# Financial intermediaries in the midst of market manipulation: Did they protect the fool or help the knave?

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## Abstract

A hedge fund manager's bang-the-close trades in platinum futures provides a natural experiment for investigating the response of financial intermediaries (floor traders) to suspected manipulative trades. We show that the fund manager's trades generated artificially high settlement prices, and that the price impact of these trades exceeded those predicted by various competitive benchmarks designed to account for their immediacy and exceptionally large size. We consider this empirical evidence in light of theoretical models that predict tacit collusion (implicit cooperation) can arise in trading environments with a small number of participants engaged in long-term repeated interactions.

## 1. Introduction

How do market participants dynamically respond to a single instigator's repetitive, long-term attempts at market manipulation? Do financial intermediaries act to mitigate, facilitate, or magnify the effect of the manipulation? To what extent is tacit collusion possible in an environment with repeated interaction of a small number of participants? The answers to these questions have important implications for optimal market design, market surveillance, and litigation settlement. We provide new insights into these topics by studying the response of financial intermediaries to a well-documented case of alleged commodities futures manipulation. We also develop insight into how manipulative schemes can persist, particularly in the context of the recent evidence of collusive manipulation of the LIBOR rate fixing and allegations of other manipulations of important exchange rate and commodity price benchmarks.

In this study, we examine whether financial intermediaries mitigated, facilitated, or magnified an alleged manipulative scheme initiated by a customer. Regulatory enforcement actions and our own empirical evidence suggest that a hedge fund portfolio manager (the customer) directed unusually large market-on-close (MOC) orders to the New York Mercantile Exchange's (NYMEX) platinum futures trading floor to "bang the close."[1] These MOC orders had the apparent aim and effect of inflating daily contract settlement prices throughout an extended period beginning in November 2007 and ending in May 2008.[2] We study the response of floor traders (the financial intermediaries) filling the customer's orders

[1] See Commodity Futures Trading Commission (CFTC) dockets 10-09 and 11-17: "In the matter of Moore Capital Management, LP, Moore Capital Advisors, LLC and Moore Advisors, Ltd., Respondents" http://www.cftc.gov/ucm/groups/public/@lrenforcementactions/documents/legalpleading/enfmooreorder04292010.pdf ; "In the matter of Christopher Louis Pia, Respondent" http://www.cftc.gov/ucm/groups/public/@lrenforcementactions/documents/legalpleading/enfpiaorder072511.pdf; and "Wild Trading in Metals Puts Fund Manager in Cross Hairs", Susan Pulliam, *Wall Street Journal*, August 19, 2010. http://online.wsj.com/news/articles/SB10001424052748704289504575312452485699806 [Accessed November 10, 2013]

[2] We note that a federal district court held that the allegations in the CFTC complaint did not establish manipulative intent because those claims had been settled by consent. See *In Re: Platinum & Palladium Commodities Litigation*, No. 10-cv-3617, 2011 WL 4048780, Document 70 (United States District Court, Southern District of New York, Sept. 13, 2011).

on these bang-the-close trades. At this time, the bulk of futures trading volume had migrated to an electronic trading platform. Nevertheless, floor trades still accounted for about 20% of total NYMEX volume in platinum futures contracts. By rule, both exchange floor and electronic limit order book trades during the closing two minutes of trading were averaged to calculate that day's contract settlement price. During this alleged manipulation episode, the portfolio manager (PM) routinely submitted exceptionally large buy orders on the (less liquid) floor just seconds before the end of the closing settlement period. We use the PM's alleged attempt to manipulate official daily platinum contract settlement prices as a natural experiment within which to examine whether financial intermediaries reduce or reinforce the price impact of these alleged manipulative trades.

This episode qualifies as a well-specified natural experiment for our purposes for three reasons. First, an ongoing class action lawsuit provides us with detailed publicly available data on the actual trades executed by the PM, as well as his private communications with floor brokers.[3] These data permit the precise identification of the dates and times of bang-the-close trades necessary to compare market outcomes on days with and without the PM's alleged manipulative trading. Second, the specific trades of this PM are likely to be non-informative regarding commodity fundamentals. Moreover, the PM focused his trading on the floor, rather than seeking potentially more competitive prices on the electronic trading platform; this behavior limited outside competition for his order flow from participants other than the floor traders. Third, the side-by-side electronic trading platform provides natural pricing benchmarks to assess whether floor traders executed these bang-the-close trades at competitive prices. Note that our main research interest is not in the PM, who serves here as a customer, but in the behavior of the floor traders, who serve as financial intermediaries. Indeed, our analysis does not require us to understand the motives for the PM's trades. In some sense, whether the PM's large MOC orders were the work of a fool

[3] See *In Re: Platinum & Palladium Commodities Litigation*, No. 10-cv-3617, 2011 WL 4048780 (United States District Court, Southern District of New York, December 8, 2011) http://www.classlawsuit.com/wp-content/uploads/2012/01/Platinum-Complaint.pdf

or a knave is beside the point. A competitive market should protect a fool and otherwise neutralize a knave.

The open outcry exchange floor has been traditionally viewed as a model competitive trading environment for futures contracts, well suited for both price discovery and order execution. Thus, given that this bang-the-close trading episode lasted for seven months, it seems reasonable to expect that sharp floor traders would detect the pattern of these repetitive MOC orders and infer that they contained little or no new information. Consequently, one would expect the floor traders to price the end-of-day trades competitively according to the expected costs of unwinding them.

We find evidence that the floor traders consistently executed these MOC platinum trades at prices significantly higher than our competitive price benchmarks. Furthermore, we find that the platinum floor traders executed the PM's buy orders at increasingly noncompetitive prices, from an average of 15-40 ticks above benchmarks in the first half of the alleged manipulation period to an average of 50-100 ticks above benchmarks in the second half of the alleged manipulation period. Moreover, during the alleged manipulation period, an *ex post* simulated trading exercise suggests that floor traders may have reaped excessive profits of more than $2.5 million over 95 days with minimal measureable risk. Thus, we provide evidence that even open outcry floor trading can lead to noncompetitive pricing generating quantitatively important outcomes.

While alternative explanations for these price patterns may exist, we cannot rule out the existence of tacit collusion among the floor traders. Tacit collusion refers to coordination without direct communication. It is a process by which agents recognize their shared, interdependent economic interests and, in response, set prices at profit-maximizing, supra-competitive levels. Pirrong (1996) suggests that repeated interactions among floor traders in a setting where the activities of all parties can be observed make an open outcry system conducive to collusive behavior. For instance, floor traders might jointly raise their offers to the disadvantage of a customer who needs to buy a large number of contracts within a short period of time. Pirrong conjectures that incentives for individual traders to deviate from the

collusive equilibrium as well as outside competition from non-floor traders limit any collusive profits of floor traders to perhaps one to two ticks.

The noncompetitive pricing distortions we find during the alleged bang-the-close manipulation episode in the fragmented platinum futures market are orders of magnitude larger than those conjectured by Pirrong (1996) for a typical open outcry market. The net effect of the prices offered by the platinum floor traders reinforced the desired impact of the customer's alleged manipulative trades. Thus, noncompetitive prices cannot only persist, but may also be reinforced, where the market maker environment consists of a small number of participants who repeatedly interact.

## 2. Background

Platinum futures contracts are listed by, and subject to, the rules and regulations of NYMEX. Though acquired by CME Group in August 2008, NYMEX remains a separate self-regulatory organization. A platinum futures contract calls for delivery of 50 troy ounces that is at least 99.95 percent pure.[4] Prices are quoted in U.S. dollars and cents per troy ounce with a minimum price fluctuation ("tick size") of $0.10 per troy ounce. Trading terminates on the third last business day of the delivery month. NYMEX lists contracts for a quarterly cycle of January, April, July, and October, but also fills out the trading menu with contracts for the current and next two calendar months.

Open outcry trading of platinum futures takes place on a NYMEX trading floor in New York for a session beginning at 8:20 a.m. and ending at 1:05 p.m. (all times are Eastern). Electronic trading takes place via the CME Globex and CME ClearPort platforms for a near 24-hour session beginning at 6:00 p.m. on the date preceding a given day's open outcry session and ending at 5:15 p.m. in the evening (more than four hours after the open outcry session's 1:05 p.m. close). During the period under study, the daily settlement price for a platinum futures contract is calculated as the volume-weighted average price (VWAP) of all NYMEX floor and Globex transactions conducted during a two-minute closing period that begins at 1:03 p.m. and ends at 1:05 p.m.

[4] Delivery may take place on any business day beginning on the first business day of the delivery month or any subsequent business day of the delivery month, but not later than the last business day of the current delivery month.

During the period under study, the NYMEX platinum open outcry floor was characterized by a small number of traders (fewer than ten on any given date)[5], intermittent supervision by compliance officers, and fragmented order flow from outside participants. Indeed, trading volumes on open outcry venues have shriveled over the past decade with the rise of much less expensive electronic trading platforms. Many futures contracts now trade exclusively on an electronic platform. But beyond trading costs, open outcry markets differ from electronic markets across a number of dimensions. Among these, Sarkar and Tozzi (1998) list differences including the identities of the main suppliers of liquidity ("locals" versus large market-making firms), primary costs of the trading infrastructure, information sources, operating efficiency, and possible sources of trading abuse. One important difference concerning information flow relates to potential trading abuse. Whereas the orders entered in the newer electronic markets via offsite keyboards are anonymous, open outcry floor traders observe the behaviors of other floor traders.[6]

### *2.1 Noncompetitive Prices in Financial Markets*

Recent investigations have alleged that certain money market traders working for major banks colluded to set daily LIBOR fixings at artificial levels in order to profit from positions in related derivative contracts (Financial Services Authority, 2012). The LIBOR collusion case shows that tacit cooperative agreements can survive in groups whose members interact repeatedly over time while observing each other's behavior.[7] In an earlier example, Christie and Schultz (1994) provide evidence of implicit collusion among NASDAQ stocks dealers, who systematically inflated effective bid-ask spreads and increased dealing profits by avoiding odd-eighth quotes. Christie and Schultz argue that NASDAQ

[5] See Commodity Futures Trading Commission (CFTC) docket 10-09.

[6] Boyd *et al.* (2013) argue that the ability of floor traders to observe and mimic each other leads to a higher prevalence of herding behavior in floor-based trading compared with electronic trading.

[7] The daily LIBOR fixing was calculated by rule as the cross-bank average rate using only the trimmed data from the middle eight of the 16 panel members of the British Bankers Association's (BBA) daily rate survey. Traders in different banks raised or lowered a particular day's LIBOR by submitting artificially high or low rates for any given day's survey. Even small perturbations of daily LIBOR fixings can generate huge illicit gains since the payoffs to various important interest swap and deposit rate futures contracts are indexed to these rates.

dealers engaged in an infinitely repeated game with complete and perfect information, in which the current and historical quotes were available to all dealers. The game theory "folk theorem" shows that, under such conditions, collusion may be a possible equilibrium outcome if the future costs to each player of deserting the equilibrium exceed the immediate gains (Friedman, 1971). Similar conditions appear to characterize the LIBOR fixing process, as well as many other important financial markets. Dutta and Madhavan (1997) argue that implicit collusion can arise even from non-cooperative behavior among dealers, but that institutional arrangements such as order flow direction by brokers to their preferred dealers as well as price matching agreements are important in sustaining higher-than-competitive bid-ask spreads. In the context of uniform-price auctions for Treasury securities, Back and Zender (1993) show that collusive strategies can be self-reinforcing.

Pirrong (1996) points out that tacit collusion may also emerge among futures floor traders since these traders interact in a transparent setting on a daily basis over a long period of time. Thus, floor traders as a group can punish any individuals who defect from the cooperative agreement by refusing to trade with them, or by only offering business on unfavorable terms. In contrast, those who cooperate can be rewarded. Pirrong (1996) posits that two forces limit the impacts of such collusive behavior in futures markets. First, the gains from any one trader's defection from the tacit cooperative agreement may exceed the costs of punishment if price distortions become too large. Second, competition from off the floor ("upstairs") traders submitting limit orders disciplines the degree by which collusive floor traders can move prices through cooperation. In the case of NYMEX metals contracts, the Globex trading platform should resolve this potential collusion by opening the system to client limit orders to the extent that floor and electronic order flows are fully integrated. Such outside competition fits the Pirrong conjecture why even collusive floor prices should be kept close to competitive prices.

Markham (1991) describes the Federal Bureau of Investigation's 1989 sting operations on the Chicago futures exchanges.[8] This investigation resulted in indictment of 48 traders charged with hundreds

[8] See Greising and Morse (1991) for details.

of violations of federal laws and provided evidence of an anti-competitive symbiotic relationship between brokers and floor traders. Supporting Pirrong's contention, however, many of the convictions in these cases involved transgressions of limited size. For example, one convicted yen futures trader was sentenced to $7,000 in restitution, four months imprisonment, a $40,000 fine, and 600 hours of community service. Another currency trader convicted of seven counts of commodity fraud in a Swiss franc futures trial also pled guilty to wire fraud count involving cheating customers of $12.50.

Bang-the-close trading is a blatant example of closing price manipulation. Closing prices are often the focus of manipulation, due to their importance in the determination of fund performance and net asset values, and for the settlement of derivative contracts. For example, Carhart *et al*. (2002) and Bernhardt and Davies (2005) find significant evidence of "painting the tape" at the end-of-quarters by mutual fund managers.[9] Ni *et al*. (2005) explore whether closing stock prices may be manipulated on option expiration dates. Kumar and Seppi (1992) consider the manipulation of settlement prices for futures contracts that are cash settled. Comerton-Forde and Putnins (2011) attempt to measure the quantitative impact of known instances of closing price manipulation in equity markets.

### *2.2 Details of the Alleged Manipulation of Platinum Futures Settlement Prices*[10]

During the period between November 2007 and May 2008, a portfolio manager working for a major hedge fund is alleged to have engaged in closing price manipulation of the platinum NYMEX futures contracts.[11] The PM placed large market buy orders on the floor just seconds before the end of the closing period. By using such MOC orders, the portfolio manager placed no apparent limit on how high a

[9] Bernhardt and Davies (2009) develop a theoretical model of end-of-quarter "painting the tape" by mutual funds.
[10] The PM is alleged to have also manipulated the palladium futures market. We focus only on his trades in platinum futures.
[11] Another well-known case of alleged manipulation of futures markets using "bang-the-close" trades involves Optiver Holding BV. The CFTC accused Optiver Holding, two of its subsidiaries, and three employees with manipulation and attempted manipulation of crude oil, heating oil, and gasoline futures on the NYMEX. The traders are alleged to have used "bang-the-close" trades in at least 19 instances during March 2007 to manipulate the settlement prices of the oil futures contracts. See: http://www.cftc.gov/ucm/groups/public/@lrenforcementactions/documents/legalpleading/enfoptiveruscomplaint072408.pdf

price he would pay to buy large numbers of contracts during a short window of time in an illiquid market. Moreover, he ignored the obvious alternative of "walking the book" of limit orders concurrently available on the more liquid Globex platform.

We do not fully analyze the motives behind the PM's bang-the-close trades. Clearly, artificially high settlement prices benefitted the daily marked-to-market cash flows on the PM's existing long platinum contract positions. But the benefits of such marked-to-market cash flows would only be transitory unless bang-the-close price impacts persist. Private communications with his brokers suggest that, on particular days, one aim was to push prices through certain technical targets ("new highs"), perhaps with the goal of inducing follow-on trading by momentum investors.

An MOC order is an order to buy or sell at the end of the trading session during the two-minute closing period at a price within the closing range of prices. On the days he chose to trade, the PM typically entered his MOC buy orders in the last 10 seconds of the closing period. Thus, his information set at the time of the order included complete knowledge of intraday price movements and a good understanding (if not precise data) of whether the day had been average, high, or low in terms of trading volume. Based on this understanding of market conditions and feedback from his futures commission merchant, the PM made the final decision on whether or not to trade. His futures commission merchant reflected feedback gleaned from his firm's floor broker about the likely price effect of various order sizes.[12] If the PM did decide to trade, he then made his MOC order size decision (usually 50 or 100 contracts). Floor traders then saw the PM's MOC order to buy, say, 50 contracts, and responded with offerings based upon their knowledge of the market (e.g., where platinum is trading concurrently on Globex) and their perception of prices they will have to pay to offset the positions after the floor's close. The futures commission merchant's floor broker typically executed the buy order at the best offer in a single trade that filled the PM's full desired size.

[12] For additional details about the alleged role of the registered futures commission merchant see Commodity Futures Trading Commission (CFTC) docket 1:12-cv-01873-WHIP.

*2.3 Settlement Price Artificiality*

Traditional microstructure models decompose bid-ask spreads, and by extension, the price impact of trades, into three components: (i) order processing costs; (ii) inventory holding costs; and (iii) adverse selection.[13] We believe that the adverse selection component of the PM's trades is likely to have declined over time, as other floor traders became aware of the repeated nature of the bang-the-close trades and the apparent lack of *new* fundamental information behind these trades. Therefore, we expect that the price impact of the PM trades in a competitive market should be driven primarily by the order processing and inventory holding costs associated with trades of a given size and given market conditions.

To control for these costs, we construct competitive price benchmarks that reflect the size of each of the PM's trades and the corresponding market conditions. We then compare the actual execution prices of the PM's trades to two alternative benchmark competitive prices: 1) the average price that would be achieved by a market order of the same size if it were executed immediately against the depth available on the Globex limit order book, and 2) an estimate of the average price at which the PM's floor trader counterparty could unwind the new position on Globex after the floor's close. Our constructed benchmarks are tied tightly to the specific conditions applicable to competitive pricing in the platinum futures markets. This approach is more precisely targeted than the general screening approach for collusion of Abrantes-Metz and Bajari (2009, 2012).

The PM bypassed the Globex platform when he chose to execute his bang-the-close trades via the exchange floor. We use the prices from concurrent closing-period trades on the Globex platform to discern market conditions absent the PM's activity. Specifically, we define a *Counterfactual Settlement Price* as the VWAP of Globex trades during the closing period. We then use the official daily *Settlement Price* to define *Settlement Price Artificiality* as

*Settlement Price Artificiality = Settlement Price – Counterfactual Settlement Price.* *(1)*

[13] See Van Ness, Van Ness, and Warr (2001) for a survey of empirical models.

Assuming that, aside from the PM's bang-the-close trades, floor trades were priced competitively, we can interpret *Settlement Price Artificiality* as driven by the difference in average execution prices for the PM and the VWAP on closing-period Globex trades, so that

$$\textit{Settlement Price Artificiality} \approx \Theta^{PM} * (\textit{Trade Price}^{PM} - \textit{Counterfactual Settlement Price}) \qquad (2)$$

where $\Theta^{PM}$ represents the volume of contracts traded by the PM on the floor during the closing period expressed as a fraction of total volume traded (floor plus Globex) during the closing period (i.e., $\Theta^{PM} = \text{Volume}^{\text{PM}}/\text{Volume}^{\text{Total}}$).

### *2.4 Trade Price Inflation due to the PM's Choice of Order Structure ("Size and Immediacy")*

We distinguish between the expected direct price impact of the PM's trades based on the characteristics of his trades and any indirect impact of these trades, which we interpret as excess mark-ups that possibly reflect noncompetitive practices by floor trader counterparties. The PM's direct impact is a *Size and Immediacy Mark-Up* attributable to his decision to trade an unusually large number of contracts via a MOC floor order. This mark-up is a pure bang-the-close impact capturing the price effect due to the PM's demand for an immediate fill on an unusually large contract order assuming competitive market making conditions. We measure this component as the difference between the *Globex Average Walk-the-Book Price* that the PM could have otherwise immediately achieved by executing his chosen contract trade size via the electronic Globex platform (following a "walk-the-book" strategy) and the *Globex Best Offer* price (for at least one contract):

$$\textit{Size and Immediacy Mark-Up} = \textit{Globex Average Walk-the-Book Price} - \textit{Globex Best Offer}. \qquad (3)$$

Together with the best Globex offer, this *Size and Immediacy Mark-Up* determines the *Conditional Competitive Price* defined as

$$\textit{Conditional Competitive Price} = \textit{Globex Best Offer} + \textit{Size and Immediacy Mark-Up}. \qquad (4)$$

*2.5 Excess Floor Trader Mark-Up*

We define *Excess Floor Trader Mark-Up* as the difference between the PM's achieved *Trade Price*$^{PM}$ and the *Conditional Competitive Price*:

$$\textit{Excess Floor Trader Mark-Up} = \textit{Trade Price}^{PM} - \textit{Conditional Competitive Price.} \quad (5)$$

In our framework, both the *Size and Immediacy Mark-Up* due directly to the PM's decisions as well as the *Excess Floor Trader Mark-Up* contribute to *Settlement Price Artificiality*:

$$\textit{Settlement Price Artificiality} \approx \Theta^{PM} * (\textit{Globex Best Offer} + \textit{Size and Immediacy Mark-Up} + \textit{Excess Floor Trader Mark-Up} - \textit{Counterfactual Settlement Price}). \quad (6)$$

## 3. Data

From CME DataMine, we obtained exchange data for all NYMEX platinum futures contract trades during the period from July 1, 2007 to June 30, 2008. These data include the official record of trade times and prices, but only include trade quantities for the Globex trades. We also obtain all of the tick-by-tick, time-stamped-to-the-millisecond CME Group Market Data messages needed to recreate the 5-quote-deep GLOBEX limit order book. We also obtained daily settlement prices for platinum futures from Bloomberg Financial.

We obtained the PM's bang-the-close trade data from public court records.[14] We define the alleged manipulation period as beginning with the PM's first reported bang-the-close trade on November 19, 2007 and ending with his last reported bang-the-close trade on May 21, 2008.[15] On May 22, 2008, the CFTC began to investigate bang-the-close trading in metals futures contracts. The PM chose to trade on 95 days of the 125 alleged manipulation period days. We split these 95 bang-the-close trade days into two

[14] The details of the bang-the-close trades in NYMEX platinum futures contacts made by Moore Capital are reported on pages 80-84 of the Third Consolidated Amended Class Action Complaint, *In Re: Platinum and Palladium Commodities Litigation,* No. 10 Civ. 3617.

[15] Our November 19, 2007 to May 21, 2008 alleged manipulation period differs from the "class period" of October 17, 2007 to June 6, 2008 used in the class action lawsuit.

samples: the first 47 days ("first half") and the next 48 days ("second half"). The second half of the alleged manipulation period begins on February 13.

Figure 1 plots the daily contract trading volume (left axis) and daily settlement price (right axis) of the active platinum futures contract from July 1, 2007 to June 30, 2008. Prior to January 2008, volume fluctuated around a central value of about 1,000 contracts per day. But starting in January 2008 and continuing through March 2008, daily trading volume more than doubled to about 2,500 contracts per day and grew significantly more volatile. Trading volume declined to about 1,500 contracts per day over the final three months of the sample but remained volatile. The increase in contract trading volume over the January 2008-March 2008 period contract coincided with a roughly 40% rise in platinum futures prices over the same period. This dramatic rise in platinum futures prices reflected a general bull market in commodities that occurred in the first half of 2008.

Figure 2 presents the lot size distribution of all Globex-executed individual trades for front-month platinum over the full sample. The preponderance of one-lot trades suggests that platinum futures contracts trade in a "thin" market. The PM's typical 50-lot or 100-lot MOC orders were unusual in this market.

Figure 3 plots the average Globex trading volume by hour across all days in our one-year sample. Average hourly Globex trading volume peaks at about 230 contracts during the same 8:00 a.m. hour that encompasses the opening of NYMEX floor trading and declines each hour to drop below 100 contracts by the floor's close (during the 1:00 p.m. hour). Volume is light during the afternoon, picks up with the 8:00 p.m. start of the Asian business day, and then increases again with the 3:00 a.m. start of the London business day.

Figure 4 presents median contract volume for 21 two-minute intervals centered on platinum's 1:03 p.m.-1:05 p.m. closing interval (plotted as two-minute interval number 11). Panel A of this figure presents results for data outside the alleged manipulation period. Not surprisingly, median contract volume peaks during the closing interval and then falls during the next 20 minutes. Note that a single PM order of 100 contracts would be more than triple the median number of contracts traded during the closing

interval over the period prior to the alleged manipulation. Panel B presents results for data during the alleged manipulation period. One striking difference between the results in Panels A and B regards the fall in volume during the two minutes immediately after floor's 1:05 PM close. For data outside the alleged manipulation period, this fall is dramatic: the 1:06 p.m.-1:07 p.m. interval's median volume is just 37% of the closing interval's volume (10 versus 27). For alleged manipulation period data, however, the decline is very slight: the 1:06 p.m.-1:07 p.m. interval's median volume is about 95% of the closing interval's volume (35 versus 37). These results suggest that some traders experienced a special need to quickly unwind contracts during the alleged manipulation period. Note that the peaks of 27 and 37 contracts for the closing period in these subsamples lie well below the typical 50 and 100 contract lot order placed on the floor by the PM.

## 4. Empirical Analysis of Price Manipulation and Noncompetitive Prices

### *4.1 The PM's Trades*

If the PM chose to trade, he usually bought a lot-size of 50 or 100 contracts (on a few days he bought 25 or 75 contracts instead). He began the program by buying lots of 50 contracts, but bought 100 contracts more frequently during the upward move in platinum prices in February and early March of 2008. He then changed his size to a mix of 50 or 100 contracts in mid-March 2008 against the backdrop of a volatile, but trendless, platinum market.

Figure 5 plots the active platinum contract's *Settlement Price Artificiality* (left axis) along with the *Settlement Price* (right axis). *Settlement Price Artificiality* values are plotted in a way that distinguishes the days on which the PM executed bang-the-close trades (light shaded bars) from those days that he did not (dark shaded bars). Table 1 summarizes these data via estimated means and median values for samples split into three periods (outside the alleged manipulation period, first half of alleged manipulation period, and second half of alleged manipulation period) for each of three PM trade size categories (days with no PM trades, days when the PM trades 25 or 50 contracts, and days when the PM

trades 75 or 100 contracts). For each sample, p-values for tests of null hypothesis that the respective sample's mean or median Settlement Price Artificiality equals zero are presented in parentheses.

Outside the alleged manipulation period, the mean value for *Settlement Price Artificiality* is $0.47 with an associated p-value of .01 for a test of the hypothesis that the mean equals 0. The median value for *Settlement Price Artificiality* is $0.00 (with an associated p-value of .22). While a median value of zero for *Settlement Price Artificiality* is expected over this sample, the positive and statistically significant mean artificiality value is surprising.[16]

Over the first half of the alleged manipulation period, we find mean and median *Settlement Price Artificiality* to be statistically indistinguishable from zero on days in which the PM does not trade. When the PM does trade, the estimated mean and median *Settlement Price Artificiality* are positive, highly statistically significant, and depend on the size of the trade. Mean artificiality is $1.72 for trades of 25 or 50 contracts and $4.14 for trades of 75 or 100 contracts (the corresponding median values are $1.41 and $2.95).

Over the second half of the alleged manipulation period, mean *Settlement Price Artificiality* for days in which the PM does not trade is a statistically significant $3.06, while the corresponding median artificiality is just $0.01. When the PM does trade, the mean and median *Settlement Price Artificiality* are positive, highly statistically significant, and size-dependent. Moreover, *Settlement Price Artificiality* estimates are two to four times larger than corresponding estimates from the first half of the manipulation period. For example, mean *Settlement Price Artificiality* is $7.91 (versus $1.72) for trades of 25 to 50 contracts and $9.88 (versus $4.14) for trades of 75 or 100 contracts. This roughly $10 mean *Settlement Price Artificiality* for the latter case represents 100 ticks. Estimates of the median show a similar pattern: median *Settlement Price Artificiality* is $4.81 (versus $1.31) for trades of 25 to 50 contracts and $8.30

[16] We presume the court records to be reliable. But one potential explanation of this result would be that the court records do not capture a few of the PM's trades from the pre-class period. Alternatively, we cannot rule out the possibility that other traders might be engaging in bang-the-close trades in this earlier period. We note that, in the context of equity markets, Comerton-Forde and Putnins (2009) argue that many instances of closing price manipulation are undetected by authorities.

(versus $2.95) for trades of 75 or 100 contracts. The P-values presented in bottom row offer strong evidence against the null hypothesis that the mean (or median) *Settlement Price Artificiality* is the same in each half of the alleged manipulation period.

### *4.2 Bang-the-Close PM Trade Prices*

Figures 6a and 6b depict market conditions and trading activity in platinum futures contracts on both Globex and the exchange floor for 15 minutes before and 15 minutes after around the floor's 1:05 PM EST close for two specific days. Figure 6a presents data for November 19, 2007, the first date of the PM's alleged manipulative bang-the-close trading in platinum. Court records show that the PM bought a total of 50 January 2008 contracts in a single trade recorded at 1:05 p.m. EST at a price of $1,458 per ounce. The figure plots all individual trades during this 30-minute period. The sizes of the plotted symbols for the Globex trades and the PM's floor trades are proportional to the number of contracts constituting each trade. Because we have no contract size data for floor trades other that those of the PM, we plot these remaining floor trades without size variation. Finally, we depict three price benchmarks: the official settlement price (solid line); the Globex closing period VWAP price (light dashed line); and the Globex post-close, buyer-initiated VWAP price (dark dashed line). Buyer-initiated trades are identified using the algorithm proposed by Lee and Ready (1991). Figure 6b presents corresponding data for May 21, 2008, the last date of the PM's alleged manipulative in platinum. On this date, the PM bought a total of 50 July 2008 contracts in a single trade recorded at 1:05 p.m. EST at a price of $2,224 per ounce.

Figures 6a and 6b illustrate the main patterns and price impacts surrounding the PM's alleged bang-the-close trading strategy. First, the PM's trades are unusually large compared to those taking place on Globex in the prior 15 minutes. Second, the execution price paid by the PM to floor traders who sold him his contracts is inflated relative to prices that were being transacted on Globex during the two-minute closing period. Third, the PM's trades caused artificiality in the official platinum settlement price relative to the Globex closing period VWAP benchmark. Fourth, floor traders who sold the PM his contracts

should have been able to unwind their short positions profitably as evidenced by the discount of the post-close, buyer-initiated VWAP to the price paid by the PM.

Figure 7 provides a useful overview regarding whether the prices at which floor traders filled the PM's MOC orders were consistently inflated throughout our entire sample period. This figure plots the *PM Price Spread to Counterfactual Settlement*, defined as the difference between *Trade Price*$^{PM}$, the price paid by the PM on his MOC floor trades, and the *Counterfactual Settlement Price* based upon the Globex-only closing period VWAP:

$$PM\ Price\ Spread\ to\ Counterfactual\ Settlement = Trade\ Price^{PM} - Counterfactual\ Settlement\ Price \quad (7)$$

By construction, the *Counterfactual Settlement Price* ignores all prices from the PM's trades (as well as all other closing period trades from the exchange floor). Thus, the *Counterfactual Settlement Price* is a pre-event price benchmark that summarizes the state of the Globex market prior to the PM's floor trades in the final seconds of the closing period. Moreover, *Counterfactual Settlement Price* is an easily calculable benchmark against which NYMEX and CFTC market surveillance officials could assess pricing of the PM's trades during the manipulation period. For added context, Figure 7 also displays the 50-contract *Size and Immediacy Mark-up*, which can be calculated for all days in the sample regardless of whether or not the PM chooses to trade. Figure 7 shows that the *PM Price Spread to Counterfactual Settlement*, while volatile, is consistently positive. Moreover, this trade price spread routinely exceeds $10 (100 ticks) per contract, especially during 2008, and clearly exceeds the corresponding *Size and Immediacy Mark-up* on many days. Figure 7 provides *prima facie* evidence that the prices paid by the PM to floor traders filling his MOC orders were inflated.

### *4.3 Trade Price Inflation due to the PM's Choice of Order Structure ("Size and Immediacy")*

Table 2 presents means and medians of the *Size and Immediacy Mark-up* across days grouped by the alternative buy order sizes used by the PM: 25, 50, 75, or 100 contracts. Again, this mark-up captures the price impact cost of stressing a competitive market and is calculated as the difference between the

VWAP of implied buyer-initiated trades that could have been transacted on Globex at the beginning of the closing period (by walking the book of existing Globex orders) and the best Globex offer. We present estimates for three subsamples: the first half of the alleged manipulation period (November 19, 2007 to February 12, 2008), the second half of the alleged manipulation period (February 13, 2008 to May 21, 2008), and the remaining data from outside the alleged manipulation period (combining data from July 1, 2007 to November 17, 2007 and May 22, 2008 to June 30, 2008). Panel A presents results using data for all days between July 1, 2007 and June 30, 2008 on which the corresponding walk-the-book depth existed at the beginning of the closing period. The number of available walk-the-book observations declines for larger order sizes: there are 246 25-lot observations, 230 50-lot observations, 119 75-lot observations, and 38 100-lot observations. Panel B presents results using data for only those "high liquidity" days on which a 100-lot walk-the-book order exists. For each sample, p-values for tests of null hypothesis that the respective sample's mean or median Settlement Price Artificiality equals zero are presented in parentheses.

Table 2 shows that "size and immediacy" are priced in the Globex limit order book. For a 50-lot order, Panel A reports that the 114 observations from outside the alleged manipulation period subsample averaged $2.09. Thus, the average price for a buyer who immediately consumed 50 contracts of posted Globex limit order liquidity was $2.09 above the best offer for a 1-lot. The typical (median) trade for this subsample would have entailed a $1.70 mark-up. These estimates are statistically different than zero at standard levels of significance. Thus, as expected, a trader pays up to walk the book. Corresponding point estimates for both halves of the alleged manipulation period are somewhat larger. For a 50-lot order, the 51 observations in the first half of the alleged manipulation period subsample averaged $2.42 (median value of $2.19). The 65 observations in the second half of the alleged manipulation period subsample averaged $4.96 (median value of $3.85).

These Panel A estimates provide benchmarks for the effect of the PM's decision to stress the market by choosing a 50-lot MOC order during the bang-the-close trading episode. A fair estimate of a

pure bang-the-close market impact for a 50-lot MOC decision was $2.42 (first half) or $4.96 (second half). A smaller sample of just 38 observations (19 inside the alleged manipulation period; 19 outside the alleged manipulation period) is available for the *Size and Immediacy Mark-up* for a 100-lot MOC order. The corresponding point estimates of a pure bang-the-close market impact for this 100-lot order size range between $2.52 and $4.40. The p-values presented in bottom row offer strong evidence against the null hypothesis that the mean (or median) *Size and Immediacy Mark-up* is the same in each half of the alleged manipulation period for 25-lot, 50-lot, and 75-lot trade sizes.

Because walk-the-book depth varies across days, the larger order sizes are not available on all days within the full sample and the days on which they are available may be high liquidity days. Panel B presents alternative estimates of mean and median *Size and Immediacy Mark-up* to subsamples restricted to only those days in which 100-lot walk-the-book depth exists. Though based upon small sample sizes, point estimates for a 100-lot price impact are roughly $0.40 larger than the point estimates for a 50-lot price impact. The p-values presented in bottom row offer weaker evidence against the null hypothesis that the mean (or median) *Size and Immediacy Mark-up* is the same in each half of the alleged manipulation period, most likely due to the much smaller sample sizes.

We believe that our *Size and Immediacy Mark-up* estimates represent conservative benchmarks because they do not account for possible interaction of a large order with new (or hidden) limit orders. Our walk-the-book benchmark does not capture the dynamic nature of the limit book in response to order flow as analyzed in Parlour (1998), Hollifield *et al*. (2004), Foucault *et al*. (2005), and Rosu (2009). Sandas (2001) finds that "limit order books offer too little depth or imply price schedules that are too steep relative to the order book changes in response to trades." In a competitive environment with adverse selection costs, market makers may find it unprofitable to submit limit orders further away from the inside quote given their lower probability of execution. But, as market orders arrive and the limit order book shifts, these potential orders have a higher probability of execution and, as such, are submitted in response. As such, our walk-the-book benchmark constructed using only posted liquidity likely overestimates the price impact of large walk-the-book orders because it underestimates actual liquidity.

*4.4 PM Trade Price Inflation Using a Pre-Event Benchmark ("Excess Mark-Up")*

Table 3 presents our estimates of the *Excess Mark-Up*. We measure this mark-up as the difference between the execution price of the PM's orders and the walk-the-book price observed on Globex at the beginning of the closing period. We calculate estimates of mean and median values for *Excess Mark-Up* for observations grouped into trades of either 25 or 50 lots and trades of either 75 or 100 lots during each half of the alleged manipulation period. We present results for walk-the-book prices calculated three different ways. The "Actual" method uses the observed walk-the-book price for the PM's actual order size for a given day. However, the sample size for 75- and 100-contract trades using actual data is small (just five first-half observations and four second-half observations) since these walk-the-book quote sizes are infrequently observed. To broaden our sample, we use two additional calculation methods for the 75- and 100-contract trades. The "Actual 50-contract + .40" method simply adds a constant $0.40 to the contemporaneously observed walk-the-book price for a 50-contract order to match against any 75-lot or 100-lot PM trade day (the $0.40 value is based on our results in table 2). In contrast, the "Slope Extrapolation" method estimates the 75-contract walk-the-book price by adding the difference between the actual 50-contract and 25-contract prices to the actual 50-contract walk-the-book price. The "Slope Extrapolation" method estimates the 100-contract walk-the-book price by adding twice the difference between the actual 50-contract and 25-contract prices to the actual 50-contract walk-the-book price. P-values for tests of the null hypothesis that the respective sample's mean or median *Excess Mark-Up* equals zero are presented in parentheses.

Over the first half of the alleged manipulation period, we find no evidence that the mean or median *Excess Mark-Up* differed from zero at standard levels of statistical significance. For the 25- and 50-lot trades, the mean *Excess Mark-Up* was $0.47 and was statistically indistinguishable from zero. For the 75- and 100-lot trades, estimates of the mean *Excess Mark-Up* ranged between $0.95 and $2.59 depending upon the method used, but all were statistically indistinguishable from zero.

The results for the second half of the alleged manipulation period are quite different. We find evidence that median and mean values for the *Excess Mark-Up* in each PM trade size category are positive, large, and statistically significant. The median values are $2.43 for the 25-lot/50-lot trade sample and range between $1.53 and $4.31 for the 75-lot/100-lot trade sample. The mean values are $5.90 for the 25-lot/50-lot trade sample and range between $2.79 and $7.98 for the 75-lot/100-lot trade sample. The P-values presented in bottom row offer strong evidence against the null hypothesis that the mean (or median) *Excess Mark-Up* is the same in each half of the alleged manipulation period for the 25-lot or 50-lot trade grouping. Corresponding results for the 75-lot or 100-lot trade grouping depend on the estimation method used. Strong evidence against the null comes when the "Actual 50-contract + .40" method is used.

### *4.5 PM Trade Price Inflation Using a Post-Event Benchmark ("Excess Mark-Up$^{ex\ post}$")*

Our second measure of trade price inflation is the difference between *Trade Price*$^{PM}$, the price paid by the PM on his floor trades, and *B-VWAP*$^{post\text{-}close}$, a hypothetical floor trader's post-close average PM trade unwind price. We calculate *B-VWAP*$^{post\text{-}close}$ as the VWAP of the sequence of actual post-close, buyer-initiated Globex trades that sum to the bang-the-close contract amount traded by the PM. This unwind price is an *ex post* benchmark that captures any deleterious impacts of possibly persisting price effects that floor traders who sold to the PM might face when covering their short contract positions via Globex purchases after the close of floor trading. We define *Excess Mark-Up*$^{ex\ post}$ as

$$Excess\ Mark\text{-}Up^{ex\ post} = Trade\ Price^{PM} - B\text{-}VWAP^{post\text{-}close}. \quad (8)$$

In a competitive market, floor traders seeing the PM's MOC order to buy, say, 50 contracts, should respond with offerings based upon their perception of prices they will have to pay to offset these positions after the floor's close. Under the assumption of perfect competition by risk-neutral floor traders, the PM would be able to trade at a price equal to the expected cost of unwinding the 50-lot position after

the close. Thus, we interpret *Excess Mark-Up*$^{ex\ post}$ as an excess profitability measure that provides another index of noncompetitive floor trade prices.

Table 4 presents estimated mean and median values of *Excess Mark-Up*$^{ex\ post}$ based upon an average unwind price defined as the VWAP for hypothetical floor trader post-close Globex unwinding trades for a position matching the PM's size. We present results for the 25- or 50-contract and 75- or 100-contract trade size groupings during the first and second halves of the alleged manipulation period under two alternative unwind trade scenarios. The first scenario assumes that floor traders account for 100% of all observed post-close buyer-initiated trading activity on days that the PM trades. The second scenario assumes that floor traders account for only 50% of all observed post-close buyer-initiated trades on days that the PM trades. (We implement the latter standard simply by calculating a post-close VWAP for an order that is twice the size as the PM's actual order.) P-values for tests of the null hypothesis that the respective sample's mean or median *Excess Mark-Up* equals zero are presented in parentheses. The P-values presented in the bottom row are for tests of null hypothesis that the means (or medians) of *Excess Mark-Up* in each half of the alleged manipulation period are equal.

The results in Table 4 provide strong evidence that the prices for the trades that filled the PM's MOC orders did not reflect competitive conditions. In the first half of the alleged manipulation period, estimated mean values of *Excess Mark-Up*$^{ex\ post}$ for 25- or 50-contract trades are roughly $2.60 and highly significant under either unwind scenario. Corresponding estimates of the mean *Excess Mark-Up*$^{ex\ post}$ or the 75- or 100-contract trades are statistically significant and larger than $4.00 under either unwind scenario. The P-values presented in bottom row offer strong evidence against the null hypothesis that the mean (or median) *Excess Mark-Up* is the same in each half of the alleged manipulation period for all cases.

Figure 8 presents the cumulative profit of a hypothetical floor trader who executed the PM's bang-the-close trades and unwound the acquired short positions through offsetting purchases of contracts beginning immediately after the close on Globex using the actual sequence of observed buyer-initiated

trades. We again assume either that the floor trade consumed 100% or 50% of post-close buyer-initiated volume. Our calculations suggest that floor traders reaped excessive profits of more than $2.5 million over the 95 days of the PM's bang-the-close platinum trading, with minimal apparent risk. Both cumulative profit time series are essentially drawdown free (i.e., monotonically increasing), indicating that floor traders filling the PM's MOC orders consistently traded occurred at noncompetitive prices.

*4.6 Observations and qualifications*

We find strong evidence that the PM's alleged manipulative trades were executed at noncompetitive prices and that the magnitude of the mispricing was larger in the second half of the alleged manipulation period. We offer the following qualifications of these results. First, our price benchmarks derived from the CME data may contain errors in measurement due to problems in the original trade reporting.

Second, Figure 5 displays large positive values for our *Settlement Price Artificiality* variable for both March 24, 2008 ($15.70) and March 27, 2008 ($18.66), days on which court records state that the PM did not execute bang-the-close trades. Assuming that the court records are reliable, the PM did not cause these outcomes. Further investigation of NYMEX floor trading records during the closing period on these two days is warranted as these observations suggest the presence of some other causal force that may also have operated during the alleged manipulation period.

Finally, our results identify an important question: Why didn't off-the-floor futures market participants who might normally have executed all their trading on the Globex platform consistently place limit orders through floor brokers to sell platinum contracts $3, $5, or $10 above the Globex price during the last 10 seconds of floor trading? Such orders, even in small 1, 2, or 5-lot sizes, would have captured a portion of the excess floor trader profits we measure. We observe no evidence that these limit orders were submitted, and if these orders were submitted, they do not appear to have had the opportunity to interact with the portfolio manager's orders. Apparently, the fragmentation of order flow across the two alternative trading channels was extreme.

Kumar and Seppi (1994) and Cheng *et al*. (2005) explain that price and quantity uncertainty are major obstacles to arbitrage. Price reporting in an open outcry market is done manually and there can be a time lag in the broadcast of this information. Furthermore, trader quotes in an open outcry market become stale if not immediately executed and do not contain market depth information until hit. It is possible that some floor quotes and orders were not visible to all market participants and may not have been broadcast outside of the floor trading environment. This potential uncertainty and incomplete information may have limited the ability of off-the-floor traders to participate in these profitable trading opportunities on the floor in the closing period.

## 5. Conclusion

We hold that a truly competitive market should protect a fool and otherwise neutralize a knave. As such, regardless of the true motives of the hedge fund portfolio manager, we believe that competition among market participants should have resulted in the price impact of his repetitive bang-the-close trades being consistent with their predictable arrival and low information content. Our focus here has been the response of the floor traders, acting as financial intermediaries, to the portfolio manager's order flow. We find that the financial intermediaries do not always set prices in a manner to reduce the impact of a single customer's large bang-the-close futures contract trades, and in fact, by their actions, may increase this impact. We show that the price impact of such bang-the-close futures contract trades *increased* over time, contrary to the predictions of a competitive market environment. During the second half of the alleged manipulation period, floor traders executed the portfolio manager's platinum futures contract buy orders at prices that were 80 to 120 ticks above competitive benchmarks. This impact is much larger than that conjectured by Pirrong (1996) as possible for collusion among traders in a typical open outcry market.

For the case of platinum, these noncompetitive prices persisted in an open outcry setting characterized by a small number of traders, intermittent supervision by compliance officers, and order flow from outside participants fragmented by the Globex platform alternative. We note that, after this

alleged manipulation incident, the NYMEX removed closing period floor trades from settlement pricing formulas. Not long after this change, floor trading in platinum effectively disappeared.

While our empirical analysis has focused on trading in a specific market over a particular time period, our results have more general implications for regulators and market venues. Our results show that even trades conducted by a single customer can trigger price impacts that are larger and more persistent than standard competitive market models would predict. Our evidence is consistent with theoretical models predicting that tacit collusion among financial intermediaries may arise in a setting with frequent, repeated interaction among a small number of similar participants in a transparent market for a homogenous product.

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Tse, Y., Zabotina, T.V., 2001. Transaction costs and market quality: Open outcry versus electronic trading. *Journal of Futures Markets* 21, 713-735.

Table 1. Mean/Median Settlement Price Artificiality

Settlement Price Artificiality is defined as the difference between actual daily settlement price and the VWAP of traded on Globex during the 2-minute closing period. This table presents estimated mean and median values of Settlement Price Artificiality for three different trade size groupings (No trading; 25 or 50 contracts; 75 or 100 contracts) during three different sample periods: the first half of the alleged manipulation period (November 17, 2007 to February 20, 2008), the second half of the alleged manipulation period (February 21, 2008 to May 21, 2008), and the remaining data from outside the alleged manipulation period (combining data from the July 1, 2007 to November 17, 2007 and May 22, 2008 to June 30, 2008 periods). For each sample, P-values for tests of null hypothesis that the respective sample's mean or median Settlement Price Artificiality equals zero are presented in parentheses. The P-values presented in the bottom row are for tests of null hypothesis that the means (or medians) of Settlement Price Artificiality in each half of the manipulation period are equal.

| | | | | PM Volume | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | None | | | 25 or 50 contracts | | | 75 or 100 contracts | | |
| Period | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. |
| Outside alleged manipulation period | 0.47 (0.01) | 0.00 (0.22) | 119 | | | | | | |
| First half of alleged manipulation period | -0.44 (0.52) | -0.32 (0.37) | 9 | 1.72 (0.00) | 1.41 (0.00) | 28 | 4.14 (0.00) | 2.95 (0.00) | 19 |
| Second half of alleged manipulation period | 3.06 (0.02) | 0.01 (0.02) | 21 | 7.91 (0.00) | 4.81 (0.00) | 22 | 9.88 (0.00) | 8.30 (0.00) | 26 |
| P-value of test second half different from first | 0.09 | 0.03 | | 0.00 | 0.00 | | 0.00 | 0.00 | |

Table 2. Mean/Median Size and Immediacy Price Impact across Alternative Globex Order Sizes

The Size and Immediacy (walk-the-book) Price Impact is defined as the difference between the implied VWAP of a hypothetical Globex buy market order of a given size (say, 50 contracts) and the best offer for at least 1 contract as of the beginning of the closing period (1:03 p.m.). This table presents estimated mean and median values of Size and Immediacy Price Impact for four different trade sizes (25 contracts; 50 contracts; 75 contracts; 100 contracts) during three different sample periods: the first half of the alleged manipulation period (November 17, 2007 to February 20, 2008), the second half of the alleged manipulation period (February 21, 2008 to May 21, 2008), and the remaining data from outside the alleged manipulation period (combining data from the July 1, 2007 to November 17, 2007 and May 22, 2008 to June 30, 2008 periods). Panel A uses all available data regardless of whether the Globex book is deep enough on a given day to generate walk-the-book trades in all four size categories. Panel B restricts the sample to just those days where the Globex limit order book is at least 100 contracts deep. For each sample, P-values for tests of null hypothesis that the respective sample's mean or median Settlement Price Artificiality equals zero are presented in parentheses. The P-values presented in the bottom row are for tests of null hypothesis that the means (or medians) of Settlement Price Artificiality in each half of the alleged manipulation period are equal.

Panel A: Using all data

| Bang-the-Close Trade Size: | | 25 | | | 50 | | | 75 | | | 100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Statistic: | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. |
| Outside alleged manipulation period | 1.69 (0.00) | 1.51 (0.00) | 120 | 2.09 (0.00) | 1.70 (0.00) | 114 | 2.12 (0.00) | 1.43 (0.00) | 63 | 2.34 (0.00) | 1.46 (0.00) | 19 |
| First half of alleged manipulation period | 1.92 (0.00) | 1.64 (0.00) | 57 | 2.42 (0.00) | 2.19 (0.00) | 51 | 2.40 (0.00) | 1.44 (0.00) | 31 | 2.52 (0.00) | 1.51 (0.00) | 13 |
| Second half of alleged manipulation period | 2.86 (0.00) | 2.38 (0.00) | 69 | 4.96 (0.00) | 3.85 (0.00) | 65 | 4.70 (0.00) | 4.34 (0.00) | 25 | 4.40 (0.04) | 2.72 (0.03) | 6 |
| P-value of test that second half is different from first | 0.00 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | | 0.21 | 0.19 | |

Panel B: Using only data for high liquidity days in which a 100-lot walk-the-book order is observable

| Bang-the-Close Trade Size: | | 25 | | | 50 | | | 75 | | | 100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Statistic: | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. |
| Outside alleged manipulation period | 1.52 (0.00) | 1.50 (0.00) | 19 | 1.87 (0.00) | 1.41 (0.00) | 19 | 1.83 (0.00) | 1.28 (0.00) | 19 | 2.34 (0.00) | 1.46 (0.00) | 19 |
| First half of alleged manipulation period | 1.68 (0.00) | 1.67 (0.00) | 13 | 2.13 | 2.18 (0.00) | 13 | 2.06 (0.00) | 1.36 (0.00) | 13 | 2.52 (0.00) | 1.51 (0.00) | 13 |
| Second half of alleged manipulation period | 2.70 (0.00) | 2.45 (0.03) | 6 | 4.01 (0.02) | 3.56 (0.03) | 6 | 4.23 (0.02) | 3.41 (0.03) | 6 | 4.40 (0.04) | 2.72 (0.03) | 6 |
| P-value of test that second half is different from first | 0.02 | 0.05 | | 0.04 | 0.16 | | 0.06 | 0.08 | | 0.21 | 0.19 | |

Table 3. Mean/Median Excess Mark-Up measured versus a Walk-the-Book Benchmark

The Excess Mark-Up is defined as the difference between the VWAP of the PM's bang-the-close trades and the walk-the-book price. This table presents estimated mean and median values of Excess Mark-Up for two trade size groupings (25 or 50 contracts; 75 or 100 contracts) for the first and second halves of the alleged manipulation period. We present results for walk-the-book prices calculated three different ways. The "Actual" method uses the observed walk-the-book price for an order size equal to that of the Portfolio Manager. However, the sample size for 75- and 100-contract trades using actual data is small since these sizes are infrequently observed. We use two additional calculation methods for the 75- and 100-contract trades. The "Actual 50-contract + .40" method simply adds a constant $0.40 to the contemporaneously observed walk-the-book price for a 50-contract order size equal to the Portfolio Manager's trade size. The "Slope Extrapolation" method estimates the 75-contract walk-the-book price by adding the difference between the actual 50-contract and 25-contract prices to the actual 50-contract walk-the-book price. The "Slope Extrapolation" method estimates the 100-contract walk-the-book price by adding twice the difference between the actual 50-contract and 25-contract prices to the actual 50-contract walk-the-book price. P-values for tests of the null hypothesis that the respective sample's mean or median Excess Mark-Up equals zero are presented in parentheses. The P-values presented in the bottom row are for tests of null hypothesis that the means (or medians) of Excess Mark-Up in each half of the alleged manipulation period are equal.

| Bang-the-Close Trade Size: | 25 or 50 contracts | | | 75 or 100 contracts | | | 75 or 100 contracts | | | 75 or 100 contracts | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calculation method: | Actual | | | Actual | | | Actual 50-contract + .40 | | | Slope Extrapolation | | |
| Statistic: | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. |
| First half of alleged manipulation period | 0.47 (0.21) | 0.52 (0.24) | 25 | 2.59 (0.34) | 1.28 (0.50) | 5 | 1.75 (0.07) | 0.59 (0.20) | 18 | 0.95 (0.44) | 0.81 (0.50) | 18 |
| Second half of alleged manipulation period | 5.90 (0.00) | 2.43 (0.00) | 21 | 2.79 (0.34) | 1.59 (0.27) | 4 | 7.98 (0.00) | 4.31 (0.00) | 25 | 4.61 (0.02) | 1.53 (0.03) | 25 |
| P-value of test of null that first- and second-half values are equal | 0.00 | 0.00 | | 0.96 | 0.62 | | 0.01 | 0.04 | | 0.14 | 0.19 | |

Table 4. Mean/Median Excess Mark-Up Using Unwind Price

The Excess Mark-Up based upon an average unwind price is defined as the difference between the VWAP of the PM's bang-the-close trades and the VWAP for hypothetical post-close unwinding trades for a position of matching size on Globex. This table presents estimated mean and median values of Excess Mark-Up for two trade size groupings (25 or 50 contracts; 75 or 100 contracts) during the first and second halves of the alleged manipulation period. We present results for two alternative unwind trade scenarios. The first assumes that floor traders account for 100% of all observed post-close buyer-initiated trading activity on days that the PM trades beginning immediately after the close and continuing until the position size sold to the PM is unwound. The second assumes that floor traders account for only 50% of all observed post-close buyer-initiated trading activity on days that the PM trades beginning immediately after the close and continuing until the position size sold to the PM is unwound. P-values for tests of the null hypothesis that the respective sample's mean or median Excess Mark-Up equals zero are presented in parentheses. The P-values presented in the bottom row are for tests of null hypothesis that the means (or medians) of Excess Mark-Up in each half of the alleged manipulation period are equal.

| Bang-the-Close Trade Size: | 25 or 50 contracts | | | | | | 75 or 100 contracts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calculation: | 100% of Post-Close Volume | | | 50% of Post-Close Volume | | | 100% of Post-Close Volume | | | 50% of Post-Close Volume | | |
| Statistic: | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. | Mean | Median | No. obs. |
| First half of alleged manipulation period | 2.64 (0.00) | 2.14 (0.00) | 28 | 2.57 ( 0.00) | 1.47 ( 0.00) | 28 | 4.39 (0.00) | 4.03 (0.00) | 19 | 4.03 ( 0.03) | 4.13 ( 0.02) | 19 |
| Second half of alleged manipulation period | 10.66 (0.00) | 8.46 (0.00) | 22 | 12.86 ( 0.00) | 10.86 ( 0.00) | 22 | 10.47 (0.00) | 9.02 (0.00) | 26 | 12.47 ( 0.00) | 9.56 ( 0.00) | 26 |
| P-value of test of null that first- and second-half values are equal | 0.00 | 0.00 | | 0.00 | 0.00 | | 0.03 | 0.03 | | 0.05 | 0.07 | |

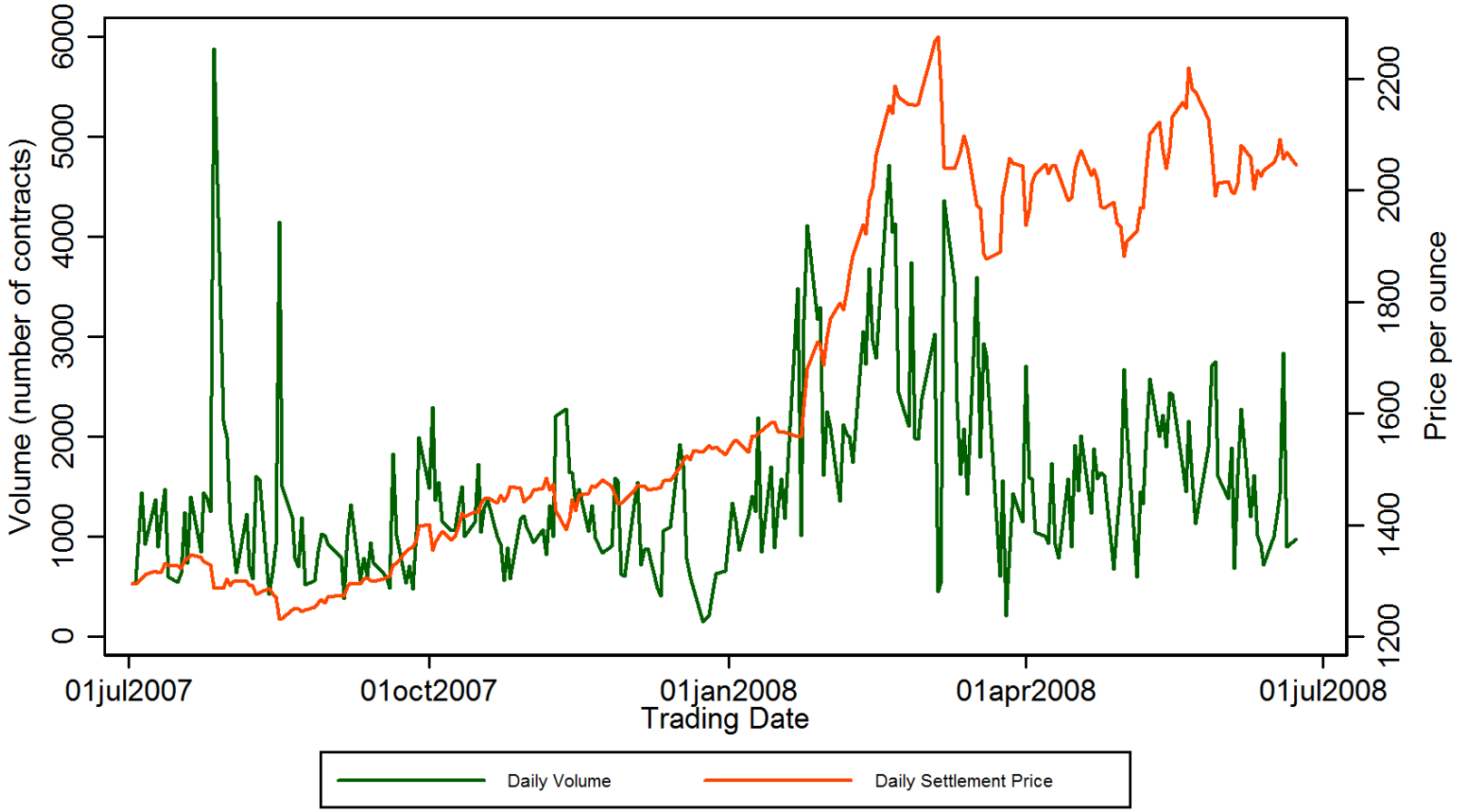


Figure 1. Platinum Daily Trading Volume (Number of Contracts) and Daily Settlement Price

We plot only the NYMEX active platinum future contract.

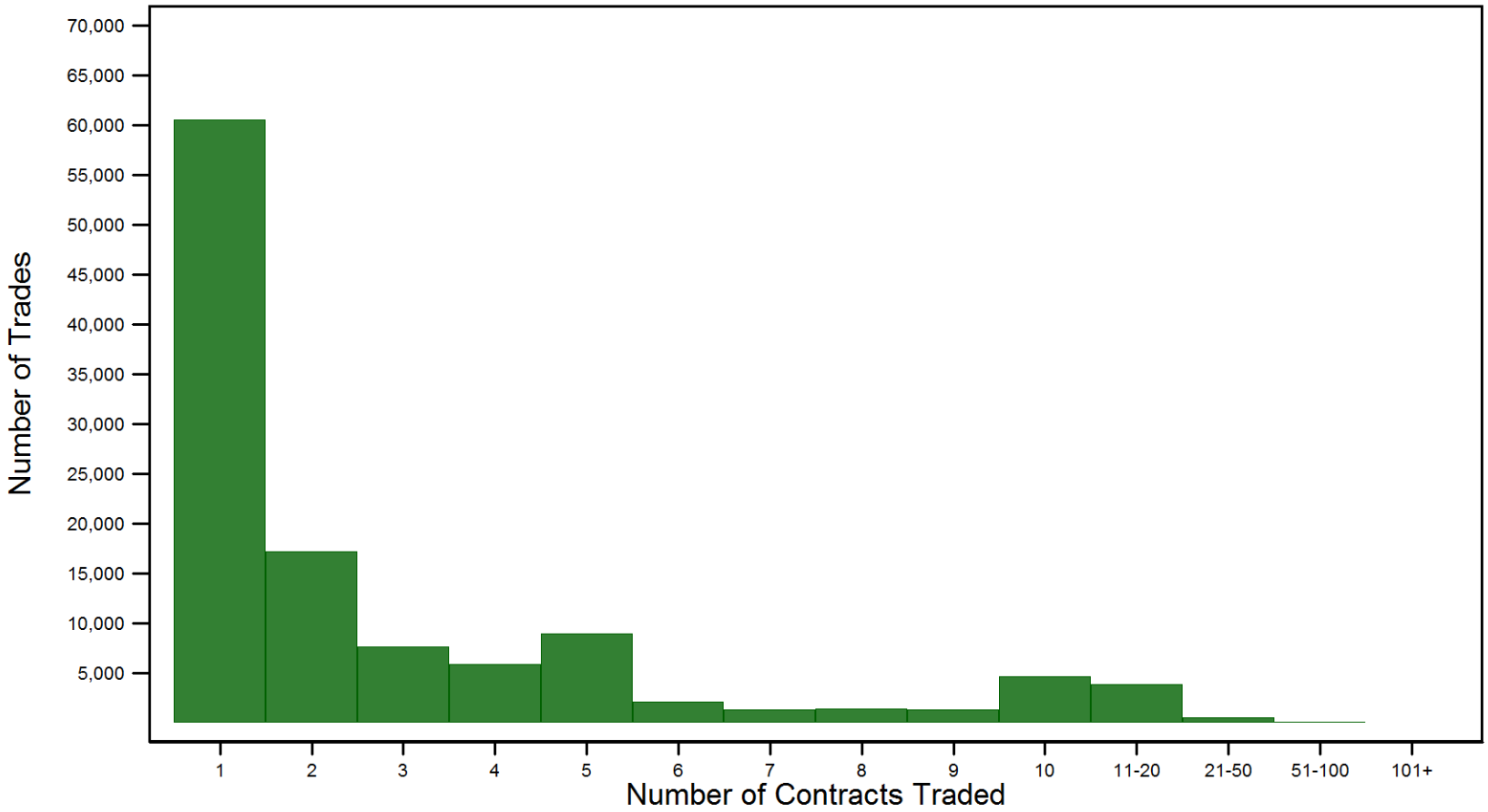


Figure 2. Number of Trades across Trade Size (Number of Contracts)

We plot only the NYMEX active platinum future contract. Sample period is July 1, 2007 to June 30, 2008.

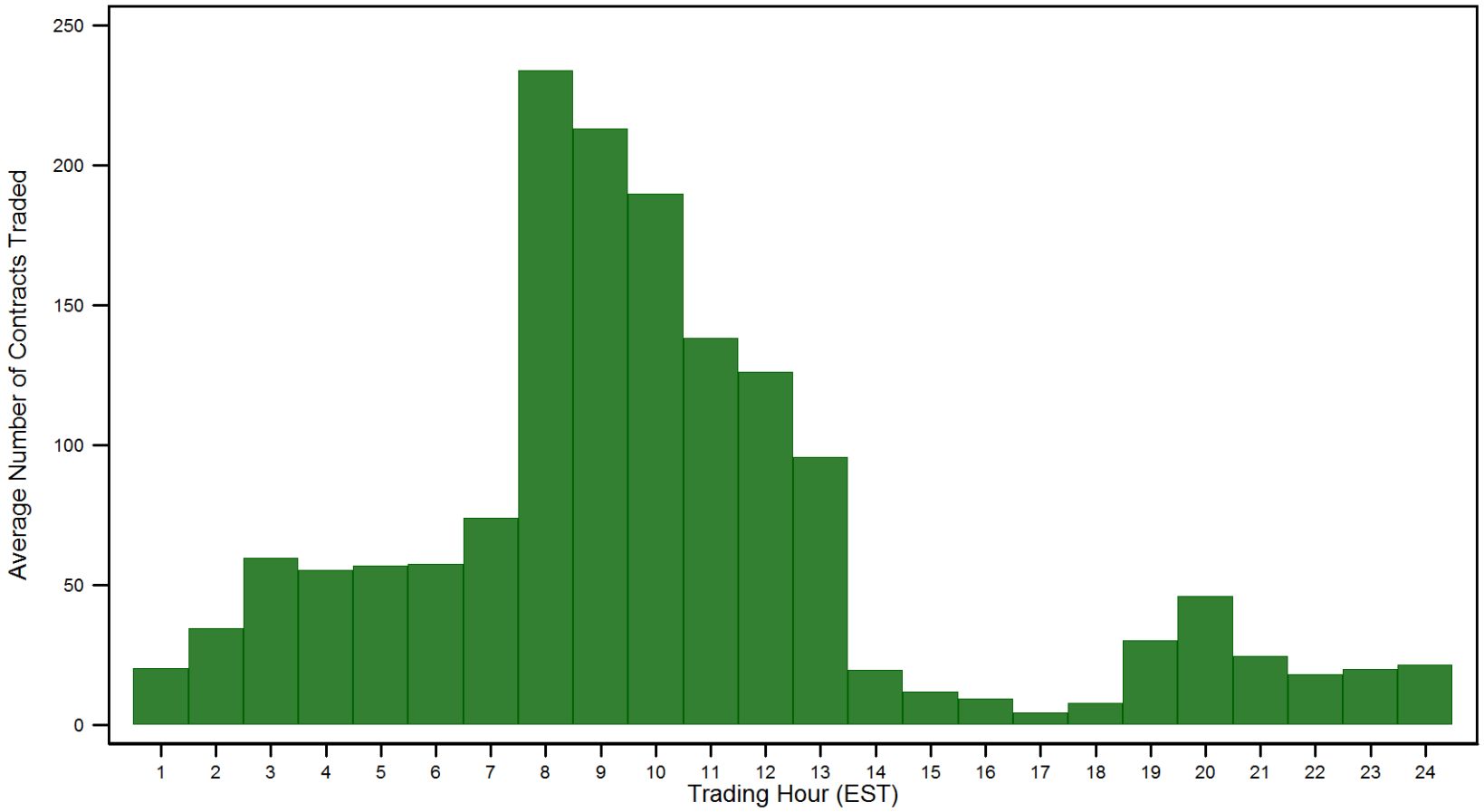


Figure 3. Average Trading Volume per Trading Hour

We plot only the NYMEX active platinum future contract. Sample period is July 1, 2007 to June 30, 2008.

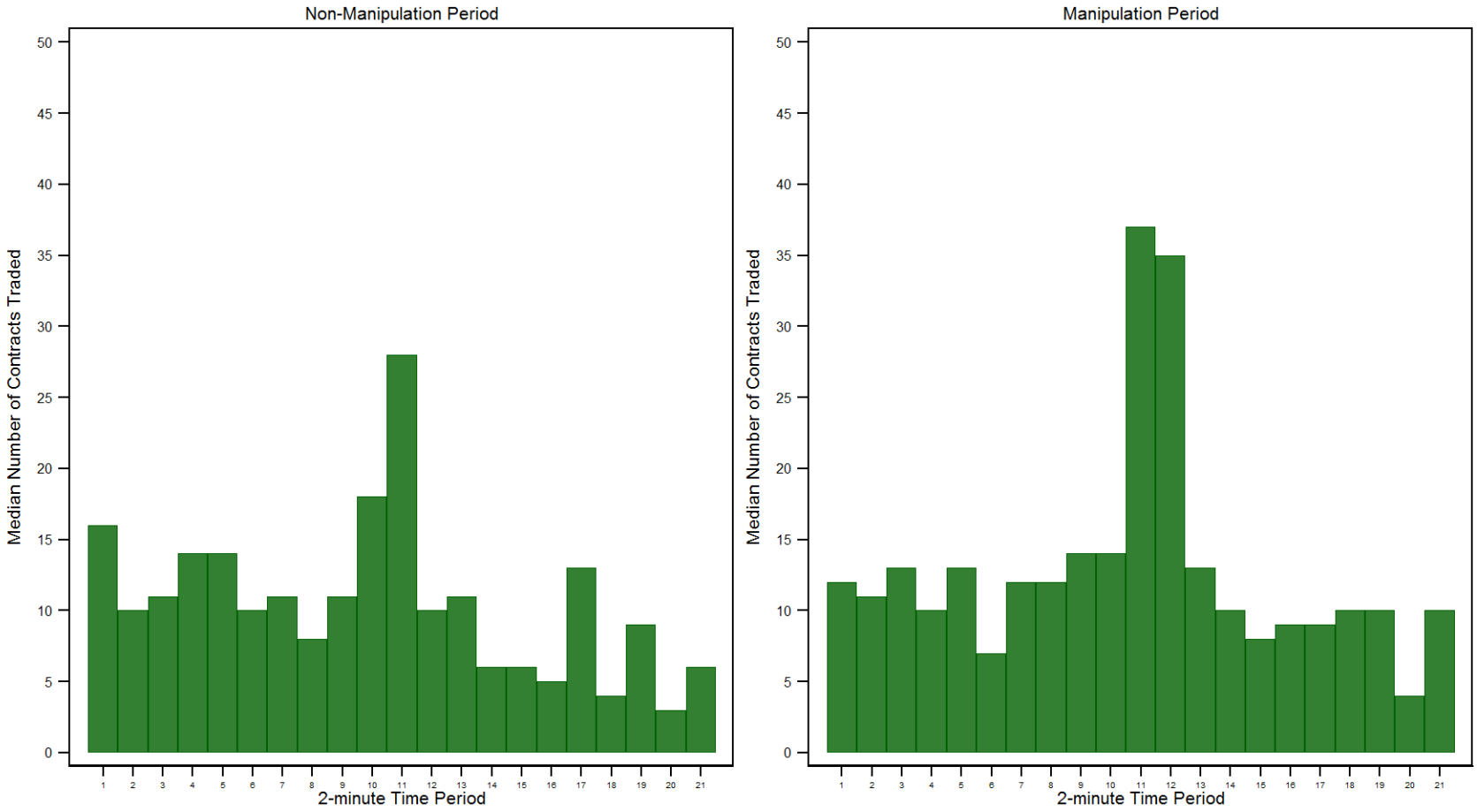


Figure 4. Median Trading Volume per 2-minute period around the Closing Time

Closing time is 13:03-13:05 EST. On the chart this is Time Period No. 11. Sample period is July 1, 2007 to June 30, 2008.

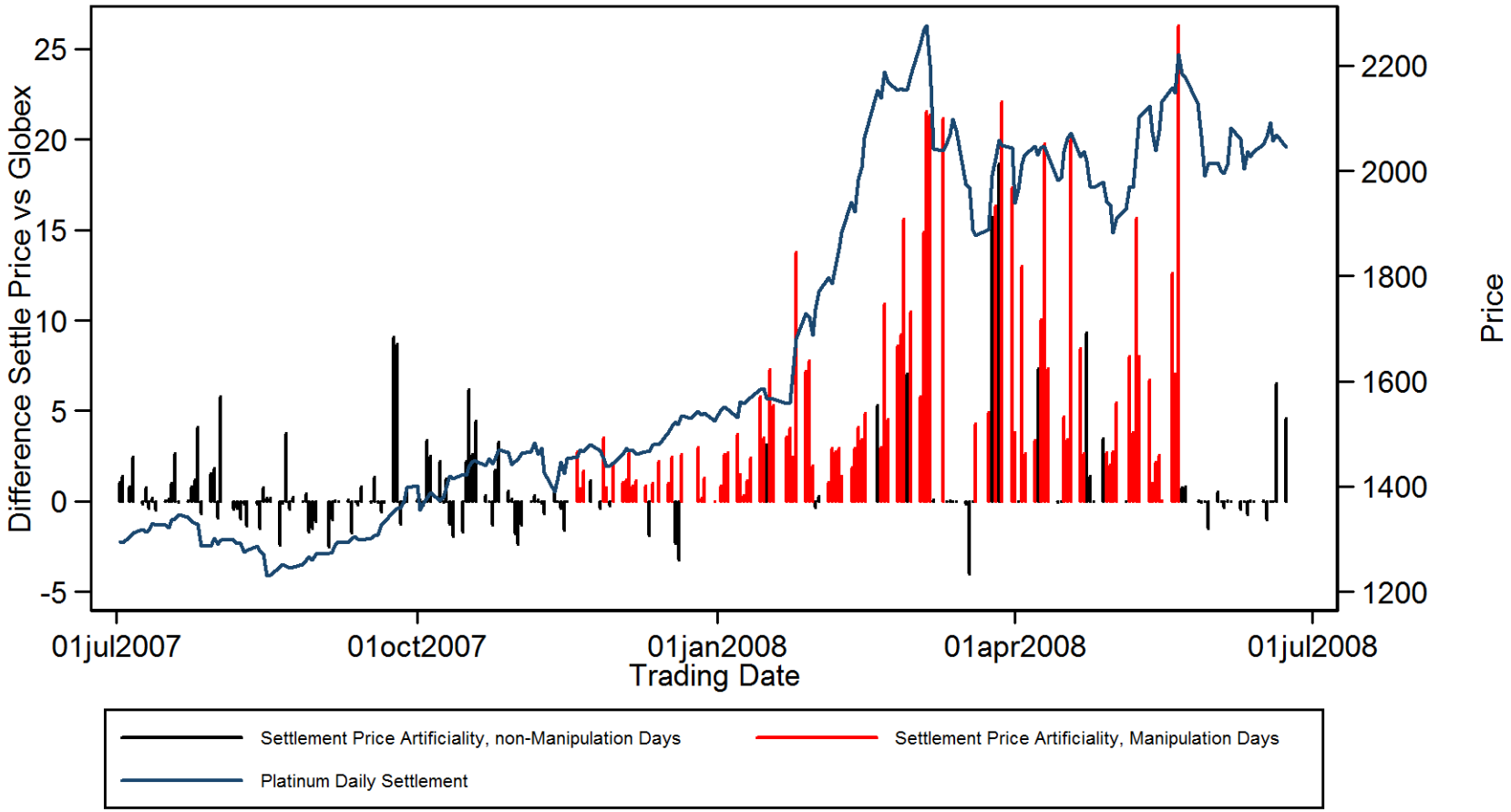


Figure 5. Settlement Price Artificiality on Alleged Manipulation vs. Non-Manipulation Days

We define the Settlement Price Artificiality as the difference between Actual Daily Settlement Price and the Counterfactual Settlement Price, measured in dollars, estimated as the VWAP of trades on Globex during the 2-minute closing period.

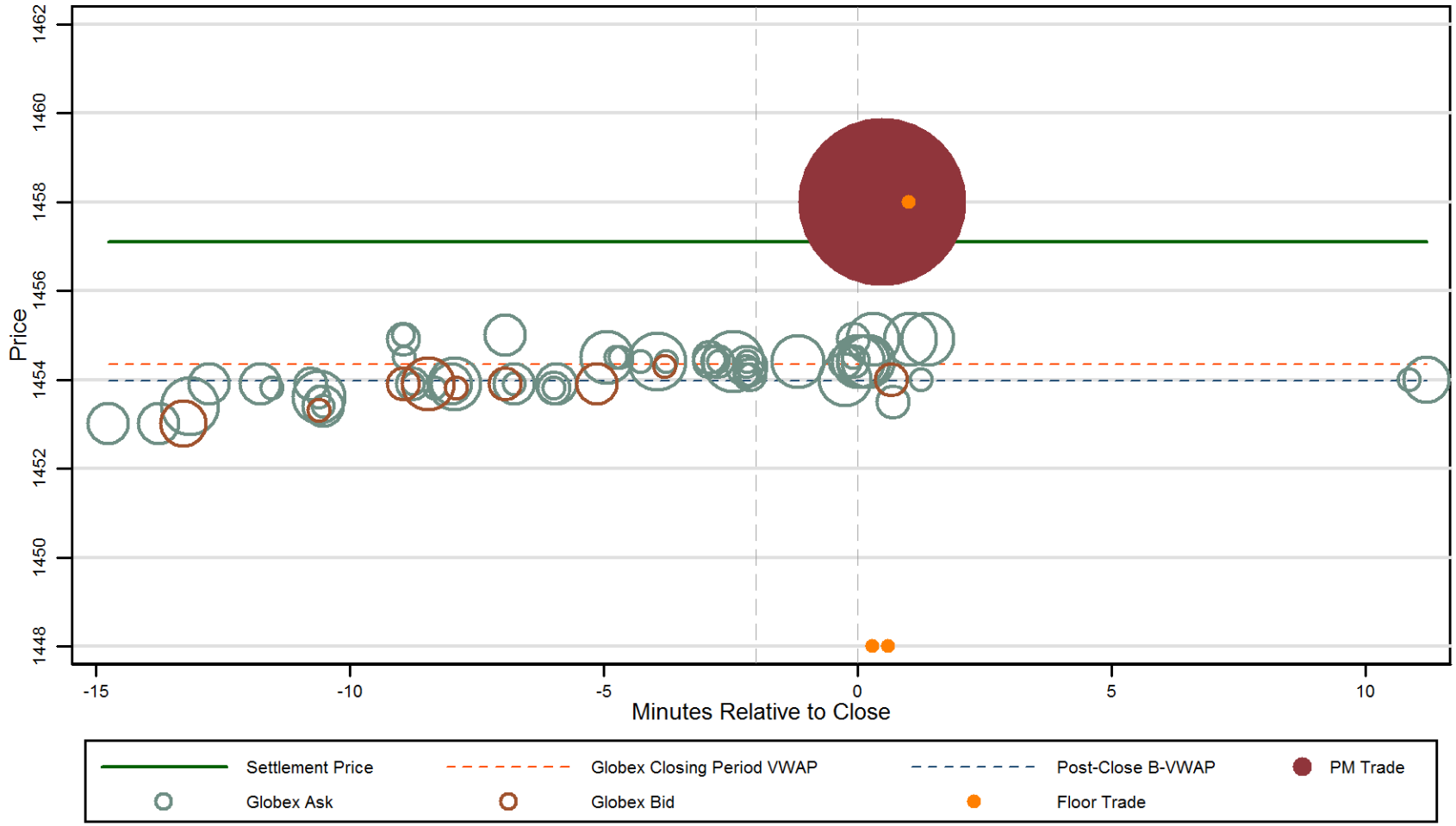


Figure 6a. Platinum Futures Trading on the Floor and Globex during the 30 minutes around the Floor Close (Nov 19, 2007)

The size of the plotted symbol for each trade is proportional to trade size. November 19, 2007 is the first date of alleged manipulative trading in platinum. The PM bought a total of 50 January 2008 contracts in a single trade recorded at 1:05 PM EST at a price of $1458/ounce.

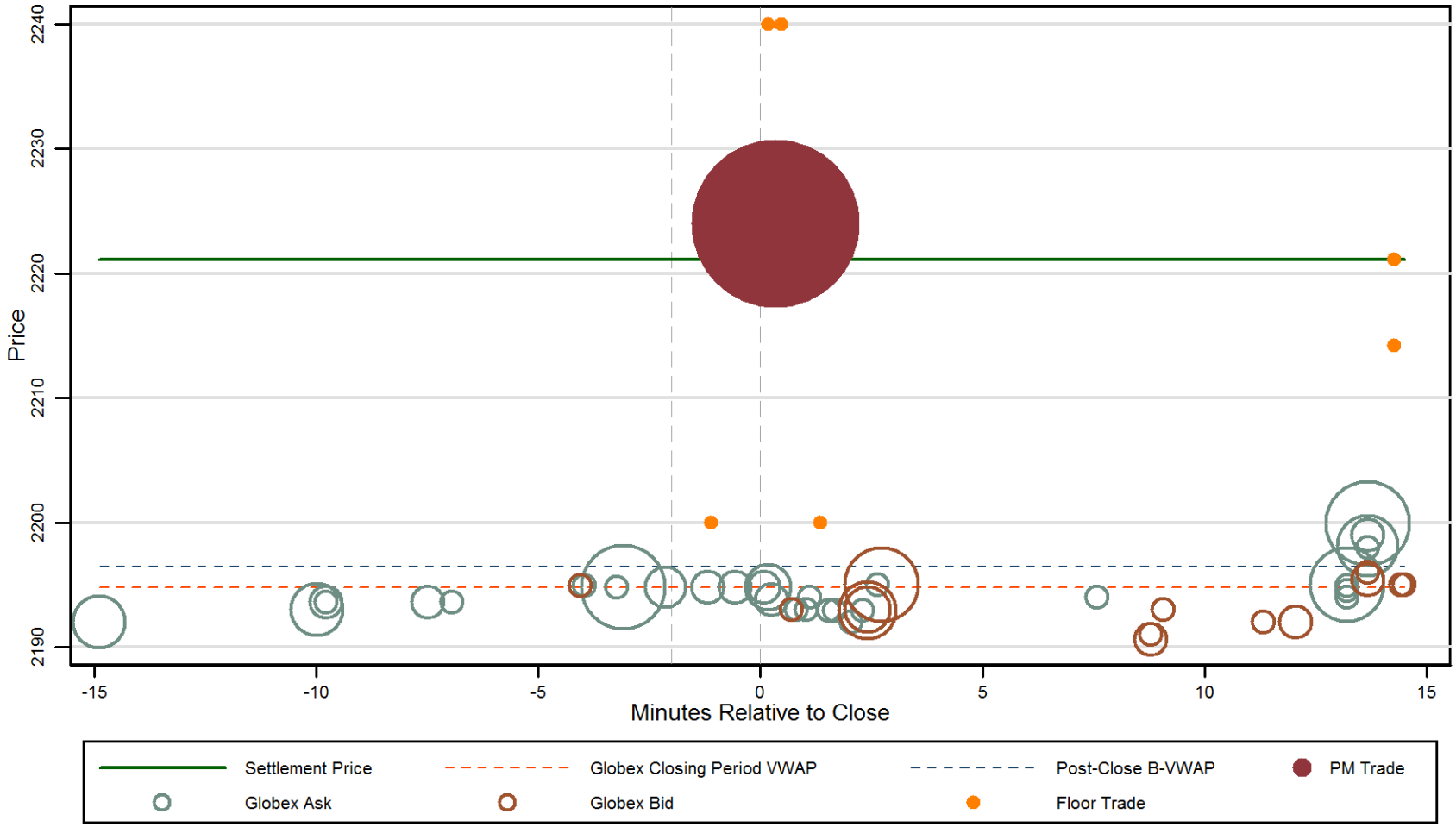


Figure 6b. Platinum Futures Trading on the Floor and Globex during the 30 minutes around the Floor Close (May 21, 2008)

The size of the plotted symbol for each trade is proportional to trade size. May 21, 2008 is the last date of alleged manipulative PM trading in platinum. The PM bought a total of 50 July 2008 contracts in a single trade recorded at 1:05 PM EST at a price of $2224/ounce.

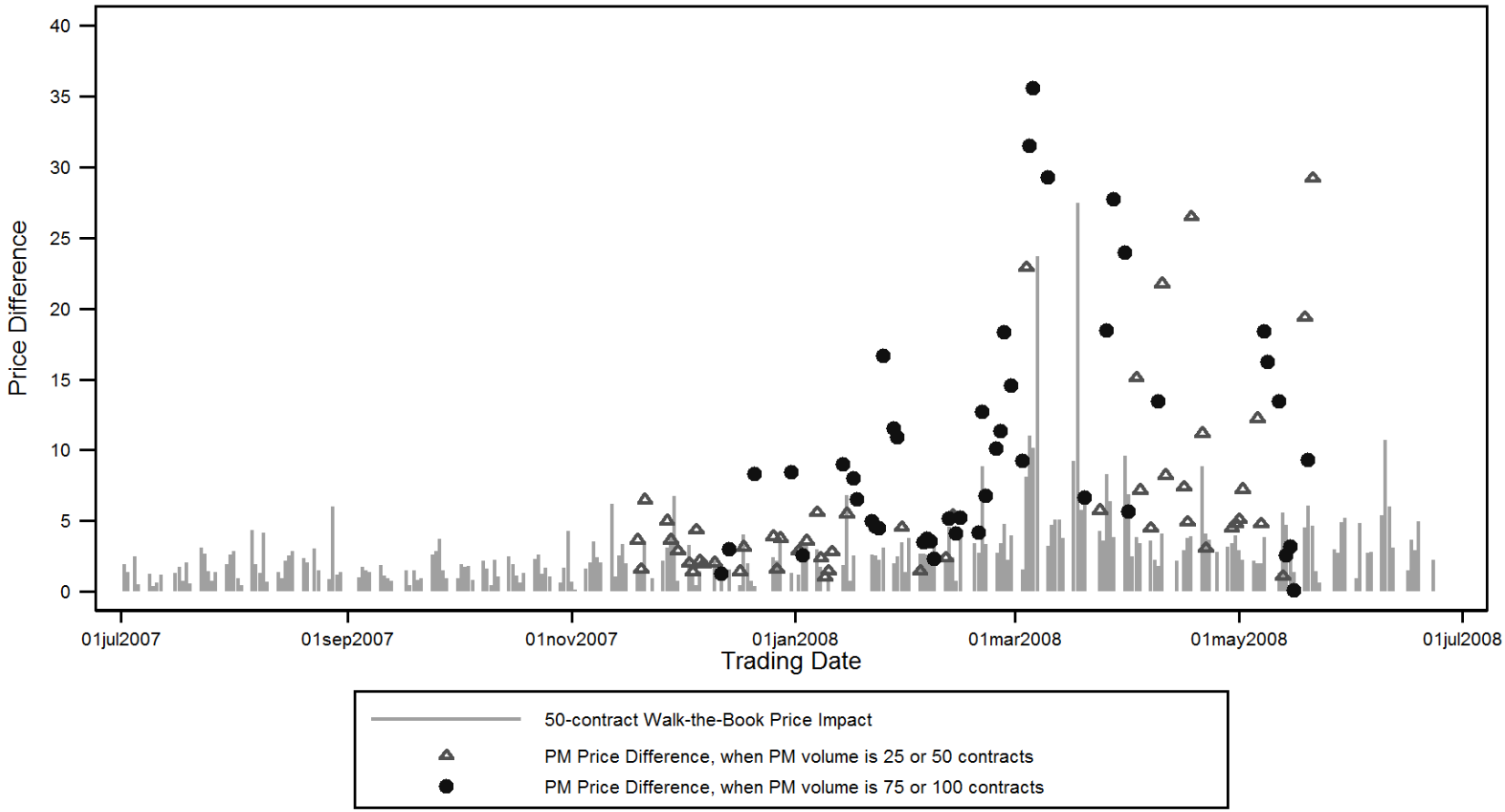


Figure 7. Portfolio Manager Trade Price Difference vs. Size and Immediacy Mark-up for a 50-contract "Walk-the-Book" trade. PM Trade Price Difference equals the difference between the PM's Trade Price and the Globex Counterfactual Settlement Price.

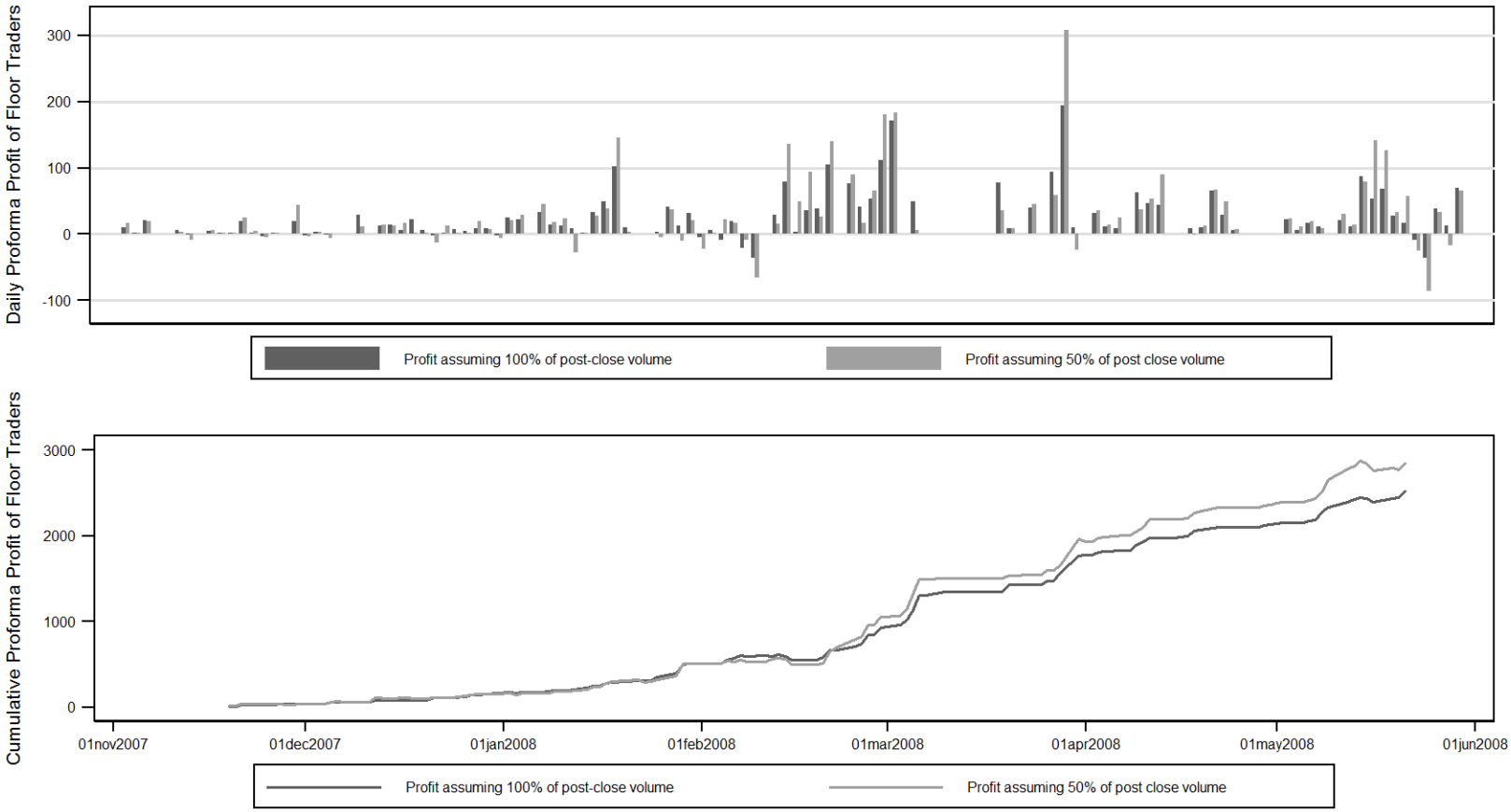


Figure 8. Pro-forma Daily Cumulative Profit of Floor Traders Executing the Bang-The-Close Trades.

All numbers are in $thousands. The pro-forma profits are calculated assuming that a hypothetical floor trader executed the PM's bang-the-close trades and unwound the acquired short positions through offsetting purchases of contracts beginning immediately after the close on Globex using 100% or 50% of the actual sequence of observed buyer-initiated trades.