.m. – 3 p.m.; Saturdays, 10 a.m. – noon. This is not only because it reduces timing mismatches in the quotes, but also because they are comparable periods of the trading day. Oftentimes opening and closing price behavior can behave differently and while high frequency quotes allow for quotations across time zones at the same time of day this can't be done while also preserving the period of the trading day considered.

tended to be very liquid and traded on both the NYSE and CSE (Brown et al. 2008). We use the original Dow Jones Index from September 1886 until October 1896, when the index is then split into the Dow Jones Railroad Index and the Industrial Index. We use hand-collected data from the *New York Times* and *Commercial and Financial Chronicle* for each security in the index at a given point in time and rely on Farrell (1972) for changes in the composition of the indices. Data are sampled from the last trading day of each month. We collected firm-specific information on NYSE high, low, open, and closing transaction prices, bid and ask closing prices, and trading volume . For NYSE stocks listed on the CSE, we use data on CSE closing prices as well as CSE trading volume. For our robustness checks, we hand-collected daily data on high, low, close, and open transaction prices as well as trading volumes from January 1892- December 1901 for all stocks on both exchanges[9]. In addition, we collect daily closing bid and ask quotes on the NYSE starting in 1893[10]. We also use end-of-month broker call loan rates from the NBER macro-history database for the entire sample period. We construct an absolute difference estimator using daily high, low, open, and closing transaction prices to estimate CSE bid-ask spreads and NYSE bid-ask spreads prior to 1893. Our estimated NYSE bid-ask spreads have an 88% correlation with actual bid-ask spreads on the Big Board from 1892-1925. Our estimator performs slightly better in-sample than that used by Corwin and Schultz (2012), which has an 81% correlation with actual NYSE spreads over the same period. In addition, our estimator has the desirable property that unlike that

[9] We are currently working to collect additional data to improve the sample period before and after the introduction of clearing for our robustness analysis.
[10] Beginning on May 24, 1882, the *New York Times* reports NYSE bid-ask spreads on a daily basis. The data on daily bid-ask spreads continue through April 14, 1886. Between April 15, 1886, and May 12, 1893, the *New York Times* does not report bid-ask spreads for the NYSE. In this time interval, we gather monthly bid-ask spread data from the *Commercial and Financial Chronicle*. The bid-ask spread data are reported for Thursday trading and are matched with the appropriate trading volume data from the *New York Times*.

used by Corwin and Schultz, it is always positive, which was not the case for our Corwin-Schultz bid-ask estimates in our sample period. For more details on the methodology and a comparison of the bid-ask spreads see the appendix.

3.2 Clearinghouse Data

The NYSE started clearing securities in stages, beginning with four stocks in May 17th, 1892, followed by four stocks each week. By 1894, more than 90% of volume was cleared on the exchange. Only a handful of stocks were added to the clearinghouse each year. The dates stocks were added and dropped from clearing on the NYSE were hand collected from the minutes of the *Committee on the Clearing House of the New York Stock Exchange* at the New York Stock Exchange archives. The recorded minutes of the clearinghouse hese were useful for understanding the function and implementation of netting trades on the exchange. Data on broker defaults on the NYSE were collected from the NYSE archives *Committee on Admissions* and *List of Suspended Members.* Information on CSE broker defaults were collected from the *Annual Reports of the Consolidated Stock and Petroleum Exchange of New York.*

4 Empirical Methodology

4.1 Model

In the presence of counterparty risk and market liquidity costs, we can write the price of an asset as its fundamental value minus market liquidity costs and counterparty risk plus market microstructure effects:

$$P_{i,t,E} = P_{i,t}^{Fun} - P_{i,t,E}^{MktLq} - P_{i,t,E}^{CP} + \epsilon_{i,t,E} \qquad (1)$$

where $P_{i,t,E}$ is the price on exchange E (either NYSE or CSE) for stock i at time t, $P_{i,t}^{Fun}$ is the firm fundamental value, which is independent of exchange, $P_{i,t,E}^{MktLq}$ is the discount caused by the market liquidity premia which include both the explicit and implicit costs of trading[11] and how they co-vary with the pricing kernel (Acharya and Pedersen 2005, Brunnermier and Pedersen 2009, Garleanu and Pedersen 2011), $P_{i,t,E}^{CP}$ is the discount caused by the counterparty risk premium, and $\epsilon_{i,t,E}$ is market microstructure noise with mean zero, such as bid-ask bounce.

Therefore, for stocks on the NYSE,

$$P_{i,t,NYSE} = P_{i,t}^{Fun} - P_{i,t,NYSE}^{MktLq} - P_{i,t,NYSE}^{CP} + \epsilon_{i,t,NYSE}.$$

The expected change in the NYSE price after the introduction of clearing is therefore the change in the stock price caused by changes in the fundamental value and changes in the expected market liquidity and counterparty risk premia, or equivalently:

$$\mathrm{E}[\Delta P_{i,NYSE}] = E[\Delta P_i^{Fun}] - E[\Delta P_{i,t,NYSE}^{MktLq}] - E[\Delta P_{i,t,NYSE}^{CP}]. \qquad (2)$$

Furthermore, if we assume for simplicity that the expected market liquidity premium is the same before and after the introduction of multilateral netting, we can rewrite (2) as:

$$\mathrm{E}[\Delta P_{i,NYSE}] = \mathrm{E}[\Delta P_i^{Fun}] - E[\Delta P_{i,t,NYSE}^{CP}], \qquad (3)$$

where expected changes in price are driven by changes in expected fundamental value and the counterparty risk premium.

We are interested in estimating just the $E[\Delta P_{i,t,NYSE}^{CP}]$ caused by the introduction of multilateral netting. If the introduction of the clearinghouse were exogenous, we could simply estimate a panel regression

[11] The explicit costs includes commissions and the bid-ask spread, while implicit costs include price movement from larger orders (market depth) and borrowing costs to finance the trading position (margin).

$$P_{i,t,NYSE} = \alpha_i + D1_{\{clear,i,t\}} + \epsilon_{i,t}, \quad (4)$$

where $1_{\{clear,i,t\}}$ is a dummy variable indicating when a stock starts clearing and D is the average treatment effect of clearing on the stock price. The problem, as is made clear in equation (3), is that if the introduction of clearing coincides with changes in the fundamental value of the firm, the exclusion restriction is violated and casual interpretation of β_t as the effect of clearing on counterparty risk is no longer valid. In other words, since the introduction of multilateral netting through clearing is typically driven by or coincident with financial crises and other major market events any changes in firm value could be driven by the events rather than any changes caused by the introduction of clearing. For example, the introduction of clearing on the NYSE was driven, in part, by financial panics in the early 1890s (McSherry and Wilson 2013). Without an alternative identification strategy, it would be impossible to identify the effect of the introduction of the NYSE clearinghouse. Fortunately, our historical experiment provides a unique opportunity to do exactly this.

4.2 Dual-Listed Security Prices on CSE as a Control

Ideally, to determine the effect of clearing on counterparty risk, we would have prices for identical securities which do not experience any change in counterparty risk as a control and run a differences-in-differences analysis. Fortunately, such securities exist. During the late 19th and early 20th centuries, stocks were dual-listed on the NYSE and CSE. Further, there was no change in the trading environment at the CSE at the time the NYSE introduced its clearinghouse. For the CSE price we have that

$$P_{i,t,CSE} = P_{i,t}^{Fun} - P_{i,t,CSE}^{MktLq} - P_{i,t,CSE}^{CP} + \epsilon_{i,t,CSE}. \quad (5)$$

Using the CSE prices as a control, the difference in prices between the dual-listed securities is:

$$P_{i,t,NYSE} - P_{i,t,CSE} = P_{i,CSE}^{MktLq} - P_{i,NYSE}^{MktLq} + P_{i,t,CSE}^{CP} - P_{i,t,NYSE}^{CP} + \epsilon_{i,t,NYSE} - \epsilon_{i,t,CSE} \quad (6)$$

where the fundamental value drops out of the equation. Then looking at the difference after the introduction of clearing we have

$$\mathrm{E}[\Delta P_{i,NYSE}] - \mathrm{E}[\Delta P_{i,CSE}] = E[\Delta P_{i,t,CSE}^{MktLq}] - E[\Delta P_{i,t,NYSE}^{MktLq}] - E[\Delta P_{i,t,NYSE}^{CP}], \quad (7)$$

so that the difference-in-difference between the expected prices on the two exchanges is caused by changes in the relative market liquidity premium and changes in the counterparty risk premium on the NYSE. Notice that since there is no change in clearing on the CSE the expected change in the CSE counterparty risk premium, $E[\Delta P_{i,t,CSE}^{CP}]$, is zero and drops out of equation (7).

If the difference in expected market liquidity between the two exchanges is the same before and after the introduction of clearing on the NYSE[12], then the difference-in-difference in prices can be written as s

$$\Delta\mathrm{E}[P_{i,t,NYSE}] - \Delta\mathrm{E}[P_{i,t,CSE}] = -E[\Delta P_{i,t,NYSE}^{CP}], \quad (8)$$

which is a casual estimate of the effect of clearing on the counterparty risk premium. Formally, our baseline empirical specification is

$$\hat{P}_{i,t,NYSE} - \hat{P}_{i,t,CSE} = \alpha_i + D1_{\{clear,i,t\}} + X_{i,t}'\beta + \epsilon_{i,t}, \quad (9)$$

where $\hat{P}_{i,t,CSE}$ and $\hat{P}_{i,t,NYSE}$ are the normalized closing prices on the NYSE and CSE. Throughout our analysis we consider two normalizations for price: (1) dividing by the average closing prices on both exchanges and (2) dividing by the NYSE bid-ask spread.

[12] Of course, trading might migrate to the NYSE since the clearinghouse improved the NYSE trading environment which might result in a degradation of trading conditions on the CSE. However, as we later show, trading volumes and spreads on both exchanges remained relatively stable after the NYSE clearinghouse was introduced.

The former is natural since it is the percentage premium or discount an investor would require for holding the same stock on the NYSE relative to the CSE. The latter is also intuitive since it adjusts for the relative cost of trading the security and indicates how many bid-ask spreads the price on the NYSE deviates from the same security on the CSE. As discussed above, $1_{\{clear,i,t\}}$ is a dummy variable indicating when a stock starts clearing and D is the average treatment effect of clearing on the relative normalized stock prices. In addition, we include stock-specific time varying controls, $X_{i,t}$, including bid-ask spreads and volumes.

Last, it is important to note that in this specification, we are implicitly assuming that there are no spillovers in counterparty risk reduction when only a fraction of NYSE stocks join the clearinghouse. That is, it is likely that counterparty risk for stocks not yet cleared will almost certainly experience some reduction in counterparty risk once a sufficient fraction of NYSE stock volume is cleared. We investigate this effect, which we call *contagion*, in section 4.4.

4.3 Price Volatility Induced by Counterparty Risk

Since counterparty risk was driven by the costs of financing overnight positions, we would expect the counterparty risk premium to be small during periods of calm, but increase dramatically during times of financial market distress. Because the cost of financing overnight positions was likely much less after the onset of multilateral netting, its introduction may have significantly reduced or eliminated the impact of short-term financing shocks on NYSE stocks. Hence, interest rate shocks should not reduce stock prices on the NYSE relative to the CSE after the establishment of a clearinghouse[13]. We formalize this test by interacting call loan rates with the clearinghouse dummy to yield the following empirical model

$$\hat{P}_{i,t,NYSE} - \hat{P}_{i,t,CSE} = \alpha_i + D1_{\{clear,i,t\}} + D_2 C_t \times 1_{\{clear,i,t\}} + \phi C_t + X_{i,t}{}'\beta + \epsilon_{i,t} \quad (10)$$

where C_t is the call loan rate, ϕ is the estimated effect of call loan rate spikes on NYSE relative prices pre-clearing, and D_2 is the estimated effect of the introduction of clearing on call loan rate sensitivity.

Before the introduction of the NYSE clearinghouse, interest rate volatility,the volatility of the NYSE-CSE price spread, and NYSE return volatility will move in response to fluctuations in counterparty risk. The three measures of volatility should fall following the introduction of clearing. Suppose that we consider the change in volatility of the price difference, instead of the expectation, and make slightly stronger assumptions (relative to those needed to arrive at equation 8).[14]We can rewrite equation (8) as follows:

$$\Delta\sigma[P_{i,t,NYSE} - P_{i,t,CSE}] = \Delta\sigma[P^{CP}_{i,t,NYSE}] \quad (11)$$

Equation (11) indicates that the change in the volatility of the daily price premium provides an estimate of the change in counterparty risk volatility caused by clearing. We estimate the volatility of price spreads by taking the absolute value of the price differences on each date and then scaling to generate an estimate for the volatility[15].

[13] One might wonder whether the onset of multilateral netting might also affect the magnitude of interest rate shocks. Although this is theoretically a possibility, anecdotal evidence (see Meeker, 1922) suggests that the main driver of shocks to the call loan rate was the commercial paper market. Indeed Bernstein *et al.* (2010) find the correlation between the commercial paper rate and the call loan rate were over 90% during our sample period.

[14] Previously we assumed no changes in the relative market liquidity premium. In this case we need to assume no changes in the volatility of the market liquidity premium, but in addition we have to assume no change in the volatility of relative market microstructure noise or in the covariance between the counterparty risk premia, market liquidity premia, and/or market microstructure premia.

[15] If $X \sim N(\mu, \sigma)$ then the absolute value of X is distributed folded-normally distributed. If the expected normalized price difference is sufficiently small then the volatility is proportional to the absolute value of

4.4 Counterparty Risk and Contagion

Counterparty risk can be divided into two parts: contagion risk and direct counterparty risk. Contagion risk is higher for an asset, A, when a broker is more likely to default on their other positions, starting a cascade which results in default on a trade for asset A. When other stocks start to clear, contagion risk is smaller, even if asset A is not a member of the clearinghouse The reduction in direct counterparty risk is the direct effect of a stock clearing after accounting for any contagion risk reduction. One of the benefits of analyzing the introduction of clearing on the NYSE is that clearing was introduced in stages. Using prices on the CSE as a control again, we can decompose the volatility induced by counterparty risk by estimating the following model

$$\sigma[\hat{P}_{i,t,NYSE} - \hat{P}_{i,t,CSE}] = \alpha_i + D1_{\{clear,i,t\}} + \gamma PercClear_{i,t} + X_{i,t}'\beta + \epsilon_{i,t} \quad (12)$$

$PercClear_{i,t}$ is the percentage of stocks already clearing.[16] We also include a dummy for the stock that is clearing which allows a natural interpretation for D as the change in counterparty risk caused by direct counterparty risk, while γ is the percent caused by a change in contagion risk. Since the breakdown of these two types of risks depend on how connected traders of those securities are to the network of traders, we would expect these to vary across securities.

5 Results

X. In particular $\sigma \sim \sqrt{\frac{\pi}{2}} E[|X|]$. For the purposes of our paper this is the estimate we use, but we have also used estimates of μ and numerically solved for σ, but any reasonable estimates of μ are so small that any change in results are negligible. Results are available on request.

[16] We consider weights by both \$ sales and equally weighted, but focus on \$ sales for our primary analysis since it is more representative of the actual volume of trading of the security.

We first compare the sign and volatility of the counterparty risk premium before and after the introduction of clearing on the NYSE. To do so, we econsider equation (6):

$$P_{i,t,NYSE} - P_{i,t,CSE} = P_{i,CSE}^{MktLq} - P_{i,NYSE}^{MktLq} + P_{i,t,CSE}^{CP} - P_{i,t,NYSE}^{CP} + \epsilon_{i,t,NYSE} - \epsilon_{i,t,CSE}.$$

Since market liquidity is better on the NYSE than the CSE (Brown et al. 2008 and Table 1 summary statistics) we would expect $E\left[P_{i,CSE}^{MktLq} - P_{i,NYSE}^{MktLq}\right] > 0$, which means that when counterparty risk is small, stocks on the NYSE trade at a premium relative to the CSE. In the presence of counterparty risk, (i.e. in times of financial market crisis *before* stocks are cleared on the NYSE), stocks on the NYSE might well trade at a discount relative to the CSE because counterparty risk might be much larger on the NYSE than at the CSE. This means that in times of financial distress the sign of the left-hand side of equation (6) might be negative.

Since before the introduction of clearing on the NYSE the counterparty risk premium is likely to vary substantially with market conditions so that the sign of (6) should vary over time. If the introduction of clearing eliminates (or substantially reduces) the counterparty risk premium, equation (6) would imply that that after the onset of clearing on the NYSE , prices on the Big Board should be consistently higher than those on the CSE.

In Figure 1, we plot the 12-month moving average of the price on the NYSE minus the price on the CSE normalized by the NYSE bid-ask spread. Prior to the introduction of clearing the price difference is highly volatile, but after the introduction of clearing, it quickly stabilizes with the NYSE consistently trading at premium to the CSE. In Figure 2, we graph a portfolio of dual-listed stocks which is long the NYSE and short the CSE, rebalancing monthly. Cumulative returns are volatile prior to the introduction of clearing on the NYSE, but smoothly declining afterwards[17]. We formally test this hypothesis using empirical specification (9) in Table 2. The introduction of clearing on the NYSE reduces the average counterparty risk premium by 24bps or 73 NYSE bid-ask spreads. The specification includes firm fixed effects, clustering standard errors at a stock level, and identical securities on the CSE as a control. The market liquidity premium is larger than the counterparty risk premium leading to an average 9bp discount on the NYSE relative to the CSE before the introduction of clearing. Netting trades on the Big Board reduces the counterparty risk premium, causing NYSE stocks to trade at a 15bp premium. The results are robust to including stock-specific time-varying market liquidity controls on the NYSE and CSE, including the bid-ask spread on the NYSE, the dollar trading volume on the NYSE, and the dollar trading volume on the CSE.

We next investigate the drivers of the counterparty risk premium on the NYSE. Since brokers had to fund substantial levered positions overnight, shocks to overnight borrowing rates were an important determinant of counterparty risk prior to clearing on the NYSE. In Figure 1 we also plot the 12-month moving average of the collateralized overnight borrowing rate, the broker's call loan rate. As expected, prior to the introduction of clearing NYSE stocks tend to trade at a discount relative to identical securities on the CSE during periods when the call loan rate is high and at a premium when call loan rates are low.

After the introduction of clearing, shocks to call loan rates appear unrelated to changes in the NYSE-CSE relative prices. We test the hypothesis explicitly in Columns

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[17] These results are consistent since a higher price on the NYSE since, $P_{i,NYSE}^{MktLq} > P_{i,CSE}^{MktLq}$, implies a lower return on the NYSE, $E[R_{i,NYSE}^{MktLq}] > E[R_{i,CSE}^{MktLq}]$, since investors are compensated on the CSE for the additional market liquidity risk/costs.

4-6 of Table 2. Column 4 shows that there is not a statistically significant relationship between the normalized difference in NYSE and CSE prices and the call loan rate for the full sample period. This is because it is masked by the change in the relationship between call loan rates and counterparty risk after the introduction of clearing. In Column 5, we run the econometric specification described in equation (10) and find that before the introduction of clearing, a one percentage point increase in the call loan rate is associated with more than a 2bps reduction in the relative price of NYSE stocks that also trade on the CSE. The effect is not statistically significant, however, after the introduction of clearing. A one standard deviation increase in the call loan rate in the pre-clearinghouse period is associated with approximately an 8bp reduction in the price on the NYSE relative to the CSE[18]. As expected, we do not find evidence of a relationship between call loan rates and our normalized measure of relative NYSE-CSE prices in the post-clearinghouse period(see Column 6). The results are consistent with the introduction of clearing mitigating the impact of overnight funding shocks on counterparty risk for NYSE stocks.

Since after the introductions of clearing, shocks to the call loan rate no longer affect prices on the NYSE relative to the CSE, and call loan rates continue to be volatile after the introduction of clearing (see Figure 6), we would expect a decline in the volatility of NYSE returns coming from the reduction in the counterparty risk premium volatility. In Figure 3 we show the volatility of the counterparty risk premium and observe a dramatic decline after the introduction of clearing. We also find in Table 3 that the monthly volatility of the NYSE relative price falls 26bps or 1.16 NYSE bid-ask

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[18] The standard deviation of the call loan rate was 3.7 percent before the introduction of the NYSE clearinghouse.

spreads after the introduction of clearing. The results are robust to including stock-specific time-varying market liquidity controls such as bid-ask spreads on the NYSE and CSE and the broker call loan rate interacted with a post-clearinghouse dummy. The results represent a lower bound on the effects of clearing since other stocks clearing reduce the counterparty risk for non-clearing stocks, reducing the estimated effect of clearing on counterparty risk. Since most stocks were already clearing by the end of 1893, we include a post 1893 dummy variable instead of the post-clearinghouse dummy. Post-1893, the volatility of the counterparty risk premium fell by 42bps. These findings suggest that the introduction of the clearinghouse reduced the volatility of the counterparty risk premium by between 26 and 42bps.

In Table 4, we attempt to distinguish the effects of contagion risk through network spillovers from the effects of direct counterparty risk. We first include date fixed effects and find that the point estimate and significance for the effect of clearing on the counterparty risk premium volatility falls. This suggests the Consolidated control is affected by the treatment (i.e., clearing of NYSE stocks) and that there may be spillover effects in the trader network. To test this hypothesis, we estimate a model that includes both a dummy for clearing and for the percentage of all stocks clearing. The clearinghouse dummy is no longer significant and the percentage of stocks clearing captures all effects when normalizing by price[19]. The results are robust to including stock-specific time-varying market liquidity controls on the NYSE and CSE and the broker call loan rate interacted with a post-clearinghouse dummy.

[19] The co-efficient on the *% of Dow Clearing* has a natural interpretation since it is the expected reduction in counterparty risk if 100% of all other stocks clear.

When we consider the volatility of the counterparty risk premium normalized by the NYSE bid-ask spread however, we find that the effect of all other stocks clearing and the onset of clearing a particular stock are both significant and about the same size. This suggests that under the cross-sectional weighting that is, normalized by prices, contagion risk seems to explain all the reduction in counterparty risk. On the other hand, when we normalize instead by bid-ask spread, at least half the decline appears to come from direct counterparty risk. Since contagion risk depends on how connected traders of a given stock are to the rest of the trader network, there could be variation in the cross-section. In particular, we would expect stocks trading higher volumes on a day to be more affected by others stocks clearing because of they are more connected to the network. We test this explicitly in Column 5 of Table 4 by considering only stocks not yet clearing and including a dummy for stocks with high trading volume[20]. Consistent with the prediction, there is a 38bp reduction in counterparty risk premium volatility for high trading volume securities not yet clearing. The counterparty risk premium does not appear to be affected for low trading volume securities, however. The results are robust to normalizing by NYSE bid-ask spread instead of prices.

We run a number of robustness checks to test whether our results are driven by changes in counterparty risk coming from the introduction of clearing, or changes in asynchronous trading, market liquidity, or financial crises. If asynchronous trading declines after the introduction of clearing, this might confound interpretation of our results. In Figure 4, we see that despite the sudden decline in counterparty risk (shown in Figure 3), there is not a sudden increase in trading volume that would be consistent with a story about a decline or change in asynchronous trading for the two rival exchanges. .

[20] The *High Volume* dummy is 1 for stocks with a trading volume higher than the median trading volume.

The lack of any sudden change in volume is also inconsistent with results being driven by changes in relative market liquidity. We test this explicitly in Columns 1 and 2 of Table 5 and do not find a significant change in relative trading volumes after the introduction of clearing. We also show in Columns 3-6 of Table 5 that all baseline results are robust to restricting our analysis to only days with at least 500 shares (5 standard contracts) traded on both exchanges and including non-linear relative measures of market liquidity on both exchanges for each stock as a control. In Columns 1-3 of Table 6, we show that the basic tenor of the results remain unchanged when we use daily data for all stocks on the NYSE or CSE. The results hold if we consider only stocks with at least 20 observations before and after the introduction of clearing, including estimated bid-ask spreads on the CSE as a control, and using open instead of closing prices. Again the findings are not consistent with changes in asynchronous trading or market liquidity as drivers of the change in the relative NYSE-CSE price volatility after the introduction of clearing. Similarly in figure 5 and column 6 of table 6 we examine NYSE-CSE relative bid-ask spreads for the same securities. We do not find evidence of a sudden change in the relative market liquidity between the NYSE and CSE.

Another possibility is that the reduction in counterparty risk is driven by reduced macro-economic risk, independent of the introduction of clearing. The explanation seems unlikely since in the period after clearing there are numerous major panics, including the Panic of 1907, where call loan rates increased precipitously. Indeed, the incidence of financial crises did not fall until the introduction of the Federal Reserve (see Bernstein et al. 2010 and Figure 6). Our findings suggest that relative prices were no longer sensitive to call loan rate shocks after the introduction of clearing. In 1911 Shea noted that “the clearing system of the exchange was severely tested during the Panic of 1907, and its efficiency was fully demonstrated.” The results are also robust to restricting our analysis to the period prior to the passage of the Aldrich-Vreeland Act in 1909 and the subsequent introduction of the Federal Reserve (Column 7 of Table 5). This leaves a 17 year period after the introduction of clearing on the NYSE where financial crises were as frequent as the period prior to 1892.

6 Conclusion

In this paper, we have shown that the introduction of multilateral net settlement through a centralized clearing party can mitigate the effect on prices of counterparty risk. We use an historical experiment to examine the effects of netting trades through a clearinghouse on counterparty risk for NYSE stocks. We can identify the effect of introducing multilateral net settlement on NYSE stocks because the same securities were trading concurrently on the Consolidated Stock Exchange, arrival exchange that already had a centralized clearing party. This is important, because the introduction of clearing is usually driven by economic events, so that before vs. after comparisons can be contaminated by these events. In our setting, however, changes in counterparty and liquidity risk can be more easily attributed to the introduction of a clearinghouse. The results suggest that prior to the introduction of net settlement on the NYSE, identical stocks on the NYSE traded at a discount of 9bp relative to the Consolidated Stock Exchange, the NYSE’s principal competitor. After the establishment of a clearinghouse, NSYE stocks traded at a premium of 15bp. The difference of 24bp is statistically significant. Furthermore, the change can be attributed almost entirely to the reduction in counterparty risk.

Before netting trades, stocks on the NYSE traded at a premium relative to the same stocks on the CSE a great majority of the time. However, when overnight collateralized borrowing rates rose sharply, prices on the NYSE fell precipitously relative to those on the CSE. A one standard deviation increase in interest rates (3.7 percentage points) reduced the value of stocks on the NYSE by 8bp relative to identical stocks on the CSE. After the introduction of clearing, the difference between prices on the NYSE and the CSE were no longer affected by changes in the call loan interest rate.

The reduction in counterparty risk also reduced NYSE stock volatility by 26-42bps. We use the staggered introduction of clearing on the NYSE to show that at least half of the average reduction in counterparty risk is driven by a reduction in contagion risk through spillovers in the trader network. Overall, our results indicate that clearing can cause a significant improvement in market stability and increase asset value through a reduction in network contagion and the counterparty risk premium.

Appendix: Estimating CSE Bid-Ask Spreads

We use daily data from 1892-1901, which include estimated bid-ask spreads from the Consolidated Stock Exchange (CSE) for our robustness tests that are shown in Figure 5 and reported in Table 6. We estimate the bid-ask spreads since historical data on CSE bid and ask prices do not exist for this period. Daily data on open, high, and low transactions prices were hand collected from the *New York Times* from 1892-1901.

For our analysis, we consider a daily estimator of the bid-ask spread based on daily high and low prices presented by Corwin and Schultz (2012), which we will refer to as the CS estimator. We also constructed our own estimator which uses absolute differences (AD) of open and closing prices in addition to high and low prices to arrive at an estimate of the bid-ask spread. This is referred to as the AD estimator. We focus on estimators that utilize high and low prices, rather than time series covariance estimators, like in Roll (1984). Corwin and Schultz (2012) find that the standard deviation of their estimates is ¼ to ½ as large as the estimator presented in Roll (1984).

The high minus low price spread on a given day combines both the fundamental variance of a stock price as well as any bid-ask spread, but while the variance grows proportionally with time, the bid-ask spread does not. This is the basic insight behind the CS estimator which gives an estimate of the bid-ask spread by comparing the high-low price ratio over two consecutive days to the high-low price ratio on each of those days. In particular let, β, be the sum of the squared difference between the log of the high, *H*, and low prices, *L*, on two consecutive days, *t* and *t+1*,

$$\beta = E\left[\sum_{j=0}^{1}\left(\ln\left(\frac{H_{t+j}^{0}}{L_{t+j}^{0}}\right)\right)^{2}\right] \qquad (13)$$

and γ be the squared log difference of the high and low price over the two days,

$$\gamma = \left[ln \left(\frac{H^0_{t,t+1}}{L^0_{t,t+1}} \right) \right]^2 \tag{14}$$

then the CS estimate, *S*, for the bid-ask spread is

$$S = \frac{2(e^{\alpha} - 1)}{1 + e^{\alpha}} \tag{15}$$

where α is the following function of β and γ:

$$\alpha = \frac{\sqrt{2}\beta - \sqrt{\beta}}{3 - 2\sqrt{2}} - \sqrt{\frac{\gamma}{3 - 2\sqrt{2}}} \tag{16}$$

Corwin and Schultz find that this estimator has excellent properties, including a time series correlation between high-low spread estimates and true spreads of about 0.9. We find that even in our period, 1892-1901, there is an 83% time series correlation between the monthly average actual bid-ask spread on the NYSE and the CS estimated bid-ask spreads. One of the unfortunate properties of this estimator is that estimates of the bid-ask spread can be negative. In simulations, Corwin and Schultz show that for stocks with a true bid-ask spread of 50bps, setting negative values to zero results in an average estimate of the bid-ask spread of 143bps. As the true bid-ask spreads become larger, the number of negative values diminishes and the bias becomes negligible. Unfortunately, this does not appear to be the case in our analysis. When we use the CS estimator from 1892-1901, we find that more than ½ of all bid-ask spread estimates are negative. This is especially problematic in our analysis since in one of our normalization methods we divide by the bid-ask spread, so we need the bid-ask spread to be strictly positive. To avoid this issue we set negative values to the minimum bid-ask spread on the NYSE, 1/8th.

Since in our period more than half of all observations require this ad-hoc adjustment, we considered another bid-ask estimator as a robustness check. In particular, we estimate the bid-ask spread by taking the minimum non-zero pair-wise absolute differences (AD) between the open, close, high, and low prices on two consecutive days. The insight for the estimator is that if we observe two prices and there is no change in fundamental value, or the change is small relative to the minimum tick size, then if the prices differ, the absolute difference between them is equal to the bid-ask spread. In our period the tick sizes were 1/8th which means that as long as fundamental value between two prices differ by less than 1/16th and observed prices differ we can recover the exact bid-ask spread. Unlike the CS estimator the AD estimator is never negative, by construction, since the estimate is bounded below by the minimum1/8th tick size. In addition, Figure A1 shows that the AD estimator does a good job of predicting actual bid-ask spreads during this period. For NYSE stocks from 1892-1901, we find an 88 percent time series correlation between the monthly average actual bid-ask spread on the NYSE and the AD estimated bid-ask spreads and a 75 percent correlation in changes in the averages. This compares favorably with the CS estimator which has correlations of 83 percent and 57 percent in levels and changes respectively, which is why we use the AD estimator in our primary analysis. The bid-ask spread estimates using the AD and CS estimators have over an 80 percent correlation during this period. As shown in Figure A2, the results are robust to using either estimator[21].

[21] Results using CS estimator are available upon request.

Figure A1. Validity of Estimated Bid-Ask Spreads for CSE and NYSE 1892-1901

This figure shows bid-ask spreads for security market data hand collected at a daily frequency from the *New York Times* from January 1892 – Dec 1901 for all stocks on the NYSE or CSE. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. The blue line is the actual bid-ask spread on the NYSE. The red and green lines are the estimated bid-ask spread on the NYSE and CSE respectively using the absolute difference (AD) method. For a description of the estimation method see the appendix.

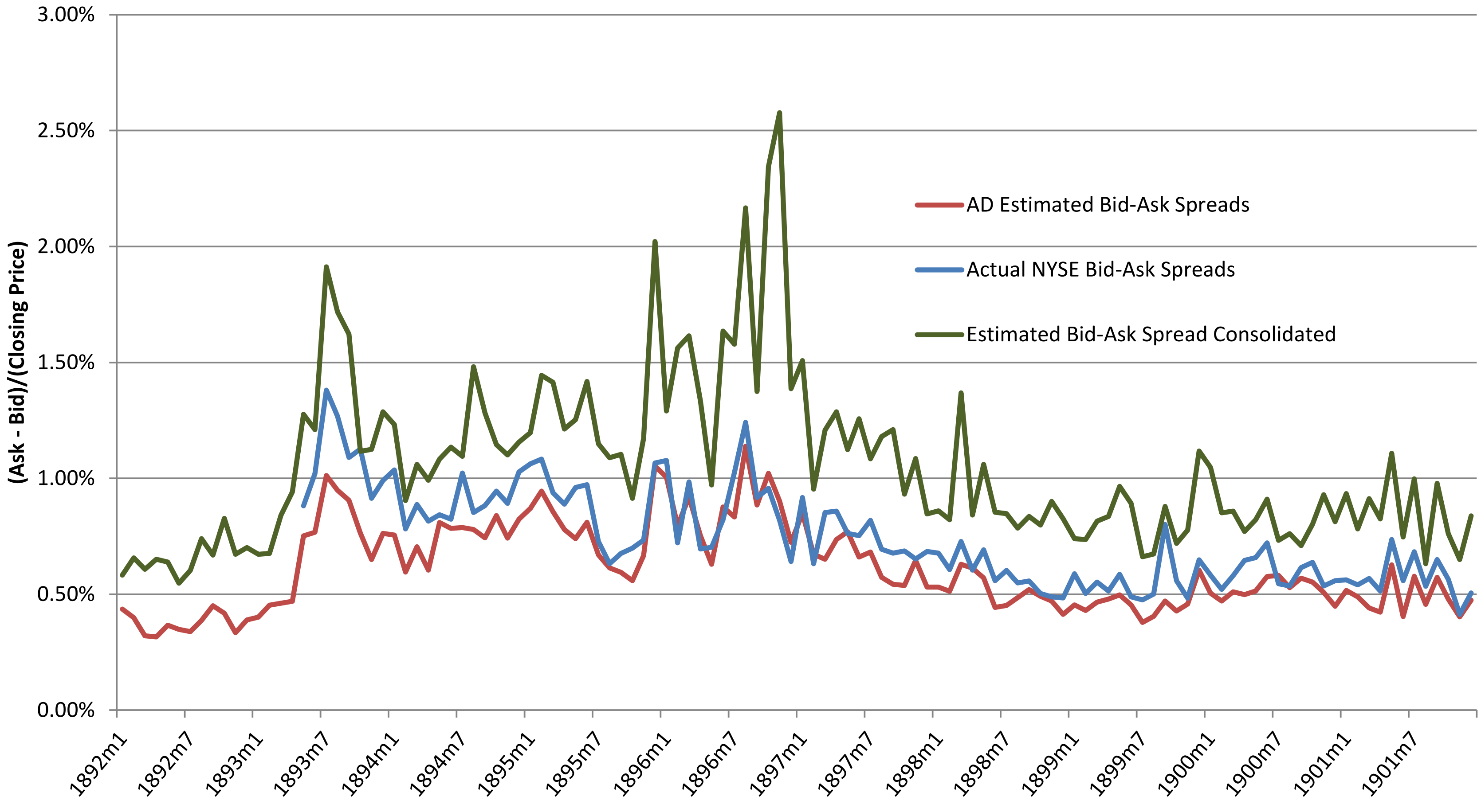

Figure A2. CS vs. AD vs. Actual Bid-Ask Spreads for NYSE 1892-1901

This figure shows bid-ask spreads for security market data hand collected at a daily frequency from the *New York Times* from January 1892 – Dec 1901 for all stocks on the NYSE or CSE. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. The solid black line is the actual bid-ask spread on the NYSE. The solid red and dashed blue lines are the estimated bid-ask spread on the NYSE using the absolute difference (AD) and Corwin-Schultz (CS) estimators, respectively. For a description of the estimation methods see the appendix.

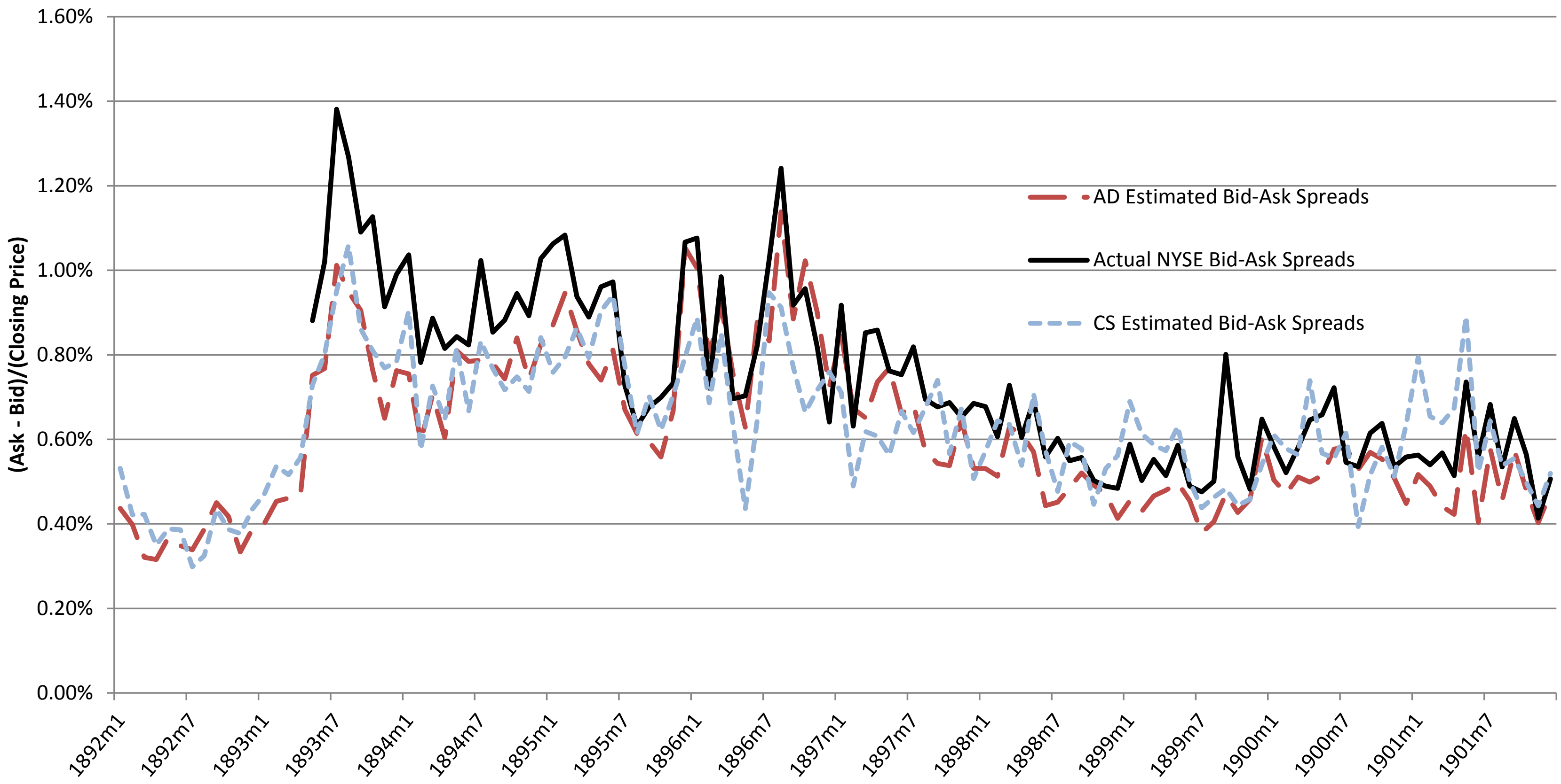

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Figure 1

Counterparty Risk Premium and Introduction of Netting on NYSE (1886-1925)

In this figure we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. *NYSE-Con/NYSE Bid-Ask* is the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE and *Call Loan Rate* is the overnight collateralized broker borrowing rate. The period prior to the establishment of the NYSE clearinghouse May 17th, 1892 is highlighted in red.

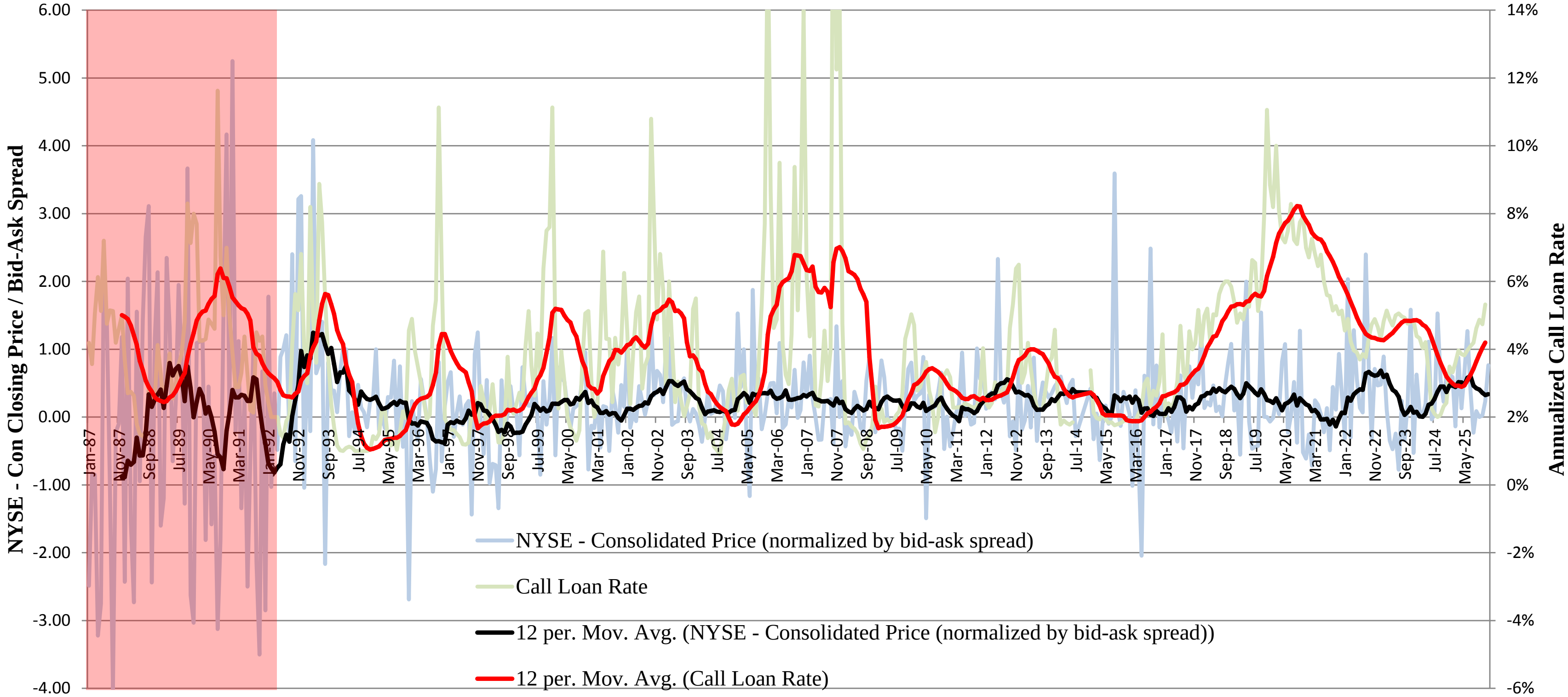

Figure 2

Long NYSE/Short CSE Cumulative Portfolio Returns (1886-1925)

In this figure we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. The blue plot on the left axis is the cumulative portfolio returns from going long a NYSE stock against the identical security on the CSE, equally weighted and rebalanced monthly. The black line on the right axis is the percent of stocks clearing on the NYSE who are members of a Dow Jones Index.

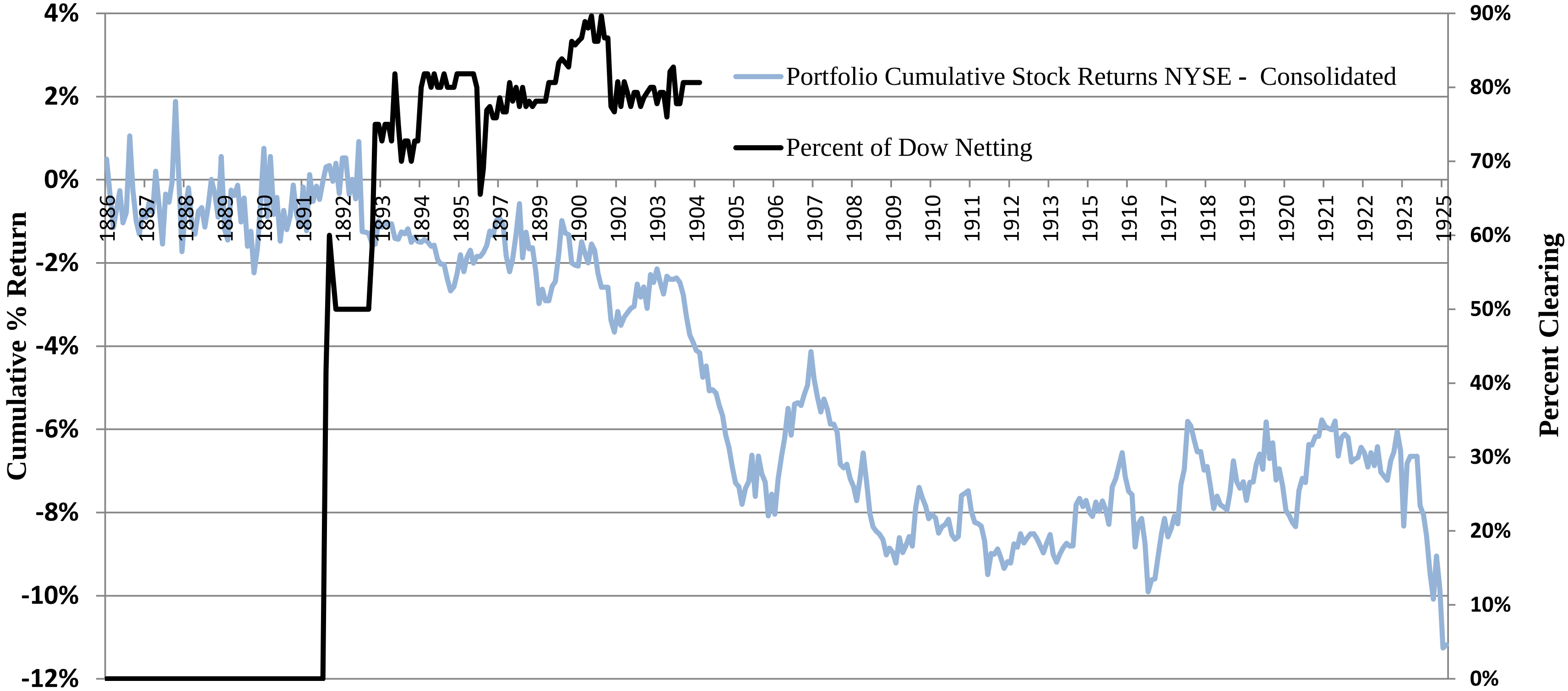

Figure 3.

NYSE-CSE Premium Volatility and Introduction of Netting on NYSE (1886-1925)

In this figure we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the *volatility* of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99^{th} percentile. The blue plot is the σ (*NYSE-CSE)/NYSE Bid-Ask* which is the estimated volatility of the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. The red dash lines indicate the average before and after the end of 1893. The black line on the right axis is the percent of stocks clearing on the NYSE who are members of a Dow Jones Index.

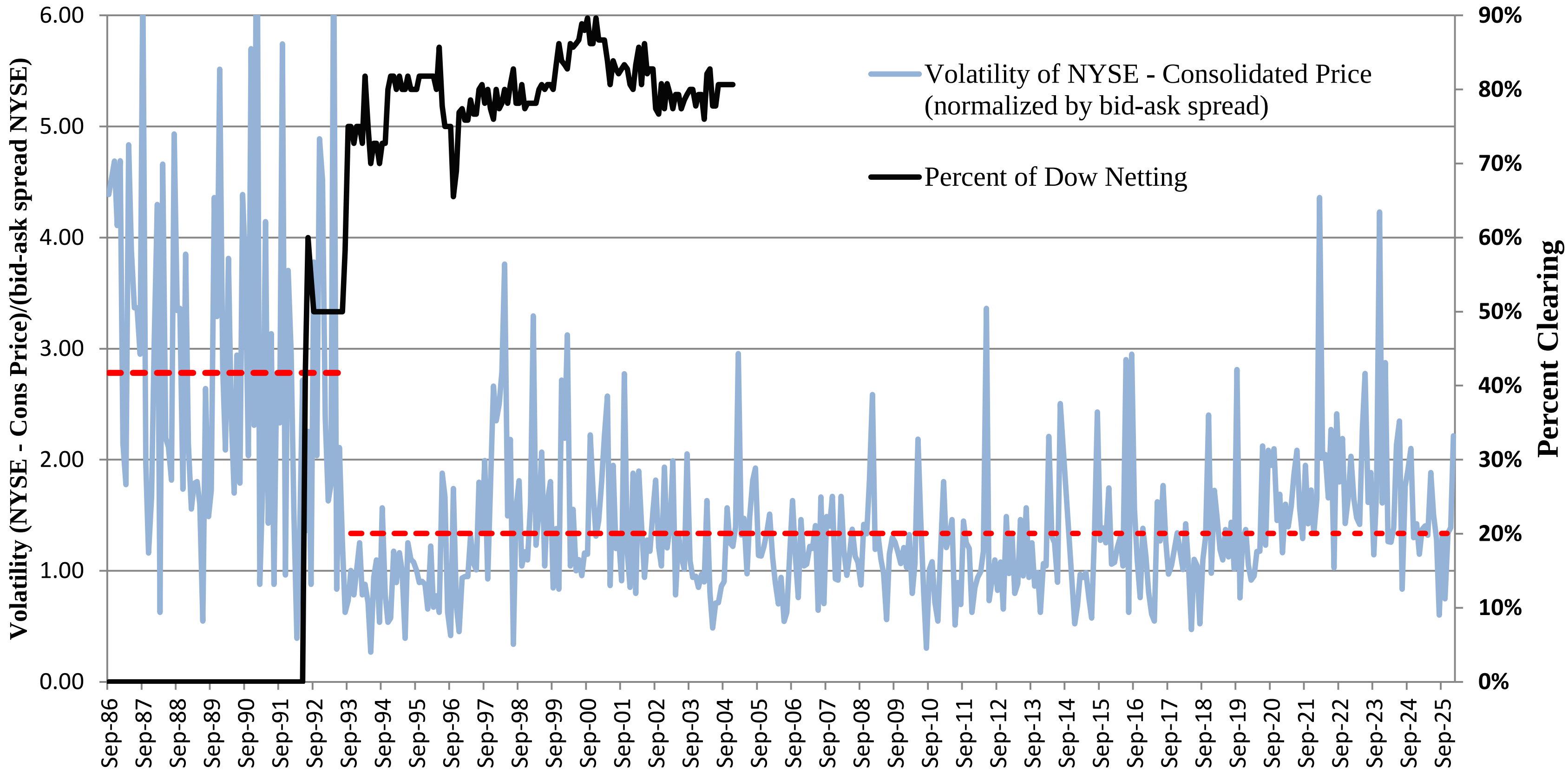

Figure 4.
Daily Volumes for Dow Jones Stocks on NYSE and CSE 1886-1900

In this figure we show that the introduction of clearing on the NYSE is not associated with a change in the relative trading on the NYSE vs. the CSE and that the introduction of multilateral net settlement through a centralized clearing party on the reduced the premium and volatility of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. The green dashed line indicates the establishment of the NYSE clearinghouse May 17th, 1892. All data is winsorized at the 99th percentile.

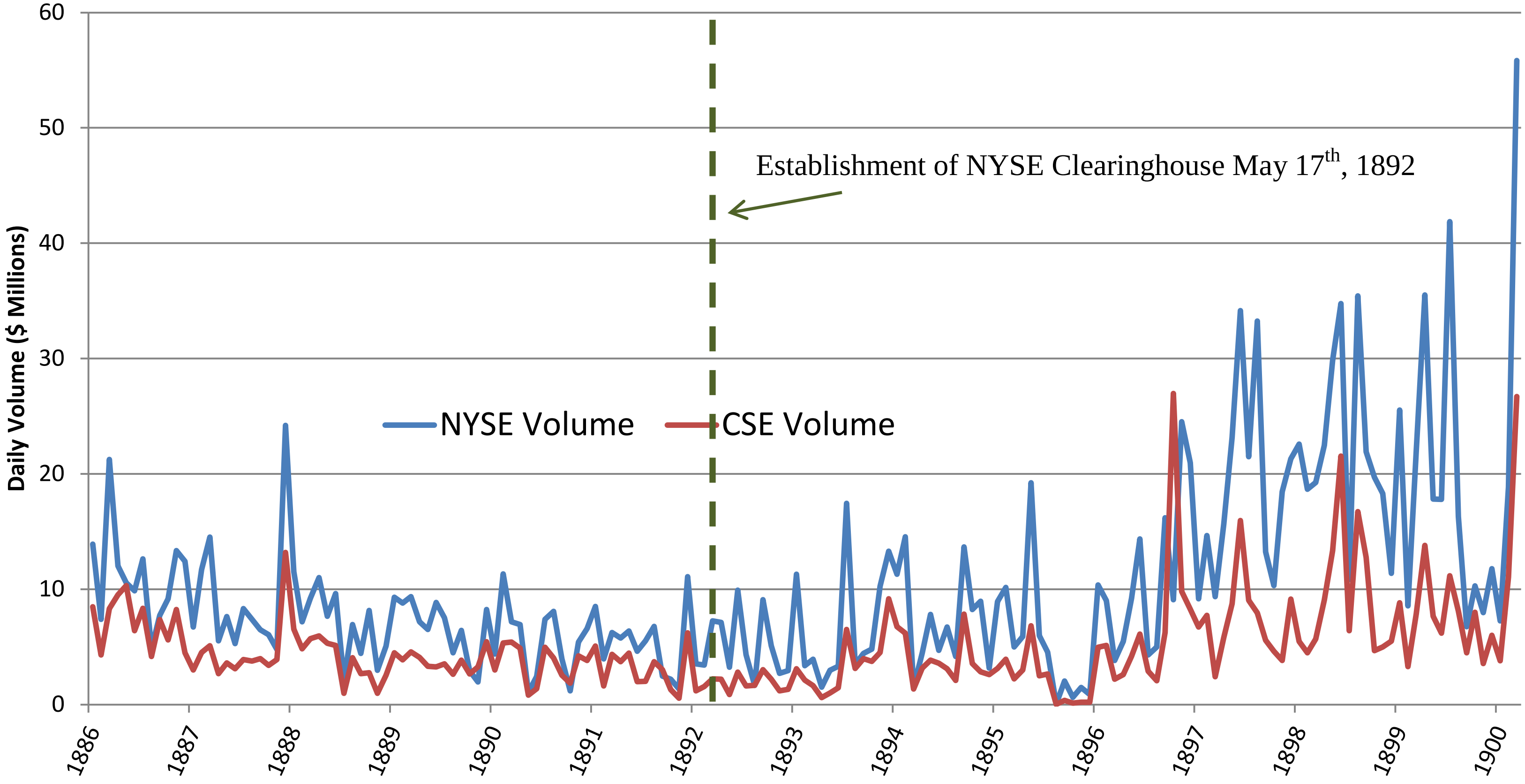

Figure 5
CSE/NYSE Bid-Ask Spreads 1892-1901

In this figure we show that the introduction of clearing on the NYSE is not associated with a change in the relative trading on the NYSE vs. the CSE and that the introduction of multilateral net settlement through a centralized clearing party on the reduced the premium and volatility of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a daily frequency from the *New York Times* from January 1892 – Dec 1901 for all stocks on the NYSE or CSE. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. For a description of the estimation of the bid-ask spreads see the appendix note.

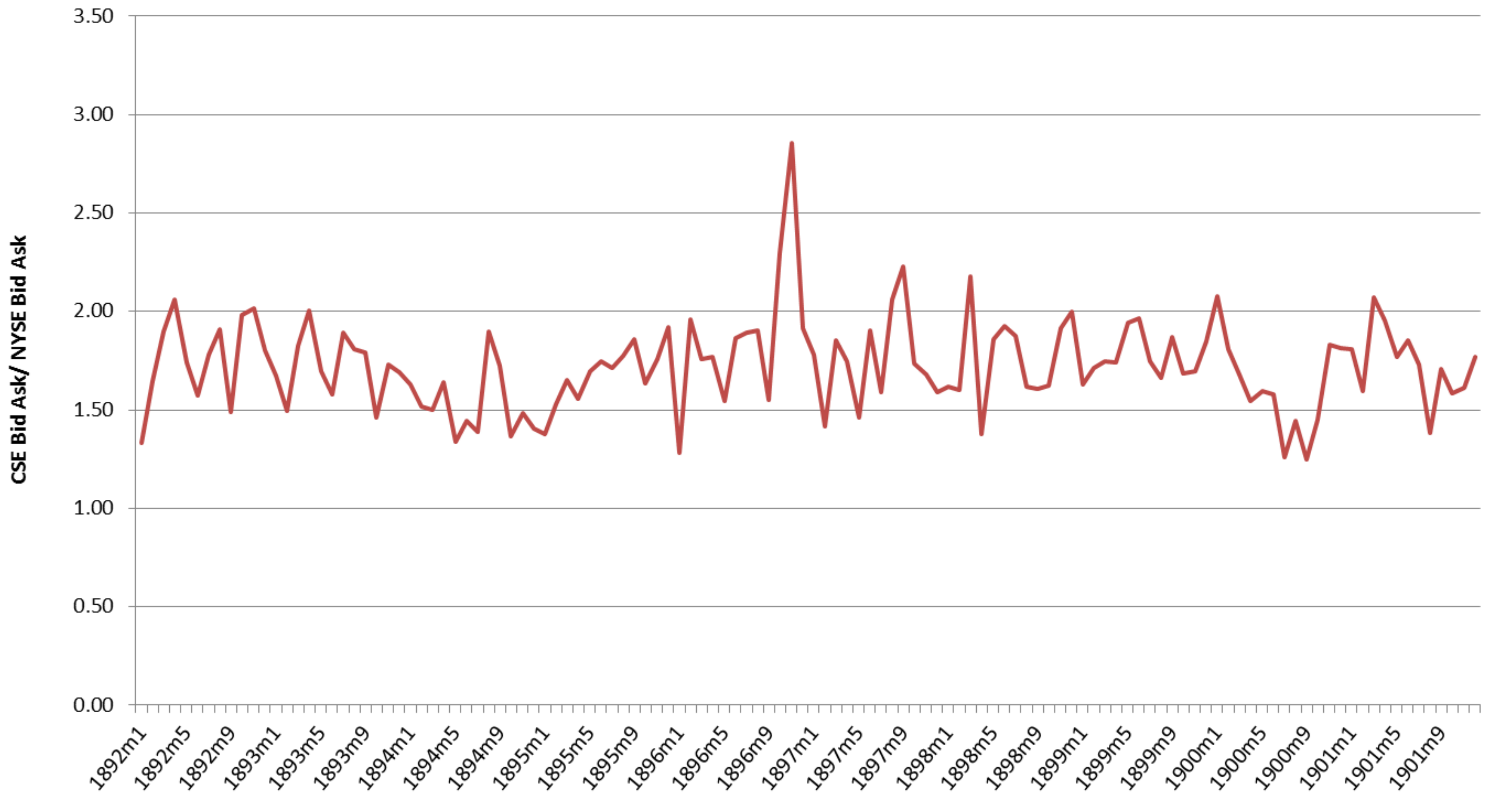

Figure 6
Call Loan Interest Rates 1886-1925
(Overnight Collateralized Borrowing Rate)

In this figure we show that the introduction of clearing on the NYSE is not associated with a change in macro-economic risk and that the introduction of multilateral net settlement through a centralized clearing party on the reduced the premium and volatility of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Closing monthly broker call loan rates are taken from NBER macro-history database for the entire period

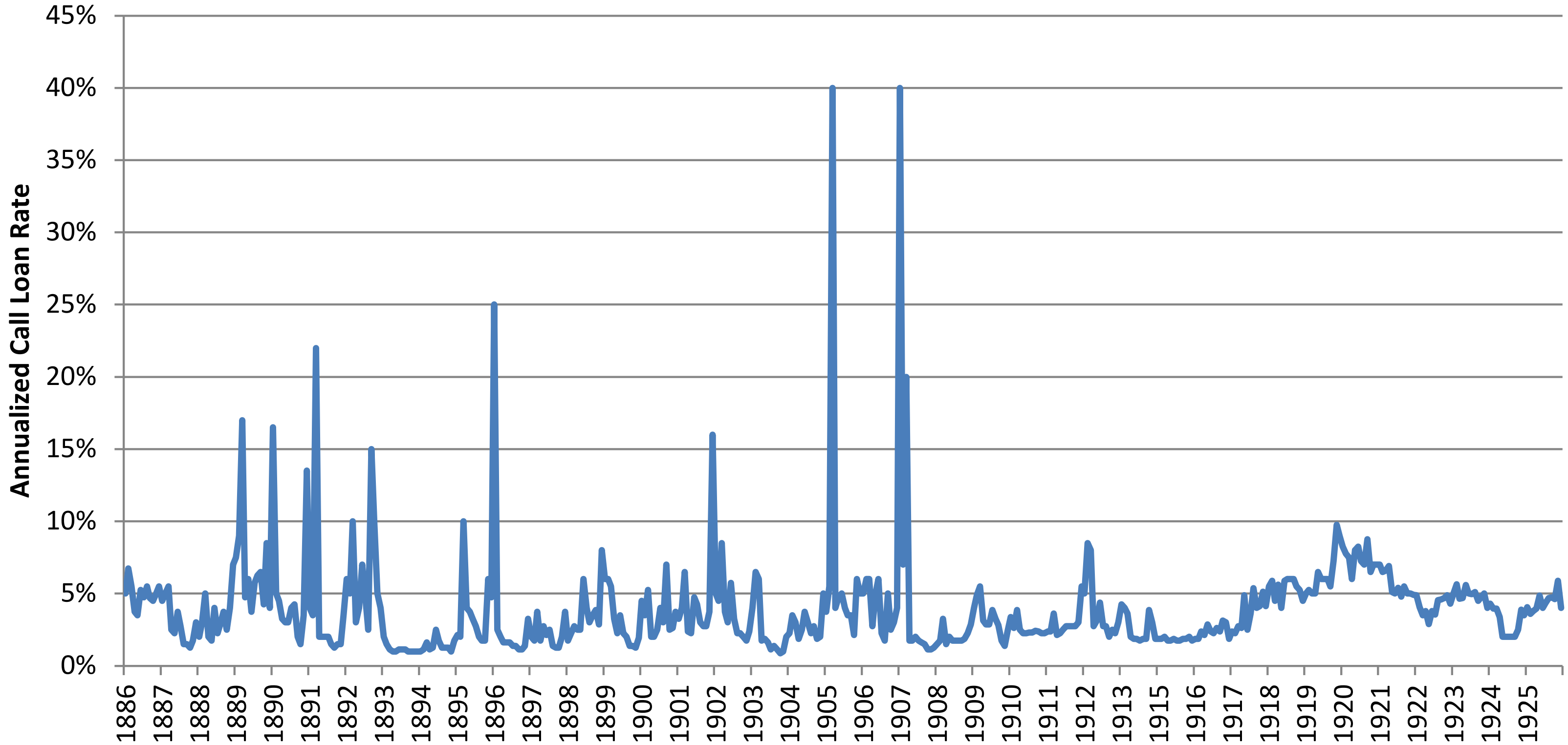

Table1. Summary Statistics
A. Dow Jones Stocks Monthly

Notes: This table reports the sample statistics for the trading data for stocks on the NYSE or CSE. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. All data is winsorized at the 99th percentile. To be included in the first level of summary analysis a security must trade at least 1 share on both exchanges on a given date, while for the second, which is the one used in our primary econometric specifications, we require at least 200 shares (2 standard contracts).

	NYSE Closing Price	NYSE Trading Volume (# Shares)	CSE Trading Volume (#Shares)	NYSE Trading Volume ($000s)	CSE Trading Volume ($000s)	NYSE Bid-Ask Spread (bps)
			With Minimum 1 Shares *Traded (n = 9,373)*			
Mean	84.4	13,726	3,241	1,352	322	52
Median	81.4	4,400	410	324	29	32
Standard Dev.	42.4	29,340	8,710	3,304	965	66
Minimum	4	5	5	0.2	0.04	7
Maximum	323	489,444	291,870	52,300	24,100	1,818
			With Minimum 200 Shares *Traded (n = 6,065)*			
Mean	85.5	19,911	4,958	1,972	493	41
Median	81.0	8,425	1,150	644	88	26
Standard Dev.	41.1	34,912	10,432	3,966	1,164	52
Minimum	4.7	200	200	3.6	1.4	7
Maximum	319.5	489,444	291,870	52,300	24,100	1,481

B. All NYSE/CSE Stocks Daily

Notes: This table reports the sample statistics for the trading data for stocks on the NYSE or CSE. Security market data were hand collected at a daily frequency from the *New York Times* from January 1892 – Dec 1901 for all stocks on the NYSE or CSE. All data is winsorized at the 99th percentile. To be included in the first level of summary analysis a security must trade at least 1 share on both exchanges on a given date, while for the second, which is the one used in our primary econometric specifications, we require at least 200 shares (2 standard contracts) and 20 observations before and after the introduction of clearing.

	NYSE Closing Price	NYSE Trading Volume (#Shares)	CSE Trading Volume (#Shares)	NYSE Trading Volume ($000s)	CSE Trading Volume ($000s)	NYSE Bid-Ask Spread (bps)	CSE Bid-Ask Spread (bps)
				With Minimum 1 Shares *Traded (n = 62,959)*			
Mean	56.3	10,122	3,055	743	252	68	120
Median	47.4	3,750	320	167	14	37	41
Standard Dev.	38.5	19,930	7,613	1,873	773	92	241
Minimum	0.8	1	2	0.004	0.009	9	9
Maximum	259	957,955	262,250	75,200	30,800	625	1,667
				With Minimum 200 Shares *Traded and 20 Observations before and after Clearing (n = 28,161)*			
Mean	64.6	15,820	5,789	1,255	496	44	49
Median	58.4	8,310	1,880	456	96	28	28
Standard Dev.	37.4	24,633	10,022	2,509	1,070	53	87
Minimum	0.8	200	200	0.6	0.4	9	9
Maximum	230	957,955	262,250	75,200	30,800	625	1,667

Table 2.Average Counterparty Risk Premium

Notes: Following econometric specifications (9) and (10), in this table we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from September 1886 – December 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. In column 1, *NYSE-CSE/Close* is the price on the NYSE minus the CSE normalized by the average closing price on both exchanges. *Post-clearinghouse* is a stock-specific dummy variable which equals 1 if a stock is cleared on the NYSE. In column 2, *NYSE-Con/NYSE Bid-Ask* is the LHS variable and is the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. Column 3 shows the results including stock-specific time-varying market liquidity controls on the NYSE and CSE. These include the bid-ask spread on the NYSE, the dollar trading volume on the NYSE, and the dollar trading volume on the CSE. Column 4 shows the results after including *Call Loan Rate*, the overnight collateralized borrowing rate. Column 5 includes an interaction term between the *Post-Clearinghouse* dummy variable and the *Call Loan Rate* as described in specification (10). Column 6 repeats the analysis in column 4, but restricting the sample to only stocks already clearing. All specifications are run with security-level fixed effects and errors are clustered at the security-level. P-Values: * 10%; ** 5%; ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	NYSE-CSE /Close (%)	NYSE-CSE / NYSE Bid-Ask	NYSE-CSE /Close (%)	NYSE-CSE /Close (%)	NYSE-CSE /Close (%)	NYSE-CSE /Close (%)
Post-Clearinghouse	0.24***	0.73***	0.24***	0.23***	0.12*	
	(0.06)	(0.13)	(0.06)	(0.06)	(0.07)	
Call Loan Rate				-0.003	-0.02***	0.002
				(0.001)	(0.005)	(0.002)
Call Loan Rate x					0.02***	
Post Clearinghouse					(0.005)	
Constant	-0.09***	-0.29***	-0.11***	-0.09**	-0.00	-0.01
	(0.05)	(0.08)	(0.04)	(0.05)	(0.005)	(0.02)
Security Fixed Effects	Y	Y	Y	Y	Y	Y
Stock Liquidity Controls	N	N	Y	Y	Y	Y
Only Post-Clearinghouse	N	N	N	N	N	Y
# Clusters	90	90	90	90	90	51
# Observations	5,997	5,984	5,994	5,994	5,994	3,904
Adjusted R-squared	0.01	0.01	0.01	0.01	0.01	0.03

Table 3.Counterparty Risk Premium Volatility

Notes: Following econometric specifications (9), (10) and (11), in this table we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the *volatility* of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from Sept 1886 – Dec 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. In column 1, σ (*NYSE-CSE)/Close* is an estimate of monthly volatility of the price on the NYSE relative to the CSE, normalized by the average closing price on both exchanges in percent. *Post-clearinghouse* is a stock-specific dummy variable which equals 1 if a stock is cleared on the NYSE. In column 2, σ (*NYSE-CSE)/NYSE Bid-Ask* is the volatility of the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. Column 3 shows the results with stock-specific time-varying market liquidity controls on the NYSE and CSE including the stock's bid-ask spread on the NYSE and dollar trading volume on NYSE, and CSE. Column 4 shows results after including *Call Loan Rate*, the overnight collateralized borrowing rate, and an interaction term between the *Post-Clearinghouse* dummy variable and the *Call Loan Rate* as described in specification (10). Column 5 repeats the analysis in column 4, but restricting the sample to only stocks already clearing. Column 6 includes a dummy, *Post 1893*, which is equal to 1 for all securities after 1893. All specifications are run with security-level fixed effects and errors are clustered at the security-level. P-Values: *10%; **5%; ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) / NYSE Bid-Ask	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /Close (%)
Post-Clearinghouse	-0.26**	-1.16***	-0.26***	-0.22**		
	(0.13)	(0.40)	(0.10)	(0.11)		
Post 1893						-0.42***
						(0.07)
Call Loan Rate				0.10*	0.01	
				(0.06)	(0.02)	
Call Loan Rate x				-0.08		
Post Clearinghouse				(0.06)		
Constant	0.68***	2.31***	0.50***	0.45***	0.22***	0.71***
	(0.09)	(0.26)	(0.07)	(0.09)	(0.02)	(0.06)
Security Fixed Effects	Y	Y	Y	Y	Y	Y
Stock Liquidity Controls	N	N	Y	Y	Y	Y
Only Post-Clearinghouse	N	N	N	N	Y	N
# Clusters	90	90	90	90	51	90
# Observations	5,997	5,984	5,994	5,994	3,904	6,004
Adjusted R-squared	0.22	0.17	0.29	0.29	0.16	0.29

Table 4.Contagion (Indirect Counterparty) Risk Premium (TBD)

Notes: Following econometric specifications (12), in this table we show the estimated effect of the introduction of multilateral net settlement through a centralized clearing party on the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day broken out by contagion risk and direct counterparty risk. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from Sept 1886 – Dec 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. In column 1, *σ (NYSE-CSE)/Close* is an estimate of monthly volatility of the price on the NYSE relative to the CSE, normalized by the average closing price on both exchanges in percent. *Post-clearinghouse* is a stock-specific dummy variable which equals 1 if a stock is cleared on the NYSE. This column includes date fixed effects. Column 2 also includes the effects of spillovers by including, *% of Dow Clearing*, which is the percent of NYSE stocks in a Dow Jones Index currently clearing. Column 3 shows results after including *Call Loan Rate*, the overnight collateralized borrowing rate, and an interaction term between the *Post-Clearinghouse* dummy variable and the *Call Loan Rate* as described in specification (10). Column 4 is the same as column 2, but *σ (NYSE-Con)/NYSE Bid-Ask* is the volatility of the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. Column 5 restricts the sample to only stocks not clearing to show spillover effects and contagion risk. This regression includes variable, *High Trading Volume,* which is 1 if the $ trading volume is higher than the median for all stocks over the period. This variable is then interacted with *% of Dow Clearing*. Column 6 is the same as column 5 but looks at *σ (NYSE-CSE)/NYSE Bid-Ask.* All specifications are run with security-level fixed effects and errors are clustered at the security-level. P-Values: *10%; **5%; ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /NYSE Bid-Ask	σ (NYSE-CSE) /Close (%)	σ (NYSE-CSE) /NYSE Bid-Ask
% of Dow Clearing		-0.27***	-0.27***	-0.64*	0.03	0.41
		(0.07)	(0.06)	(0.37)	(0.21)	(0.35)
Post Clearinghouse	-0.20*	-0.07	-0.03	-0.70***		
	(0.11)	(0.11)	(0.12)	(0.13)		
% of Dow Clearing x					-0.38**	-0.97**
High Trading Volume					(0.17)	(0.38)
Call Loan Rate			0.09			
			(0.06)			
Call Loan Rate x			-0.09			
Post Clearinghouse			(0.06)			
High Trading Volume					0.25**	0.67**
					(0.12)	(0.25)
Constant	0.73***	0.56***	0.52***	2.62***	0.41***	1.50***
	(0.05)	(0.07)	(0.08)	(0.26)	(0.12)	(0.24)
Security Fixed Effects	Y	Y	Y	Y	Y	Y
Date Fixed Effects	Y	N	N	N	N	N
Stock Liquidity Controls	Y	Y	Y	Y	Y	Y
Only Pre-Clearing Stocks	N	N	N	N	Y	Y
# Clusters	90	90	90	90	50	50
# Observations	5,994	5,994	5,994	5,983	2,090	2,086
Adjusted R-squared	0.33	0.30	0.30	0.19	0.40	0.33

Table 5.
Monthly Data Robustness Tests for Changes in Microstructure Noise or Market Liquidity

Notes: In this table we show that the introduction of clearing on the NYSE is not associated with a change in the relative trading on the NYSE vs. the CSE and that the introduction of multilateral net settlement through a centralized clearing party on the reduced the premium and volatility of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a monthly frequency from the *New York Times* and *Commercial and Financial Chronicle* from Sept 1886 – Dec 1925 for all stocks in the Dow Jones Indices. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99^{th} percentile. In column 1, *$ Volume (NYSE-CSE)*, is the difference in the dollar volume of trading for a stock on the NYSE minus the volume on the CSE on the same day. *Post-clearinghouse* is a stock-specific dummy variable which equals 1 if a stock is cleared on the NYSE. Column 2 shows the same as column 1, but now the looking at *Volume (% CSE)*, which is the dollar trading volume on the CSE divided by the sum of the trading volume on the NYSE and CSE for a given security on a given day. In specifications in columns 3-5 securities are restricted to those with at least 500 contracts trading on the NYSE and CSE on a given day. In column 3, *σ (NYSE-Con)/Close* is an estimate of monthly volatility of the price on the NYSE relative to the CSE, normalized by the average closing price on both exchanges in percent. In column 4, *σ (NYSE-Con)/NYSE Bid-Ask* is the volatility of the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. In column 5, *NYSE-CSE/Close* is the price on the NYSE minus the CSE normalized by the average closing price on both exchanges. Column 6 is the same as column 5 but only restricts to at least 200 shares traded on both exchanges and includes relative stock-specific time-varying market liquidity controls. These include *$ Volume (NYSE-CSE)*, *Volume (% CSE)*, and natural logs of $ volume on both the NYSE and CSE. Column 7 repeats the baseline results in table 2 column 1, but only for the period prior to passage of the Aldrich-Vreeland Act in 1909. All specifications are run with security-level fixed effects and errors are clustered at the security-level. P-Values: *10%; **5%; ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable:	$ Volume (NYSE-CSE)	Volume (% CSE)	σ (NYSE-Con) /Close (%)	σ (NYSE-Con) /NYSE Bid-Ask	(NYSE-Con) /Close (%)	(NYSE-Con) /Close (%)	(NYSE-Con) /Close (%)
Post Clearinghouse	251,209	-3.45	-0.28**	-1.26**	0.29***	0.23***	0.24***
	(354,478)	(2.49)	(0.13)	(0.52)	(0.08)	(0.06)	(0.06)
Constant	1,310,949***	20.96***	0.48***	2.56***	-0.014***	-0.24	-0.15***
	(230,860)	(1.62)	(0.09)	(0.34)	(0.06)	(0.23)	(0.05)
Security Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Stock Liquidity Controls	N	N	Y	Y	Y	Y	Y
NYSE/CSE Stock Liquidity Controls	N	N	N	N	N	Y	N
Period	1886-1925	1886-1925	1886-1925	1886-1925	1886-1925	1886-1925	1886-1908
Min Traded Shares	200	200	500	500	500	200	200
Data Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
Price Used	Close	Close	Close	Close	Close	Close	Close
# Clusters	90	90	85	85	85	90	62
# Observations	5,996	5,996	4,272	4,264	4,272	5,994	2,983
Adjusted R-squared	0.21	0.28	0.31	0.20	0.02	0.01	0.01

Table 6.
Daily Data Robustness Tests for Changes in Microstructure Noise or Market Liquidity

Notes: In this table we show that the introduction of clearing on the NYSE is not associated with a change in the relative trading on the NYSE vs. the CSE and that the introduction of multilateral net settlement through a centralized clearing party on the reduced the premium and volatility of the closing price of a stock on the New York Stock Exchange relative to the closing price on the Consolidated Stock Exchange for the same security on the same day. Security market data were hand collected at a daily frequency from the *New York Times* from January 1892 – Dec 1901 for all stocks on the NYSE or CSE. To be included in the analysis a security must trade at least 200 shares on both exchanges on a given date. All data is winsorized at the 99th percentile. In column 1, σ *(NYSE-Con)/Close* is an estimate of monthly volatility of the price on the NYSE relative to the CSE, normalized by the average closing price on both exchanges in percent. *Post-clearinghouse* is a stock-specific dummy variable which equals 1 if a stock is cleared on the NYSE. In column 2, σ *(NYSE-Con)/NYSE Bid-Ask* is the volatility of the price on the NYSE minus the CSE normalized by the bid-ask spread on the NYSE. Column 3 shows results if we only include stocks with at least 20 daily observations before and after the introduction of clearing. Column 4 shows results with stock-specific time-varying market liquidity controls. In addition to the estimated bid-ask spread on the NYSE, the dollar trading volume on the NYSE, and the dollar trading volume on the CSE. *CSE Bid-Ask Control*, indicates that it also includes the estimated bid-ask spread on the CSE. Column 5 shows results using opening instead of closing transaction prices. In column 6, *Bid-Ask (%) NYSE-CSE*, is the NYSE minus CSE percent bid-ask spreads (normalized by price) on each exchange. All specifications are run with security-level fixed effects and errors are clustered at the security-level. P-Values: *10%; **5%; ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	σ (NYSE-Con) /Close (%)	σ (NYSE-Con) /NYSE Bid-Ask	σ (NYSE-Con) /Close (%)	σ (NYSE-Con) /Close (%)	σ (NYSE-Con) /Close (%)	Bid-Ask (%) NYSE-CSE
Post-1893	-0.18***	-0.49***	-0.24***	-0.24***	-0.23***	-0.06
	(0.06)	(0.08)	(0.07)	(0.07)	(0.06)	(0.07)
Constant	0.93***	2.18***	0.87***	0.48***	0.60***	-0.31
	(0.05)	(0.06)	(0.05)	(0.04)	(0.06)	(0.06)
Security Fixed Effects	Y	Y	Y	Y	Y	Y
Stock Liquidity Controls	N	N	N	Y	Y	N
CSE Bid-Ask Control	N	N	N	Y	Y	N
Period	1892-1901	1892-1901	1892-1901	1892-1901	1892-1901	1892-1901
Min Traded Shares	200	200	200	200	200	N/A
Min Pre & Post Obs	N/A	N/A	20	20	20	20
Data Frequency	Daily	Daily	Daily	Daily	Daily	Daily
Price Used	Close	Close	Close	Close	Open	Close
# Clusters	188	188	48	48	48	48
# Observations	37,682	37,666	28,165	28,100	28,097	43,271
Adjusted R-squared	0.16	0.08	0.05	0.10	0.05	0.10