Market abuse under different close price determination mechanisms: A European case

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Abstract

We examine the presence and the severity of closing price manipulation across two regulatory shifts in the close price determination mechanism in the Athens stock exchange. First, we assess the transition from a value-weighted average price (VWAP) method to a plain-vanilla closing call auction method (CCAM). Second, we examine the effectiveness of additional features of CCAMs in deterring closing price manipulation. We use tick level data with full investor details for a group of highly traded stocks. Our results suggest that the CCAM managed to reduce - but not eliminate - closing price manipulation. CCAMs with additional anti-manipulation features are not effective in eliminating closing price manipulation either. Manipulation is dynamic and investors quickly adapt to new circumstances and opportunities; post-CCAM implementation sell-based closing price manipulation has increased, while part of the manipulation activity has shifted to the reference price formation.

JEL Classification: D44, G14, G24

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1. Introduction

Stock markets offer liquidity services that enable investors to allocate asset holdings and manage financial risks. In offering such activities stock markets are governed by trading rules and a set of procedures under which trading orders are conveyed, matched, and executed. It is these rules and procedures that protect participant rights, reduce uncertainty, deter fraud and market manipulation, foster liquidity and ensure the creditworthiness of participating investors (O'hara, 1997).

Applied research in the field of market abuse is limited since it requires the use of high-frequency data and information on investor details. As a workaround, many researchers examine the presence of manipulation based on past prosecuted manipulation cases or theoretically by examining changes of securities stylized facts, such as returns, volatility, and bid-ask spreads during a period when manipulation may have been more likely. To the best of our knowledge, only a handful of studies use datasets with investor details. Analytically for these type of studies, Felixson and Pelli (1999), examine the Finnish stock exchange and present statistical results in favor of closing price manipulation, while Khwaja and Mian (2005) reach similar conclusions for the case of Pakistan. In other similar studies, Kucukkocaoğlu (2008) and Kadiouglu et al., (2015) provide evidence that closing call auction methods have eliminated closing price manipulation in the Turkish stock exchange; another study reaching a similar conclusion for the case of Indonesia (Saputra & Prijadi, 2017).

In this paper we investigate whether changes in the close price determination mechanism have reduced closing price manipulation. We use a comprehensive tick level dataset that includes full investor details, over two distinct periods that are characterized by changes in the close price determination mechanism. In the first period, we examine the transition from a value-weighted average price (VWAP) method to a closing call auction method (CCAM). In the second period, we compare two variants of a CCAM with additional attributes. In our basic tests we focus on investors that represent a significant proportion of the volume of transactions for each of the periods under examination; we call these strategic manipulators.

We contribute to the literature on market abuse in three ways. This is the first study, to the best of our knowledge, to focus on *strategic manipulators* (in contrast to daily or intraday manipulators), who are identified using their net position over an extended time period. Thus, this approach is better aligned with the concept of long-term manipulation within the Market Abuse Regulation (MAR) and Market Abuse Directive (MAD), which are the cornerstones that guarantee the integrity of European financial markets and increase investor confidence. Second, using a quasi-experimental design we assess: i) the efficacy of a plain CCAM compared to a VWAP, and ii) the efficacy of CCAM's extra anti-manipulation attributes upon long-term closing price manipulation. Third, we are the first to examine the "Achilleas heal" of CCAMs – the reference price – for evidence of a shift in strategic manipulators' targeted price. We argue that when a CCAM is in place, closing price manipulation studies should also investigate for manipulation via the reference price. Failure to do so may lead to the

biased conclusion that closing price manipulation has eclipsed, whereas part of the action may have shifted around the reference price.

Our results suggest that closing price manipulation is not eliminated by the adoption of a CCAM, either of the plain-vanilla type or of a sophisticated variant with anti-manipulation attributes. We obtain statistical evidence that long-term market manipulators continue to influence the close price, but at a significantly lower degree after the abolition of the VWAP. Following the introduction of a CCAM an adjustment to the manipulative techniques is observed, whereby the reference price before the closing auction may be used to manipulate the close price. The change in the anti-manipulation attributes of the CCAM during the second period of the study has not deterred manipulators from influencing the reference price. We believe that our results would be of interest to investors and regulators as the implementation of CCAMs concentrates the bulk of trading into the last few minutes of the trading session (Reuters, 2019).

The remainder of the paper is structured as follows. Section 2 presents a literature review. Section 3 presents the dataset and market microstructure characteristics. Section 4 presents and discusses the empirical analysis. A final section concludes and provides policy implications.

2. Literature review

2.1 Close price – Importance and market abuse regulation

The close price is arguably the most important signal to market participants as it reflects the final valuation assessment during a trading session; therefore, the one typically reported in the media. Among academic researchers, the close price is important since most of the empirical research focusing on stock market dynamics uses it to construct the logarithmic return; the quantity of interest in econometric modelling. Recent advances in machine learning techniques also rely on the close price (Dash & Dash, 2016), it is also relevant in academic research (Batten et al., 2018; Wong et al., 2003) and popular among technical analysis indicators used by practitioners, like the moving average convergence divergence (MACD) and the relative strength index (RSI) (Edwards et al., 2018).

In the financial industry the net asset value (NAV) of mutual funds, calculated using the close price, is the basis for benchmarking and remuneration of the fund and the fund manager respectively. Derivatives and structured products like stock options, futures and exchange-traded funds (ETFs) depend on the underlying stocks for their pricing. The close price is also important in a range of corporate activities. For example, the valuation of private companies typically relies on the use of multiples from listed companies, such as the price to earnings (P/E) or enterprise value to EBITDA (EV/EBITDA) ratios, with the close price entering in these calculations. Corporate bank loans may be backed by a portfolio of securities that is monitored on a timely, close

price basis for valuation purposes. The close price is also relevant in mergers and acquisitions (M&A) between listed firms when there is exchange of shares for cash or shares for shares (Cumming et al., 2020).

Based on the importance of the close price many market participants with trading expertise may try to manipulate it at the expense of inexperienced ones. For example, fund managers' last-minute transactions are conducted to "mark-up" the prices of their own stocks, thus making quarter-end and year-end NAVs for mutual fund equities to be abnormally high (Carhart et al., 2002). Close price as benchmark for the value of derivative products can also be manipulated for margin maintenance and settlement of derivatives contracts at expiration (Corredor et al., 2001; Jarrow, 1992; Kumar & Seppi, 1992).

Following the 2008 Global Financial Crisis, efficiency, fairness, and transparency within financial markets have received significant attention with regulators taking appropriate action to promote such principles. In this respect, the Market Abuse Directive (MAD), was replaced by the Market Abuse Regulation (MAR) and the Directive on Criminal Sanctions for Market Abuse (CSMAD or MAD II) in 2016, in an EU-wide attempt to promote market fairness and transparency in European stock markets. Recent research provides evidence that the adoption of MAD II by the EU countries has been effective in preventing market manipulation (Cumming et al., 2020; Shahzad & Mertens, 2017).

To deter closing price manipulation trading venues worldwide use CCAM to determine the close price. These mechanisms are perceived to improve the price discovery process and prevent manipulation by generating an equilibrium price that reflects market supply and demand (Barclay et al., 2008; Comerton-Forde et al., 2007; Kandel et al., 2012; Pagano & Schwartz, 2003). As such, most of the trading venues in Europe use CCAM as the close price determination mechanism or are taking necessary steps towards its implementation.[2] Taking a step further, the Markets in Financial Instruments Directive (MiFID) II addresses the importance of the call auction design and introduces additional features. According to Article 19§1 of MiFID II *"Trading venues shall ensure that appropriate mechanisms to automatically halt or constrain trading are operational at all times during trading hours"* (ESMA, 2015). Thus, all EU trading venues are required to apply volatility interrupters in their call auction mechanisms.[3] Hence, extensions to plain-vanilla CCAMs have also been adopted. Cordi et al., (2017) provide support for a closing batch mechanism that has randomized closing times and extensions if volatility thresholds are breached. Mechanisms that prolong the duration

[2] Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Ireland, (the) Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden and the UK have introduced closing auction mechanism in their trading venues.

[3] Volatility Interrupter is defined as the automatic halt in the trading of specific security and the activation of an interruption in the matching mechanism of a particular security when the price of the trade that is going to be executed exceeds specific price thresholds set by the exchange. These thresholds are usually defined as the percentage deviation of the price of a security with reference to the last price (Reference price) that was executed for the particular security. The importance of volatility interrupters became apparent when in the Covid-19 financial crisis, stock markets in the US hit four circuit breakers.

of the call auction in case of price deviation with reference to a pre-defined limit are adopted (ESMA, 2017).

2.2 Market abuse empirical evidence

Market abuse refers to insider trading and stock market manipulation, both of which rely upon information asymmetries between contracted parties. The former refers to trading on the use of information that is only available to the insider, which can lead to abnormal profits at the expense of the less informed market participants (e.g., front running) see Bhattacharya et al., (2014), Cumming et al., (2020), Ferretti et al., (2019), Mao et al., (2019) and references therein. The latter is an umbrella term that encompasses advancing the bid, improperly matched orders, layering, momentum ignition, painting the tape, quote stuffing, spoofing, trash and cash, wash trades to name but a few (EU, 2014, 2015; Lee et al., 2013). Stock market manipulation can be divided into three different types: information-based, action-based, and trade-based (Allen & Gale, 1992). Information-based manipulation refers to the release and spreading of rumors and false information about stocks (Van Bommel, 2003). Action-based manipulation is carried out through actions other than trading that change the observable value of the assets.[4] In the case of trade-based manipulation, traders aim to create uncertainty about the drivers of stock returns by placing bid and ask quotes accordingly. Large traders are better suited to engage in stock manipulation due to the volume of trading they engage into, while such strategies are found to produce abnormal gains (Jarrow, 1992).

Empirical research on stock market manipulation follows two strands. One strand is based on prosecuted case studies, another on econometric modeling of data with investor details. Regarding prosecuted cases stock market manipulation has taken place in the stock markets of Canada (Comerton-Forde & Putnicnš, 2011, 2013), Hong-Kong (Gerace et al., 2014), Taiwan (Huang & Cheng, 2015), Turkey (Öugüt et al., 2009), the US (Aggarwal & Wu, 2006; Comerton-Forde & Putnicnš, 2011, 2013) as well as in the East Asian regions (Shah et al., 2019). The evidence suggest that manipulators obtain wealth at the expense of others and market efficiency is negatively impacted. Liquidity, returns, bid-ask spreads, volatility and trading activity are worse off due to manipulation. Moreover, the negative effects of manipulation spread to stocks irrespective of their liquidity and/or market capitalization; hence necessitating appropriate course of action (Aggarwal & Wu, 2006; Shah et al., 2019). Empirical studies using data with investor details are limited due to the data availability, see for example Felixson and Pelli (1999), Khwaja and Mian (2005), Lee et al., (2013) and references therein.

Even though the CCAM has been adopted by most major exchanges in the world, there is no conclusive evidence on its effectiveness. According to some studies the CCAM

[4] See for example Hillion and Suominen (2004) where brokers act as manipulators in order to give a good impression of execution quality to their customers.

deters closing price manipulation worldwide (Cordi et al., 2017) and in specific exchanges such as, Paris (Biais et al., 1999; Kandel et al., 2012; Pagano & Schwartz, 2003), US (NASDAQ) (Pagano et al., 2013; Pagano & Schwartz, 2003), Singapore (Comerton-Forde et al., 2007), New Zealand (Pinfold & He, 2012), Italy (Kandel et al., 2012) and Taiwan among others (Huang & Cheng, 2015). Besides, the CCAM has also reduced volatility, bid-ask spreads and increased liquidity (Barclay et al., 2008; Kandel et al., 2012).

Another strand of research finds that the CCAM is ineffective in reducing closing price manipulation. For example, in the Australian stock exchange the CCAM increased end-of-day activity with arbitrageurs and fund managers influencing the close price (Aitken et al., 2005). In addition and for the cases of India (Camilleri & Green, 2009), Hong Kong (Park et al., 2019; Suen & Wan, 2013) and a worldwide sample of twelve exchanges (Comerton-Forde & Rydge, 2006) suspensions of the CCAM increased liquidity, reduced volatility and increased closing price manipulation of illiquid stocks. To the defense of CCAMs, it has been noted that it is not the implementation of the mechanism *per se* that deters closing price manipulation but specific anti-manipulation attributes that plain-vanilla variants of the CCAMs typically lack (Comerton-Forde & Rydge, 2006; Park et al., 2019).

Anti-manipulation features present in the CCAM are of four key types: i) the ability to modify/cancel orders within the auction period, ii) the randomization of the auction time, iii) the dissemination of the projected closing auction price and full order book, iv) the use of volatility interruption systems (Domowitz & Madhavan, 2001). Volatility interruption systems in the CCAM include: a) volatility extensions, which extend the duration of the auction period if the projected close price exceeds a specific threshold, and b) price volatility bands (dynamic and static), which allow the close price to fluctuate between pre-defined thresholds. Comerton-Forde and Rydge (2006) argue that certain algorithm designs are more effective at reducing closing price manipulation. Certain attributes, such as transparency and volatility interrupters allow investors to reevaluate their strategy when there is a price shock, which may affect the existence of closing price manipulation. Even subtle changes in the CCAM attributes (i.e., randomized closing time) may have a substantial effect in deterring closing price manipulation (Camilleri & Green, 2009; Park et al., 2019). Randomization of the closing auction increases the uncertainty of the exact auction duration; thus making closing price manipulation attempts more costly (Cordi et al., 2017; Malaga et al., 2010). The ability that market participants can modify/cancel orders during the auction phase has been found to reduce closing price manipulation (Biais et al., 1999), at the expense of reduced liquidity and increased volatility (Cordi et al., 2017). Félez-Viñas and Hagströmer (2017) find that the volatility extensions improve market integrity at the end of the trading day and reduce close price volatility by about 40% for small-cap stocks. The continuous dissemination of the projected closing auction price and the full order book aim at increasing transparency throughout the pre-close period. On the one hand increased transparency improves market integrity and deters market manipulation (Cordi et al., 2017). On the other hand, transparency makes traders unwilling to insert

orders before the auction, suggesting manipulative behavior because of less liquidity and increased price volatility (Domowitz & Madhavan, 2001).[5] In sum, no unique best CCAM exists in deterring closing price manipulation.

Our research integrates to the above theoretical framework and offers a better view on the effectiveness of closing price determination mechanisms upon market abuse, while introducing the concept of strategic long-term manipulators for the first time.

3. Dataset and market microstructure

3.1 Dataset

We use data from the Athens Stock Exchange (ASE) in Greece since the ASE serves as a good example for stock market research for several reasons. First, it is ranked 12th based on trading volume among the 28 EU countries, rendering it a natural average candidate for our research questions. In terms of volatility, in the period leading to the 2008 Global Financial Crisis the ASE general index exhibited only about 2 percentage points higher volatility than the Stoxx 50, which tracks the blue-chip stocks in the Eurozone. Second, professional participants (e.g., local and foreign institutional investors) accounts for almost 75% of the total ASE's trading activity, in line with the international trend of increased institutional investor participation in trading venues (see Table 1). Additionally, the proportion of foreign institutional investors has been consistently high, even during the protracted period of the Greek financial crisis, further corroborating the importance of the ASE to the international investor community.[6] Third, trading in the ASE follows all of the EU legislative regimes regarding capital markets; hence it is fully compliant with the MiFID II on algorithmic trading (ALGO), direct electronic access (DEA) and high-frequency trading (HFT). Fourth, the share of the CCAM in the ASE trading has increased to 11.8% over the 2014-2019 period and is in line with other EU countries.[7]

[Table 1 around here]

The closing price determination mechanism in the ASE changed twice, and in each case, we consider the 3 months before and after the date of the transition. The first

[5] Differences in CCAMs across exchanges can be even more complex as no single anti-manipulative strategy exists. In the UK (London Stock Exchange) the close price is determined by a CCAM unless there is no trade during the auction or the volume is not representative of a rolling twelve month period, in which case a 10-minute VWAP is applied. In Germany (Deutsche Bourse) a 5-minute auction phase determines the close price unless the price exceeds a threshold (dynamic-static tolerance percentage), in which case the auction is extended for 2-minutes. Similarly in the Nordic exchanges (OMX and the Oslo Bourse) a closing auction of 5-minutes is performed and can be extended if a price limit is breached. In Poland (Warsaw stock exchange) a 10-minute closing auction is performed, but in the case that dynamic or static price limits are breached the chairman of the exchange can define a new dynamic limit or decide on the close price.

[6] For example, the annualised volatility of the ASE during the period of the second close price determination mechanism we investigate is almost double that of the Stoxx 50. This level is significantly reduced from the peak levels observed during the Greek financial crisis in the 2010-2015 period.

[7] Source: Athens Exchange Group

period extends from 29/8/2005 to 28/2/2006, the second from 31/10/2016 to 28/4/2017.[8] During the first period, we examine the impact of the introduction of a Closing Call Auction Mechanism (CCAM) upon closing price manipulation. The CCAM was introduced on 28/11/2005. During the second period, we examine the change in the CCAM, which changed from an Enhanced Closing Call Auction Mechanism (ECCAM) to an Alternative Closing Call Auction Mechanism (ACCAM), effectively abolishing the price tolerance attribute. This change became effective on the 30/1/2017. In both cases, the use of a sample period of 3 months before and after the transition is consistent with the relevant literature and industrial practice (AFM, 2017; Kadiouglu et al., 2015). Furthermore, it provides sufficient time to examine the behavior of market participants under the assumption that they may adjust their trading behavior to a new closing price determination mechanism.

Our dataset is one of the most comprehensive in this line of literature as it is at the tick level and contains full investor details.[9] We use the 15 most active stocks in terms of trading activity; thus, accounting for 67% and 88% of the total ASE trading activity on each occasion, respectively. We opt for the most marketable stocks, as these should be the least susceptible to closing price manipulation (Aggarwal & Wu, 2006; Camilleri & Green, 2009; Comerton-Forde & Rydge, 2006; Cordi et al., 2017).

According to the MAR (596/2014) two signals that may indicate abusive behavior and market manipulation are defined as: *"Orders to trade given or transactions undertaken which represent a significant proportion of the daily volume of transactions in the relevant financial instrument on the trading venue concerned, in particular when these activities lead to a significant change in the price of the financial instruments"* and *"Buying or selling of a financial instrument at the reference time of the trading session (e.g. opening, closing, settlement) in an effort to increase, to decrease or to maintain the reference price (e.g. opening price, closing price, settlement price) at a specific level – (usually known as marking the close)".*

Hence, to identify an investor as possible close price manipulator two conditions need to be met. First, the investor needs to have a substantial exposure in a stock to influence the price. To capture this, we calculate for each investor the accumulated net exposure in each stock during the sub-periods before and after the transition in the close price determination mechanism. Subsequently we rank and isolate the top 5 investors having a positive (negative) net exposure, which we dub as "big buyers" ("big sellers"). By calculating the net exposure over a 3-month period a manipulator can be considered as a "strategic manipulator" according to the MAD.[10] Second, the investor needs to

[8] We are mindful of the changing conditions between these two periods as a result of the increasing regulation at EU level towards a strong financial framework (i.e., the Capital Markets Union) in response to the 2008 Global Financial Crisis. For this reason, we opt to keep the samples separate and avoid drawing conclusions between the first and second periods.

[9] Such details include the investor identification number, the transaction timestamp, the transaction type, price and volume.

[10] Earlier studies consider an intraday manipulator (Felixson & Pelli, 1999). However, the market abuse directives recognise that strategic manipulators are more likely to be engaging in such practices.

participate at the close price determination phase. Concerning this second condition, a signal of possible manipulation is that the executed transactions represent a significant proportion of the stock's daily trading volume. The top 5 investors account for 8% and 7% of the daily traded volume in the first and second transition phase respectively.[11] Furthermore, as an extra test for the validity of our hypothesis, we compare the closing price manipulation ability of investors with a large net exposure vis-à-vis to that of small investors. As small investors we consider all those participants that have on average between 50-150 shares, which we dub as "Bottom 50-150".[12]

Figure 1 plots the evolution of the FTSE Large Capitalization index over the two sample periods in the ASE, from which our sample is derived. A visual inspection shows a comparable behavior of the index in both periods with a mild upward trend. Concerning the information activity for the sample stocks over the two periods of study the value of trades for the 15 most marketable stocks in the first and second periods is around 24.2 and 5.1 billion Euros, respectively while the volume of trades account for 1.3 and 7.9 billion shares, respectively. Table 2 presents activity information for the sample stocks over the two periods of study.

[Table 2 around here]

[Figure 1 around here]

3.2 Market microstructure

Trading in the ASE is based on an electronic order-driven system, which is an Order Driven Market with Market Makers participation based on ASE's Rule Book. The ASE trading rules are fully compliant with the new MiFID II functionality and almost 27% of the trading is performed through algorithmic trading.[13] Although, in recent years there is a trend of shifting trading from primary trading platforms to dark pools and off-trading platforms, the trading activity in Greek instruments do not appear to be fragmented beyond the local market since 98.85% takes place in the ASE with only 1.15% taking place in other trading venues.[14]

The trading methods that are supported for securities trading are i) the Continuous Automatic Matching Method (CAMM), which is the main trading method and ii) the Call Auction Method (CAM), which determines the calculation of the auction price and the matching of the orders at the specific auction price. The auction is performed at the price where volume maximization is achieved with the trading being anonymous and according to price/time priority. The CAM is used in the opening and closing parts of a trading session, dubbed as Opening Call Auction Methods (OCAM), and Closing Call Auction Method (CCAM), respectively. In our paper we focus on the CCAM.

[11] As a robustness check we also use the top 15 investors, which command between 13-14% across the two periods of study. The results remain qualitatively similar.
[12] We exclude small investors with less than 50 shares due to very thin trading. By comparison the top 5 investors have at least 700,000 shares on average.
[13] Source: Athens Exchange Group
[14] Source: Fidessa Fragmentation Index

During the two examined periods, the ASE switched two times the processes that are used to calculate the close price. First, the ASE changed from the VWAP of a percentage of trades to the CCAM. Second, it switched from the Enhanced Closing Auction Method (ECCAM) to the Alternative Closing Call Auction Method (ACCAM). We elaborate on these mechanisms next.

At the start of our first period, a trading session in the ASE consists of three phases: i) the opening auction phase (10:30 - 11:00); ii) the continuous trading phase (11:00 – 16:00); iii) the close trading phase (16:00 - 16:30). The close price of each day is calculated at 16:00, i.e., at the start of the last session. The determination of the close price is governed by the exact method used. Prior to the 27/11/2005 the determination of the close price was based on the VWAP of the 10% of the daily transactions that occurred before 16:00, starting from the last one before the start of the close trading session and moving backwards until the absolute number of transactions that correspond to the 10% of daily transactions has been reached.

After the 27/11/2005 and to accommodate the introduction of the CCAM that replaces the VWAP the trading session consists of four phases: i) the opening auction phase (11:15 – 11:24); ii) the continuous trading phase (11:24 – 16:30); iii) the closing call auction phase (16:30 – 16:39); iv) the close trading phase (16:39 – 17:00). Just before the execution of the auction the trading system creates a list of possible auction prices at which the executable volume is maximized. If more than one price maximizes the volume, then the price closest to the "reference price" is chosen. The reference price is the last recorded price just before the closing auction phase. Thus, the reference price is crucial, as it is the base price according to which volume is maximized.

The CCAM was operational until the 28/06/2007 when it was enhanced to include features purported to deter market manipulation, such as volatility extensions and interruptions, non-synchronous closing times, increased transparency of projected close price, full order book, and a price tolerance deviation mechanism.[15] According to this ECCAM in case the closing auction price deviates by more than ±3% (i.e., price tolerance range) or the projected auction volume comes entirely from Market orders (e.g., MKT order rule), then the ECCAM is overruled in favor of the VWAP of the 30% of last trades of the daily transactions. Under the ECCAM, it has been possible to extend the closing auction phase under periods of extreme volatility (e.g., projected auction price deviated by more than 3%) and/or the projected auction volume coming entirely from market orders. The extension period was 3-min followed by a random time of 1-min, under which the auction could happen instantaneously. Following this extension period, the system performs additional validations in order to calculate the close price, namely: i) if the projected auction price continues to deviate by more than ±3%; ii) if the projected auction volume is less than 30% (e.g., volume min rule) of the daily volume; iii) if the total projected volume of the auction comes entirely from market

[15] The four phases within a trading session during the implementation of the enhanced closing auction mechanism are as follows: i) the opening auction phase (10:15 – 10:30); ii) the continuous trading phase (10:30 – 17:00); iii) the closing auction phase (17:00 – 17:10); iv) the close trading phase (17:10 – 17:20).

orders. If these validations are not confirmed, then the VWAP method over the last 30% of the trades is used instead.

After a decade that the ECCAM has been operational, it has been abolished on the 30/1/2017 in favor of the ACCAM. Compared to its predecessor, the ACCAM abolished the price tolerance range rule but preserved the volatility extensions, the provisions for the dissemination of projected close price, the full order book, and the non-synchronous closing times. The market schedule remained unchanged.

4. Empirical analysis

To examine the effectiveness of the closing auction mechanism in reducing closing price manipulation we employ a difference in difference (DiD) framework in a panel context. In particular, we estimate the following equation (Eq 1) using robust standard errors. To account for potential differences in the baseline return across the stocks as well as stock-specific closing price manipulation in the periods before and after the transition of the close price determination mechanism we introduce intercept and slope fixed effects.

$$\begin{aligned} r_{t:t-15} = {} & \beta_0 + \beta_1 \mathrm{BB} + \beta_2 \mathrm{BAP} + \beta_3 \mathrm{BB} \times \mathrm{BAP} + \beta_4 \mathrm{BB} \times \mathrm{Period} \\ & + \beta_5 \mathrm{BAP} \times \mathrm{Period} + \beta_6 \mathrm{BB} \times \mathrm{BAP} \times \mathrm{Period} + \gamma_1 \mathrm{BS} \\ & + \gamma_2 \mathrm{SAP} + \gamma_3 \mathrm{BS} \times \mathrm{SAP} + \gamma_4 \mathrm{BS} \times \mathrm{Period} \\ & + \gamma_5 \mathrm{SAP} \times \mathrm{Period} + \gamma_6 \mathrm{BS} \times \mathrm{SAP} \times \mathrm{Period} + \varepsilon_{it} \end{aligned} \tag{1}$$

where $r_{t:t-15}$ is the logarithmic return over the last 15-min in a trading day; BB (Big Buyer) and BS (Big Seller) are dummy variables taking the value 1 when the respective investor is ranked in the Top-5 (i.e., or the Bottom 50-150 for comparison purposes) according to net exposure, zero otherwise; BAP (Buy Auction Participation) and SAP (Sell Auction Participation) are dummy variables taking the value 1 when the investor buys or sells during the auction phase respectively, zero otherwise; Period is a dummy variable taking the value 1 following the adoption of the new close price determination mechanism (i.e., CCAM in 2005 and ACCAM in 2017), zero otherwise; ε_{it} is the stochastic error term.

The double interaction term $\mathrm{BB} \times \mathrm{BAP}$ ($\mathrm{BS} \times \mathrm{SAP}$) indicates when a Big Buyer (Big Seller) respectively enters the auction phase increasing the net exposure. A positive (negative) estimated coefficient gives statistical evidence for the existence of closing price manipulation. The triple interaction term $\mathrm{BB} \times \mathrm{BAP} \times \mathrm{Period}$ ($\mathrm{BS} \times \mathrm{SAP} \times \mathrm{Period}$) gauges the effect of the transition to new close price determination mechanism upon closing price manipulation, and a negative (positive) indicating a reduction following implementation. A statistically insignificant triple interaction term suggests that the transition of the close price determination mechanism did not have an effect. The intercept term reflects the return before the close that a typical investor is expected

to earn and may be used as a benchmark for the economic value of the strategic manipulators' gain.

The intuition behind the 15-min return is that the exact price before the closing session is used (e.g., the price of the trade just before the trades used for the calculation of the VWAP of 10% for the first sub period and the reference price for the rest sub periods as defined before the closing auction). In this way, we can capture exactly the movement of the price that leads to a significant change driven by the big buyers/sellers of the whole sub-period. Felixson and Pelli (1999) and Kucukkocaoğlu (2008) used the relevant stock price 15-min before closing phase, which could not be used in our case due to the peculiarities of the ASE closing auctions, while Kadiouglu et al., (2015) used the price as determined by the VWAP of each investor on the basis of the shares of those trading between 15-min before and close of session on the day under consideration, which again is not appropriate as we do not account for day investors but for strategic ones.

The robustness of four close price determination methods against possible manipulative techniques is evaluated next. First, we examine the effect of the change of the closing algorithm from a 10% VWAP to the CCAM, which does not have any special design attributes. Second, we investigate the impact of the transition from the ECCAM to the ACCAM, with the former comprising of four unique auction features purported to deter closing price manipulation, and the latter excludes one of these, namely the price tolerance rule. Third, we examine the possibility of closing price manipulation via the reference price.

4.1 Transition from VWAP to CCAM

First, we examine the impact of the introduction of the CCAM in the ASE. Table 3 presents the estimated coefficients and standard errors of Equation 1, as well as goodness-of-fit information, for the Top 5 (Panel A) and the Bottom 50-150 (Panel B) net buyers/sellers.

[Table 3 around here]

A cursory inspection of the results reveals strong evidence of price manipulation when the VWAP method was operational, which is confirmed by the positive and significant coefficient on the double interaction term Big Buyer X Buy Auction Participation. The magnitude of the coefficient suggests that price manipulators can gain an average return of 0.555% in the last quarter of the trading day. This return is significantly higher than the average return that other market participants (-0.116%), or even big buyers (-0.319%), observe. The transition from the VWAP to the CCAM has managed to significantly reduce price manipulation, as verified by the triple interaction term Big Buyer X Buy Auction Participation X Period. In particular, the negative and significant

coefficient suggests that following the transition the price manipulation has decreased by 107%.[16]

However, price manipulation from net sellers is observed following the introduction of the CCAM, as suggested by the negative and significant triple interaction term Big Seller X Sell Auction Participation X Period. In particular, big sellers that participate at the auction can gain returns of around 0.578% in the last quarter of the trading day; substantially higher than other market participants.

Comparison of the Top 5 net buyers/sellers to the Bottom 50-150 shows that the latter are not capable, as perhaps expected, to conduct price manipulation. This is verified by the insignificant coefficient on the double interaction terms Big Buyer X Buy Auction Participation and Big Seller X Sell Auction Participation. Following the change to the CCAM we find statistically significant negative and positive coefficients on the triple interaction terms Big Buyer X Buy Auction Participation X Period and Big Seller X Sell Auction Participation X Period respectively. This gives *prima facie* evidence that the change in the close price determination method has made such attempts increasingly costly. The Bottom 50-150 investors that may engage in such practices do not have the sufficient exposure to effectively manipulate the close price; instead they are faced with a significantly lower than the average return.

Overall our results suggest that the main effect of the introduction of the CCAM has been to significantly reduce the price manipulation of the top net buyers. By contrast, top net sellers may influence the close price more easily compared to the VWAP. Attempts to manipulate the close price by low net buyers/sellers are costlier under the CCAM, which acts as a further deterrent to such practices.

4.2 Transition from ECCAM to ACCAM

The second examination relates to the transition from the ECCAM to the ACCAM in the ASE. Both methods are of the closing auction type, but the former includes the price tolerance rule; as described in section 3.2. Table 4 presents the estimated coefficients and standard errors of Equation 1, as well as goodness-of-fit information, for the Top 5 (Panel A) and the Bottom 50-150 (Panel B) net buyers/sellers.

[Table 4 around here]

Our results give strong evidence of price manipulation while the ECCAM was operational. In particular the coefficients of both double interaction terms Big Buyer X Buy Auction Participation and Big Seller X Sell Auction Participation are highly significant, bearing a positive and a negative sign respectively. Investors ranked in the top 5 according to net exposure that participate at the auction can attract around 0.347% during the last quarter of the trading session. This return is considerably higher than the average return that other market participants (-0.028%), or even big buyers (-0.006%), observe. A comparison of the coefficients of the double interaction term Big Buyer X

[16] This is calculated as $\ln((0.555 - 0.365)/0.555)$

Buy Auction Participation across the two panels, further shows that the Bottom 50-150 investors are not capable of manipulating the close price; thus they are penalised with a negative return of around -0.242% for the same period. A similar conclusion is verified for the investors holding short positions, i.e., the big sellers. Hence closing price manipulation can be lucrative for those investors that engage into this practice with the necessary volume.

Our results suggest that the transition to the ACCAM did not reduce the price manipulation in the ASE. This is verified by the lack of statistical significance for the triple interaction terms Big Buyer X Buy Auction Participation X Period and Big Seller X Sell Auction Participation X Period respectively. Further analysis (see Models 3, 4) shows that closing price manipulation was reduced in a subset of stocks, namely three out of eleven in the case of long positions (Big Buyer) and one out of seven in the case of short positions (Big Seller).

4.3 The Reference price effect

CCAMs may be susceptible to closing price manipulation via the "reference price", which is the last price before the start of the auction phase. To gauge the impact of the reference price upon closing price manipulation, we introduce a dummy variable (Reference Price) that takes the value 1 if either the big buyer or the big seller makes the last trade just before the auction trying to influence the close price by setting up the reference price of the auction, zero otherwise. In line with the layout of Equation 1, we use a double interaction term Reference Price X Period to measure the impact of the transition from the ECCAM to the ACCAM, and also include stock slope fixed effects. With regards to the estimated coefficient of the Reference Price we would expect a positive sign if the big buyer or big seller attempts to manipulate the close price succeeds by increasing (decreasing) it to the desired level and at the same time trying to influence the reference price just before the auction phase. Table 5 presents these results.

[Table 5 around here]

The Reference Price variable provides interesting reading as under the ECCAM it bears a positive and significant coefficient. This suggests that manipulators can also affect the reference price and drive the close price at their desired level. A closer investigation of the individual stock marginal effects (see Models 3, 4) reveals that closing price manipulation via the reference price is particularly strong for certain stocks and may be affected by firm-specific factors and/or investor expectations and information. The interaction term Reference Price X Period fails to reach statistical significance levels. This suggests that the transition to the ACCAM has not reduced the opportunity for possible manipulation via the reference price prior to the auction.

Overall our results suggest that the transition from the ECCAM to the ACCAM where the price tolerance rule was abolished, had limited effect in reducing closing price manipulation. Hence our results here are consistent with the strand of the literature that suggesting that evidence of closing price manipulation is still present under different

types of CCAMs. Furthermore, closing price manipulation under CCAMs may also be exercised via the reference price.

5. Conclusions and policy implications

In this paper we assess the efficacy of closing price determination mechanisms in reducing closing price manipulation. Our analysis is based in the Athens stock exchange over two distinct periods; 2005-2006 and 2016-2017. The first period is characterized by the transition from a value-weighted average price (VWAP) method to a closing call auction method (CCAM); the second by the addition of extra anti-manipulation attributes in the already operational CCAM. We introduce the concept of a *strategic manipulator*; an investor that builds a position over an extended period prior to engaging in manipulation. For our empirical analysis we rely on a comprehensive tick level dataset with investor information.

Our findings show that closing price manipulation decreased significantly by around 107% following the introduction of the CCAM. However, closing price manipulation was not eliminated. We find that the abolition of the price tolerance rule, the key change between the CCAMs over the second period, only had a marginal effect on closing price manipulation. Furthermore, our results indicate that the "Achilleas' heal" of a CCAM is the *reference price*, which is the last recorded price just before the closing auction phase. Our results indicate that the reference price is targeted consistently by possible manipulators, and the change in CCAM attributes did not affect their ability to do so.

Our results have important policy recommendations. Firstly, the adoption of a closing price determination mechanism should be a dynamic process, subject to continuous evaluation and corrective action. The dynamic nature of the process would make it difficult for possible manipulators to adapt their strategies taking advantage of the weaknesses of a closing price mechanism. For example, it may be suggested that volatility interrupters parameters may be readjusted on a regular basis according to current metrics every time. Secondly, regulatory authorities should monitor for price manipulation via the reference price, when a CCAM is operational. Thirdly, although much of the research advocates about the efficacy of CCAM against (intraday/daily) closing price manipulation, we advocate that long-term manipulation is markedly different and more resilient to CCAMs. Hence regulators should be actively monitoring it.

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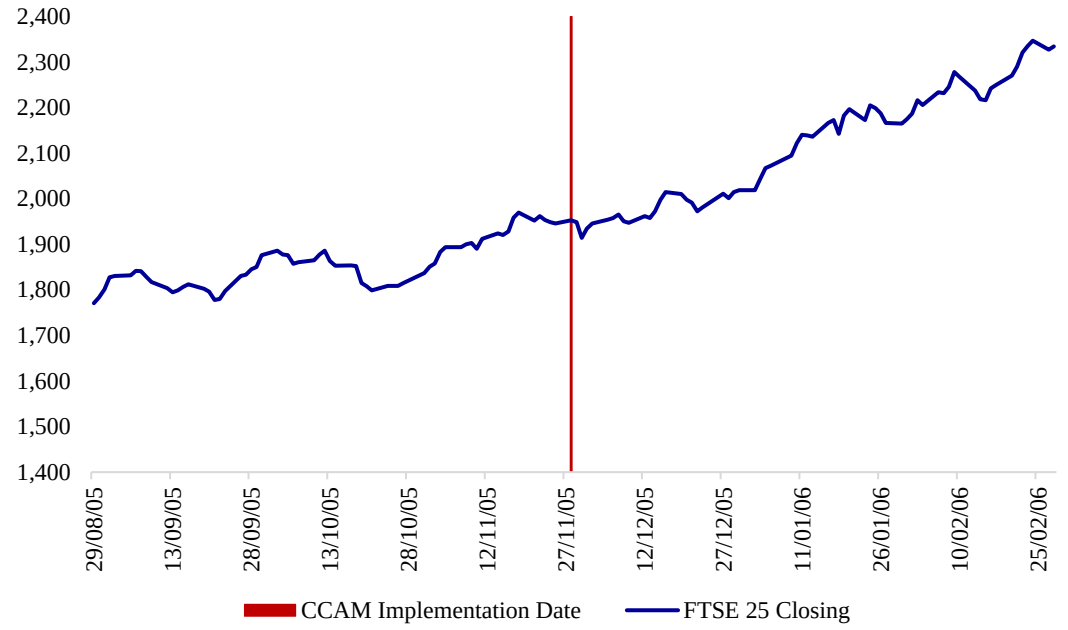
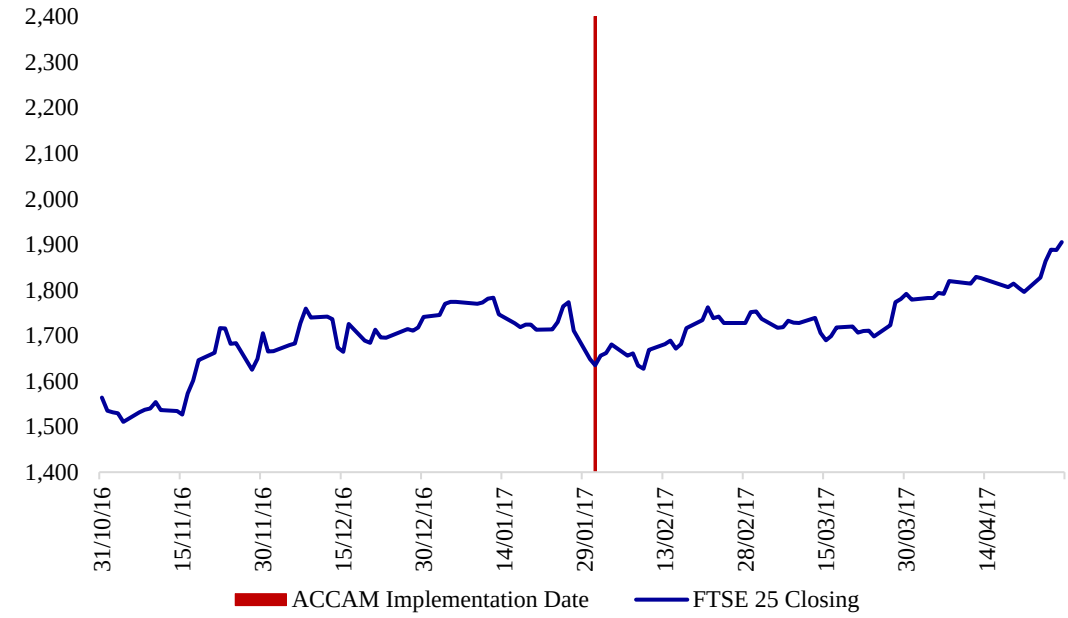
Figure 1. Evolution of the FTSE Large Capitalization Index

Panel A: 29/08/2005 – 28/02/2006



Panel B: 31/10/2016 – 28/04/2017



Notes: The figure plots the evolution of the FTSE Large Capitalization Index that features the 20 (Panel A) and 25 (Panel B) most active stocks in the Athens Stock Exchange, of which our sample covers the 15 most active over the period 29/08/2005 - 28/2/2006 (Panel A) and 31/10/2016 - 28/4/2017 (Panel B). A first visual inspection verifies an upward trend in both periods. The solid vertical lines represent the change from the VWAP to the CCAM method on the 27/11/2005 (Panel A) and from ECCAM to ACCAM method on the 31/01/2007 (Panel B), see section 3 for more details.

Table 1. Investor participation (%) in the ASE total turnover.

Year	Foreign Institutional Investors	Local Private Investors	Local Institutional Investors	Other Investors
2005	50.59	28.77	16.40	4.24
2006	51.36	28.73	16.30	3.61
2016	57.11	16.94	23.99	1.96
2017	56.26	18.85	24.01	0.88

Notes: The table presents the pecentage participation of foreign, local private and local institutional investors in the Athens Stock Exchange (ASE) total turnover in the two periods of investigation, namely 2005-2006 and 2016 – 2017. Source: Athens Exchange Group

Table 2. Trading activity information

	Period 29/8/2005 – 28/2/2006				Period 31/10/2016 – 28/4/2017		
Stock	Number of Trades	Volume of Trades	Value of Trades	Stock	Number of Trades	Volume of Trades	Value of Trades
I	158,969	211,586	3,713	I’	171,446	634,922	1,121
II	200,248	101,696	3,564	II’	234,232	3,478,040	806
III	158,071	114,688	3,207	III’	190,676	2,788,905	520
IV	195,442	95,508	2,512	IV’	232,895	752,522	468
V	165,220	73,116	2,042	V’	102,600	59,452	506
VI	171,236	85,478	1,576	VI’	97,517	63,441	547
VII	131,324	63,011	1,189	VII’	54,850	15,392	212
VIII	75,561	60,982	1,088	VIII’	44,202	15,412	209
IX	59,441	57,149	1,067	IX’	55,660	20,421	127
X	101,723	183,225	928	X’	58,286	7,779	146
XI	162,339	166,383	845	XI’	32,788	8,560	181
XII	99,111	29,130	782	XII’	62,555	33,772	99
XIII	42,865	27,812	676	XIII’	14,815	4,419	96
VIV	112,879	43,778	523	VIV’	46,095	12,630	58
XV	39,955	15,985	503	XV’	30,088	7,772	52
Total	**1,874,384**	**1,329,527**	**24,215**		**1,428,705**	**7,903,439**	**5,148**

Notes: The table presents activity information the sample stocks over the two periods of study. Volume of Trades is measured in thousands and Value of Trades in million Euros. The stocks are the 15 most liquid in the ASE in each respective period. We do not include the stocks identifiers for confidentiallity purposes.

Table 3. Transition from VWAP to CCAM.

	Panel A: Top 5 investors				Panel B: Bottom 50-150 investors			
Variables	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Big Buyer	-0.319	-0.313	*0.128*	*0.182*	0.044**	0.047**	*-0.036*	*-0.026*
	(0.200)	(0.199)	*[8]*	*[10]*	(0.022)	(0.022)	*[12]*	*[13]*
Buy Auction Participation	-0.047**	-0.043*	-0.044*	-0.048**	-0.048**	-0.044*	-0.044*	-0.048*
	(0.023)	(0.023)	(0.023)	(0.023)	(0.025)	(0.025)	(0.025)	(0.025)
Big Buyer X Buy Auction Participation	0.555***	0.535***	*1.396*	*1.400*	0.055	0.050	*0.978*	*0.676*
	(0.202)	(0.201)	*[5]*	*[5]*	(0.051)	(0.051)	*[2]*	*[3]*
Big Buyer X Period	0.299	0.305	*0.405*	*0.489*	-0.053**	-0.050**	*0.015*	*0.033*
	(0.201)	(0.200)	*[10]*	*[9]*	(0.022)	(0.022)	*[13]*	*[12]*
Buy Auction Participation X Period	-0.155***	-0.155***	-0.155***	-0.154***	-0.102***	-0.109***	-0.108***	-0.102***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.025)	(0.025)	(0.025)
Big Buyer X Buy Auction Participation X Period	-0.365*	-0.379*	*-1.058*	*-1.059*	-0.179***	-0.143***	*-0.537*	*-0.543*
	(0.206)	(0.206)	*[5]*	*[5]*	(0.054)	(0.055)	*[6]*	*[6]*
Big Seller	-0.389*	-0.340	*-0.112*	*-0.041*	-0.032	-0.021	*0.039*	*-0.008*
	(0.234)	(0.233)	*[9]*	*[13]*	(0.021)	(0.021)	*[12]*	*[13]*
Sell Auction Participation	0.089***	0.086***	0.086***	0.089***	0.094***	0.090***	0.091***	0.094***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)
Big Seller X Sell Auction Participation	0.361	0.304	*0.273*	*0.270*	-0.021	-0.017	*-0.075*	*-0.074*
	(0.262)	(0.260)	*[9]*	*[9]*	(0.074)	(0.073)	*[5]*	*[6]*
Big Seller X Period	0.377	0.350	*0.043*	*0.068*	0.021	0.001	*-0.005*	*0.008*
	(0.235)	(0.234)	*[10]*	*[9]*	(0.021)	(0.021)	*[14]*	*[14]*
Sell Auction Participation X Period	0.164***	0.153***	0.154***	0.164***	0.145***	0.134***	0.134***	0.144***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.020)	(0.020)	(0.020)
Big Seller X Sell Auction Participation X Period	-0.578**	-0.541**	*-0.802*	*-0.813*	0.173**	0.158**	*0.262*	*0.252*
	(0.264)	(0.263)	*[6]*	*[6]*	(0.076)	(0.076)	*[7]*	*[7]*
Period	0.146***	0.157***	0.157***	0.146***	0.153***	0.167***	0.167***	0.153***
	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	-0.116***	*-0.133*	*-0.140*	-0.116***	-0.119***	*-0.117*	*-0.065*	-0.119***
	(0.006)	*[13]*	*[11]*	(0.006)	(0.007)	*[14]*	*[13]*	(0.007)
Stock intercept FE	No	Yes	Yes	No	No	Yes	Yes	No
Stock slope FE	No	No	Yes	Yes	No	No	Yes	Yes
# Trades/Day	7,280	7,280	7,280	7,280	7,260	7,260	7,260	7,260
# Observations	933,777	933,777	933,777	933,777	920,509	920,509	920,509	920,509
R-squared	0.001	0.007	0.008	0.002	0.001	0.007	0.009	0.004
F-statistic	242.38***	912.29***	184.65***	27.68***	294.82***	953.82***	214.55***	71.08***

Notes: The table report estimated coefficients and Huber-White robust standard errors in parenthesis for the equation 1. Big buyer (big seller) corresponds to the top 5 investors per net exposure in Panel A, and the bottom 50-150 investors in Panel B, see section 3.1 for more details. Coefficients in italics in models 3-4 are the average estimated coefficients of the statistically significant stocks and the value in square brackets represents the number of statistically significant stocks at the 5% significance level as minimum. *, **, *** denote statistical significance at the 10, 5 and 1% levels.

Table 4. Transition from ECCAM to ACCAM.

	Panel A: Top 5 investors				Panel B: Bottom 50-150 investors			
Variables	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Big Buyer	-0.006	-0.005	*0.041*	*0.013*	0.019*	0.032***	*0.045*	*0.059*
	(0.026)	(0.026)	*[2]*	*[4]*	(0.010)	(0.010)	*[8]*	*[7]*
Buy Auction Participation	-0.325***	-0.339***	-0.339***	-0.325***	-0.298***	-0.301***	-0.300***	-0.298***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Big Buyer X Buy Auction Participation	0.347***	0.343***	*0.422*	*0.410*	-0.242***	-0.240***	*-0.427*	*-0.429*
	(0.042)	(0.041)	*[11]*	*[11]*	(0.039)	(0.040)	*[5]*	*[5]*
Big Buyer X Period	0.005	-0.004	*-0.165*	*-0.161*	-0.048***	-0.058***	*-0.088*	*-0.083*
	(0.033)	(0.033)	*[2]*	*[2]*	(0.013)	(0.013)	*[9]*	*[9]*
Buy Auction Participation X Period	0.067***	0.077***	0.077***	0.067***	0.074***	0.072***	0.072***	0.073***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Big Buyer X Buy Auction Participation X Period	-0.089	-0.104*	*-0.456*	*-0.449*	0.036	0.016	*0.263*	*0.261*
	(0.054)	(0.053)	*[3]*	*[3]*	(0.054)	(0.054)	*[2]*	*[2]*
Big Seller	-0.002	-0.012	*0.148*	*0.015*	0.026***	0.031***	*0.022*	*-0.002*
	(0.026)	(0.026)	*[3]*	*[5]*	(0.009)	(0.009)	*[8]*	*[10]*
Sell Auction Participation	0.312***	0.287***	0.287***	0.312***	0.274***	0.266***	0.266***	0.273***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Big Seller X Sell Auction Participation	-0.252***	-0.265***	*-0.368*	*-0.393*	0.176***	0.166***	*0.405*	*0.339*
	(0.043)	(0.043)	*[7]*	*[7]*	(0.042)	(0.041)	*[7]*	*[8]*
Big Seller X Period	0.001	0.006	*0.026*	*0.032*	-0.048***	-0.052***	*-0.006*	*-0.001*
	(0.033)	(0.035)	*[6]*	*[6]*	(0.012)	(0.011)	*[12]*	*[12]*
Sell Auction Participation X Period	-0.068***	-0.0570***	-0.057***	-0.068***	-0.057***	-0.059***	-0.059***	-0.058***
	(0.011)	(0.0111)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Big Seller X Sell Auction Participation X Period	0.079	0.083	*0.389*	*0.402*	-0.004	0.012	*-0.126*	*-0.127*
	(0.055)	(0.055)	*[1]*	*[1]*	(0.056)	(0.056)	*[2]*	*[2]*
Period	0.052***	0.057***	0.057***	0.052***	0.051***	0.056***	0.056***	0.051***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	-0.028***	*-0.018*	*-0.018*	-0.028***	-0.006***	*-0.009*	*0.008*	-0.006***
	(0.002)	*[15]*	*[15]*	(0.002)	(0.002)	*[14]*	*[13]*	(0.002)
Stock intercept FE	No	Yes	Yes	No	No	Yes	Yes	No
Stock slope FE	No	No	Yes	Yes	No	No	Yes	Yes
# Trades/Day	3,004	3,004	3,004	3,004	3,004	3,004	3,004	3,004
# Observations	375,152	375,152	375,152	375,152	315,360	315,360	315,360	315,360
R-squared	0.016	0.030	0.030	0.017	0.017	0.031	0.033	0.019
F-statistic	464.14***	416.91***	85.09***	50.99**	419.12***	383.99***	90.35**	57.81**

Notes: The table report estimated coefficients and Huber-White robust standard errors in parenthesis for the equation 1. Big buyer (big seller) corresponds to the top 5 investors per net exposure in Panel A, and the bottom 50-150 investors in Panel B, see section 3.1 for more details. Coefficients in italics in models 3-4 are the average estimated coefficients of the statistically significant stocks and the value in square brackets represents the number of statistically significant stocks at the 5% significance level as minimum. *, **, *** denote statistical significance at the 10, 5 and 1% levels.

Table 5. The Reference price effect.

	Top 5 investors			
Variables	(1)	(2)	(3)	(4)
Big Buyer	-0.009	-0.009	*0.044*	*0.014*
	(0.026)	(0.026)	*[2]*	*[4]*
Buy Auction Participation	-0.325***	-0.339***	-0.339***	-0.325***
	(0.008)	(0.008)	(0.008)	(0.008)
Big Buyer X Buy Auction Participation	0.341***	0.334***	*0.434*	*0.422*
	(0.042)	(0.041)	*[10]*	*[10]*
Big Buyer X Period	0.008	0.001	*-0.157*	*-0.152*
	(0.033)	(0.033)	*[2]*	*[2]*
Buy Auction Participation X Period	0.067***	0.077***	0.077***	0.067***
	(0.011)	(0.011)	(0.011)	(0.011)
Big Buyer X Buy Auction Participation X Period	-0.084	-0.098*	*-0.455*	*-0.537*
	(0.055)	(0.054)	*[3]*	*[2]*
Big Seller	-0.008	-0.019	*0.142*	*0.014*
	(0.026)	(0.026)	*[2]*	*[5]*
Sell Auction Participation	0.312***	0.287***	0.287***	0.312***
	(0.009)	(0.009)	(0.009)	(0.009)
Big Seller X Sell Auction Participation	-0.258***	-0.273***	*-0.393*	*-0.398*
	(0.043)	(0.043)	*[7]*	*[8]*
Big Seller X Period	0.005	0.011	*0.027*	*0.033*
	(0.033)	(0.033)	*[6]*	*[6]*
Sell Auction Participation X Period	-0.068***	-0.057***	-0.057***	-0.068***
	(0.011)	(0.011)	(0.011)	(0.011)
Big Seller X Sell Auction Participation X Period	0.083	0.088	*0.412*	*0.424*
	(0.056)	(0.056)	*[1]*	*[1]*
Period	0.052***	0.057***	0.057***	0.052***
	(0.003)	(0.003)	(0.003)	(0.003)
Reference Price	0.091*	0.118**	*0.180*	*0.185*
	(0.047)	(0.047)	*4*	*3*
Reference X Period	-0.076	-0.100	—	—
	(0.059)	(0.059)		
Constant	-0.028***	*-0.017*	*-0.017*	-0.028***
	(0.002)	*[15]*	*[15]*	(0.002)
Stock intercept FE	No	Yes	Yes	No
Stock slope FE	No	No	Yes	Yes
# Trades/Day	3,004	3,004	3,004	3,004
# Observations	375,152	375,152	375,152	375,152
R-squared	0.016	0.030	0.030	0.017
F-statistic	402.62***	389.44***	70.78**	41.71**

Notes: The table report estimated coefficients and Huber-White robust standard errors in parenthesis for the equation 1. Big buyer (big seller) corresponds to the top 5 investors per net exposure in Panel A, and the bottom 50-150 investors in Panel B, see section 3.1 for more details. Coefficients in italics in models 3-4 are the average estimated coefficients of the statistically significant stocks and the value in square brackets represents the number of statistically significant stocks at the 5% significance level as minimum. *, **, *** denote statistical significance at the 10, 5 and 1% levels.