Market Makers as Information Providers: the Natural Experiment of STAR[1]

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Abstract

Market makers are financial intermediaries that are supposed to provide additional liquidity, but do not have any information-related obligation. This paper studies the unique case of the Italian Stock Exchange, where market makers are also obliged to facilitate information disclosure about the firms they cover. We focus on a group of small/medium capitalization stocks (STAR) that are assigned a specialist starting from 2001. We show that their liquidity requirements were not effective and that the main impact of the specialists´ introduction was due to their information provision obligations. We find that specialists' activity as information providers reduces the spread and price volatility, the probability of informed trading (PIN), and the adverse selection component of the spread. An event study provides evidence that the informational meetings organized by specialists are perceived as useful by market participants.

KEYWORDS: specialists, information disclosure, limit order books, market quality, information asymmetries

JEL CODES: G10, G14, D82

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Abstract

Market makers are financial intermediaries that are supposed to provide additional liquidity, but do not have any information-related obligation. This paper studies the unique case of the Italian Stock Exchange, where market makers are also obliged to facilitate information disclosure about the firms they cover. We focus on a group of small/medium capitalization stocks (STAR) that are assigned a specialist starting from 2001. We show that their liquidity requirements were not effective and that the main impact of the specialists´ introduction was due to their information provision obligations. We find that specialists' activity as information providers reduces the spread and price volatility, the probability of informed trading (PIN), and the adverse selection component of the spread. An event study provides evidence that the informational meetings organized by specialists are perceived as useful by market participants.

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1. Introduction

In financial markets information on less traded stocks is generally supplied by firms or by analysts. This paper investigates an alternative channel of information disclosure by considering the role of market makers as information providers. Market makers (also termed specialists) are financial intermediaries that are supposed to provide additional liquidity but do not usually have any information-related obligation. We here study the unique trading environment of the Italian Stock Exchange, where market makers have obligations aimed at facilitating information disclosure of the listed firms.

In April 2001, Borsa Italiana (BIt from now on) started assigning a specialist to a group of small-medium capitalization stocks, that were named STAR. The main novelty of this experiment is that market makers have information disclosure requirements. Information obligations require specialists to act as analysts on STAR stocks and to produce at least two detailed financial analyses per year; specialists are also required to organize at least two yearly meetings, named roadshows, with professional investors. The purpose of the paper is to study how these information disclosure requirements affect market quality.

In the other markets specialists generally have only liquidity requirements, the most relevant being the maximum quoted spread (Bessembinder, Hao and Lemmon, 2008). In the Italian case, instead, for the 59 companies that were assigned a specialist between 2001 and 2005, the maximum spread requirement was not effective[2], and this creates an ideal setting to focus on the effect of the information disclosure provided by market markers.

We use high frequency data covering four sample periods, one before and three after the companies joined the STAR group. We find that after the assignment of the specialist, spread and volatility decrease for STAR stocks compared to a matched sample of control stocks, whilst volume does not change significantly. In the longer run, spread and volatility decrease substantially and volume increases significantly: we show that this improvement in market quality is due to a decrease in information asymmetries (and, in turn, in adverse selection costs) induced by the specialists' disclosure requirements. Accordingly, we find that information asymmetries, measured by the probability of informed trading (PIN) as in Easley, Kiefer, O'Hara and Paperman (1996), significantly decrease after the companies are assigned a specialist; furthermore, by estimating the model of Glosten and Harris (1988), we document that the component of the spread due to traders' inability to efficiently process information decreases. To verify that the short term reduction in the price impact is due to adverse selection costs and not to inventory adjustments, we estimate a VAR model similar to Hasbrouck (1991) and find evidence of a permanent decrease in adverse selection costs.

These findings are consistent with any framework of asymmetric information and rational price formation, e.g. Grossman and Stiglitz (1980), where the activity of the specialists as information suppliers is modelled as information disclosure to uninformed market participants. In order driven markets, when informed traders act as liquidity providers, adverse selection costs decrease especially for uninformed traders, who become more willing to supply liquidity and thus reduce both price impact and spread (Rindi, 2008).

This analysis is closely related to the field of research on the relation between analysts' activity and market liquidity. A vast body of literature examines the stock price reaction to analysts' forecasts but little attention has been devoted to the effects of analysts' information on adverse selection costs and liquidity. Most previous works, as Brennan and Subrahmanyam (1995), Roulstone (2003) and Kanagaretnam, Lobo and Whalen (2005) find that liquidity is positively associated with analyst coverage; others (e.g. Chung, McInish, Woods and Whynowski, 1995) document a negative association. Hence a dominant view does not exist on whether analysts´ activity fosters liquidity by reducing information asymmetries, or it is instead perceived as a signal of the presence of higher information asymmetries.

[2] Clearly, if the spread requirement is not really effective the other liquidity requirements cannot be efficient either.

STAR specialists differ from the analysts considered in previous works, because they are directly involved in trading on the same stocks about which they provide information. Furthermore, previous studies are concerned with the contemporaneous association between analyst coverage and market quality; as a consequence, they cannot clearly identify the causal effect of analysts´ activity on liquidity and other indicators of market quality. By contrast, we compare a period before the introduction of the specialists to later periods and we are able test effect over time of the additional information provided to the market.

This analysis is also related to two recent empirical works that study the effect on market quality[3] of the introduction of specialists with only liquidity requirements. Venkataraman and Waisburd (2006) find that introducing specialists in the Paris Bourse leads to an increase in liquidity for a sample of stocks traded through a call auction; their analysis also differs from ours as we consider specialists trading in a limit order book. Anand, Tanggaard and Weaver (2006) document an improvement in market quality after the introduction of specialists in the limit order book of the Stockholm Stock Exchange; in this case, however, specialists' maximum spread obligations are effective and there are no requirements in terms of information disclosure.

The remainder of this paper is organized as follows. Section 2 describes the dataset and the sample choice; section 3 outlines the hypotheses that motivates the empirical analysis, and section 4 discusses the results on market quality. Section 5 focuses on information asymmetries and the market reaction to roadshows, and section 6 concludes.

[3] Theoretical literature also examines the role of specialists in providing liquidity and on how they compete with limit order books. Grossman and Miller (1988) show that specialists can increase liquidity by reducing temporary imbalances in the order flow. Seppi (1997) shows that a hybrid market structure (with a limit order book and specialists) can provide better liquidity than a pure limit order book depending on the order size, whereas Parlour and Seppi (2002) identify conditions under which a hybrid market Pareto-dominates a pure limit order book. Finally, Viswanathan and Wang (2002) show that introducing specialists in a limit order book can improve the welfare of customers.

2. Dataset and samples

2.1 Institutional background: The Italian Stock Exchange and STAR stocks

STAR stocks have a capitalization lower than one billion euro and are traded in the Italian electronic limit order book, named MTA (Mercato Telematico Azionario); the peculiarity of these stocks, compared to the Blue Chips, is that they are assigned a specialist by BIt. Trading for STAR stocks takes place on a standard electronic platform which works as an order driven double auction market similar to Euronext or the English TradElect. There are four trading phases: an opening call auction, from 8:00am to 9:10am; a continuous phase, from 9:10am to 5:25pm, and a closing call auction, from 5:25pm to 5:35pm. Stocks can also be traded (on a voluntary basis) in the after-hours market from 6:00pm to 8:30pm. We examine data from the continuous auction, where all market participants submit orders, which are then matched by the centralized mechanism according to standard price and time priority rules.

Specialists act as analysts for STAR stocks and have specific obligations of information disclosure: they have to produce at least two financial analyses each year, along with the presentation of the most recent available data, expectations about future economic results and a comparison with previous estimates. All the studies and research reports have to be timely transmitted to the stock exchange. In addition, specialists have to organize at least twice per year meetings with professional investors which are referred to as roadshows.

Borsa Italiana also assigns to the specialists some liquidity obligations, namely to quote a maximum spread and to assure minimum depths and minimum trading volume. Yet, as shown in section 2.3, these liquidity requirements are not effective. Following the rules set by BIt, specialists are granted a lump sum payment by STAR firms, and their reward does not depend on trading activity.

2.2 Sample stocks, control stocks and sample periods

Specialists were assigned to STAR stocks starting from April 2001; our sample includes the 59 stocks that were offered a specialist between April 2001 (when STAR stocks were created) and February 2006, and that were previously listed on BIt. Table 1 reports the dates corresponding to the beginning of the specialists' activity. These dates are dispersed around the sample periods as a group of 31 stocks were assigned a specialist on four dates in 2001, one stock in 2002, another group of three stocks in 2004 and 24 stocks in 2005.

The dispersion of the dates reduces the probability of observing confounding effects due to market elements not related to the specialists' activity; however, in order to control for further possible confounding effects, we build a control sample of stocks with the same capitalization requirements as STAR stocks[4]. Following the approach proposed by Huang and Stoll (1996), each STAR stock is matched to another stock that minimizes the score: $\sum_{i=1}^{5}\left(\frac{x_i^{STAR}-x_i^{control}}{(x_i^{STAR}+x_i^{control})/2}\right)^2$; where x_i is either price, or market capitalization, trading volume, market-to-book ratio, or leverage.

We consider four periods, one before and three after the stocks were assigned a specialist. The *pre*-STAR period goes from four to one month before the event and the *post*-STAR period goes from one to four months after the event; the *post1*-STAR and *post2*-STAR periods include the same months as the *post*-STAR, but one and two years ahead, respectively. The reason why we consider the *post1* and *post2*-STAR periods is that we are especially interested in the longer run effects of the specialists' activity.

BIt provided us with data on transaction prices and bid-ask quotes from November 2000 to February 2006 for each STAR stock except four companies. Hence, for the *pre* and *post* periods we worked with a sample of 55 stocks; because three stocks were assigned a specialist in 2004 and 24 in 2005 (for some of these stocks the *post1* and *post2* periods would exceed February 2006), we

[4] We thank Luca Filippa (head of Research & Development, Borsa Italiana) for suggesting us the choice of the control sample.

ended up with a sample of 32 stocks for the *post1* and of 30 stocks for the *post2*-period, respectively.

2.3 Liquidity and information disclosure requirements in the sample

To investigate the effect of the information disclosure requirements on STAR stocks, first of all we have to check whether the liquidity requirements imposed by BIt on the specialists are not actually effective during the sample period. To this end we compare the average spread prevailing in the *pre*-period to the maximum spread required for the specialists. As Table 1 shows, we find that, on average, the maximum spread is 5.8 times greater than the spread observed in the *pre*-period. Furthermore, even by looking at any single stock in the sample, we find that the maximum spread required is greater than the spread observed in the *pre*-period[5]. This means that the maximum spread rule is not effective; therefore we are able to focus on the role of information disclosure requirements by comparing the period before the introduction of the specialists to later periods.

3 Empirical hypotheses

To our knowledge, a micro-financial model that discusses the effectiveness of information disclosure by liquidity providers in limit order markets does not exist. One difficulty faced by the theoretical analysis is that if the existing models of limit order trading (e.g. Parlour, 1998) are extended to include asymmetric information among market participants, they do not provide a closed form solution for the equilibrium price function[6]. Hence, the closest theoretical framework

[5] We also looked at all the days in the *pre*-period and found that for all the stocks the maximum spread required was greater than the average spread observed.

[6] Models of limit order book are still very few in number and each concentrates on a specific feature of the trading process. Parlour (1998) shows how the state of the two sides of the book influences the choice between limit and market orders. Goettler, Parlour and Rajan (2008) introduce asymmetric information into Parlour's model and find a numerical solution for the equilibrium price function. Glosten (1994) and later Biais, Martimort and Rochet (2000) model the discriminatory pricing function which governs the limit order book, but do not include the choice between limit and market orders, and also assume that liquidity providers are only uninformed. Foucault (1999) concentrates on the winner's course problem of a limit order trader who runs the risk of being picked off by scalpers when public information arrives, and, finally, both Foucault, Kadan and Kandel (2005) and Rosu (2008) focus on liquidity provision in a model with patient and impatient traders without public and private information.

we can use to derive empirical predictions for the effects of information disclosure in an order driven market is a centralized auction model in the spirit of Grossman and Stiglitz (1980). We refer to this class of models and formulate testable hypotheses regarding the effects on market quality of the introduction of specialists as information providers.

In standard models of Rational Expectations with risk averse informed and uninformed traders (e.g. Brown and Zhang, 1997), and noise traders, the equilibrium price solves as a function of the fundamental value of the asset, as well as of all the unknown random variables which affect agents' trading strategies. For example, if q is the future value of the asset, $s = q + e$ the informed traders' noisy signal and ϕ is a proxy for noise trading, the equilibrium price function looks like:

$$p = \varsigma_1 q + \varsigma_2 \phi \qquad (1)$$

where ς_1 tells us how aggressively agents trade on the signal q, and ς_2 measures the price impact of a noise trader's order and can be used as a measure of liquidity. A simple measure of volatility can be derived by taking the variance of the price function (1).

BID-ASK SPREAD – Going back to the early literature on asymmetric information (Kyle, 1985 and Glosten and Milgrom, 1985), it has been repeatedly shown that an increase in information disclosure reduces adverse selection costs, as perceived by the uninformed marker makers who set the equilibrium price after having observed the aggregate order flow; it therefore reduces the price impact and the bid-ask spread. Also in order-driven markets, where instead liquidity providers are both informed and uninformed, an increase in information disclosure induces uninformed traders to supply cheaper liquidity as they can better screen between informed and noise traders. Therefore, there seems to be a consensus around the idea that information disclosure reduces the bid-ask spread by curtailing adverse selection costs (e.g. Pagano and Roell, 1996). In terms of equation (1) we expect that, following information disclosure, the parameter ς_2 of price impact decreases[7].

[7] Clearly, the price impact in models with uniform pricing rule is a proxy of the semi-spread.

Furthermore, as this paper deals with stocks of small-medium capitalization, which are generally fairly illiquid, one can intuitively envisage the effects of the disclosure of fresh information as a sort of enhancement of the transaction price pattern towards the true value of the asset. In fact, due to the poor price discovery mechanism which characterizes illiquid stocks, it is not uncommon to observe prices that are stuck away from the fundamental value and that, as soon as information is provided, suddenly converge to the new path which is more informationally efficient. The overall effect of this process is that market participants become more informed.

This leads to our first hypothesis:

Hypothesis 1: the bid-ask spread of STAR stocks decreases following the introduction of the specialists

PRICE VOLATILITY and TRADING VOLUME – To examine the effect of information disclosure on price volatility one has to consider two opposite effects. On the one hand, we expect that information disclosure reduces adverse selection costs and, in terms of equation (1), the parameter ς_2 of price impact, which in turn reduces price volatility[8]. On the other hand, disclosure makes uninformed traders more informed and induces them to trade more aggressively on the information they possess (i.e. their reaction to information increases); this effect raises the ς_1 parameter of the fundamental value of the asset, q, and, consequently, increases volatility.

It follows that the overall effect of information disclosure on price volatility has to be assessed empirically, and we expect the equilibrium outcome to depend on the liquidity level of each stock. For already liquid stocks, the reduction in the price impact will be marginal as the order book is tight and deep, whereas the impact of informational shocks will be substantial as in the market there are many agents who are ready to internalize the new information and trade more aggressively. In

[8] Notice that adverse selection costs can arise both from illegal private information and from costly information. Before the assignment of the specialists STAR stocks were fairly unknown to market participants and it was not uneasy to impact their price through normal trading.

the case of illiquid stocks, instead, even though the arrival of new information induces more agents to trade, we expect the main effect to be on the price impact. The arrival of new information on STAR stocks drives market prices towards the fundamental values, thus reducing price variations around them. This allows us to formulate our second hypothesis:

Hypothesis 2: price volatility of STAR stocks decreases following the introduction of the specialists information disclosure induces more agents to trade and hence increases trading volume.

Finally, in a stylized model in the spirit of Brown and Zhang (1997), information disclosure should increase uninformed traders' willingness to enter the market and therefore it should enhance trading volumes, especially in the longer run. This allows us to set our third hypothesis:

Hypothesis 3: trading volume of STAR stocks increases following the introduction of the specialists.

4. Empirical analysis: market quality

We focus on three measures of market quality: spread, volatility and trading volume. These measures are computed during the trading day from 11am to 4pm. We use this time interval as Kandel, Rindi and Bosetti (2008) show that it was not affected by the introduction of the closing auction which took place during the sample period under analysis. However, we also replicated the analysis by considering the time interval from 9:30am to 5pm and we obtained qualitatively analogous results.

We use two measures of spread: the percentage quoted spread and the time-weighted quoted spread. The percentage quoted spread is computed as the difference between the best ask and the best bid relative to the mid-quote. The time weighted quoted spread is computed by weighing each quoted spread observation on the time between two subsequent quotes. We use the following weighted version of the realized volatility measure proposed by Andersen, Bollerslev, Diebold and Labys (2003)[9] :

$$\sqrt{\frac{1}{N}\sum_{i=1}^{N}\frac{\ln^{2}\left(\frac{p_i}{p_{i-1}}\right)}{\frac{(t_i - t_{i-1})}{T}}}$$

where p_i is the spread mid-quote at time *t*. The spread mid-points are used rather than transaction prices in order to control for the bid-ask bounce. *N* is the number of observations in the specific sample period and *T* is the number of seconds in the time interval considered. Because the dataset contains all quote revisions and, hence, the time between two subsequent observations is not constant, we weigh each observation by the duration (in seconds) between subsequent quote updates. Finally, trading volume is defined as the sum of transaction volumes (in euros) in the time interval considered.

Table 2 presents descriptive statistics for the measures of market quality considered.

4.1 Measures of market quality: univariate analysis

Table 3 compares the average change in the three measures of market quality for STAR and control stocks in the different sub-periods under analysis. For each measure, *y*, we concentrate on the difference in differences, defined as:

$$DID = [y_{STAR}(After) - y_{STAR}(\Pr e)] - [y_{Control}(After) - y_{Control}(\Pr e)]$$

where *Pre* and *After* refer to observations before and after the introduction of STAR. We compute a paired-sample *t*-test and a signed-rank Wilcoxon test for the null hypothesis that the average or the median of this difference is equal to zero.

[9] This measure is computed by assuming that stock prices follow a brownian motion. In Andersen et al. (2003) volatility is not weighted on time because observations are equally distant.

SPREAD - For treatment stocks the average quoted spread (Panel A) and the average time-weighted quoted spread (Panel B) decrease over the three sample periods; this difference is significantly greater (in absolute value) than the difference experienced by control stocks. It is important to notice that the spread reduction is three and four times larger in the *post1* and the *post2* periods. As expected, the specialists' activity as information providers builds up over time.

VOLATILITY – Volatility (Panel C) for STAR stocks decreases in the *post* and *post2* periods, whereas it increases in the *post1*-period. However, volatility for STAR stocks significantly decreases across the three sample periods compared to control stocks; the reduction is smaller during the *post1*-period.

TRADING VOLUME – STAR stocks exhibit a decrease in volume (Panel D) in the *post* and *post1* periods and an increase in the *post2*-period. Volume increases with respect to the control sample in the *post1* and *post2* periods, but these changes are not significantly different from zero.

The results of the univariate analysis support hypothesis 1 and 2. Conversely, hypothesis 3 cannot be confirmed.

4.2 Measures of market quality: multivariate analysis

In the univariate analysis we employ one observation for each stock in each sub-period. We also consider a multivariate approach, where we use one observation for each day in the sample period.

Following Venkataraman and Waisburd (2006), for each market quality measure, *y*, we estimate the following model:

$$y_{i,t} = \beta_0 + \beta_1 Control_i + \beta_2 After_{i,t} + \beta_3 (After_{i,t} * Control_i) + \varepsilon_{i,t}$$

where *Control* is a dummy for control stocks and *After* is a dummy variable which is equal to 0 during the *pre*-period and *1* during the other sample periods. The interpretation of the model coefficients is straightforward and allows us to compare changes in the market quality measures both between the treatment and the control sample, and between the period before and the periods after the introduction of the specialists. If β_1 is positive, it means that, all else equal, *y* is greater for control stocks than for STAR stocks. β_2 is positive if *y* increases for STAR stocks after the introduction of the specialists. More importantly, if β_3 is positive, the increase in the dependent variable is greater for control stocks than for STAR stocks. The model is estimated with three sets of data separately for each after-STAR period: *post*, *post1* and *post2*. Table 4 reports the results.

SPREAD – In the models for the quoted spread (Panel A) and for the time-weighted quoted spread (Panel B), for the three period comparisons, β_2 is significant and negative, while β_3 is significant and positive. This confirms the findings of the univariate analysis and suggests that the introduction of the specialists consistently decreases spread and time-weighted spread of STAR stocks relative to that of control stocks during the three sample periods. Even more interestingly, the decrease in spread more than doubles from the post to the post1 period and it is more than three times greater in the post2 period.

VOLATILITY – The results for volatility (Panel C) also confirm the univariate findings. β_2 is significant and negative in the *pre* vs. *post* and *pre* vs. *post2* comparisons, and it is negative but not significant in the *pre* vs. *post1* comparison. However, β_3 is significant and negative over the three period comparisons; this indicates that volatility for treatment stocks decreases more (and increases less in the *post1*-period) than for control stocks.

TRADING VOLUME – Volume (Panel D) is affected by the introduction of the specialists. Right after the introduction of the specialists (a month later) the variation in volume for STAR stocks is not significantly different from that of control stocks (β_3 is not significant). This result was not unexpected as from informal conversations with professionals acting as specialists on STAR stocks, we learnt that it takes a while to build volume in fairly illiquid stocks, especially when spread requirements are not effective. In the *post1*-period the effects of specialists on volume is positive as volume for STAR stocks performs better than volume for control stocks (β_3<0 and significant).

Finally, STAR volume increases two years after the introduction of the specialists and this increase in greater than for control stocks (in the *pre* vs. *post2* comparison β_2>0, β_3<0, and both parameters are significantly different from zero).

To control for unobservable variables that might affect market quality, we also estimate the model with firm-pair fixed effects; the results, reported in Table 5, are qualitatively analogous.

The results of the multivariate analysis confirm hypothesis 1 and 2. Hypothesis 3 can also be confirmed for the *post1* and *post2* periods.

5. Empirical analysis: Information Disclosure, Asymmetric Information and Probability of Informed Trading

The results in Section 4 show that after the introduction of the specialists spread and volatility significantly decrease. If this improvement is due to the information disclosure requirements imposed on the specialists, we expect information asymmetries to concurrently decrease.

We study how information asymmetries, measured by the probability of informed trading, vary for STAR stocks in the four sub-periods under analysis. Accordingly, we investigate the pattern of the informational component of the bid-ask spread by estimating the standard Glosten and Harris (1988) model, which relates price changes to the order flow; following Hasbrouck (1991), we also study the long run price impact of trades in the context of a VAR model. Finally, to further inquire into the effect of disclosure, we examine the market reaction to the information released in roadshows[10].

5.1 Information Asymmetries and the Probability of Informed Trading

We measure information asymmetries by estimating the probability of informed trading (PIN) as it is derived in the model of Easley et al. (1996). This method to studying information asymmetries has been extensively used in market microstructure, corporate finance, asset pricing and financial accounting. The model considers a market for a single risky asset, where a competitive market maker receives orders from informed and uninformed traders[11]. The market game is repeated over *T* days. At the beginning of each day an information event occurs with probability α, and it is good news with probability $(1-\delta)$ and bad news with probability δ. Orders from informed traders (who know whether the event is good or bad news) and uninformed traders (who trade for liquidity reasons) follow a Poisson process with daily intensity μ and ε, respectively. The probability of observing *B* buys and *S* sells on day *t*, conditional on the parameters of the model ($\Theta \equiv [\mu, \varepsilon, \beta, \delta]$), can be derived as:

$$\Pr[y_t = (B,S) \mid \Theta] = \alpha(1-\delta)e^{-(\mu+2\varepsilon)} \frac{(\mu-\varepsilon)^B \varepsilon^S}{B!S!} + \alpha\delta e^{-(\mu+2\varepsilon)} \frac{(\mu+\varepsilon)^S \varepsilon^B}{B!S!} + (1-\alpha)e^{-2\varepsilon} \frac{\varepsilon^{B+S}}{B!S!}$$

where y_t contains the number of buys and sells on day *t*.

The likelihood function is then computed by assuming that $\{y_t\}_{t=1}^T$ are i.i.d. We use the reformulated log-likelihood proposed by Easley, Engle, O'Hara and Wu (2002):

$$L(\{y_t\}_{t=1}^T \mid \Theta) = \sum_{t=1}^{T} [-2\varepsilon + M\ln(x) + (B-S)\ln(\mu+\varepsilon)] +$$

$$+ \sum_{t=1}^{T} \ln[\alpha(1-\delta)e^{-\mu} x^{S-M} + \alpha\delta e^{-\mu} x^{B-M} + (1-\alpha) x^{B+S-M}]$$

where *M*=min(*B*,*S*)+max(*B*,*S*)/2, and $x = \dfrac{\varepsilon}{\mu+\varepsilon}$.

The probability of informed trading is defined as the ratio of the arrival rate of informed orders to the arrival rate of all orders:

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[10] We do not examine the market reaction to the release of specialists' financial reports because we could not obtain the complete list of the corresponding dates from BIt.

[11] The model has been applied to both quote driven and order driven markets. An example of application to order driven markets is Atkas, de Bodt, Declerck and Van Oppens (2007), in which PIN is estimated using data from the electronic limit order book of Euronext.

$$PIN = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon}$$

To obtain the estimate of PIN, we only need the number of buys and sells in each day in the sample[12]. To classify trades as buys or sells we use the algorithm proposed by Lee and Ready (1991). A trade is classified as a buy if its execution price is above the previous midquote and it is classified as a sell if its execution price is below; if the execution price is equal to the previous midquote, then it is compared to the price of the previous trade and the trade is classified as a buy (sell) if there has been an upward (downward) price change. In the comparison between the execution price and the previous midquote, we require the midquote to be five seconds older than the trade[13].

RESULTS **–** Table 6 compares the estimates of PIN for STAR and control stocks in the different sample periods. We concentrate again on the difference in differences (*DID*), defined as in subsection 4.1 The results show that moving from the pre to the post-period, the change in the STAR stocks' PIN is not significantly different from that experienced by control stocks; comparing, instead, the pre with the *post1* and *post2* periods, we find that PIN significantly decreases relatively to the control sample.

5.2 The informational component of the bid-ask spread

The observed decrease in information asymmetry suggests that the concurrent improvement in liquidity can be related to the different degree of information disclosure characterizing STAR stocks before and after the assignment of the specialists.

[12] We maximize the likelihood function numerically by using the Nelder-Mead method; the computation is performed through a Matlab routine. We exclude the sub-periods with less than ten trades on average. The maximization converges for 94.6% of the stock/periods. Moreover, we compute the hessian of the parameters of the model by using the Newton-Rhapson-Simpson method and we derive the standard errors. According to the corresponding *z*-tests, the estimates of the parameters are significantly different from zero at the 10% level.

[13] We apply the five-second adjustment because we were advised by BIt that there could be small delays in quote reporting.

Indeed, specialists have the objective of improving and fastening the dissemination of the companies' information. Hence, we expect the outcome of this disclosure activity to be the general improvement of traders' ability to process information about STAR stocks. This has the effect of reducing the impact of traders' orders on stock prices, thus making it difficult to obtain profits out of the companies' information disclosure. If market participants are generally more informed, they are no longer able to move prices when submitting their orders, and the adverse selection component of the spread due to traders' inability to efficiently exploit information, becomes significantly smaller.

We interpret the reduction in the probability of informed trading observed in the data as evidence of increased informational efficiency of STAR stocks rather than only as reduced probability of insider trading. We verify this conjecture by using the Glosten and Harris (1988) model, which relates price changes to order flow.

The reduced form of the model is the following:

$$\Delta P_t = c_0 \Delta Q_t + c_1 \Delta x_t + z_0 Q_t + z_1 x_t + u_t$$

where $\Delta P_t = P_t - P_{t-1}$ is the price change, Q_t is the transaction sign (it is equal to +(-) 1 for buyer(seller)-initiated trades), x_t is the size of the trade multiplied by its sign, $\Delta Q_t = Q_t - Q_{t-1}$ is the transaction sign change, $\Delta x_t = x_t - x_{t-1}$ is the change in the signed trade size, and finally u_t is a white noise error term.

We interpret the coefficients c_0 and c_1 as standard measures of order processing costs, with the latter relating fixed costs to order size. The relative interpretation of the coefficients z_0 and z_1 is more intricate. z_1 captures the adverse selection component of the spread due to order size, that is traditionally related to insider trading; following Easley and O'Hara (1987), in fact, large orders are generally considered as vehicle of private information. z_0, instead, indicates the effect on price changes of all the orders, independently of their size: it is precisely this adverse selection component that we expect to decrease after the introduction of the STAR specialists. We expect z_0 to reduce more than z_1 as the specialists' activity influences the informativeness of all market participants, not only of those submitting large orders. In addition, STAR stocks are of small-medium capitalization, and their average trade size is fairly small, with little size variability: hence, we expect that when all traders on these stocks become more informed, it will be the generality of the orders rather than those of large size that will reveal better informational efficiency.

To determine the sign of the transaction, we use again the Lee and Ready (1991) algorithm. We estimate the model for each stock and each period with ordinary least squares, and compute Newey-West standard errors to take serial correlation into account. For most of the stocks in the sample we find that c_1 and z_1 are not significantly different from zero: according to *t*-tests, c_1 and z_1 are significantly different from zero at the 10% level only for 28.05% and 18.98% of the stock/periods, respectively; according to *F*-tests both coefficients are not significantly different from zero for 62.43% of the stock/periods; on the contrary, c_0 and z_0 are significantly different from zero for all the sample stocks. The results imply that for these small-cap stocks trade size contributes to explain a negligible part of the variation in price[14].

Therefore, we estimate the model by restricting c_1 and z_1 to be equal to zero. Table 7 reports the difference in differences (*DID*) concerning c_0 and z_0. Order processing costs are not affected by the introduction of the specialists: c_0 decreases for STAR stocks and for control stocks, but the two average variations are not significantly different. As conjectured, we find that z_0 significantly decreases for STAR stocks more than for control stocks in the *post, post1* and *post2* periods[15].

[14] Van den Bongard and Klar (2007) estimate the Glosten and Harris (1988) model using data from Xetra, the German equity market; they also find that for small stocks trade size has a negligible impact on price variation.

[15] As a robustness check, we also estimated the model by including among the regressors daily volatility measured as described in section 4, and obtained analogous results.

5.3 A VAR approach to model information asymmetries

The results of the Glosten and Harris (1988) model indicate that the price impact of trades decreases after the introduction of the specialists. This can be interpreted as a reduction in both inventory and/or adverse selections costs. In our case, it is unlikely that the advent of the specialists reduces inventory costs; however, to attribute the observed price impact reduction to adverse selection costs we have to investigate its longer run pattern. In fact, theory predicts that the price impact due to inventory costs is transitory, and only the price impact due to adverse selection costs is permanent.

In markets where traders actively manage their inventory, prices reverse back to their fundamental in the absence of new information.

Hasbrouck (1991) proposes a straightforward methodology to evaluate the longer run impact of trades on price changes by estimating a structural VAR model. The VAR also allows one to take into account serial correlation in the order flow and the feedback effect of price changes on the order flow. We consider the following specification:

$$\begin{cases} \Delta P_t = a_0 Q_t + a_1 Q_{t-1} + ... + a_5 Q_{t-5} + b_1 \Delta P_{t-1} + ... + b_5 \Delta P_{t-5} + \varepsilon_{1,t} \\ Q_t = c_1 Q_{t-1} + ... + c_5 Q_{t-5} + d_1 \Delta P_{t-1} + ... + d_5 \Delta P_{t-5} + \varepsilon_{2,t} \end{cases}$$

where $\Delta P_t = P_t - P_{t-1}$ is the price change, Q_t is the transaction sign (it is equal to +(-) 1 for buyer(seller)-initiated trades), and $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are white noise uncorrelated error terms. Notice that to identify the model it is assumed that price changes have no contemporaneous effect on order flow changes; this is a natural assumption in markets that work as limit order books where trades are done at prices available before the trade. As in the previous analysis, we use the Lee and Ready (1991) algorithm to determine transaction signs.

Within this framework, the long run impact of trades on returns can be captured by the impulse response function (IRF) of order flow on price changes, which can be obtained by the VMA representation of the structural model[16]. We take step 20 as the limit point of the system because the prevalence of the adjustment is complete approximately after step 10.

Figures 1 and 2 present the cumulative IRF for STAR and control stocks. For STAR stocks the IRF gradually moves downwards and it has a marked shift in the *post1*-period. For control stocks the pattern is different: the IRF goes up in the *post*-period and it moves downwards only in the *post2*-period.

Table 8 reports the cumulative IRF at step one (the contemporaneous) and 20. The difference in differences (*DID*) is always negative and significantly different from zero, indicating that the IRF decreases more for STAR stocks than for control stocks in the three period-comparisons at both step one and 20. The results regarding the contemporaneous effect are consistent with those obtained estimating the Glosten and Harris (1988) model. The results concerning step 20 can be interpreted as a longer-run reduction in the price impact of trades and therefore suggest a reduction in adverse selection costs.

5.4 Market reaction to the release of information: roadshows

Disclosure requirements for STAR stocks prescribe that specialists organize meetings, called roadshows, with professional investors. At least two roadshows per year must be held: one in Milan and the others in London or in New York. To analyze the market reaction to roadshows we use a standard event study approach.

We examine two metrics of market reaction commonly used in the literature on the usefulness of accounting information[17]: abnormal returns and abnormal trading volume. Abnormal returns (*AR*) are computed as the residuals from the market model:

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[16] The structural model can be written as vector autoregression: $\begin{pmatrix} 1 & b_0 \\ 0 & 1 \end{pmatrix}\begin{pmatrix} \Delta p_t \\ Q_t \end{pmatrix} = \sum_{k=1}^{5}\begin{pmatrix} a_k & b_k \\ c_k & d_k \end{pmatrix}\begin{pmatrix} \Delta p_{t-k} \\ Q_{t-k} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix}$. The impulse response function can then be computed from the VMA representation of the model: $\begin{pmatrix} \Delta p_t \\ Q_t \end{pmatrix} = \sum_{k=0}^{5}\begin{pmatrix} a_k^* & b_k^* \\ c_k^* & d_k^* \end{pmatrix}\begin{pmatrix} \Delta p_{t-k} \\ Q_{t-k} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix}$. Precisely, the IRF of transaction sign on price change at step N is: $IRF(N) = \sum_{i=0}^{N} b_i^*$.

$$AR_{it} = R_{it} - (\hat{a}_i + \hat{b}_i R_{mt})$$

where $\hat{a}$ and $\hat{b}$ are the estimated parameters, R_m is the return on the ALLSTARS index[18], whereas R_i is the return on stock i. Because we are not able to distinguish between good and bad news, we examine an absolute response metric, *ABRET*.

Following Cready and Hurtt (2002), we define absolute abnormal returns (*ABRET*) as:

$$ABRET_{it} = [|AR_{it}| - E(|AR_i|)] / \sigma(|AR_i|)$$

where $E(|AR_i|)$ and $\sigma(|AR_i|)$ are the mean and the standard deviation of $|AR_i|$ over the estimation period respectively.

Furthermore, we define abnormal trading volume (*AVOL*) as in a number of works that build on Beaver (1968):

$$AVOL_{it} = [V_{it} - E(V_i)] / \sigma(V_i)]$$

where V_{it} is trading volume of stock *i* on day *t*, standardized on the number of outstanding shares, and $E(V_i)$ and $\sigma(V_i)$ are the mean and the standard deviation of trading volume over the estimation period, respectively.

For the computation of both abnormal returns and abnormal trading volume we take the *345* days before the roadshows as the estimation period. We also checked for the date of the quarterly earning announcements and verified that these two disclosure events do not overlap.

RESULTS – Table 9 and Figures 3 and 4 present the mean absolute abnormal returns and the mean abnormal volume around roadshows. There is a peak right around the information disclosure date, being abnormal returns significantly different from zero from day -1 to +3. The impact of disclosure on trading volume persists for a wider window: abnormal volume is significantly different from zero from day -8 to +8, with the only exception of day +3. This is probably evidence

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[17] See Kothari (2001) for a critical survey of this literature.

[18] The ALLSTARS Index is a market-cap weigheted index which measures the performance of all the firms belonging to the STAR group.

of some information leakage close to the roadshow dates. Overall, we can interpret this result as evidence that market participants perceive the information released in the roadshows as useful. This further confirms our conjecture that information disclosure had a driving role in the performance of STAR stocks.

6. Conclusions

Pre-trade transparency is a timely issue in financial market design and regulation. The amount and precision of the information disclosed to market participants before trading has been at the center of a wide empirical and theoretical literature. Little research instead has so far investigated possible channels of information disclosure other than firms and analysts. This paper raises a new question: should information be disclosed by firms and analysts, or by intermediaries? To our knowledge, there is no evidence on the effects of information disclosure by dealers. The concern of conflict of interest prevents regulators from introducing this disclosure vehicle. However, our results show that information disclosure by specialists can improve market quality and hence suggest that reputational concerns might prevent front-running and adverse selection costs[19].

We here study the effect on market quality of the introduction of specialists in STAR, a group of small-medium capitalization stocks listed on the limit order book of Borsa Italiana. The peculiarity of STAR is that specialists have information disclosure requirements: precisely, they are required to provide financial analyses on the stocks and to interact with institutional investors and the listed firms on a regular basis. Because liquidity requirements were not effective during the periods examined, we are able to focus on the effect of disclosure requirements and, thus, on the role of specialists as information providers.

[19] A recent intervention of STAR regulators is concerned with the consequences of information disclosure requirements for specialists. BIt limit order book is anonymous, i.e. traders' identities are not visible; in an exception to the general rule, starting from the migration of the Italian platform on TradeElect 2008 (London Stock Exchange) specialists' identity codes are publicly visible. The introduction of this new trading feature aims at reassuring counterparties that specialists do not use the information they hold opportunistically. Such intervention recognizes the function of specialists as information providers. See, for a thorough discussion of specialists' trading behavior in anonymous and transparent settings, Reiss and Werner (2004).

We find that, after the introduction of the specialists, spreads and volatility decrease relatively to a matched sample of control stocks. More interestingly, these changes get stronger as time passes. We also find a reduction in information asymmetries and in the adverse selection component of the spread, the former measured by the probability of informed trading (PIN), the latter captured by the Glosten and Harris (1988) model and by a VAR model in the spirit of Hasbrouck (1991). Finally, following an event study approach, we show that the meetings organized by specialists with institutional investors are perceived as useful for investment decisions.

We show that the decrease in information asymmetries observed after the introduction of the specialists is due to an improvement in the degree of information disclosure. As specialists have the objective of improving and fastening the dissemination of the companies' information, the outcome of this disclosure activity is the general improvement of traders' ability to process information about STAR stocks. This reduces the impact of traders' orders on stock prices and, hence, the adverse selection component of the spread. Analogously, the decrease in the price impact reduces price variations around the fundamental, and volatility decreases.

In this work we concentrate on a unique trading environment and we show how relevant can be the disclosure requirements implemented by a stock exchange to improve market quality for small-medium size stocks. It follows that regulators may find this information dissemination mechanism preferable when firm-specific incentives for disclosure are not effective. Future research can tackle the issue of how to optimally design and regulate the contracts among specialists, companies and customers.

Table 1: Sample and control stocks
This table presents the stocks in the sample and the corresponding control stocks. The sample contains all the stocks that entered STAR from November 2000 to February 2006. Because we did not receive complete data from BIt, we excluded four stocks (Centrale del latte Torino, Cementir,Digital Bros and IT Way). The table also reports the maximum spread required (as a percentage of the midquote) for specialists at the time they started their market making activity, as well as the average spread for the *Pre*-period.

	STAR stocks	*Date of entry in STAR*	*Date of exit from STAR*	*Maximum spread required*	*Average spread in the pre-period*	*Control stocks*
1	Banca Finnat	01/04/2001		3.00%	2.10%	Banca Profilo
2	BPEL	01/04/2001		4.50%	0.95%	Mediacontech
3	Brembo	01/04/2001		3.50%	0.87%	Aeroporto di Firenze
4	Centrale del latte Torino	01/04/2001		-	-	-
5	CSP International	01/04/2001	06/06/2005	4.50%	1.13%	Poligrafici Editoriale
6	Ducati	01/04/2001		2.50%	0.50%	Monrif
7	ERG	01/04/2001	19/12/2005	2.50%	0.54%	SNIA
8	Interpump	01/04/2001		3.50%	0.70%	Acegas
9	Irce	01/04/2001		4.50%	2.07%	Danieli
10	La Doria	01/04/2001		4.50%	1.16%	Basicnet
11	Manuli Rubber Industries	01/04/2001	29/01/2004	3.50%	1.04%	Pininfarina
12	Mariella Burani	01/04/2001		3.50%	0.90%	ACSM
13	Mirato	01/04/2001		4.50%	0.84%	Caltagirone Editore
14	Navigazione Montanari	01/04/2001		3.00%	1.18%	Schiapparelli
15	Reno De Medici	01/04/2001		3.50%	0.91%	Ergo Previdenza
16	Sabaf	01/04/2001		4.50%	0.68%	Permasteelisa
17	Saes Getters	01/04/2001		4.50%	1.50%	Data Service
18	Targetti Sankey	01/04/2001		3.50%	1.76%	FMR ART 'E'
19	Banca Pop. Intra	01/07/2001		4.50%	0.54%	SNAI
20	Cremonini	01/07/2001		3.00%	0.70%	Beghelli
21	IMA	01/07/2001		4.50%	1.59%	Olidata
22	Jolly Hotels	01/07/2001	03/08/2007	4.50%	0.94%	Ricchetti
23	Meliorbanca	01/07/2001		3.50%	0.59%	Class Editori
24	Richard Ginori	01/07/2001		3.50%	1.53%	Bastogi
25	Aedes	24/09/2001		4.50%	0.84%	IPI
26	Amga	24/09/2001	01/11/2006	3.50%	0.78%	Eutelia
27	Cembre	24/09/2001		4.50%	3.32%	Filatura di Pollone
28	Cementir	24/09/2001	19/03/2007	-	-	-
29	Emak	24/09/2001		4.50%	1.27%	Grandi Viaggi
30	Stefanel	24/09/2001		4.50%	1.29%	Trevi
31	Vittoria Assicurazioni	26/11/2001		4.50%	2.85%	Ciccolella
32	Gefran	27/05/2002		4.50%	1.07%	Finarte
33	Sogefi	15/01/2004		3.50%	0.63%	Ratti
34	Actelios	20/09/2004		4.50%	1.07%	Zucchi
35	Banca Ifis	29/11/2004		4.50%	1.27%	Gabetti
36	Acotel Group	19/09/2005		4.50%	0.65%	Maffei
37	BB Biotech	19/09/2005		4.50%	0.18%	De Longhi
38	Buongiorno	19/09/2005		2.50%	0.30%	IMMSI
39	Cad It	19/09/2005		4.50%	0.64%	INTEK
40	Cairo Communication	19/09/2005		4.50%	0.38%	Viaggi Ventaglio
41	CDC	19/09/2005		4.50%	0.49%	Gewiss
42	DADA	19/09/2005		3.50%	0.36%	Linificio
43	Datalogic	19/09/2005		3.50%	0.43%	Acque potabili
44	Dea Capital	19/09/2005		2.50%	0.32%	Premafin
45	Digital Bros	19/09/2005		-	-	-
46	Dmail Group	19/09/2005		4.50%	0.50%	AS Roma
47	El.En.	19/09/2005		4.50%	0.60%	Caltagiorne

48	Engineering	19/09/2005	4.50%	0.64%	SOL
49	Esprinet	19/09/2005	3.00%	0.35%	Marcolin
50	Fidia	19/09/2005	4.50%	0.83%	CAM-FIN
51	I.Net	19/09/2005	3.50%	0.48%	Kaitech
52	IT Way	19/09/2005	-	-	-
53	Mondo TV	19/09/2005	4.50%	0.56%	Exprivia
54	Poligrafica S. Faustino	19/09/2005	4.50%	0.43%	KME
55	Prima Industrie	19/09/2005	4.50%	0.68%	Mittel
56	Reply	19/09/2005	4.50%	0.61%	Enertad
57	TAS	19/09/2005	4.50%	0.69%	Mediterranea Acque
58	TXT	19/09/2005	4.50%	0.53%	Sadi Servizi
59	Fullsix	30/11/2005	3.50%	0.58%	Brioschi

Table 2: Measures of market quality - descriptive statistics
This table reports descriptive statistics for the four measures of market quality considered (quoted spread in Panel A, time-weighted quoted spread in Panel B, volatility in Panel C, and trading volume in Panel D) in the four periods around the introduction of the specialists.

Panel A: Spread

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average STAR	0.0092	0.0083	0.0103	0.0071	*Average Control*	0.0102	0.0109	0.0141	0.0109
St. dev. STAR	0.0060	0.0042	0.0050	0.0039	*St. dev. Control*	0.0093	0.0071	0.0100	0.0097

Panel B: Time-weighted spread

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average STAR	0.0087	0.0079	0.0099	0.0069	*Average Control*	0.0095	0.0102	0.0132	0.0105
St. dev. STAR	0.0058	0.0041	0.0049	0.0039	*St. dev. Control*	0.0089	0.0069	0.0096	0.0106

Panel C: Volatility

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average STAR	0.0306	0.0284	0.0369	0.0267	*Average Control*	0.0366	0.0375	0.0559	0.0401
St. dev. STAR	0.0124	0.0104	0.0104	0.0088	*St. dev. Control*	0.0147	0.0156	0.0193	0.0133

Panel D: Trading volume

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average STAR	226,250	205,599	126,237	186,988	*Average Control*	259,928	249,433	165,326	244,616
St. dev. STAR	334,856	289,029	181,337	229,980	*St. dev. Control*	296,693	401,124	256,254	413,114

Table 3: Measures of market quality - univariate tests

This table compares the difference in the measures of market quality (quoted spread in Panel A, time-weighted quoted spread in Panel B, volatility in Panel C, and trading volume in Panel D) examined between the periods after the introduction of the specialists and the *pre* period. The average difference for STAR (column STAR) and control (column Control) stocks are reported; in addition, the difference in differences (column STAR-Control), defined as *DID* in Section 4, is presented. A *t*-test and a Wilcoxon signed-rank test for the null hypothesis that the average or the median of *DID* is equal to zero are presented. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Spread

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0009	0.0007	-0.0016	-2.6907***	-2.958***
post1-pre	-0.0016	0.0021	-0.0036	-3.2737***	-3.104***
post2-pre	-0.0049	-0.0008	-0.0041	-3.3436***	-3.096***

Panel B: Time-weighted spread

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0008	0.0007	-0.0015	-2.3833***	-2.765***
post1-pre	-0.0013	0.0019	-0.0032	-3.0686***	-2.805***
post2-pre	-0.0046	-0.0004	-0.0042	-3.2089***	-3.137***

Panel C: Volatility

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0022	0.0009	-0.0031	-1.9967*	-1.676*
post1-pre	0.0004	0.0135	-0.0131	-3.4537***	-2.805***
post2-pre	-0.0097	-0.0015	-0.0082	-2.2512***	-2.026**

Panel D: Trading volume

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-28,275	-15,086	-13,190	-0.2146	0.9
post1-pre	-22,239	-93,491	71,252	1.1811	1.421
post2-pre	38,705	-37,396	76,101	0.827	0.984

Table 4: Measures of market quality - multivariate analysis (1)

This table reports the results of the regression: $y_{i,t} = \beta_0 + \beta_1 Control_i + \beta_2 After_{i,t} + \beta_3 (After_{i,t} * Control_i) + \varepsilon_i$; where the subscript *i* refers to stock *i*, the subscript *t* refers to day *t*, *Control* is a dummy variable for the control stocks, *After* is a dummy variable for the period after the introduction of STAR; *y* is either the quoted spread (Panel A), or the time-weighted quoted spread (Panel B), or volatility (Panel C), or trading volume (Panel D). The model is estimated using data from the periods *pre* and *post* (column *pre vs. post*), or from the periods *pre* and *post1* (columns *pre vs. post1*) or from the periods *pre* and *post2* (column *pre vs. post2*). *T*-tests are reported in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Spread

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0090***	0.0118***	0.0114***
	(61.44)	(48.03)	(63.51)
After	-0.0007***	-0.0015***	-0.0043***
	(-3.79)	(-4.58)	(-17.18)
Control	0.0010***	0.0002	-0.0018***
	(4.99)	(0.82)	(-7.06)
(Control)*(After)	0.0014***	0.0034***	0.0042***
	(5.03)	(7.04)	(11.86)
R^2	0.0122	0.0147	0.0394

Panel B: Time-weighted spread

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0085***	0.0111***	0.0108***
	(61.15)	(47.72)	(63.4)
After	-0.0006***	-0.0012***	-0.0040***
	(-3.3)	(-3.81)	(-16.71)
Control	0.0010***	0.0003	-0.0016***
	(5.11)	(1.12)	(-6.97)
(Control)*(After)	0.0011***	0.0025***	0.0038***
	(4.08)	(5.52)	(11.28)
R^2	0.0103	0.0102	0.0373

Panel C: Volatility

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0307***	0.0372***	0.0355***
	(46.66)	(32.41)	(36.51)
After	-0.0021**	-0.0002	-0.0087***
	(-2.35)	(-0.15)	(-6.42)
Control	0.0060***	0.0059***	0.0036***
	(6.43)	(3.63)	(2.65)
(Control)*(After)	0.0034**	0.0128***	0.0101***
	(2.59)	(5.64)	(5.28)
R^2	0.0102	0.0221	0.0172

Panel D: Trading volume

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	232507.4***	152796.2***	156808.3***
	(19.73)	(13.95)	(9.79)
After	-29611.23*	-22525.36	38466.61*
	(-1.78)	(-1.47)	(1.72)
Control	32014.19*	111140.7***	127998.6***
	(1.92)	(7.17)	(5.67)
(Control)*(After)	16651.9	-72267.15***	-71878.71**
	(0.71)	(-3.33)	(-2.28)
R^2	0.0011	0.0109	0.0053

Table 5: Measures of market quality - Multivariate analysis (2) [model with fixed effects]

This table reports the results of the regression: $y_{i,t} = \beta_0 + \beta_1 Control_i + \beta_2 After_{i,t} + \beta_3 (After_{i,t} * Control_i) + \varepsilon_i$; where the subscript *i* refers to stock *i*, the subscript *t* refers to day *t*, *Control* is a dummy variable for the control stocks, *After* is a dummy variable for the period after the introduction of STAR; *y* is either the quoted spread (Panel A), or the time-weighted quoted spread (Panel B), or volatility (Panel C), or trading volume (Panel D). The model is estimated using data from the periods *pre* and *post* (column *pre vs. post*), or from the periods *pre* and *post1* (columns *pre vs. post1*) or from the periods *pre* and *post2* (column *pre vs. post2*). Firm-pair fixed effects (for each pair of sample/control stocks) are used. *Z*-tests are reported in brackets.***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Spread

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0090***	0.0116***	0.0113***
	(73.88)	(56.3)	(67.76)
After	-0.0008***	-0.0014***	-0.0043***
	(-4.42)	(-4.98)	(-18.42)
Control	0.0012***	0.0007**	-0.0014***
	(7.2)	(2.28)	(-6.06)
(Control)*(After)	0.0015***	0.0035***	0.0042***
	(6.03)	(8.63)	(12.77)
R^2	0.0121	0.0145	0.0389

Panel B: Time-weighted spread

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0084***	0.0108***	0.0107***
	(73.6)	(55.19)	(67.76)
After	-0.0006***	-0.0011***	-0.0039***
	(-3.79)	(-4.01)	(-17.95)
Control	0.0012***	0.0008***	-0.0013***
	(7.44)	(2.79)	(-5.94)
(Control)*(After)	0.0011***	0.0027***	0.0038***
	(4.68)	(6.96)	(12.16)
R^2	0.0103	0.01	0.0367

Panel C: Volatility

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	0.0307***	0.0372***	0.0356***
	(48.21)	(32.55)	(36.59)
After	-0.0022**	-0.0001	-0.0087***
	(-2.52)	(-0.04)	(-6.42)
Control	0.0063***	0.0057***	0.003419**
	(6.97)	(3.52)	(2.46)
(Control)*(After)	0.0033***	0.0132***	0.0103***
	(2.61)	(5.87)	(5.38)
R^2	0.0103	0.022	0.0172

Panel D: Trading volume

	pre vs. post	*pre vs. post1*	*pre vs. post2*
Constant	232945.8***	157420***	161335.5***
	(20.5)	(14.83)	(10.34)
After	-27657.5*	-22891.4	38044.96*
	(-1.73)	(-1.55)	(1.76)
Control	26989.18*	103935.7***	119897***
	(1.67)	(6.88)	(5.42)
(Control)*(After)	22393.03	-73357.8***	-70710.1**
	(0.99)	(-3.5)	(-2.31)
R^2	0.0011	0.0109	0.0053

Table 6: Probability of informed trading (PIN)

This table presents the results of the estimation of the probability of informed trading (PIN), following Easley et al. (1996). Panel A reports descriptive statistics for PIN in the four periods around the introduction of the specialists. Panel B compares the average difference in PIN between the periods after the assignment of the specialists and the *pre*-period for STAR (column *STAR*) and control stocks (column *Control*); a paired-sample *t*-test and a Wilcoxon signed-rank test for the null hypothesis that the average or the median difference in differences (defined as *DID* in section 4 and reported in column *STAR-Control*) is equal to zero are presented. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: PIN – descriptive statistics

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average STAR	0.2447	0.2323	0.2303	0.2320	*Average Control*	0.2343	0.2515	0.2364	0.2560
St. dev. STAR	0.0720	0.0644	0.0691	0.0419	*St. dev. Control*	0.0710	0.0846	0.0722	0.1089

Panel B: Variation in PIN

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0171	0.0209	-0.0380	-1.5062	-1.129
post1-pre	-0.0358	0.0127	-0.0485	-1.7922*	-1.721*
post2-pre	-0.0275	0.0525	-0.0800	-1.9583*	-1.932*

Table 7: Informational component of the bid-ask spread

This table presents the results of the estimation of the model of Glosten and Harris (1988), used to identify the adverse selection component of the bid-ask spread, as described in section 5. We estimate the model separately for each stock/period in the sample. We use ordinary least squares and we compute Newey-West standard errors. We restrict the coefficients related to size to be equal to zero and we consider the following specification: $\Delta P_t = c_0 \Delta Q_t + z_0 Q_t + u_t$, where $\Delta P_t = P_t - P_{t-1}$ is the price change, Q_t is the transaction sign (it is equal to 1 for buyer-initiated trades and it is equal to -1 for seller-initiated trades), and $\Delta Q_t = Q_t - Q_{t-1}$ is the transaction sign change. Panel A summarizes the average estimates (in parentheses, the proportion of coefficients significantly different from zero at the 10% level according to a *t*-test are reported). Panel B and C compare the average estimates of c_0 and z_0 between the periods after the assignment of the specialists and the *pre*-period for STAR (column *STAR*) and control stocks (column *Control*); a paired-sample *t*-test and a Wilcoxon signed-rank test for the null hypothesis that the average or the median difference in differences (defined as *DID* in section 4 and reported in column *STAR-Control*) is equal to zero are presented. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Summary of estimates

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
Average c_0	0.0188 (100%)	0.0169 (100%)	0.0091 (100%)	0.0067 (100%)	*Average* c_0	0.0134 (100%)	0.0121 (100%)	0.0138 (96.88%)	0.0082 (96.67%)
Average z_0	0.0053 (100%)	0.0054 (100%)	0.0027 (100%)	0.0023 (100%)	*Average* z_0	0.0025 (97.83%)	0.0041 (100%)	0.0053 (96.88%)	0.0031 (96.67%)

Panel B: Variation in *c0*

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0023	0.0019	-0.0042	-2.4066**	-1.425
post1-pre	-0.0034	-0.0006	-0.0028	-0.9371	-0.729
post2-pre	-0.0065	-0.0066	0.0001	0.0552	-0.524

Panel C: Variation in *z0*

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	0.0001	0.0016	-0.0015	-2.249**	-1.675*
post1-pre	-0.0009	0.0020	-0.0029	-2.4817**	-3.029***
post2-pre	-0.0013	-0.0002	-0.0011	-2.2143**	-2.376**

Table 8: Cumulative impulse response function of transaction sign on price changes

This table reports the cumulative impulse response function (IRF) of transaction sign on price changes corresponding to the VAR model described in Section 5. Panel A presents the average cumulative IRF across control stocks for the four sample periods considered. Notice that step 1 is the contemporaneous impulse. Panel B and C compare the average difference in the cumulative IRF between the periods after the assignment of the specialists and the *pre*-period for STAR (column *STAR*) and control stocks (column *Control*); a paired-sample *t*-test and a Wilcoxon signed-rank test for the null hypothesis that the average or the median difference in differences (defined as *DID* in section 4 and reported in column *STAR-Control*) is equal to zero are presented. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Panel A: Summary of estimates

STAR	*pre*	*post*	*post1*	*post2*	*Control*	*pre*	*post*	*post1*	*post2*
step 1 (cont.)	0.0207	0.0183	0.0087	0.0080	*step 1 (cont.)*	0.0093	0.0135	0.0173	0.0105
step 20	0.0098	0.0091	0.0046	0.0042	*step 20*	0.0048	0.0065	0.0085	0.0049

Panel B: Variation at impulse 1

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0020	0.0055	-0.0076	2.5464**	2.359**
post1-pre	-0.0049	0.0065	-0.0113	2.7849***	3.279***
post2-pre	-0.0059	-0.0004	-0.0055	2.5196**	2.811***

Panel C: Variation at impulse 20

	STAR	*Control*	*STAR-Control*	*t-test*	*Wilcoxon*
post-pre	-0.0006	0.0028	-0.0034	2.7478***	2.75***
post1-pre	-0.0012	0.0034	-0.0046	2.5712**	3.279***
post2-pre	-0.0017	-0.0003	-0.0014	1.8905*	1.778*

Table 9: Event study around roadshows

This table reports the mean absolute abnormal returns and abnormal volume in the days around roadshows. Absolute abnormal returns and abnormal volume are defined in Section 5. Day 0 refers to the day of the roadshow. *T*-tests for the null hypothesis that the average absolute abnormal returns or that average abnormal volume are equal to zero are also presented. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

	Absolute abnormal returns		*Abnormal volume*	
Day	*Average*	*T-test*	*Average*	*T-test*
-20	0.0011	0.0224	0.0345	0.7046
-19	-0.0430	-0.9333	0.0052	0.0942
-18	-0.0659	-1.5480	0.0235	0.4210
-17	-0.0541	-1.3777	0.0446	0.9007
-16	-0.0658*	-1.7231	0.0374	0.8692
-15	0.0238	0.5923	0.0366	0.8185
-14	-0.1202***	-3.3076	-0.0359	-0.7538
-13	0.0107	0.2582	-0.0136	-0.3433
-12	-0.0176	-0.4280	0.0260	0.6477
-11	0.0036	0.0795	0.0590	1.2464
-10	0.0674	1.4439	0.0483	1.2035
-9	0.0371	0.8422	0.0421	0.8912
-8	0.0352	0.8138	0.0844*	1.7245
-7	0.0535	1.2754	0.0839*	1.7506
-6	0.0360	0.8121	0.1145**	2.3574
-5	0.0812*	1.6878	0.0910*	1.8252
-4	0.0183	0.3910	0.1579**	2.5489
-3	0.0895*	1.7197	0.1787***	3.1695
-2	-0.0210	-0.4513	0.1650***	2.9786
-1	0.1358***	2.7007	0.1626***	3.7867
0	0.2530***	4.2209	0.2503***	4.1516
1	0.1865***	3.6262	0.2771***	5.0908
2	0.1952***	3.5723	0.1905***	3.5931
3	0.1089**	2.3817	0.0605	1.5570
4	0.0508	1.0621	0.1485***	2.8341
5	0.0992	1.4592	0.1774***	3.3331
6	0.0754	1.4713	0.1473**	2.4301
7	0.1832***	2.9164	0.1471**	2.4962
8	0.0737	1.3864	0.1921***	2.6827
9	-0.0305	-0.6977	0.0577	1.2731
10	0.0140	0.2836	0.0690	1.5705
11	0.0763	1.5375	0.0605	1.2876
12	0.0712	1.5782	0.1211	1.4843
13	0.0228	0.5209	0.1207	1.4871
14	-0.0109	-0.2567	0.1055	1.6184
15	-0.0676	-1.5907	0.0651	1.5908
16	0.0130	0.2579	0.0708	1.3762
17	0.0294	0.5836	0.0013	0.0297
18	0.0011	0.0217	0.0276	0.6724
19	-0.0268	-0.5984	0.0460	1.0043
20	-0.0547	-1.2052	0.0486	0.9533

Figure 1: Cumulative impulse response function of transaction sign on price changes – STAR stocks

This figure reports the cumulative impulse response function (IRF) of transaction sign on price changes corresponding to the VAR model described in Section 5. Precisely, it depicts the average cumulative IRF across STAR stocks for the four sample periods considered. The *x*-axis indicates the time-step (step 1 is the contemporaneous impulse), the *y*-axis indicates the cumulative IRF.

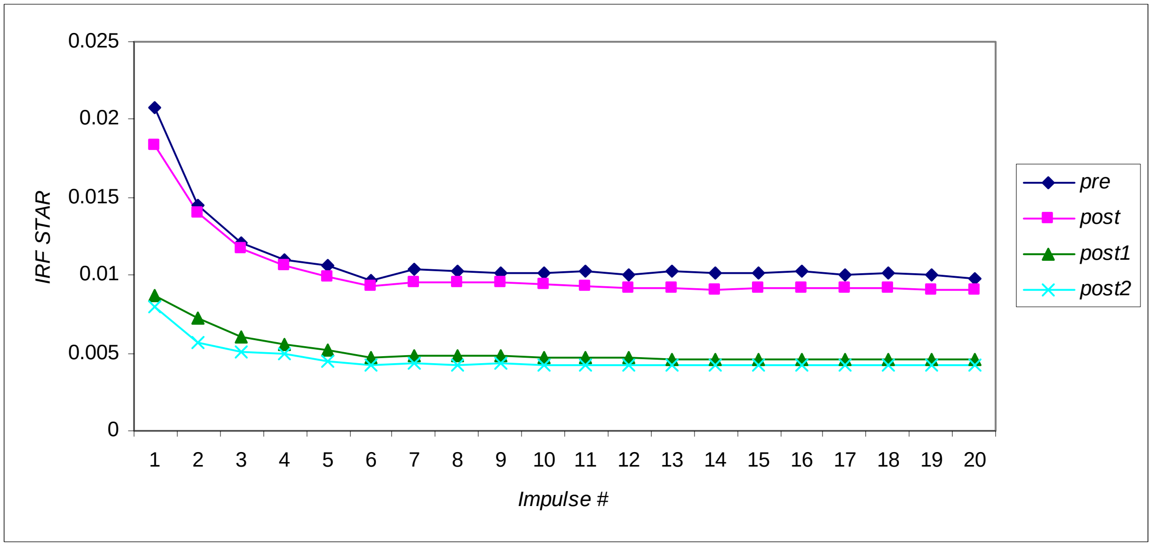


Figure 2: Cumulative impulse response function of transaction sign on price changes – Control stocks

This figure reports the cumulative impulse response function (IRF) of transaction sign on price changes corresponding to the VAR model described in Section 5. Precisely, it depicts the average cumulative IRF across control stocks for the four sample periods considered. The *x*-axis indicates the time-step (step 1 is the contemporaneous impulse), the *y*-axis indicates the cumulative IRF.

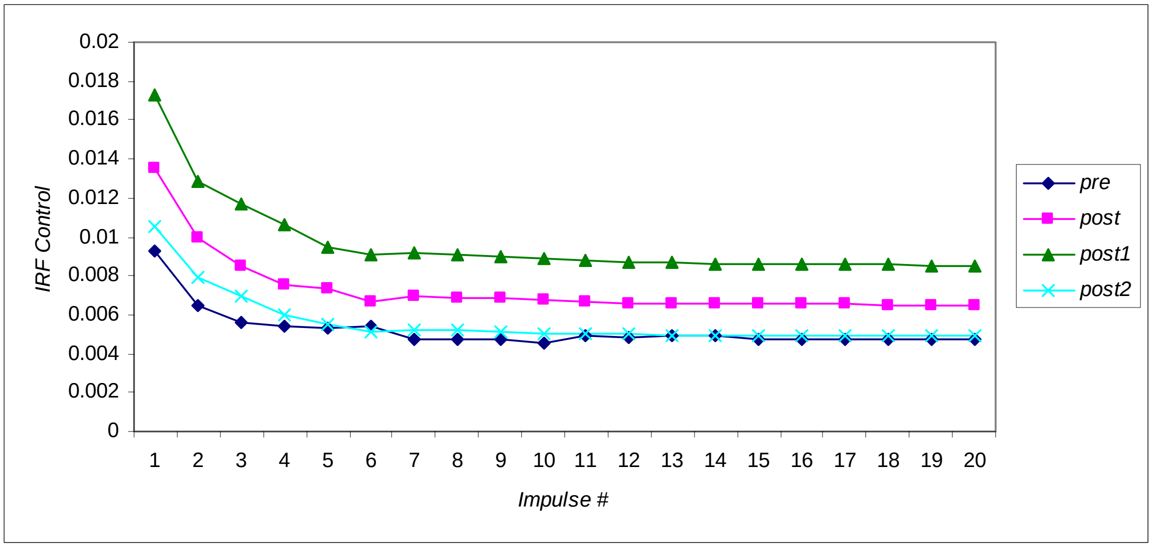


Figure 3: Absolute abnormal returns around roadshows

This figure reports (solid line) the mean absolute abnormal returns, defined as in Section 5, in the days around roadshows. Day 0 corresponds to the disclosure date. The *x*-axis indicates the day, the *y*-axis indicates the mean absolute abnormal returns. A two-standard error confidence interval (dashed lines) is also reported.

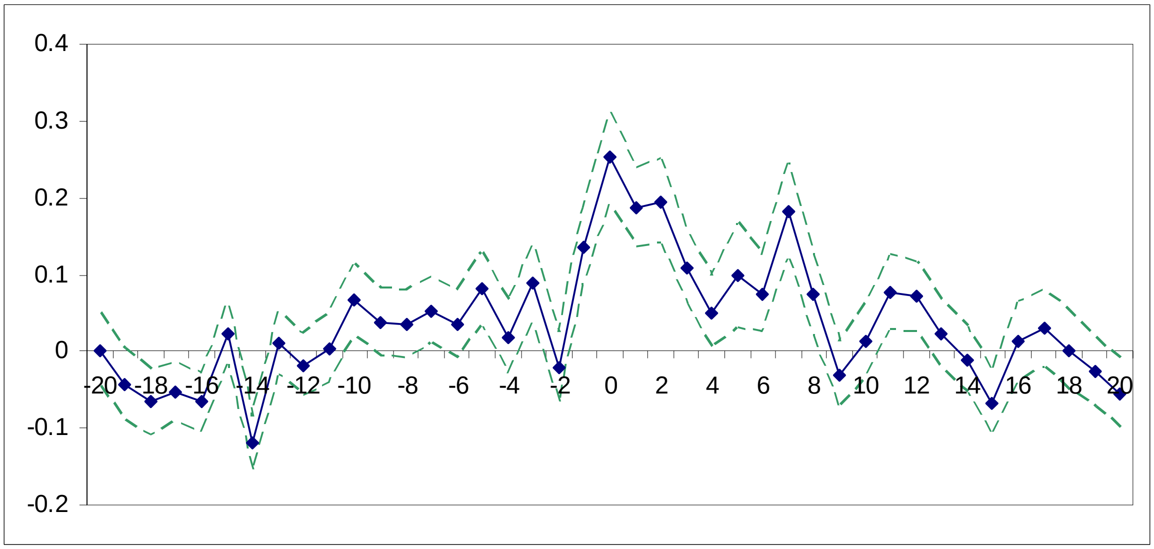
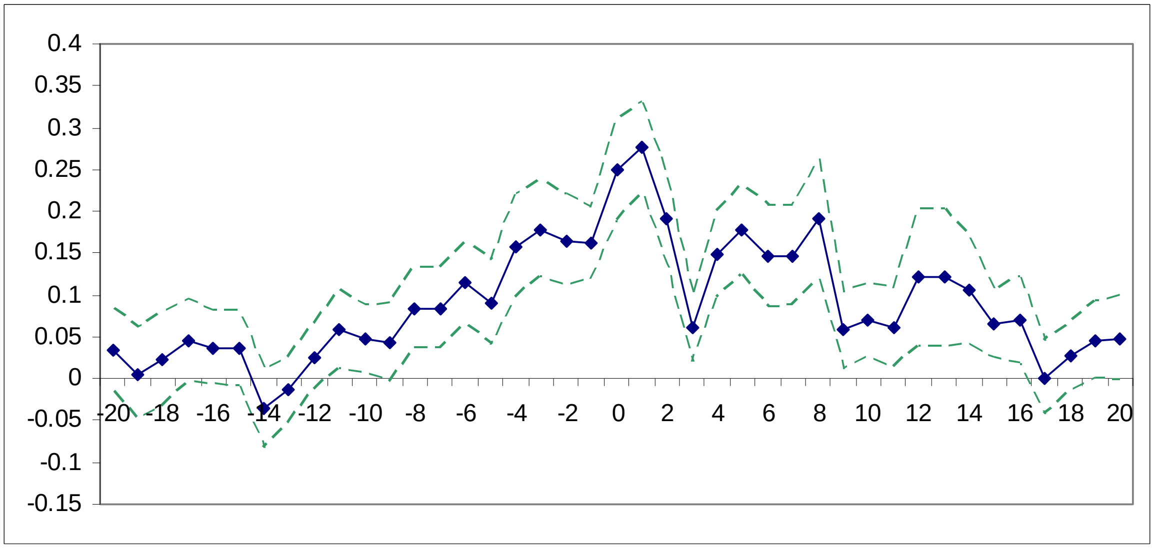


Figure 4: Abnormal volume around roadshows

This figure reports (solid line) the mean abnormal volume, defined as in Section 5, in the days around roadshows. Day 0 corresponds to the disclosure date. The *x*-axis indicates the day, the *y*-axis indicates the mean abnormal volume. A two-standard error confidence interval (dashed lines) is also reported.



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