Price Discovery in the Absence of Trading: A Look at the Malta Stock Exchange Pre-opening Period

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Abstract

This paper studies the contribution of the pre-opening period to the daily price discovery process and the factors that impacts the return generated over this period for six stocks traded on the Malta Stock Exchange. We utilise both the weighted price contribution (WPC) method and the Wang and Yang (2009) extension of the Hasbrouck (1995) information share (IS) measure applicable to sequentially trading periods. We determine the information content of the order book by measuring the impact of the relative depth and height in the overnight and opening order book and changes to the relative depth and height during the pre-opening attributable to order submissions and alterations. We find that approximately one third of daily price discovery is attributable to the preopening period. The results indicates that the impact of relative depth and height of the overnight and opening order book on opening are concentrated at the top of the order book. Furthermore, cumulative changes to the relative depth attributable to order submissions during the pre-opening most significantly impact the opening returns of less active stocks. However, we find a strong relationship between opening returns and changes in the relative height along the order book attributable to order submissions, cancellations and forward and backward price revisions over the pre-opening period.

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1. Introduction

This chapter investigates the information content of the pre-opening order book and the period's contribution to daily price discovery by analysing data for six stocks traded on the Malta Stock Exchange. By studying the information content of the order book in the pre-opening period, we can establish the extent to which order submissions and alteration to the book, in the absence of trading, contributes to the price formation process for securities trading on this exchange. In essence, the main focus of this chapter is twofold: first, we measure the proportion of daily price discovery that is attributable to the pre-opening and trading periods. To measure the proportional price discovery, we utilise two methods, the former is the familiar weighted price contribution (WPC) and the other is the Wang and Yang (2009) sequential trading period extension of the Hasbrouck (1995) information share (IS) measure. Second, we examine which order book characteristic play a pivotal role in determining the contribution to price discovery during the pre-opening. We do this by measuring the impact of the relative height and depth of overnight and opening order books, and changes therein, attributable to order submissions and alterations during the pre-opening period.

This analysis makes several contributions to the literature on market microstructure. To our knowledge, we are the first to empirically assess which characteristics of the order book information during the pre-opening period inform the price discovery process. The previous pre-opening literature such as Vives, (1995), Biais et al. (1999) Medrano and Vives (2001), Madhavan and Panchapagesan (2000) and Barclay and Hendershot (2003, 2008) customarily focus on determining the presence and extent of price discovery. In comparison to prior studies that measure the proportional contribution of the pre-opening to the daily price discovery such as Cao et al. (2000) and Barclay and Hendershott (2003, 2008), we measure and compare the two main price discovery measures utilised in the literature. In addition, this analysis examines the contribution of specific elements of order book information and traders' order submission strategy in determining opening returns. Therefore, not only do we measure the proportion of price discovery that is attributable to the pre-opening period but we also identify the factors that impact the return generated over this period.

The remainder of the chapter is organised as follows. Section 2 provides a description of the data used in empirical analysis, where in section 3 we outline the methodology and discuss the

results of our findings relative to the contribution of the pre-opening to the daily price discovery process. In section 4, we develop testable hypotheses, outline the methodology employed and present results for the impact of specific order book variables on the return generated over the pre-opening. The conclusions are presented in section 5.

2. Data

The empirical analyses conducted in this chapter utilize a unique microstructure data base obtained from the Malta Stock Exchange (MSE). The MSE is a fully electronic continuous limit order market, with no designated market makers providing liquidity. The sample utilised in this study comprises tick-by-tick data over the period January 2000 to June 2007. The data set contains all information about each event that occurs such as order submissions, revisions or cancellations, their associated price and volume, order identification attributes and any other submission rule relating to orders queued in the order book. Hence, by applying the rules governing the order book, we are able to replicate the state of the order book at every moment in time. Normal trading at the MSE begins at 10:00 am and the trading day comes to an end at 12:30 pm. Preceding the initiation of trading is the market pre-opening period which for the majority of the sample begins at 8:30 am and ends at 10:00 am.[1] It is the pre-opening period which is the main focus of this empirical analysis.

Throughout the pre-opening period, traders submit limit orders that queue to form the pre-opening limit order book. At the end of the pre-opening the opening algorithm executes suitable orders. The order book at the end of the pre-opening period, just prior to execution of the opening algorithm, is termed the opening order book. Prior to the execution of the opening algorithm, traders have the option to cancel or revise any pending limit orders without cost or obligation. Essentially, the MSE pre-opening period is similar to a single price call auction process where the market clearing price is determined by the opening algorithm.[2]

For this analysis, we select the six MSE stocks which over the sample period were the most active during the pre-opening. These correspond to the shares of HBSC Bank Malta plc (HSB),

[1] As of 23 October 2006, the preopening period changed to 9:30 am to 10:45 am with the continuous open from 10:45am to 12:30pm. This has been accounted for in our estimation.
[2] See chapter 2 for a more in-depth description of the institutional details that governs the MSE.

Bank of Valletta plc (BOV), Maltacom plc (MLC), Middlesea Insurance plc (MSI), Malta International Airport plc (MIA) and the International Hotel Investment plc (IHI). We categorise these stocks into two groups. First, the three most active stocks, that include BOV, MLC and HSB are categorised as A stocks. Second, the three remaining less active stocks, which are MSI, MIA and IHI are categorised as B stocks. In effect, these two categories are formulated to enable us to make a distinction between the characteristics of most active and less active stocks trading on the MSE. Table 1 provides a summary of the order book activity, including submissions, forward and backward price revisions, and cancellations for the six stocks utilized.

3. Price Discovery

3.1 Contribution of Pre-opening to Daily Price Discovery

The extent of price discovery which occurs throughout the market pre-opening period is the subject of debate in several theoretical and empirical studies in market microstructure research. The pre-opening is characterised by an absence of trading and the queuing of non-binding orders that await execution at the opening, thereby potentially creating an environment for aggregating information and significantly reduced adverse selection risks (see Madhavan, 1992; Economides and Schwartz, 1995; Domowitz and Madhavan, 2001). It is these factors that distinguishes the pre-opening from the continuous trading period, and highlight its importance as a feature to provide price discovery after a halt in trading.

Theoretical models of the pre-opening tâtonnement process conclude that pre-opening prices tend to converge to their fundamental value, although such convergence is noisy in models which incorporate manipulation or specialist intervention. Vives (1995) concludes that in the presence of informed and uninformed traders both submitting orders during the pre-opening, prices converge to their fundamental value at a rate proportional to the square root of time. Following the incorporation of manipulative behaviour by informed traders, both Medrano and Vives (2001) and Bursco et al. (2003) show that while prices converges to fundamentals, they are noisy around this value, a feature attributable to the added noise that manipulative behaviour induces into the learning process. Within the framework of a quote driven market with a specialist facilitating the trading process, Madhavan and Panchapagesan (2000) demonstrates

that inventory and price stability considerations lead to pre-opening prices being noisy around the fundamental value of the asset.

These models (Vives, 1995; Medrano and Vives, 2001; Bursco et al., 2003; and Madhavan and Panchapagesan, 2000) attribute price discovery to the process of learning undergone by traders participating in the pre-opening. Through observing the pre-opening order flow and the continuous updating of opening prices, traders are claimed to formulate inferences about the fundamental value of the asset. Biais et al. (1999) empirically assess the pre-opening order flow to specifically ascertain the presence of learning in light of the non-binding nature of pre-opening orders. They conclude that the pre-opening order flow is indeed informative and learning occurs only towards the end of the pre-opening period.

Since the claim is that pre-opening period facilitates price discovery after a (weekend or overnight) halt in the trading process, the obvious question is; what is the relative contribution of the pre-opening to the overall process of price discovery through an entire trading day, considering that orders are non-binding and no trade execution occurs in this period? Several studies, including Cao et al. (2000), Barclay and Hendershott (2003, 2008) and Ellul, Shin and Tonks (2005) among others, measure the proportion of price discovery over the trading day that is attributable to the pre-opening period by implementing the Weighted Price Contribution Method (WPC), introduced by Barclay and Warner (1993). Barclay and Hendershott (2003) attribute the occurrence of approximately 16% of overall price discovery for selected stocks trading on the NASDAQ to the pre-opening period, and this period accounts for approximately 74% of close-to-open price discovery.

Cao et al. (2000), in a similar view, concludes that price discovery per unit of time during the pre-opening is the same as that which occurs during the NASDAQ trading day. In addition, Barclay and Hendershott (2008) conclude that the proportion of daily price discovery that occurs at the NASDAQ opening reduced from 11.8% to 1.8% over the period 1993 to 1999 for the sample of stocks studied. Essentially, the authors find that the reduction in price discovery at the opening of the market is attributable to the pre-opening contributing more to daily price discovery. The authors find that the increased trading on off-exchange ECNs, which operates concurrent with the NASDAQ pre-opening, contributed significantly to improving price discovery during this period.

The WPC methodology is widely used as it provides fairly non-cumbersome method for quantifying price discovery occurring in designated periods within a trading day, or for stocks traded in separate locations. However, Wang and Yang (2010) argue that the WPC measure is highly sensitive to serial correlation in returns. They propose an alternative measure of price discovery based on the Information Share (IS) measure developed by Hasbrouck (1995). Specifically, Wang and Yang (2010) maintain that the WPC measures proportional weighted returns over a period only if the variance of returns is small relative to the mean return. Moreover, they show that the WPC is a function of mean returns and return serial correlations.[3] They argue that the IS more accurately measures prices discovery attributable to sequential periods within the trading day, since the IS captures variations in the efficient price of an asset traded on an exchange.

In this section, three basic questions are answered. (1) What is the relative contribution of the pre-opening period to price discovery; (2) how has this relative contribution changed over time and (3) how does the level of order book activity during the pre-opening period influence the pre-opening's contribution to the daily price discovery process for a particular stock? To empirically assess these questions, we utilise both the WPC and the IS measure proposed by Wang and Yang (2010) enabling us to compare the results from these two measures of price discovery.

3.2 Methodology

3.2.1 Information Share

The price discovery literature employs two dominant to measure the extent of price discovery in the efficient prices for assets trading in different markets and/or trading venues. Hasbrouck (1995) proposes an Information Share (IS) method that measures the respective contribution of each market to the determination of the efficient price of an asset traded simultaneously in several separate locations. The other method includes models developed in the spirit of Gonzalo and Granger (1995), which use coefficient ratios to measure the contribution of each market to the efficient price. Studies utilising this coefficient measure to estimate price discovery include:

[3] See Wang and Yang (2010) for a comprehensive proof of these claims.

Booth, So and Tse (1999), Chu, Hsieh and Tse (1999) and Harris, McInish and Woods (2002).[4] However, Yan and Ziot (2010) formulates a structural cointegration model which confirms that while both methods identify changes in efficient prices, only the IS provide information on the relative "informativeness" of different markets in relation to the price discovery process.

An important point to note is that the above family of models both rely on the premise that the asset trades simultaneously in parallel markets, which results in the price in each location being partly driven by the no-arbitrage argument. Essentially, these models then utilise a cointegrated VAR framework to model the interaction of these prices over time. Consequently, these price discovery measures are not directly applicable in measuring the relative contribution of sequential time periods within a trading day to the overall daily price discovery process. To measure the proportion of price discovery over the trading day attributable the pre-opening period, we implement a structural VAR model in the spirit of Hasbrouck (1995), formulated by Wang and Yang (2009, 2010) that measures the contribution of sequential markets (or time periods) to the efficient price of an asset within a separate time period.[5]

To illustrate, let $p_{i,t}$ and $r_{i,t}$ denote the log price and return for period *i*, respectively, on day *t* for a specific asset. Period *i* can be further sub-divided into *n* sequential trading periods. Denote the daily return from close of trade on day *t*-1to day *t* as $r_t = \sum_{i=1}^{n} r_{i,t} = p_{n,t} - p_{n,t-1}$. Assuming returns within the ith period are subject to period specific shocks $\eta_{i,t}$ that are serially uncorrelated It follows that only the component of the shock related to the fundamental changes in the assets value will enter the efficient price. Therefore, the price at the end of period *i* can be written as $p_{i,t} = m_{i,t} + u_{i,t}$, where $m_{i,t}$ is the unobservable efficient price that reflects information on the fundamental value of the asset and $u_{i,t}$ is a error term reflecting transitory factors.

The change in the efficient price from one period to the next is $\Delta m_{i,t} = m_{i,t} - m_{i-1,t}$ for *i* = 1,...,n. The changes are serially uncorrelated and capture the permanent factors in the period specific

[4] Studies that employ both methods includes Chakravarty, Gulen, and Mayhew (2004) and Covrig, Ding and Low (2004).

[5] Wang and Yang (2009) measure the contribution of four non-overlapping foreign exchange markets to price discovery in four currency pairs, and Wang and Yang (2010) measure the relative contribution overnight and daytime periods to the close-to-close price discovery process.

shocks $\eta_{i,t}$. In the spirit of Hasbrouck (1995), $\mathrm{Var}(\Delta m_{i,t})$ denotes the information flow in period *i*. Hence, if the change in the efficient price over day *t* is $\Delta m_t = \sum_{i=1}^{n} \Delta m_{i,t}$, then the information share (IS) of period *i* on day *t* is defined as

$$IS_i = \frac{\mathrm{Var}(\Delta m_{i,t})}{\mathrm{Var}(\Delta m_t)} \qquad \text{for } i = 1,...,n \tag{1}$$

Denote $p_{o,t}$ and $p_{c,t}$ as the log opening price generated by the opening algorithm at the end of the pre-opening, and log closing price on day *t* respectively. Thus, the close-to-open (opening) and open-to-close return are $r_{1,t} = p_{o,t} - p_{c,t-1}$ and $r_{2,t} = p_{c,t} - p_{o,t}$, respectively. The vector of returns is defined as $R_t = (r_{1,t},\ r_{2,t})'$.[6] Providing returns are stationary, the vector R_t can be modelled using a structural VAR process as follows:

$$\mathrm{B}_0 R_t = \mathrm{a} + \sum_{k=1}^{K} \mathrm{B}_k R_{t-k} + \eta_t \tag{2}$$

where $\eta_t = (\eta_{1,t},\ \eta_{2,t})'$ is the vector of serially uncorrelated structural shocks that are specific to the pre-opening and the trading periods respectively. In addition, $E(\eta_t) = 0$, $E(\eta_t \eta_{t-k}') = 0$ for $k \neq 0$ and $E(\eta_t \eta_t') = \mathrm{I}$, where I is the identity matrix. Due to the sequential nature of the pre-opening and the trading periods within one trading day, the close-to-open returns $r_{1,t}$ impacts the open-to-close return $r_{2,t}$ but not *vice versa*. As a consequence, B_0 will be a lower triangular matrix as follows:

$$\mathrm{B}_0 = \begin{bmatrix} b_{11} & 0 \\ b_{12} & b_{22} \end{bmatrix} \tag{3}$$

The reduced form of the structural VAR in (2) is, therefore:

$$\Psi(L) R_t = \alpha + \varepsilon_t \tag{4}$$

[6] The close-to-close return is the sum of both returns.

where $\Psi(L) = \mathrm{I} - \Psi_1 L - ... - \Psi_k L^K$, $\Psi_k = \mathrm{B}_0^{-1}\mathrm{B}_k$, $\alpha = \mathrm{B}_0^{-1}\mathrm{a}$ and the reduced form errors relates to the structural shocks by $\varepsilon_t = \mathrm{B}_0^{-1}\eta_t$. Therefore, $\varepsilon_{1,t}$ is proportional to $\eta_{1,t}$ and $\varepsilon_{2,t}$ is a linear combination of $\eta_{1,t}$ and $\eta_{2,t}$. The covariance matrix is given by, $\Omega = E(\varepsilon_t, \varepsilon_{t-s}) = \mathrm{B}_0^{-1}(\mathrm{B}_0^{-1})'$. Since B_0 is a lower triangular matrix and Ω is symmetric, the VAR can be estimated using OLS and Ω can be estimated using the lower triangular Cholesky factor of the OLS estimated variance matrix of ε_t.

3.2.2 Estimating the Information Share

From the reduced form VAR in equation (4) the moving average representation based on the Beverage-Nelson (1981) decomposition is as follows:

$$R_t = \mu + \Psi(1)^{-1}\varepsilon_t + \Psi^*(L)\varepsilon_t \tag{5}$$

where $\mu = \Psi(1)^{-1}\alpha$, $\Psi(1) = \mathrm{I} - \Psi_1 - ... - \Psi_K$, $\Psi^*(L) = \sum_{j=0}^{\infty}\Psi_j^* L^j$, $\Psi^*(L)(\varepsilon_t) \sim I(0)$ and $\Psi^*{}_j$ converges to zero as *j* increases. The matrix $\Psi(1)^{-1}$ captures the cumulative impact of the reduced form innovations (ε_t) on the returns. To derive an expression for the unobservable efficient prices $m_{i,t}$, Wang and Yang (2009) contend that the change in the log price at the end of day *t* is the accumulation of each period's return, such that:

$$p_{c,t} = \bar{p}_0 + \iota'\Psi(1)^{-1}\sum_{i=1}^{t}\varepsilon_i + u_{c,t} = \bar{p}_0 + \iota'\Psi(1)^{-1}\mathrm{B}_0^{-1}\sum_{i=1}^{t}\eta_i + u_{c,t} \tag{6}$$

where $\bar{p}_0$ is the initial price at *t* = 0, $u_{c,t} = \iota'\Psi^*(L)(\varepsilon_t) = \iota'\sum_{j=0}^{\infty}\Psi_j^*\varepsilon_{t-j}$ and ι is a vector of ones. Evident here is that equation (6) is similar to the Stock and Watson (1988) common trend representation. Thus, the price at the end of day *t* consists of the full information value of the asset and a transitory pricing error, which captures deviations from efficient prices. Hence, the efficient price can be defined as:

$$m_t = \lim_{\tau\to\infty} E\left(p_{t+\tau} \mid F_t\right) = \bar{p}_0 + \iota'\Psi(1)^{-1}\mathrm{B}_0^{-1}\sum_{i=1}^{t}\eta_t \tag{7}$$

where F_t is the information set at the end of the day *t*. Therefore, the change in the daily efficient price is

$$\begin{aligned} \Delta m_t &= m_t - m_{t-1} = \iota' \Psi(1)^{-1} \mathrm{B}_0^{-1} \eta_t = \phi' \eta_t \\ \Delta m_t &= \phi_1 \eta_{1,t} + \phi_2 \eta_{2,t} \end{aligned} \tag{8}$$

where $\phi' = (\phi_1, \phi_2) = \iota' \Psi(1)^{-1} \mathrm{B}_0^{-1}$. Since $E(\eta_t \eta_t') = \mathrm{I}$, the information share for period *i* is:

$$\mathrm{IS}_i = \frac{\mathrm{Var}(\phi_i \eta_{i,t})}{\mathrm{Var}(\phi' \eta_t)} = \frac{\phi_i^2}{\phi_1^2 + \phi_2^2}, \qquad \text{for } i = 1,2 \tag{9}$$

Note that in the Hasbrouck presentation of the IS, the ordering of prices impacts the resulting IS measure and as such upper and lower bounds are necessarily established. However, Wang and Yang (2009) demonstrates that in this formulation, the ordering of returns does not impact the value of the resulting IS measure.

3.2.3 Weighted Price Contribution

Barclay and Warner (1993) utilise the WPC method to determine the impact of different trade sizes on trade price. Their method is adopted to measure the contribution of different periods within a trading day to the price discovery process by Cao et al. (2000), Barclay and Hendershott (2003, 2008), Huang (2002) and Ellul et al (2005). In this study, the WPC of the opening and open-to-closing return to the daily stock price return will be computed and presented along with the IS measure. As define previously, if $r_{1,t}$ and $r_{2,t}$ are the opening and open-to-close returns respectively, such that $r_t = r_{1,t} + r_{2,t}$ is the close-to-close return, then the WPC for period *i* is computed as follows:

$$\mathrm{WPC}_i = \sum_{t=1}^{T} \left[|r_t| \left(\sum_{t=1}^{T} |r_t| \right)^{-1} \left(\frac{r_{i,t}}{r_t} \right) \right], \qquad \text{for } i = 1,2 \tag{10}$$

The second term in parentheses measures the relative contribution of period *i* to the close-to-close return and the product of the first two term is a weighting factor that reduces the impact of

small absolute daily returns. Essentially, the WPC relies on the average return process over the sample to reduce the effect of transitory price movements on the return series (Huang, 2002).

3.2.4 Opening Returns and Open-to-Close Returns

Ideally, opening return is calculated as the difference between the log opening price, determined by the opening algorithm, and the log price of the last trade in the previous trading day. However, two issues may arise in the case of the MSE. First, the last trade price might not reflect the last valuation for the stock at market close. Second, at the end of the pre-opening period an opening price is determine only when there are matching buy and sell orders such that the price of the best buy is at least equal to the price of the best sell order. Hence, not in all cases will there be an opening price generated at the end of the pre-opening. To alleviate these problems, we set the closing price of each stock to the mid-quote at the trading day and the opening price is set equal to either the opening price if there are executable orders or to the mid-quote at the end of the pre-opening otherwise.[7]

Table 2 presents a statistical summary of the opening (r_1) and open-to-close (r_2) returns for the six stocks utilised in this study. Evident from the table is that the average opening return for five of the six stocks is positive and all with a negative open-to-close return. This indicates that there is in general a reversal of returns after the opening: if a stock realises a positive opening return, then it is often followed by a negative return during the trading period. For all the stocks, there is evidence of excess dispersion as the standard deviation in all cases is greater than their respective mean return. The table also reveal that both the opening and open-to-close returns for the six stocks are significantly serially correlated, even at large lags as the Ljung-Box test statistics at lags four, eight, sixteen and thirty six are all statistically significant at the five percent level. This finding indicates caution should be exercised when using the WPC as a measure of sequential price discovery.

[7] An opening price is generated for the three most active stocks (BOV, MLC and HSB) between 77% and 81% of the time, and between 50% and 57% for the less active three stocks (MSI, MIA and IHI) in our sample.

3.3 Empirical Results

The estimates for both the sequential information share (IS) and the weighted price contribution (WPC) measure of the pre-opening period price contribution are reported in table 3. Results are presented for the entire sample and for each year within the sample. The IS is estimated from the structural VAR in equation (2) and the WPC is estimated using equation (10). In addition, the table reports the correlation between the opening and open-to-close return, the computed difference between the WPC and the IS measure, and the number of lags incorporated in the structural VAR model used to calculate the IS. The lag length of the structural VAR is selected using the maximum AIC statistic. Table 4 provides a summary of table 3 for both the most active (A) stocks and the least active (B) stocks. Evident from table 4 is that, on average, there is a negative relationship between opening returns and open-to-close return for both the A and B stocks for each year in the sample, and also for the full sample. Thus, a positive return during the pre-opening tends to be follow by a negative return over the subsequent trading period. For the A stocks, the average correlation ranges between -0.07 and -0.35. The B stocks tend to be even more negatively correlated, with averages ranging between -0.17 to -0.45.

The contribution of the pre-opening period to daily price discovery varies depending upon the estimation method chosen. Based on the IS measure, the proportion of price discovery attributable to the pre-opening period is on average approximately 30% for the A stocks and 32% for the B stocks. The WPC estimates are slightly higher on average for both type of stock, with approximately 35% and 38% of the daily price discovery attributable to the pre-opening across the A and B stocks respectively. Hence, the pre-opening period seems to account for similar levels of price discovery for both the most active and the least active stocks in our sample.

For both categories of stocks, there is a small reduction in price discovery during the pre-opening over the sample period, irrespective of method used. The WPC shows a more gradual decline over the period as compared to the IS, which exhibits a more volatile pattern. For the A stocks, the average IS decreased from approximately 36% to 30% with a high of 55% and low of 17% in 2003 and 2006 respectively. The WPC decreases gradually from approximately 37% to 25% over the sample period, with a high of 46% and a low of 25% in 2001 and 2007 respectively. For the B stocks, the average IS decreased from approximately 24% to 20% over the sample with a high of 47% in 2001 and a low of 20% in 2007. The WPC for the B stocks declines from

approximately 44% to 30% over the sample with a high of 48% in 2001 and a low of 30% in 2007.

On average, the difference between the IS and the WPC for both the A and B stocks is in the region of 5% - 6% respectively, for the full sample. This suggests that over the long run, both methods may produce similar conclusions. In addition, the yearly averages of the IS and the WPC for both A and B stocks are close to their respective estimates for the full sample. In contrast, the annual estimates of the WPC and the IS are similar for some year but reveal large differences for other years. In the A stocks, on average the difference between the IS and WPC ranges between -15% and 16% and between is -3% and 20% for the B stocks. These differences are driven by numerous factors that affects the IS and the WPC separately, such as the correlation between the opening and open-to-close returns, the level of excess dispersion in the return series, return serial correlation and the number of lags incorporated into the structural VAR model. However, in contrast to the finding of Wang and Yang (2010), we find no distinct relationship between these parameters and the difference between the IS and the WPC. Consequently, using the IS or the WPC to determine the level of price discovery might lead to different empirical conclusions.

Overall, irrespective of the methodology employed, the pre-opening period contributes significantly to the daily price discovery process, with values of between 30% and 38% for both the most and the less active stocks in this study. Essentially, we find no evidence that there is a significant difference between the contributions of the pre-opening to the daily price discovery process of stocks that are highly active compared to stocks that are significantly less active during the pre-opening period. We also find that the price discovery attributable to activity in the pre-opening period has been slightly reduced over the 2000 to 2007 period.

4. Limit Order Book and Opening Returns

The information content of the open limit order book is a major topic of debate in studies focusing on price discovery. On the one hand, various studies contend that only information at the top of the order book provides investors with information about the full information value of the asset. Theoretical models of Glosten (1994), Rock (1996), Angel (1997), Seppi (1997) and

Harris (1998) show that informed traders prefers the use of market orders to profit from their short lived private informational advantage. Hence, informed traders will trade-off a higher cost and reveal their private information to guarantee immediate execution of their orders, due to the non-execution risk associated with the submission of limit orders. Thus, under these assumptions the order book below the best quotes provides no information about future price discovery.

On the other hand, other studies argue that the order book below the best quotes provides informative and it composition should be a basis of ongoing research. This debate in some instances focuses on the use of limit versus market orders by informed agents to profit from their informational advantage. In essence, if informed trades utilise limit orders which are more discrete and reveals less information to the market, then the private information will be reflected in the limit order book. However, if informed traders utilise market order that are certain and immediate even though expensive and reveals their impatience, then their private information will not be present in the limit order book (Cao et al. 2009).

Bloomfield et al. (2005), show that it is more profitable for informed traders to submit proportionally more limit than market orders so as to conceal and maximise the payoff from their private information. The theoretical model of Kaniel and Lui (2006) confirms this behaviour, and concludes that limit orders in the order book will be more informative when traders posses "long-lived" information. Harris and Panchapagesan (2005) provides empirical support for this proposition by showing that specialists at the New York Stock exchange (NYSE) utilise information from the limit order book to gain advantage over limit order traders.

Essentially, the choice between the submission of market or limit orders represents a trade-off between the non-execution cost and picking off risk associated with limit orders and bearing the cost of immediate execution provided by market orders (Cohen et al., 1981, Copeland and Galai, 1983 and Handa and Schwartz, 1996). To determine this trade-off, studies argue that in formulating their order submission strategy, traders utilises information that can be inferred from the limit order book, which further supports the notion that the order book is informative. Specifically, Parlour (1998) proposes the "*crowding out*" effect, whereby traders gauge their submission of limit or market orders based on the thickness on both sides of the order book. Foucault (1999) and Foucault et al. (2005) contend that the proportion of limit order submission

relative to market order depends on the fundamental asset price volatility and the bid-ask spread, respectively. Goettler et al. (2005) also find that the level of the spread affects the trade-off between the submission of market and limit orders, such that larger spreads increase the cost of market orders and, therefore, reduce their use by informed agents.

Several empirical studies corroborate these theoretical predictions, and in the process confirming that the limit order book is informative about order strategy employed by traders. Biais et al. (1995), Al-Suhaibani and Kryzanowski (2000), Ranaldo (2004) and Ellul et al. (1995) show that the smaller the spread the greater the probability of market order relative to limit order submission. The impact of the order book depth ("*crowding out*" effect) on order choice and aggressiveness is confirmed by Biais, Hillion and Spatt (1995), Cao, Hansch and Wang (2008), Griffiths et al. (2000), Ranaldo (2004), Hall and Hautsch (2006) and Pascual and Veredas (2008). In addition, Cao et al. (2008) shows that the price dimension along the order book, referred to as order book height, is also informative and impacts the use of market versus limit orders for trade executions. Hence, from both a theoretical and empirical perspective, there is strong evidence supporting the premise that the order book is informative and should provide information about future prices and by extension price discovery.

The context of the pre-opening period differs, as there are no market orders *per se* (due to the lack of order execution). Orders submitted and not cancelled sit in the pre-opening order book, awaiting execution at the opening. The lack of continuous order execution during the pre-opening should translate into an order book that becomes increasingly informative as the pre-opening period progresses and is of its most informative at market opening. Vives (1995) maintains that in the presence of informed and uninformed traders submitting orders during the pre-opening, both types of traders will submit orders until the subsequent opening price reveals the full information value of the asset. In this situation, the structure of the pre-opening order book is informative regarding the fundamental value of the asset and, correspondingly, the return generated over the pre-opening.

To qualify the above, traders have the option to revise or cancel orders sitting in the order book during the pre-opening period, thereby creating an opportunity for traders to "game" the order book. In other words, manipulative behaviour during the pre-opening period could distort inferences about the informational content of the order book. Specifically, in the models of

Medrano and Vives (2001) and Brusco et al. (2003), manipulation by an informed trader will induce additional noise in the order book, which limits the ability of other traders to make inferences about the fundamental value of the asset. If manipulative behaviour is present, then it is expected that the pre-opening order submission strategy will provide little information about the fundamental value of the asset and consequently returns over the period. In contrast, if traders learn about the fundamental value of the asset (Biais et al. 1995) the order book will be informative about returns over the pre-opening.

In this section, we empirically asses the "informativeness" of the state of the pre-opening order book in relation to the pre-opening period return. Specifically, we investigate the information content of the overnight order book, changes to the order book throughout the pre-opening, and the state of the opening order book. To our knowledge, this is the first study that attempts to assess the relationship between the evolution of the pre-opening order book and the return realised over the pre-opening period. There are other empirical studies that examine the relationship between the limit order book and short-term returns, but these focus exclusively on the continuous trading period. For instance, Huang and Stoll (1994) show that the difference between the depth of the best buy and sell orders predicts future price change. Chordia, Roll and Subrahanyam (2002) and Boehner and Wu (2008) maintains that trading imbalances impact future returns, while Cao et al. (2009) find that order book imbalances between the buy and sell side at, and below, the top of the order book impacts future short term returns. Of these studies, this analysis is most closely related to that of Cao et al (2009).

4.1 Overnight Order Book and Opening Returns

At the end of trading each day, orders submitted which remain unexecuted queued to form the overnight order book, which subsequently serves as the initial basis for inference to traders participating in the pre-opening period. To determine the information content of the overnight order book we examine the order book on both price and liquidity dimensions. First, to examine the volume dimension, we measure relative volume imbalances along the order book. We maintain that if there is an excess amount of demand (supply) pressure in the previous trading session resulting in large unexecuted buy (sell) orders relative to sell (buy) orders queued in the overnight order book, then this excess demand (supply) will result in an upward (downward)

pressure on pre-opening prices. Alternatively stated, when the order book on the buy (sell) side is "thick" in relation to the sell (buy) side, then subsequent orders submissions and forward price revision in the buy (sell) order book will have to be more aggressive to enhance their probability of execution at the opening. This increased aggressiveness in buy (sell) orders submission or forward price revision will result in an upward (downward) pressure on opening prices.

Previous empirical studies including as Biais et al. (1995), Ranaldo (2004), Hall and Hautsch (2006), Pascual and Veredas (2008), Cao et al. (2008) among others find a positive relationship between large buy (sell) side depth and the aggressiveness of prices associated with future order submissions. Cao et al. (2009) empirically identify a positive relationship between relative excess demand and short term returns during the regular trading period. Hence, the testable hypothesis is as follows;

Hypothesis 1a: Increase in relative buy (sell) depth in the overnight order book positively (negatively) impacts opening returns.

The information content of imbalances along the price dimension of the overnight order book is captured by measuring the relative height at different steps along the order book. Similar to the volume imbalance, the price imbalances along the overnight order book measures the relative buy or sell pressure resulting from high demand or supply during the previous trading session. Essentially, the overnight order book will reflect higher buy (sell) pressure when the prices along the buy (sell) dimension of the book are closer together relative to the prices along the sell (buy) side of the order book.

If the supply side pressure exceeds that on the demand side in the previous trading session, then the absolute distance between the prices of unexecuted sell orders along the overnight order book will be (relatively) smaller than the distance between prices on the buy side. Similarly, if there was demand side pressure during the previous trading session then this should be reflected in the distance between the unexecuted buy orders that queue in the overnight order book. We argue that when the relative buy (sell) side height is small, this leads to the submission of aggressive buy (sell) orders and forward revisions which results in upward (downward) pressure on opening prices. Therefore, the testable hypothesis is;

Hypothesis 1b: Decrease in relative buy (sell) height in the overnight order book positively (negatively) impacts opening returns.

4.2 Pre-opening Order Book Evolution and Opening Returns

At commencement of the pre-opening period, traders can examine the extant order book when deciding on their optimal order placement strategy. However, as the pre-opening order book evolves and traders are able to make more reliable inferences about the full information value of the stock, we expect the submission and placement strategy to be refined accordingly. Intuitively, any changes to the state of the overnight order book are attributable to four main actions taken by traders during the pre-opening period. These are the submission of new order, revisions of order prices towards and away from the top of the order book (referred to as forward and backward revisions, respectively) and cancellation of existing orders in the order book during the pre-opening period.

During the pre-opening period, buy or sell side pressure can be ascertained by examining the increase in depth on either sides of the book as traders submit new orders. Essentially, if during the pre-opening period there is buy side pressure resulting in relatively larger incoming buy compared to sell order being submitted, then this excess demand pressure will place upward pressure on the opening price. In addition, if the supply volume is relatively greater than the demand then this will exert downward pressure on prices.

Additionally, changes in the buy and/or sell side pressure can also be ascertained by observing the order book height on both sides of the order book. If the height on the buy side relative to the sell side reduces as more order submissions on the buy side fill in any price gaps in the buy order book during the pre-opening, then this is indicative of an increase in buy side pressure. Consequently, we expect this increase in buy side pressure to have a positive impact on prices and as a consequence a positive impact on opening returns. The converse of the argument hold true as it relates to the relative sell side height. Hence, a reduction in the relative sell side height attributable to pre-opening order submission is indicative of sell side pressure which translates into downward pressure on prices. Hence, we test the following two hypotheses;

Hypothesis 2a: Cumulative increases in relative buy (sell) depth attributable to submissions during pre-opening, positively (negatively) impacts opening returns.

Hypothesis 2b: Cumulative decreases in relative buy (sell) height attributable to submissions during pre-opening, positively (negatively) impacts opening returns.

One of the main characteristics of the pre-opening period is the ability for traders to cancel or revise the price or volume of a previously submitted limit order without any cost or obligations anytime before the opening. As new orders are submitted to the order book and traders are able to form more reliable estimates about the fundamental value of the stock, then if their information set is inconsistent with inferences made from the order book, then they have the option to cancel or revise the price of their queued orders.[8] Essentially, when traders on the buy side, for instance, revise the price of an order closer to the top of the bid order book, the result is an increase in buy side pressure since the volume associated with the revised order will increase the depth closer to the top of the order book. Conversely, if a buy side trader revises a buy order away from the top of the order book, then there will be a reduction in buy side pressure on opening prices. The opposite argument holds true for order revisions on the sell side.

When traders revise the price of their order towards the top of the order book, there will be a resulting impact on the order book height: a forward revision of a buy order results in a reduction in the relative height towards the top of order book. This reduction in relative height translates into an increase in buy side pressure during the pre-opening period. Consequently, as other traders observe the decrease in the relative buy side height, they will have to contemplate revising the price of their queued order closer to the top of the buy order book in order to restore the desired order execution probability. Conversely, if the price of a buy order is revised backward from the top of the order book, this results in a reduction in buy side pressure and a reduction in the upward pressure on prices. Therefore, the testable hypotheses are as follows;

Hypothesis 2c: Cumulative increases in relative buy (sell) depth attributable to revisions during pre-opening, positively (negatively) impacts opening returns.

[8] Traders also have the option to modify the volume and other attributes associated with their order. However, their occurrence in our sample is so infrequent that as a consequence, their impact is not assessed.

Hypothesis 2d: Cumulative decreases in relative buy (sell) height attributable to revisions during pre-opening, positively (negatively) impacts opening returns.

A similar argument can be made for cancellation of queued limit orders. If sell side traders remove liquidity from the order book during the pre-opening by cancelling their orders, there are two resulting changes that indicate a reduction in sell side pressure. First, the depth at the position of the cancelled order is reduced by the amount of the cancelled volume. Second, the height at the position of the cancelled order may increase resulting in an increase in the relative sell side height. The consequent reduction in relative depth and the increase in the relative height combined reduce the downward pressure on prices. Similarly, reduction in the demand pressure due to cancellations of queued buy orders reduces the upwards pressure on the opening price due to the reduction in relative buy side depth and the increase in relative sell side depth. In addition, the relative buy side height at the position of the cancelled buy order may increase and, therefore, increase the relative buy side height. The ensuing reduction in the relative buy depth and the increase in the relative buy height results in a reduction in the upward pressure on prices. Based on these arguments, the testable hypotheses are as follows;

Hypothesis 2e: Cumulative decreases in relative buy (sell) depth attributable to cancellations during pre-opening, negatively (positively) impacts opening returns.

Hypothesis 2f: Cumulative increases in relative buy (sell) height attributable to cancellations during pre-opening, negatively (positively) impacts opening returns.

4.3 Opening Order Book and Opening Return

By the end of the pre-opening period, all queued orders constitute the opening order book and await execution by the opening algorithm. At this time the full information value of the stock should be reflected by the extant state of the order book. In an analogous fashion to the arguments presented in relation to the overnight order book, we examine the price and volume dimensions of the opening order book to determine its information content. We argue that if there is buy (sell) side pressure during the pre-opening which translate to an excess demand

(supply) for (of) the stock, then this will result in an upward (downward) pressure on the opening price. Therefore, this excess demand (supply) pressure will be reflected along both the price and volume dimension of the opening order book. Hence, the demand (supply) pressure is present when the depth on the buy (sell) side is larger relative to the depth on the sell (buy) side, which translates into an upward (downward) pressure on opening prices.

In addition, if the relatively larger demand (supply) pressure is reflected along the price dimension of the opening order book then we expect the relative height on the buy (sell) to be smaller. Hence, the smaller the relative height along the buy (sell) order book, the greater the upward (downward) pressure on opening prices. Therefore, the testable hypotheses are as follows;

Hypothesis 3a: Increase in relative buy (sell) depth in the opening order book positively (negatively) impacts opening returns.

Hypothesis 3b: Decrease in relative buy (sell) height in the opening order book positively (negatively) impacts opening returns.

During the opening session, trade execution occurs only for orders that locks or crosses the inside spread.[9] The locked or crossed order effectively supply liquidity at the open, in a similar way to market orders in the trading session, since they have execution priority at the opening. In the Cao et al. (2000) empirical study of the pre-opening period, they show that locked or crossed inside spread is informative about the fundamental value of the stock and should impact opening prices. To reveal the impact of a locked or crossed inside spread on the opening price, the side of the market that locked or crossed the inside spread will have to be determined. We therefore argue that if the buy side locked or crossed the inside spread during the pre-opening, then this results in a positive signal that is indicative of buy side pressure and therefore upward pressure on the opening price. Similarly, if the inside spread was locked or crossed by sell side traders, then this results in a negative signalling effect and therefore, translates into downward pressure on the opening price. The testable hypothesis is therefore;

[9] The inside spread is locked when the price of the best bid is equal to the price of the best ask. Similarly, the inside spread is crossed when the price of the best bid is less than the price of the best ask.

Hypothesis 3c: Buy (sell) side locking or crossing of the inside spread positively (negatively) impacts opening returns.

4.4 Econometric Methodology

4.4.1 Opening Returns

The empirical analysis focuses on the impact of the characteristics of the pre-opening order book on the returns generated from the previous close to the opening of the market. Similar to the previous section, the opening (close-to-open) return on day *t* is $r_{1,t} = p_{o,t} - p_{c,t-1}$, where $p_{o,1}$ and $p_{c,t}$ denotes the log opening and closing prices on day *t* respectively. From the previous section, the Ljung-Box test statistics indicates that $r_{1,t}$ is highly serially correlated even at high lags for all six stocks considered in this analysis. To correct for the presence of serial correlation in returns, we pre-whiten the returns (similar to Cao et al. (2009)) and focus our analysis on the innovations in opening returns. Initially, the opening return innovation is used as the dependent variable instead of the opening return in the analysis since these innovations represent the portion of return that is not explained by previous changes in returns. We corroborate our findings using the opening returns itself.

The opening return innovations are obtained by estimating an AR(*P*) model for each stock and collecting the residuals, such that

$$\varepsilon_t^* = \left(1 - \sum_{i=1}^{P} \varphi_i L^i\right) r_{1,t} - \alpha \tag{11}$$

where ε_t^* is the opening return innovation, α and φ_i are the estimated constant and slope parameters, respectively, from the AR(P) model, *L* is the lag operator and the lag length *P* is determined by the maximum Akaike Information Criterion (AIC) value. Since this study focuses on the return over the pre-opening period which only accounts for a proportion of the total returns generated over an entire trading day, we also control for the effect of the open-to-close return from the previous day $\left(r_{2,t-1} = p_{o,t-1} - p_{c,t-1}\right)$ on the opening return. For robustness checks, we also use the opening returns as the dependent variable in this analysis and report the results.

The t-statistics reported are calculated using the Newey-West heteroskedasticity and autocorrelation consistent standard errors.

4.4.2 Explanatory Variables

The hypotheses outlined in sections 4.1, 4.2 and 4.3, propose that the upward and downward pressure along the volume and price dimensions, namely the depth and height, impacts the opening returns. For instance, in section 4.1 we contend that the relative depth and height of the overnight order book impacts opening returns. To test these hypotheses, we measure the relative depth and height from the top to step five in the order book queue. If D_j^B and D_j^S denotes the total volume at position *j* in the buy and sell order book respectively, the relative depth at position *j* is therefore;

$$RD_j = \frac{D_j^B - D_j^S}{D_j^B + D_j^S}, \qquad \text{for } j = 1,...,5 \qquad (12)$$

Hence, the relative depth at position *j* is the excess demand (supply) proportional to the total volume at position *j* on both sides of the order book. Similarly, if P_j^B and P_j^S denotes the prices at position *j* in the buy and sell order book respectively, then the relative height is measured as follows,

$$RH_j = \frac{\left(\left|P_j^S - P_{j-1}^S\right|\right) - \left(P_j^B - P_{j-1}^B\right)}{\left(\left|P_j^S - P_{j-1}^S\right|\right) + \left(P_j^B - P_{j-1}^B\right)}, \qquad \text{for } j = 1,...,5 \qquad (13)$$

where, we set $P_0^B = P_0^S = 0$. Hence, the relative height measures the relative distance between the prices on either sides of the order book. Rearranging the terms in equation (13) reveals that the relative height is the difference between the spread at different steps along the order book. In addition, since $P_0^B = P_0^S = 0$, then the relative height at *j* = 1 is the relative spread. Due to the extended lack of trading activity over the weekend or long holiday period such as during Christmas, the likelihood is that the information in the overnight order book that precedes the pre-opening in these situations has a greater tendency to become “stale”. To accommodate this

possibility, we incorporate a dummy variable (DS_t) that takes the value of one if the market is closed for more than one day prior to day *t*. The first regression is therefore;

$$\varepsilon_t^* = \alpha_0 + \gamma\, r_{2,t-1} + \theta\, DS_t + \sum_{j=1}^{n} \beta_j RD_{j,t}^0 + \sum_{j=1}^{n} \lambda_j RH_{j,t}^0 + \mu_t \qquad (14)$$

In section 4.2 we argue that the changes to the relative order book height and depth over the pre-opening period impact the opening return. To measure the change in the relative height over the pre-opening period attributable to order submissions, we denote $\Delta SRH_{j,i}$ as the change in the relative height attributable to the price of an order submitted at position *j* in period *i*. Therefore, the cumulative change over the pre-opening will be $\Delta SRH_j = \sum_{i=1}^{T} \Delta SRH_{j,i}$.

By a similar construct, if $\Delta FRH_{j,i}$ and $\Delta BRH_{j,i}$ denotes the change in relative height in period *i* attributable to forward and backward order revision to position *j* in the order book, then the cumulative changes over the pre-opening are $\Delta FRH_j = \sum_{i=1}^{T} \Delta FRH_{j,i}$ and $\Delta BRH_j = \sum_{i=1}^{T} \Delta BRH_{j,i}$, respectively. In addition, if $\Delta CRH_{j,i}$ is the change in relative height in period *i* attributable to cancellation of an order from position *j* in the order book, then $\Delta CRH_j = \sum_{i=1}^{T} \Delta CRH_{j,i}$ is the cumulative cancellation change over the pre-opening period. The second regression is as follows;

$$\begin{aligned}\varepsilon_t^* = \alpha_0 + \gamma\, r_{2,t-1} &+ \sum_{j=1}^{n} \lambda_j^{SH} \Delta SRH_{j,t} + \sum_{j=1}^{n} \lambda_j^{FH} \Delta FRH_{j,t} + \sum_{j=1}^{n} \lambda_j^{BH} \Delta BRH_{j,t} \\ &+ \sum_{j=1}^{n} \lambda_j^{CH} \Delta CRH_{j,t} + \mu_t\end{aligned} \qquad (15)$$

For changes in relative depth, analogous to the changes in relative height, we focus on the cumulative changes over the pre-opening period attributable to submissions, revisions and cancellations. If $\Delta SRD_{j,i}$ is the change in the relative depth in period *i* due to an order submission at position *j* in the order book, then $\Delta SRD_j = \sum_{i=1}^{T} \Delta SRD_{j,i}$ is the cumulative impact

over pre-opening period. Similarly, $\Delta FRD_j = \sum_{i=1}^{T} \Delta FRD_{j,i}$, $\Delta BRD_j = \sum_{i=1}^{T} \Delta BRD_{j,i}$ and $\Delta CRD_j = \sum_{i=1}^{T} \Delta CRD_{j,i}$ are the cumulative changes in relative depth at position *j* attributable to forward and backward price revisions and cancellations at position *j* in the order book during the pre-opening. Therefore, the third regression is;

$$\begin{aligned}\varepsilon_t^* = \alpha_0 + \gamma\, r_{2,t-1} + \sum_{j=1}^{n} \beta_j^{SD} \Delta SRD_{j,t} + \sum_{j=1}^{n} \beta_j^{FD} \Delta FRD_{j,t} + \sum_{j=1}^{n} \beta_j^{BD} \Delta BRD_{j,t} \\ + \sum_{j=1}^{n} \beta_j^{CD} \Delta CRD_{j,t} + \mu_t\end{aligned} \tag{16}$$

Section 4.3 proposes that the relative depth and height and locking or crossing of the inside spread in the opening limit order book impacts the opening return. The relative height and depth at the end of the pre-opening will be measured in the same way as equations (12) and (13) respectively. To capture the impact of locking or crossing of the inside spread by the buy or sell side, we define four dummy variables DL^B, DC^B, DL^S and DC^S The variable DL^B and DC^B takes the value of one if the spread is locked or crossed initially during the pre-opening by an incoming buy order, respectively and DL^S and DC^S takes the value of one if the spread is initially locked or crossed by an incoming sell order, repectively. The fourth regression is therefore;

$$\begin{aligned}\varepsilon_t^* = \alpha_0 + \gamma\, r_{2,t-1} + \sigma_1\, DL_t^B + \sigma_2\, DC_t^B + \sigma_3\, DL_t^S + \sigma_4\, DC_t^S + \sum_{j=1}^{n} \beta_j RD_{j,t}^T \\ + \sum_{j=1}^{n} \lambda_j RH_{j,t}^T + \mu_t\end{aligned} \tag{17}$$

To assess the additional information contained in the order book as we move from the top to step five along the order book, we run separate regressions for *j* = 0 to *j* = 5 and report the average increase in the adjusted R^2 for the four regressions outlined above. In essence, we estimate each regression without the relative height and depth measures then recursively add these measures from steps one to five and collect the changes in the R^2. Table 5 provides a description of all the explanatory variables used in this empirical analysis.

4.5 Empirical Results

In sections 4.1 to 4.3 we argue that the relative height and depth of the overnight and opening order book and the evolution of the order book over the pre-opening period impacts the innovations in opening returns. To empirically assess this claim, we estimate equations (14), (15), (16) and (17), which regresses relative height and depth related measures at steps one to five along the order book onto opening return innovations. The opening return innovations are collected from estimating opening return AR(P) models, where the lag length is determined by maximising the AIC statistic. For robustness, we re-estimate all regressions using the actual opening returns as the dependent variable and report t-statistics based on Newey-West heteroskedasticity and autocorrelation consistent standard errors. The qualitative results are similar using either opening return innovations or opening returns.

4.5.1 Overnight Order Book and Opening Return

Tables 6 and 7 report the results for the impact of the overnight order book on opening return innovations and actual opening returns, respectively. Table 8 provides a summary of the results based on the impact on the most active (A) and least active (B) stocks separately. From panel A of table 8, it is evident that there is a strong negative relationship between the opening return innovations (ε_t^*) and the previous open-to-close return ($r_{2,t-1}$). We find that two of the three A stocks and all three B stocks have a negative and significant coefficient associated with the open-to-close return lagged on period. We find the dummy variable capturing weekend or extended market closure is not significant for either type of stock. This indicates that informational content of the overnight order book about subsequent opening returns is not affected by extended closure of the market.

Table 8 also reveals that the relative depth at the top of the order book ($RD_{1,t}^0$) positively impacts the opening returns for the A stocks but has no effect of the B stocks. This provides evidence supporting hypothesis *1a* which claims that large relative buy depth in the overnight order book resulting from large unexecuted buy order from the previous trading session, results in upward pressure on prices during the pre-opening. We find that the relative height $\left(RH_{j,t}^0\right)$ of the

overnight order book at positions j = 1, 2, 5 positively impacts the opening returns for two of the three A stocks and the relative height at j = 1 negatively impact the opening return of two B stocks. At position j = 1 the relative height is the relative spread. Therefore, large spread in the overnight order book positively impacts opening return for A stocks and negatively impacts opening return for B stocks. In essence, a large spread in the overnight order book is reduced in general by incoming (or forward revised) buy orders. This leads to an upward pressure on the opening price for the A stocks. Contrarily, when the spread is larger in the overnight order book for the B stocks, the spread is reduced by lower price of incoming sell (or forward revised) order, which results in a downward pressure on prices.

In addition, the results for the relative height for j = 2, 5 for the A stocks provides support for hypothesis *1b* since smaller relative buy sides height, which increase the relative height measure, positively impacts opening return and smaller sell side relative height, which reduces the relative height measure, negatively impacts opening returns. This suggest that demand and supply pressure present in the overnight order book from unexecuted orders in the previous trading session results in upward and downward pressure on opening prices respectively. These finding are consistent with the finding of Cao et al. (2009) for short run price change during the opening trading session.

Panel B in table 8 reports the change in the adjusted R^2 when adding the order book relative height and depth at different positions in the order book. This reveals the level of information contained in the overnight order book from the top to step five in the order book. From the based model without any relative height or depth variable included, the adjusted R^2 increase from 1.05% to 3.16% for the A stocks and from 5.62% to 6.11% for the B stocks when we incorporate relative height at step one into the regression. However, by adding steps two to five for both A and B stocks, we find only marginal increases in the adjusted R^2. This indicates that the information at the top of the opening order book is the most informative about opening returns. In addition, we arrive at almost identical conclusions if the realised opening return is used as the dependent variable in the regression instead of opening return innovations.

4.5.2 Pre-opening Order Book Evolution and Opening Return

Tables 9 and 10 report the finding for the impact of cumulative changes in relative depth during the pre-opening on opening return innovations and realised opening returns, respectively. While tables 12 and 13 report the findings of cumulative changes in relative height during the pre-opening on opening return innovations and realised opening returns respectively. Table 11 summarises the findings in tables 9 and 10, while table 14 summarises tables 12 and 13, by categorising the results for the A and B stocks. Table 15 reports the model fit statistics for the changes in the order book relative depth and height, equations (15) and (16). Table 16 reports the average adjusted R^2 and changes in the average adjusted R^2 for A and B stocks when the relative depth and height at steps one to five are incorporated into the regression.

Evident from the results in table 11, is that cumulative changes in relative depth during the pre-opening period impacts opening returns of the B stocks to a greater extent compared with the A stocks. Specifically, we find that an increase relative depth attributable to order submissions $\left(\Delta SRD_{j,t}\right)$ at the top of the order book (step j = 1) positively impacts opening return for two of the B stocks, and only one A stock. This result is consistent with the prediction of hypothesis *2a* which proposes that increases in relative buy (sell) depth during the pre-opening positively (negatively) impacts opening return. However, for the less active B stocks there is a strong negative relationship between opening return and cumulative increases in depth below the top of the order book attributable to order submissions. This finding is contradictory to the implications of hypothesis *2a*. In essence, this result suggests that when the depth below the top of the buy order book increases relative to the sell side, it may indicate a consensus that the current valuation for the asset is too high. As a result, sell side traders will have to be more aggressive in their price to attract a desired level of liquidity which, therefore, places a downward pressure on prices.

We find that cumulative increases in relative depth at the top of the order book attributable to forward price revisions $\left(\Delta FRD_{1,t}\right)$ positively impacts opening returns, consistent with hypothesis *2c*. The results indicates a positive and significant coefficient for three of the A stocks and two of the B stocks. Hence, when orders are revised towards the top of the buy (sell) order book, this results in an increase (decrease) in the relative depth measure. The increase (decrease) in relative

depth translates into an increase in buy (sell) side pressure and, as a consequence, has a positive (negative) impact on prices during the pre-opening. However, as we move away from the top of the order book we only find a weak positive effect for both types of stocks.

The results indicate that cumulative changes in the relative depth attributable to backward price revisions $\left(\Delta BRD_{j,t}\right)$ and order cancellations $\left(\Delta CRD_{j,t}\right)$ have a weak impact on opening returns for both A and B stocks. However, we find that increases in the relative depth at step 2 in the order book caused by cancelled sell orders negatively impacts opening returns for two of the B stocks and the same result is observed at step 5 for the A stocks. This result is contrary to the predictions of hypothesis *2e*. In these cases, it seems traders with orders below the top of the order book withdraw their buy (sell) order when they think the price of the stock is too high (low).

From table 14 that reports the impact on opening returns for changes in relative height during the pre-opening period, we find that changes in relative height attributable to order submissions $\left(\Delta SRH_{j,t}\right)$ has a strong impact on both the A and B stocks. We find that increases in the relative height, resulting from relatively smaller height in the buy order book, from order submissions positively impact opening returns for both the A and B stocks except for the relative spread (j = 1). Hence, the reduction in height on the buy (sell) sides indicates an upward (downward) pressure on prices during the pre-opening period and confirms hypothesis *2b*.

The results reveal a similar conclusion for the impact of cumulative changes in order book height attributable to forward price revisions $\left(\Delta FRH_{j,t}\right)$ on opening returns. Specifically, between steps 2 and 5 (inclusive) an increase in the relative height due to forward price revisions positively impacts opening returns for both A and B stocks. In addition, we find that increases in the relative height at step 2 attributable to backward price revisions also positively impact opening returns. These findings confirms hypothesis *2d* that proposes that cumulative decrease in the relative buy (sell) side height attributable to price revisions positively impacts opening returns.

We find strong evidence in support of hypothesis *2f* for the B stocks and weak evidence for the A stocks. Between steps 2 and 5 (inclusive) cumulative decreases in relative buy (sell) height due

to the cancellation of a sell (buy) order, which increases the relative height measure $(\Delta CRH_{j,t})$, positively (negatively) impacts opening returns for at least two B stocks and for no more than two of the A stocks. Hence, order cancellations during the pre-opening are indicative of a reduction in either buy or sell side pressure, depending on the type of order cancelled. Its effect mostly impacts the less active B stocks in general.

From table 16 that reports the findings about the amount of order book information concerning opening returns, we find that changes in relative height along the order book have a greater impact on opening returns as compared to relative depth. In the case of changes in relative depth, we observe incremental increases in the average adjusted R^2 from 1.1% to 3.7% for the A stocks, and from 6.4% to 10.7% for the B stocks when we add steps 1 to 5 of the changes in relative depth measure to the regression. For the B stocks, we observe a significant increase in the average adjusted R^2 when we add the first step to the model (changes in relative spread) and then marginal increases as we add steps 2 to 5 to the regression. On this basis, we conclude that changes in relative depth, even away from the top of the order book, contain significant information about the direction of opening returns. The average adjusted R^2 of the full model is 3.7% and 10.8% for the A and B stocks respectively, indicating that changes in relative depth have a greater impact on the less active stocks in comparison to the most active stocks.

Table 16 also reveals that in the case of cumulative changes in relative height, there is a significant increase in the adjusted R^2 when we add steps 1 to 5 of the changes in relative height measures to the regression. For the A stocks, adding steps 1 to 5 of the changes in the relative height measures to the regression increase the adjusted R^2 from 1.1% to 15.7% with the largest change occurring when step 2 is added to the regression. Similarly, by adding steps 1 to 5 of the changes in the relative height measures to the regression for the B stocks, we again observe a significant increase in the adjusted R^2 from 6.4% to 26.5%, with the largest marginal increase when step 2 is added to the regression. Hence, we conclude that cumulative changes in the relative height along the order book from steps 1 to 5 during the pre-opening contain significant information about the direction of opening returns.

Overall, we find that during the pre-opening period cumulative changes in relative height contain significantly more information about the opening returns compared to the cumulative changes in

the relative depth of the order book. In addition, we find that a greater amount of variation in opening returns is captured by cumulative changes in relative depth and height for the less active B stocks compared with the most active A stocks. When opening return innovations are replaced by the actual opening returns as the dependent variable in this analysis on order book evolution, we reach almost identical conclusions as those obtained when using opening return innovations.

4.5.3 Opening Order Book and Opening Returns

Tables 17 and 18 report the results for the impact of relative depth and height of the opening order book on opening return innovations and opening returns, respectively. Tables 19 provides a summary of the results in tables 17 and 18 categorised in A and B stocks. The results reveal only partial support for hypotheses *3a* which proposes that an increase in the relative buy (sell) depth in the opening order book positively (negatively) impacts opening returns. We find that the coefficient associated with the relative depth measure $\left(RD_{j,t}^{T}\right)$ is positive and significant for at most one stock at different steps along the order book for the A stocks. The results are stronger for the B stocks as the relative depth measure at step one is positive and significant for two of the three less active stocks. This indicates that an increase in demand (supply) pressure reflected in the relative depth at the top of the order book for the less active stocks exerts upward (downward) pressure on prices.

Hypothesis *3b* proposes that demand pressure along the order book reflected in the relative height along the order book $\left(RH_{j,t}^{T}\right)$ positively impacts opening returns. These findings are opposite to our predictions. At step 2 (j = 2) we find that increases in the relative height, caused by a reduction relative buy side height or increase in sell side height, negatively impacts the opening return. Hence, a reduction in buy side height below the top of the order book indicates that the price at the top of the order book is too high and as such sell side trades have to place more aggressive prices, which in turn results in a downward pressure on prices. Additionally, we find that a reduction in the relative spread (j = 1) negatively impacts the opening return for the B stocks. Hence, this indicates that the spread is lowered by incoming sell orders during the pre-opening period. This is consistent with the conclusion for the opening order book, which

indicates that when the spread is larger in the overnight order book for the B stocks, the spread is reduced by a lower price of incoming sell orders.

We find strong evidence in support of hypothesis *3c* which proposes that the initial locking of crossing of the inside spread by an incoming buy (sell) order during the pre-opening positively (negatively) impacts the opening return. The results reveal that the coefficient for variables DL_t^B and DC_t^B which takes the value of one when the initial lock or cross is due to a buy order, are positive and significant for all the A and B stocks. In addition, we find a negative and significant relationship between the locking or crossing of the inside spread by an incoming sell order $\left(DL_t^S, DC_t^S\right)$ for all the A and B stocks. Hence, the direction of the locking or crossing of the inside spread carries significant information about the direction of opening prices for both the most active and the less active stocks.

From panel B in table 19 that reports the average adjusted R^2 and the change in the adjusted R^2 when the relative depth and height at steps 1 to 5 are recursively added to the regression model. We find that when steps 1 to 5 are incorporated in the regression, the average adjusted R^2 increases from 19.9% to 22.8% for the A stocks with the largest increase of 2.2% observed when step 2 is added to the regression. In addition, we find that for the B stocks, the average adjusted R^2 increases from 26.5% to 30.9% for the B stocks, with the highest increase of 3.25% occurring when step 2 is added to the regression model. This reveals that including the dummy variables that captures locked or crossed inside spread explains a significant proportion of variability in opening returns. In addition, it is evident that most of the opening order information about opening returns is concentrated towards the top of the order book. The conclusions remain the same when the realised opening return replaces return innovations in the regressions as the dependent variable.

5. Conclusions

In this chapter we measure the proportion of daily price discovery attributable to the pre-opening period and determine the fundamental order book factors that impact the return generated over the pre-opening period. The contribution of the pre-opening to the price discovery process is measure using the Wang and Yang (2009, 2010) extension of the Hasbrouck (1995) information

share (IS) measure that is applicable to sequentially trading period or markets. In addition, we estimate the weighted price contribution (WPC), which is commonly used in the literature to measure price discovery attributable to periods within a trading day.

To determine the factors that impact the return generated over the pre-opening period, we measure the impact of the relative depth and height of the overnight and opening order book and the changes in the relative depth and height attributable to order submissions and alterations during the pre-opening period. Specifically, we measure the relative depth and height at steps one to five in the order book at the start and at the end of the pre-opening, and the changes at each step caused by order submission, forward and backward revisions and cancellations during the pre-opening. We utilise microstructure data for the three most highly active and three relatively less active stocks from the Malta Stock Exchange over an extensive sample period covering January 2000 to June 2007.

The results from the estimation of the IS and WPC reveals that the pre-opening period contributes between approximately 30% and 35% of daily price discovery for the three most active stocks and between 32% and 38% of daily price discovery for the three least active of the six stocks respectively. This indicates that the pre-opening period provides between 2% and 3% more of daily price discovery for the less active stocks compared to the most active. In addition, we find that over the sample period, there was a marginal reduction in the contribution of the pre-opening to the daily price discovery process. We find that the IS and WPC measure provides similar results over the full sample. However, the annual estimates can be significantly different depended on the measure used, leading to different conclusions about the amount of price discovery attributable to the pre-opening period.

As it relates to the impact of the order book on the returns generated over the pre-opening period, the empirical results reveal that larger relative height at steps two and five and the relative buy depth at the top of the overnight order book positively impact the returns over the pre-opening period for the three most active stocks. This indicates that the excess demand or supply pressure in the previous trading session results in relatively larger unexecuted buy or sell order queued in the overnight order book, respectively. Therefore, this excess demand results in upward pressure on prices and excess supply results in downward pressure on prices during the pre-opening. In addition, we find that cumulative increases in relative depth below the top of the order book for

the less active stocks attributable to order submissions, throughout the pre-opening, negatively impacts opening returns. Hence cumulative increases in the relative depth below the top of the order book during the pre-opening, is suggestive of the fact that price at the top of the order book is too low.

The results indicate that changes in the relative height from step one to five in the order book during the pre-opening period attributable to order submissions and alterations has a strong impact on the opening returns. We find that increases in the relative buy side height from steps two to five attributable to order submissions, cancellations and forward and backward price revisions during the pre-opening suggests an increase in demand pressure and results in an upward pressure on prices. This indicates that the changes in the order book away from the top contain significant information about opening returns. In addition, we find that the variation in opening returns that are captured by the changes in relative depth and height are relatively larger for the less active stocks compared to the most active.

The information content of the order book just before the opening (opening order book) seems to be relatively low. The results indicate weak evidence to support a positive impact between relative depth at the top of the order book and opening return for the three less active stocks. In addition, we find that smaller height on the buy side relative to the sell side at step two of the opening order book negatively impacts opening returns. However, we find that whenever the inside spread is locked or crossed initially by an incoming buy (sell) order there is a positive (negative) impact on the opening return. Hence, locking or crossing of the inside spread contains a strong signal about the fundamental value of the asset from which traders employ to inform their order submission strategy, which is consistent with the findings of Cao et al. (2008).

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Table 1
Summary of Pre-opening Order Book Activity

Action	Type	BOV	MLC	HSB	MIA	MSI	IHI
Order Submissions	Buy	7005	8579	6789	876	887	784
	Sell	6788	6640	4169	1210	1278	1529
Forward Price Revisions	Buy	2380	3585	2109	262	449	243
	Sell	2779	2753	1574	391	729	683
Backward Price Revisions	Buy	519	1080	292	56	128	62
	Sell	668	907	357	71	95	124
Order Cancellations	Buy	1213	1980	818	196	264	154
	Sell	1569	1873	736	161	166	278

Note: This table presents a summary of the order book activity during the market pre-opening period over the period January 4, 2000 to June 27, 2007. The number of orders submitted, revised forward, revised backward or cancelled are categorised into buy and sell. Other order book activity such as volume revisions or other exchange related activities are omitted.

Table 2
Statistical Summary of Opening Return (r_1) and Open-to-Close Returns (r_2)

A Stocks	**BOV**		**MLC**		**HSB**	
	r_1	r_2	r_1	r_2	r_1	r_2
Mean	0.002	-0.002	0.001	-0.001	0.003	-0.002
Maximum	0.080	0.075	0.066	0.078	0.086	0.099
Minimum	-0.078	-0.074	-0.075	-0.092	-0.064	-0.095
Std. Dev.	0.009	0.012	0.012	0.015	0.012	0.015
Skewness	1.024	-0.345	0.451	-0.318	1.495	-0.285
Kurtosis	18.47	9.75	7.76	8.43	11.92	10.90
LB(4)	163.94	64.88	151.91	28.34	752.01	214.02
LB(8)	185.12	67.87	158.44	30.08	1156.80	359.76
LB(16)	191.18	73.06	168.84	38.55	1446.90	454.32
LB(36)	211.26	109.68	191.34	52.12	1801.90	585.05
No. Obs.	1838	1838	1842	1842	1778	1778

B Stocks	**MSI**		**MIA**		**IHI**	
	r_1	r_2	r_1	r_2	r_1	r_2
Mean	-0.001	0.001	0.000	0.001	0.001	-0.001
Maximum	0.089	0.100	0.068	0.082	0.087	0.094
Minimum	-0.087	-0.088	-0.043	-0.086	-0.089	-0.090
Std. Dev.	0.014	0.017	0.010	0.012	0.015	0.018
Skewness	-0.154	0.041	0.931	-0.514	0.664	0.002
Kurtosis	11.83	11.19	10.62	11.11	9.41	8.45
LB(4)	67.29	33.31	20.66	8.32	26.68	15.31
LB(8)	111.00	43.80	30.19	14.81	36.75	19.64
LB(16)	143.18	53.99	46.97	25.36	49.06	36.50
LB(36)	178.12	90.84	78.85	57.15	60.94	64.32
No. Obs.	1470	1470	1016	1016	1492	1492

Note: This table reports the mean, maximum, minimum, standard deviation (Std. Dev.), skewness, kurtosis, Ljung-Box test statistics (LB(·)) for lags 4 to 36 and the number of observations (No. Obs.) for opening returns (R_1) and open-to-close returns (R_2) for the six stocks utilized in the empirical analyses. Additionally, the table reports the number of order submissions (No. of Sub.) and alterations including price revisions and cancellation (No. of Alt.) during the pre-opening and trading periods.

Table 3
Information Share (IS) and Weighted Price Contribution (WPC) for the Pre-opening Period

Panel A	**BOV**					**MLC**					**HSB**				
Year	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***
2000	-0.06	26.80	50.23	-23.42	1	-0.21	37.64	33.98	3.66	1	-0.43	46.78	23.05	23.73	1
2001	-0.30	44.30	43.71	0.59	1	-0.14	37.44	45.78	-8.35	1	-0.43	56.71	32.39	24.33	7
2002	-0.36	32.28	22.46	9.81	2	-0.38	34.31	12.24	22.06	1	-0.32	33.38	17.09	16.29	1
2003	-0.05	33.52	71.93	-38.41	1	-0.27	44.67	44.53	0.14	1	-0.27	41.75	48.94	-7.19	1
2004	-0.01	32.22	29.82	2.41	1	-0.01	38.54	29.88	8.66	1	-0.32	23.12	24.03	-0.91	2
2005	-0.11	33.42	34.63	-1.20	1	-0.07	30.11	36.36	-6.26	2	-0.45	36.16	49.91	-13.74	9
2006	-0.06	22.62	15.41	7.22	1	-0.29	32.41	29.59	2.82	1	-0.53	33.40	6.13	27.26	1
2007	0.06	11.90	33.79	-21.89	3	-0.30	40.24	39.34	0.91	2	0.04	22.76	15.80	6.95	1
Full	-0.15	31.39	35.89	-4.50	1	-0.20	36.60	33.217	3.38	1	-0.43	38.14	21.63	16.51	1

Panel B	**MSI**					**MIA**					**IHI**				
Year	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***	***Corr*** (r_1,r_2)	***WPC₁*** **(%)**	***IS₁*** **(%)**	***Diff*** **(%)**	***Var Lags***
2000	-0.23	46.59	36.30	10.29	1	n/a	n/a	n/a	n/a	n/a	-0.52	42.24	12.44	29.80	4
2001	-0.26	58.21	60.78	-2.57	9	n/a	n/a	n/a	n/a	n/a	-0.23	37.44	32.44	5.00	1
2002	-0.37	32.20	17.87	14.33	7	n/a	n/a	n/a	n/a	n/a	-0.37	50.98	44.45	6.53	1
2003	-0.42	49.31	21.06	28.25	5	-0.56	30.51	26.05	4.46	1	-0.36	41.22	27.67	13.55	5
2004	-0.30	38.90	17.77	21.13	2	0.08	38.88	60.91	-22.03	5	-0.29	35.93	25.31	10.62	2
2005	-0.33	37.83	23.60	14.22	1	-0.13	34.33	64.65	-30.32	1	-0.18	40.82	35.05	5.77	1
2006	-0.41	19.41	17.55	1.86	4	-0.27	28.57	22.23	6.35	1	-0.33	45.08	36.35	8.72	1
2007	-0.48	32.46	31.43	1.03	2	-0.56	33.56	13.00	20.56	3	-0.32	25.17	16.44	8.73	1
Full	-0.34	39.47	30.29	9.18	2	-0.27	33.59	39.34	-5.75	1	-0.32	39.49	26.01	13.48	4

Note: This table reports the correlation between opening return and opening-to-close return (Corr), information share (IS), weighted price contribution (WPC), the difference between the WPC and the IS (Diff) and the number of lags included in the structural VAR in the IS calculation (Var Lags) for the Pre-opening period. Panel A reports the statistics for the full sample and subsamples based on each year in the sample for the three most active stocks. Panel B reports the statistics for the full sample and subsamples based on each year in the sample for the three less active stocks.

Table 4
Summary of Pre-opening Information Share and Weighted Price Contribution

	A Stock Averages					B Stock Averages				
Year	***Corr*** **(r_1,r_2)**	***WPC_1*** **(%)**	***IS_1*** **(%)**	***Diff*** **(%)**	***Var Lags***	***Corr*** **(r_1,r_2)**	***WPC_1*** **(%)**	***IS_1*** **(%)**	***Diff*** **(%)**	***Var Lags***
2000	-0.23	37.07	35.75	1.32	1.00	-0.38	44.41	24.37	20.05	2.50
2001	-0.29	46.15	40.63	5.52	3.00	-0.24	47.82	46.61	1.21	5.00
2002	-0.35	33.32	17.27	16.06	1.33	-0.37	41.59	31.16	10.43	4.00
2003	-0.20	39.98	55.13	-15.15	1.00	-0.45	40.34	24.92	15.42	3.67
2004	-0.11	31.30	27.91	3.39	1.33	-0.17	37.91	34.67	3.24	3.00
2005	-0.21	33.23	40.30	-7.07	4.00	-0.21	37.66	41.10	-3.44	1.00
2006	-0.29	29.48	17.04	12.43	1.00	-0.34	31.02	25.38	5.64	2.00
2007	-0.07	24.97	29.65	-4.68	2.00	-0.45	30.40	20.29	10.11	2.00
Avg.	-0.22	34.44	32.96	1.48	1.83	-0.33	38.89	31.06	7.83	2.90
Full	-0.26	35.38	30.25	5.13	1.00	-0.31	37.52	31.88	5.63	2.33

Note: This table summarizes the results presented in table 2. The averages for the correlation (corr), weighted price contribution (WPC), information share (IS), the difference between the IS and the WPC (diff) and the number of lags in the structural VAR are presented for the most active (A) stocks and for the least active (B) stocks. The average yearly value for each statistic (Avg.) is reported along with the estimates for the full sample (Full).

Table 5
Description of Explanatory Variables

Variables	Description of Variable
$r_{1,t}$	Close-to-open return.
$r_{2,t}$	Open-to-close (opening) return.
ε_t^*	Opening return innovation.
$RD_{j,t}^0$	Relative depth at position *j* in the overnight order book.
$RH_{j,t}^0$	Relative height at position *j* in the overnight order book.
$RD_{j,t}^T$	Relative depth at position *j* in the opening order book.
$RH_{j,t}^T$	Relative height at position *j* in the opening order book.
$\Delta SRD_{j,t}$	Accumulated change in the relative depth at position *j* due to order submissions.
$\Delta FRD_{j,t}$	Accumulated change in the relative depth at position *j* due to forward price revisions.
$\Delta BRD_{j,t}$	Accumulated change in the relative depth at position *j* due to backward price revisions.
$\Delta CRD_{j,t}$	Accumulated change in the relative depth at position *j* due to order cancellations.
$\Delta SRH_{j,t}$	Accumulated change in the relative height at position *j* due to order submissions.
$\Delta FRH_{j,t}$	Accumulated change in the relative height at position *j* due to forward price revisions.
$\Delta BRH_{j,t}$	Accumulated change in the relative height at position *j* due to backward price revisions.
$\Delta CRH_{j,t}$	Accumulated change in the relative height at position *j* due to order cancellations.
DL_t^B	Dummy variable taking the value of one when the inside spread is locked by an incoming buy order.
DL_t^S	Dummy variable taking the value of one when the inside spread is locked by an incoming sell order.
DC_t^B	Dummy variable taking the value of one when the inside spread is crossed by an incoming buy order.
DC_t^S	Dummy variable taking the value of one when the inside spread is crossed by an incoming sell order.
DS_t	Dummy variable taking the value of one if there is not trading for more than one day previous.

Note: This table provides a summary explanation of the explanatory variables employed in the empirical analysis.

Table 6

Impact of the Overnight Order Book on Opening Return Innovations (ε_t^*)

Panel A	**BOV**		**MLC**		**HSB**		**MSI**		**MIA**		**IHI**	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	**-0.0006**	-2.07	**-0.0013**	-3.13	0.0001	0.38	0.0002	0.46	0.0000	0.06	-0.0003	-0.49
$r_{2,t-1}$	-0.0238	-1.36	**-0.0481**	-2.71	**-0.1019**	-6.00	**-0.1531**	-7.10	**-0.1840**	-7.43	**-0.1933**	-9.25
DS_t	0.0009	1.76	-0.0003	-0.47	-0.0005	-0.81	0.0002	0.23	0.0002	0.26	0.0001	0.08
$RD_{1,t}^0$	0.0004	1.15	**0.0032**	6.48	**0.0018**	3.82	-0.0002	-0.31	0.0005	1.00	0.0002	0.34
$RD_{2,t}^0$	-0.0005	-1.35	-0.0006	-1.18	-0.0009	-1.74	-0.0010	-1.64	-0.0003	-0.44	-0.0006	-0.82
$RD_{3,t}^0$	-0.0001	-0.25	-0.0003	-0.51	0.0005	0.99	0.0006	0.93	-0.0002	-0.28	-0.0014	-1.83
$RD_{4,t}^0$	0.0004	0.97	-0.0005	-1.06	-0.0004	-0.76	-0.0005	-0.65	0.0001	0.22	-0.0005	-0.50
$RD_{5,t}^0$	**-0.0012**	-3.33	-0.0004	-0.88	-0.0007	-1.55	-0.0005	-0.91	-0.0004	-0.70	0.0007	0.84
$RH_{1,t}^0$	0.0017	0.53	**0.1798**	6.05	**-0.0091**	-5.46	**-0.0099**	-4.42	-0.0048	-1.63	**-0.0122**	-3.18
$RH_{2,t}^0$	0.0000	-0.03	**0.0017**	3.58	0.0009	1.95	0.0007	1.16	0.0000	0.00	-0.0009	-1.27
$RH_{3,t}^0$	-0.0003	-0.81	-0.0001	-0.24	0.0001	0.13	-0.0003	-0.58	-0.0008	-1.60	**0.0015**	2.44
$RH_{4,t}^0$	0.0001	0.14	0.0002	0.33	0.0004	0.90	**0.0011**	2.00	0.0002	0.32	0.0002	0.31
$RH_{5,t}^0$	0.0002	0.43	**0.0012**	2.49	**0.0008**	1.97	0.0003	0.54	0.0005	1.04	0.0003	0.55
Panel B												
Adj. R2		0.01		0.06		0.05		0.05		0.07		0.08
F-stat.		**1.89**		**10.08**		**9.09**		**7.37**		**6.95**		**11.61**
Prob.		0.03		0.00		0		0		0		0
AR Lags		3		6		8		6		2		2

Note: This table reports the regression estimates of the relative height and depth from one to five steps away from the top of the order book in determining opening return innovations. Panel A reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilised in this analysis. Panel B reports the adjusted R-square (Adj. R^2), F-statistic (F-stat.) and related probability (P-val.) for all six stocks and the number of autoregressive lags used to generate the return innovation series. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 7
Impact of the Overnight Order Book on Opening Returns ($r_{1,t}$)

Panel A	**BOV**		**MLC**		**HSB**		**MSI**		**MIA**		**IHI**	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	**0.0009**	2.28	-0.0007	-1.28	**0.0031**	5.80	-0.0007	-1.22	0.0002	0.38	0.0010	1.22
$r_{2,t-1}$	-0.0559	-1.17	**-0.0855**	-2.67	**-0.2795**	-5.36	**-0.1871**	-5.60	**-0.2139**	-3.96	**-0.2211**	-6.92
DS_t	0.0008	1.62	-0.0002	-0.38	-0.0004	-0.74	0.0002	0.29	0.0001	0.15	0.0000	0.05
$RD^0_{1,t}$	0.0004	0.86	**0.0033**	4.91	**0.0021**	3.94	-0.0005	-0.72	0.0005	0.87	0.0001	0.08
$RD^0_{2,t}$	-0.0007	-1.47	-0.0007	-1.38	-0.0010	-1.46	-0.0013	-2.05	-0.0002	-0.39	-0.0006	-0.98
$RD^0_{3,t}$	-0.0001	-0.17	-0.0003	-0.48	0.0012	2.15	0.0002	0.33	-0.0001	-0.16	-0.0012	-1.68
$RD^0_{4,t}$	0.0005	1.15	-0.0004	-0.72	-0.0001	-0.14	-0.0004	-0.60	0.0002	0.37	-0.0004	-0.40
$RD^0_{5,t}$	**-0.0011**	-2.24	-0.0002	-0.48	-0.0004	-0.60	-0.0004	-0.64	-0.0004	-0.75	0.0008	1.07
$RH^0_{1,t}$	-0.0002	-0.05	**0.2004**	3.74	**-0.0116**	-4.04	**-0.0100**	-3.20	-0.0047	-1.68	**-0.0115**	-2.50
$RH^0_{2,t}$	-0.0004	-1.01	**0.0013**	2.46	0.0012	1.31	-0.0001	-0.17	0.0000	-0.01	-0.0014	-1.77
$RH^0_{3,t}$	-0.0006	-1.24	-0.0004	-0.82	-0.0007	-1.59	-0.0010	-1.60	-0.0008	-1.36	0.0011	1.59
$RH^0_{4,t}$	0.0000	0.02	0.0001	0.26	0.0001	0.21	0.0006	0.94	0.0002	0.33	0.0002	0.35
$RH^0_{5,t}$	0.0003	0.64	**0.0011**	2.14	0.0004	0.81	0.0002	0.38	0.0006	1.20	0.0003	0.66
Panel B												
Adj. R^2		0.01		0.0668		0.17		0.07		0.08		0.10
F-stat.		**2.92**		**11.97**		**31.69**		**10.75**		**8.72**		**14.11**
P-val.		0.00		0.00		0.00		0.00		0.00		0.00

Note: This table reports the regression estimates of the relative height and depth from one to five steps away from the top of the order book in determining opening return. Panel A reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilised in this analysis. The t-statistic is calculated using the Newey-West heteroskedasticity and autocorrelation consistent standard errors. Panel B reports the adjusted R-square (Adj. R^2), F-statistic (F-stat.) and related probability (P-val.) for all six stocks. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 8
Impact of Overnight Order Book Results Summary

	Opening Return Innovations (ε_t^*)				Opening Return ($r_{1,t}$)			
Panel A.	**A Stocks**		**B Stocks**		**A Stocks**		**B Stocks**	
Variable	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***
α_0	**-0.061**	**2**	-0.002	0	**0.107**	**2**	0.017	0
$r_{2,t-1}$	**-5.793**	**2**	**-17.679**	**3**	**-14.031**	**2**	**-20.737**	**3**
DS_t	0.004	0	0.014	0	0.004	0	0.012	0
$RD^0_{1,t}$	**0.180**	**2**	0.020	0	**0.196**	**2**	0.001	0
$RD^0_{2,t}$	-0.066	0	-0.063	0	-0.080	0	-0.074	1
$RD^0_{3,t}$	0.005	0	-0.032	0	0.028	1	-0.036	0
$RD^0_{4,t}$	-0.018	0	-0.026	0	0.001	0	-0.021	0
$RD^0_{5,t}$	-0.078	1	-0.007	0	-0.057	1	0.002	0
$RH^0_{1,t}$	**5.745**	**2**	**-0.898**	**2**	**6.288**	**2**	**-0.873**	**2**
$RH^0_{2,t}$	**0.084**	**2**	-0.008	0	0.070	1	-0.049	0
$RH^0_{3,t}$	-0.012	0	0.011	1	-0.058	0	-0.023	0
$RH^0_{4,t}$	0.020	0	0.048	1	0.008	0	0.031	0
$RH^0_{5,t}$	**0.069**	**2**	0.038	0	0.059	1	0.037	0
Panel B.								
Steps (j)	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***
$j = 0$	1.059		5.619		5.010		7.475	
$j = 1$	3.158	2.099	6.110	0.491	7.910	2.900	8.103	0.628
$j = 2$	3.473	0.314	6.278	0.168	8.172	0.262	8.333	0.230
$j = 3$	3.399	-0.074	6.501	0.223	8.222	0.051	8.550	0.218
$j = 4$	3.471	0.072	6.513	0.012	8.194	-0.029	8.480	-0.070
$j = 5$	3.785	0.314	6.464	-0.048	8.365	0.171	8.437	-0.043

Note: This table reports a summary of the impact of the overnight order book on opening returns and returns innovations. The t-statistic for coefficients in the opening returns regressions are based on the Newey-West heteroskedasticity and autocorrelation consistent standard errors. The stocks are categorized into two main groups. A stocks represents the three most active stocks and B stocks represents the three least active of the six stocks studied. Panel A reports the average coefficient value (Avg. Coef.) and the number of significant coefficient at the five percent level of significance for both group of stocks. The coefficient values are scaled by a multiple of 100 for better presentation in the table. Panel B reports the findings about the information below the top of the order book. Essentially, we estimate the regression for each stock without incorporation of the relative depth or height and measure the adjusted R^2 then recursively add relative depth and height from steps 1 to 5 and measuring the change in the adjusted R^2 in the resulting regressions. The average adjusted R^2 (Avg. Adj. R^2) and the percentage change in the adjusted R^2 (Change (%)) is calculated for both A stocks and B stocks.

Table 9

Impact of the Order Book Evolution on Opening Return Innovations (ε_t^*)

	BOV		MLC		HSB		MSI		MIA		IHI	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	0.0000	0.20	-0.0001	-0.21	-0.0004	-1.42	0.0004	1.02	0.0006	1.12	**-0.0012**	-2.21
$r_{2,t-1}$	-0.0208	-1.17	**-0.0584**	-3.22	**-0.1016**	-5.63	**-0.1926**	-6.27	**-0.1718**	-5.74	**-0.2823**	-9.99
$\Delta SRD_{1,t}$	0.0007	1.84	**0.0021**	4.27	**0.0013**	2.81	**0.0020**	2.80	**0.0031**	3.04	0.0002	0.19
$\Delta SRD_{2,t}$	0.0005	1.32	**0.0011**	2.28	**-0.0013**	-2.65	-0.0004	-0.44	**-0.0025**	-2.28	**-0.0023**	-2.25
$\Delta SRD_{3,t}$	-0.0005	-1.37	0.0008	1.65	-0.0007	-1.54	**-0.0024**	-2.76	**-0.0039**	-3.85	**-0.0036**	-3.17
$\Delta SRD_{4,t}$	-0.0005	-1.33	0.0002	0.50	**-0.0024**	-5.22	**-0.0021**	-2.51	**-0.0028**	-2.63	**-0.0047**	-4.01
$\Delta SRD_{5,t}$	-0.0005	-1.43	0.0000	-0.05	**-0.0017**	-3.29	-0.0004	-0.50	-0.0016	-1.47	**-0.0041**	-2.80
$\Delta FRD_{1,t}$	**0.0011**	2.01	**0.0025**	3.60	**0.0018**	2.73	**0.0044**	3.36	0.0032	1.86	**0.0068**	3.87
$\Delta FRD_{2,t}$	0.0006	1.08	**0.0021**	3.11	-0.0011	-1.55	**0.0054**	4.04	0.0001	0.03	0.0011	0.62
$\Delta FRD_{3,t}$	**0.0013**	2.26	0.0006	0.82	-0.0001	-0.19	**0.0041**	2.70	-0.0008	-0.38	0.0000	0.02
$\Delta FRD_{4,t}$	0.0006	1.09	0.0012	1.63	-0.0013	-1.57	0.0012	0.74	0.0012	0.56	0.0000	0.00
$\Delta FRD_{5,t}$	0.0001	0.11	**-0.0020**	-2.98	-0.0001	-0.13	0.0017	1.05	-0.0008	-0.35	**0.0075**	2.97
$\Delta BRD_{1,t}$	0.0016	1.42	-0.0002	-0.21	0.0030	1.86	0.0005	0.12	**0.0113**	2.81	0.0017	0.29
$\Delta BRD_{2,t}$	0.0005	0.58	-0.0004	-0.36	0.0011	0.67	0.0019	0.51	-0.0011	-0.24	0.0051	1.12
$\Delta BRD_{3,t}$	-0.0011	-1.19	**0.0025**	2.38	-0.0009	-0.60	0.0028	0.62	**-0.0078**	-2.50	0.0033	0.74
$\Delta BRD_{4,t}$	0.0007	0.76	0.0017	1.64	-0.0007	-0.46	-0.0010	-0.24	-0.0032	-0.66	0.0039	0.67
$\Delta BRD_{5,t}$	**-0.0026**	-2.81	-0.0003	-0.33	0.0017	1.18	0.0007	0.21	0.0022	0.55	-0.0023	-0.35
$\Delta CRD_{1,t}$	-0.0010	-1.08	0.0019	1.70	0.0009	0.84	0.0004	0.19	-0.0009	-0.34	**0.0060**	2.36
$\Delta CRD_{2,t}$	0.0003	0.31	0.0017	1.57	**-0.0037**	-3.74	**-0.0060**	-2.61	**-0.0100**	-3.78	-0.0028	-0.94
$\Delta CRD_{3,t}$	0.0002	0.26	-0.0013	-1.29	**-0.0023**	-2.42	-0.0027	-1.18	**-0.0073**	-2.68	-0.0004	-0.15
$\Delta CRD_{4,t}$	-0.0001	-0.16	-0.0012	-1.27	**-0.0022**	-2.38	-0.0013	-0.67	**-0.0063**	-2.30	-0.0057	-1.91
$\Delta CRD_{5,t}$	**-0.0017**	-2.35	0.0002	0.19	**-0.0022**	-2.39	-0.0005	-0.27	**-0.0086**	-3.39	-0.0047	-1.46

Note: This table reports the regression estimates of the changes in the relative depth attributable to submission, revisions and cancelations from one to five steps away from the top of the order book in determining opening return innovations. The table reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilized in this analysis. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 10
Impact of the Order Book Evolution on Opening Returns ($r_{1,t}$)

	BOV		MLC		HSB		MSI		MIA		IHI	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	**0.0016**	5.47	**0.0008**	2.18	**0.0020**	5.24	-0.0007	-1.06	0.0005	1.23	0.0008	1.33
$r_{2,t-1}$	-0.0558	-1.15	**-0.0994**	-3.04	**-0.2942**	-5.54	**-0.2521**	-5.38	**-0.2235**	-4.27	**-0.3345**	-7.58
$\Delta SRD_{1,t}$	0.0007	1.28	**0.0022**	4.17	**0.0019**	3.07	**0.0033**	2.25	**0.0019**	2.09	0.0002	0.18
$\Delta SRD_{2,t}$	0.0005	0.95	**0.0012**	2.10	-0.0010	-1.66	-0.0022	-1.68	-0.0003	-0.35	-0.0021	-1.50
$\Delta SRD_{3,t}$	-0.0003	-0.64	0.0012	1.92	-0.0005	-0.75	**-0.0040**	-2.56	**-0.0022**	-2.02	**-0.0034**	-2.50
$\Delta SRD_{4,t}$	-0.0005	-0.93	0.0007	1.17	**-0.0021**	-3.51	**-0.0031**	-2.44	**-0.0022**	-2.34	**-0.0049**	-3.76
$\Delta SRD_{5,t}$	-0.0007	-1.56	0.0002	0.45	**-0.0018**	-2.89	-0.0013	-0.95	-0.0004	-0.45	**-0.0037**	-2.19
$\Delta FRD_{1,t}$	0.0011	1.95	**0.0027**	3.23	**0.0029**	3.11	0.0026	1.46	**0.0042**	3.42	**0.0066**	3.28
$\Delta FRD_{2,t}$	0.0004	0.70	**0.0023**	2.88	-0.0006	-0.64	0.0003	0.13	**0.0056**	4.17	0.0018	1.06
$\Delta FRD_{3,t}$	0.0011	1.31	0.0009	0.98	0.0006	0.57	-0.0011	-0.33	**0.0042**	3.52	0.0000	0.03
$\Delta FRD_{4,t}$	0.0005	0.67	**0.0016**	1.97	-0.0008	-0.78	0.0009	0.38	0.0014	1.01	-0.0001	-0.04
$\Delta FRD_{5,t}$	-0.0001	-0.11	**-0.0020**	-2.16	0.0002	0.30	-0.0013	-0.48	0.0019	1.49	**0.0074**	2.56
$\Delta BRD_{1,t}$	0.0010	0.62	-0.0006	-0.27	0.0013	0.63	**0.0091**	2.19	0.0002	0.06	0.0008	0.16
$\Delta BRD_{2,t}$	0.0005	0.39	-0.0003	-0.19	**0.0047**	2.10	-0.0046	-0.72	0.0023	0.49	0.0049	1.55
$\Delta BRD_{3,t}$	-0.0004	-0.26	**0.0028**	2.13	-0.0003	-0.14	**-0.0098**	-2.51	0.0026	0.64	0.0037	0.77
$\Delta BRD_{4,t}$	0.0009	0.51	0.0019	1.19	-0.0007	-0.29	-0.0059	-1.12	-0.0013	-0.39	0.0033	0.68
$\Delta BRD_{5,t}$	-0.0028	-1.29	-0.0004	-0.24	0.0017	0.72	0.0022	0.72	0.0006	0.23	-0.0028	-0.45
$\Delta CRD_{1,t}$	-0.0017	-1.39	0.0020	1.75	-0.0008	-0.52	-0.0019	-0.71	0.0000	-0.01	0.0052	1.92
$\Delta CRD_{2,t}$	0.0000	0.01	**0.0025**	1.97	**-0.0041**	-2.88	**-0.0111**	-3.29	**-0.0062**	-2.66	-0.0035	-1.14
$\Delta CRD_{3,t}$	0.0002	0.14	-0.0009	-0.69	**-0.0031**	-2.06	**-0.0095**	-2.93	-0.0029	-1.43	-0.0010	-0.34
$\Delta CRD_{4,t}$	-0.0002	-0.24	-0.0008	-0.61	**-0.0029**	-2.23	**-0.0070**	-2.74	-0.0020	-0.99	-0.0051	-1.77
$\Delta CRD_{5,t}$	-0.0020	-1.68	0.0004	0.42	**-0.0039**	-2.62	**-0.0078**	-3.78	-0.0010	-0.47	-0.0038	-1.11

Note: This table reports the regression estimates of the changes in relative depth attributable to submissions, revisions and cancellations from one to five steps away from the top of the order book in determining opening return. The table reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilized in this analysis. The t-statistic is calculated using the Newey-West heteroskedasticity and autocorrelation consistent standard errors. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 11
Impact of Order Book Evolution Results Summary

	Opening Return Innovations (ε_t^*)				Opening Return ($r_{1,t}$)			
	A Stocks		B Stocks		A Stocks		B Stocks	
Variable	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***
α_0	-0.014	0	-0.007	1	0.148	3	0.021	0
$r_{2,t-1}$	**-6.028**	**2**	**-21.558**	**3**	**-14.983**	**2**	**-27.003**	**3**
$\Delta SRD_{1,t}$	0.133	1	**0.177**	**2**	**0.161**	**2**	**0.182**	**2**
$\Delta SRD_{2,t}$	0.013	1	**-0.171**	**2**	0.026	1	-0.154	0
$\Delta SRD_{3,t}$	-0.014	0	**-0.327**	**3**	0.011	0	**-0.318**	**3**
$\Delta SRD_{4,t}$	-0.089	1	**-0.322**	**3**	-0.062	1	**-0.338**	**3**
$\Delta SRD_{5,t}$	-0.074	1	-0.203	1	-0.076	1	-0.178	1
$\Delta FRD_{1,t}$	**0.181**	**3**	**0.479**	**2**	**0.222**	**3**	**0.445**	**2**
$\Delta FRD_{2,t}$	0.053	1	0.218	1	0.068	1	0.255	1
$\Delta FRD_{3,t}$	0.056	1	0.111	1	0.085	0	0.103	1
$\Delta FRD_{4,t}$	0.017	0	0.079	0	0.045	1	0.074	0
$\Delta FRD_{5,t}$	-0.067	1	0.282	1	-0.062	1	0.270	1
$\Delta BRD_{1,t}$	0.144	0	0.450	1	0.056	0	0.337	1
$\Delta BRD_{2,t}$	0.039	0	0.196	0	0.164	1	0.087	0
$\Delta BRD_{3,t}$	0.013	1	-0.059	1	0.070	1	-0.115	1
$\Delta BRD_{4,t}$	0.057	0	-0.011	0	0.070	0	-0.128	0
$\Delta BRD_{5,t}$	-0.041	1	0.018	0	-0.050	0	-0.001	0
$\Delta CRD_{1,t}$	0.060	0	0.182	1	-0.017	0	0.109	0
$\Delta CRD_{2,t}$	-0.058	1	**-0.626**	**2**	**-0.055**	**2**	**-0.694**	**2**
$\Delta CRD_{3,t}$	-0.112	1	-0.347	1	-0.127	1	-0.446	1
$\Delta CRD_{4,t}$	-0.117	1	-0.443	1	-0.131	1	-0.470	1
$\Delta CRD_{5,t}$	**-0.124**	**2**	-0.461	1	-0.185	1	-0.420	1

Note: This table reports a summary of the impact of changes in the order book height and depth during the pre-opening (order book evolution) on opening returns and returns innovations. The stocks are categorized into two main groups. A stocks represents the three most active stocks and B stocks represents the three least active of the six stocks studied. The table reports the average coefficient value (Avg. Coef.) and the number of significant coefficient at the five percent level of significance for both group of stocks. The coefficient values are scaled by a multiple of 100 for better presentation in the table.

Table 12

Impact of the Order Book Height Evolution on Opening Return Innovations (ε_t^*)

	BOV		MLC		HSB		MSI		MIA		IHI	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	-0.0002	-0.95	**-0.0014**	-4.00	-0.0001	-0.31	**0.0019**	3.47	0.0005	1.26	-0.0008	-1.51
$r_{2,t-1}$	-0.0217	-1.27	**-0.0474**	-2.96	**-0.1019**	-5.85	**-0.1314**	-4.67	**-0.1478**	-5.12	**-0.1838**	-7.31
$\Delta SRH_{1,t}$	0.0016	0.44	**0.2593**	8.51	**-0.0185**	-9.01	**-0.0284**	-7.97	**-0.0310**	-6.52	**-0.0446**	-9.28
$\Delta SRH_{2,t}$	**0.0035**	9.49	**0.0074**	17.19	**0.0035**	7.10	**0.0086**	8.57	**0.0079**	9.85	**0.0140**	12.84
$\Delta SRH_{3,t}$	0.0005	1.40	**0.0019**	4.63	**0.0018**	4.09	**0.0054**	5.81	**0.0027**	3.71	**0.0119**	14.88
$\Delta SRH_{4,t}$	**0.0007**	2.08	**0.0012**	2.86	**0.0009**	2.27	**0.0057**	7.23	**0.0028**	4.57	**0.0064**	9.09
$\Delta SRH_{5,t}$	**0.0011**	3.42	**0.0010**	2.50	**0.0025**	6.59	**0.0021**	2.67	**0.0020**	3.22	**0.0057**	8.93
$\Delta FRH_{1,t}$	0.0464	0.91	-0.0055	-0.12	**-0.0349**	-3.28	**-0.4361**	-6.13	-0.0690	-0.81	0.0357	0.58
$\Delta FRH_{2,t}$	**0.0051**	10.44	**0.0086**	14.73	**0.0059**	8.01	**0.0110**	6.94	**0.0076**	6.39	**0.0158**	10.03
$\Delta FRH_{3,t}$	**0.0023**	4.26	**0.0016**	2.59	**0.0018**	2.29	0.0032	1.84	0.0016	1.09	**0.0090**	5.70
$\Delta FRH_{4,t}$	**0.0016**	2.93	**0.0016**	2.45	**0.0025**	3.15	**0.0041**	2.20	-0.0013	-0.92	**0.0071**	4.23
$\Delta FRH_{5,t}$	0.0005	0.90	0.0006	0.97	**0.0026**	3.06	0.0022	1.30	-0.0005	-0.34	**0.0033**	2.44
$\Delta BRH_{1,t}$	0.0621	1.18	**0.2559**	5.18	**-0.2121**	-2.51	**0.5071**	3.40	-0.2990	-1.50	-0.1230	-1.11
$\Delta BRH_{2,t}$	**0.0042**	5.04	**0.0095**	11.59	**0.0033**	2.54	**0.0052**	2.31	**0.0083**	2.97	**0.0105**	3.02
$\Delta BRH_{3,t}$	0.0008	0.93	**0.0044**	4.39	-0.0008	-0.60	0.0049	1.76	-0.0010	-0.38	0.0022	0.63
$\Delta BRH_{4,t}$	0.0010	1.10	**0.0029**	2.87	0.0025	1.77	0.0037	1.22	0.0006	0.14	0.0072	1.95
$\Delta BRH_{5,t}$	**-0.0027**	-3.11	0.0003	0.30	0.0016	1.23	0.0042	1.22	-0.0001	-0.04	-0.0015	-0.35
$\Delta CRH_{1,t}$	0.0119	1.84	**0.2455**	4.03	-0.0076	-1.56	**-0.0336**	-3.20	**-0.0443**	-3.64	**-0.0521**	-6.09
$\Delta CRH_{2,t}$	0.0004	0.51	**0.0046**	4.74	-0.0008	-0.82	**0.0082**	3.03	0.0011	0.46	**0.0087**	3.28
$\Delta CRH_{3,t}$	0.0002	0.30	0.0011	1.20	0.0017	1.93	**0.0075**	3.68	0.0019	1.00	**0.0109**	5.03
$\Delta CRH_{4,t}$	**0.0017**	2.23	0.0007	0.86	0.0015	1.84	**0.0071**	3.90	**-0.0044**	-2.32	**0.0040**	2.58
$\Delta CRH_{5,t}$	-0.0002	-0.24	**0.0024**	3.07	**0.0020**	2.71	**0.0041**	2.34	**-0.0041**	-2.33	**0.0043**	3.95

Note: This table reports the regression estimates of the changes in the relative height attributable to submission, revisions and cancelations from one to five steps away from the top of the order book in determining opening return innovations. The table reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilised in this analysis. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 13
Impact of the Order Book Height Evolution on Opening Returns ($r_{1,t}$)

	BOV		MLC		HSB		MSI		MIA		IHI	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	0.0015	**4.35**	-0.0006	-1.24	**0.0025**	6.89	0.0008	1.47	0.0006	1.38	0.0012	2.11
$r_{2,t-1}$	-0.0580	-1.31	**-0.0873**	-3.17	**-0.2952**	-5.77	**-0.2115**	-4.63	**-0.1781**	-3.35	**-0.2350**	-6.30
$\Delta SRH_{1,t}$	-0.0008	-0.12	**0.2675**	4.12	**-0.0262**	-7.75	**-0.0325**	-5.50	**-0.0304**	-3.92	**-0.0459**	-6.20
$\Delta SRH_{2,t}$	**0.0034**	7.78	**0.0076**	13.09	**0.0042**	5.41	**0.0087**	7.39	**0.0079**	8.89	**0.0140**	9.95
$\Delta SRH_{3,t}$	0.0003	0.63	**0.0021**	4.10	**0.0019**	2.65	**0.0053**	3.83	**0.0028**	3.16	**0.0118**	9.52
$\Delta SRH_{4,t}$	0.0009	1.57	**0.0013**	2.98	0.0005	1.02	**0.0059**	4.61	**0.0029**	2.34	**0.0064**	6.66
$\Delta SRH_{5,t}$	**0.0014**	2.95	0.0009	1.83	**0.0021**	3.51	**0.0024**	2.53	**0.0020**	1.99	**0.0059**	6.27
$\Delta FRH_{1,t}$	-0.0245	-0.18	-0.0021	-0.02	-0.0318	-1.28	**-0.4565**	-3.08	-0.0669	-0.56	0.0389	0.30
$\Delta FRH_{2,t}$	**0.0051**	6.13	**0.0088**	11.38	**0.0071**	7.66	**0.0108**	5.75	**0.0076**	6.96	**0.0158**	8.81
$\Delta FRH_{3,t}$	**0.0023**	2.96	**0.0018**	2.16	**0.0019**	2.27	**0.0036**	2.48	0.0016	1.28	**0.0092**	4.80
$\Delta FRH_{4,t}$	**0.0017**	2.16	0.0016	1.60	**0.0029**	2.91	**0.0047**	2.05	-0.0012	-0.94	**0.0074**	4.56
$\Delta FRH_{5,t}$	0.0005	0.75	0.0005	0.52	**0.0024**	2.24	0.0023	1.22	-0.0002	-0.13	0.0033	1.40
$\Delta BRH_{1,t}$	0.0075	0.07	**0.2532**	2.79	-0.1236	-0.57	**0.5325**	2.18	-0.3142	-1.38	-0.1023	-1.02
$\Delta BRH_{2,t}$	**0.0040**	2.56	**0.0099**	6.58	**0.0045**	2.49	0.0045	1.76	**0.0088**	2.82	**0.0119**	3.53
$\Delta BRH_{3,t}$	0.0005	0.33	**0.0040**	2.94	0.0005	0.25	0.0056	1.54	-0.0020	-0.59	0.0027	1.29
$\Delta BRH_{4,t}$	0.0008	0.44	**0.0032**	2.12	0.0042	1.49	0.0052	1.49	-0.0001	-0.02	**0.0083**	3.24
$\Delta BRH_{5,t}$	-0.0032	-1.59	0.0002	0.13	0.0034	1.67	0.0049	1.10	0.0002	0.08	-0.0009	-0.25
$\Delta CRH_{1,t}$	0.0136	1.65	**0.2409**	2.29	-0.0030	-0.32	**-0.0324**	-3.41	**-0.0409**	-4.83	**-0.0491**	-4.90
$\Delta CRH_{2,t}$	0.0003	0.24	**0.0039**	3.26	-0.0015	-1.09	**0.0077**	2.72	0.0005	0.16	**0.0087**	3.05
$\Delta CRH_{3,t}$	0.0000	-0.03	0.0007	0.73	0.0000	-0.02	**0.0074**	2.42	0.0015	0.64	**0.0107**	3.09
$\Delta CRH_{4,t}$	0.0017	1.61	0.0003	0.35	0.0005	0.34	**0.0081**	3.57	-0.0047	-1.90	**0.0042**	2.69
$\Delta CRH_{5,t}$	-0.0001	-0.10	**0.0019**	2.10	0.0007	0.56	**0.0049**	2.93	-0.0041	-1.94	**0.0047**	3.73

Note: This table reports the regression estimates of the changes in relative height attributable to submissions, revisions and cancellations from one to five steps away from the top of the order book in determining opening return. The table reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilised in this analysis. The t-statistic is calculated using the Newey-West heteroskedasticity and autocorrelation consistent standard errors. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 14
Impact of Overnight Order Book Results Summary

	Opening Return Innovations (ε_t^*)				Opening Return ($r_{1,t}$)			
	A Stocks		B Stocks		A Stocks		B Stocks	
Variable	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***
α_0	-0.056	1	0.055	1	0.112	2	0.087	1
$r_{2,t-1}$	**-5.699**	**2**	**-15.435**	**3**	**-14.683**	**2**	**-20.821**	**3**
$\Delta SRH_{1,t}$	8.082	1	**-3.466**	**3**	**8.019**	**2**	**-3.625**	**3**
$\Delta SRH_{2,t}$	**0.479**	**3**	**1.016**	**3**	**0.505**	**3**	**1.023**	**3**
$\Delta SRH_{3,t}$	**0.140**	**2**	**0.667**	**3**	**0.144**	**2**	**0.662**	**3**
$\Delta SRH_{4,t}$	**0.095**	**3**	**0.498**	**3**	0.091	1	**0.507**	**3**
$\Delta SRH_{5,t}$	**0.154**	**3**	**0.327**	**3**	**0.144**	**2**	**0.345**	**3**
$\Delta FRH_{1,t}$	0.201	1	-15.645	1	-1.947	0	-16.151	1
$\Delta FRH_{2,t}$	**0.650**	**3**	**1.144**	**3**	**0.699**	**3**	**1.139**	**3**
$\Delta FRH_{3,t}$	**0.190**	**3**	0.459	1	**0.198**	**3**	**0.481**	**2**
$\Delta FRH_{4,t}$	**0.192**	**3**	**0.332**	**2**	**0.208**	**2**	**0.365**	**2**
$\Delta FRH_{5,t}$	0.122	1	0.168	1	0.113	1	0.181	0
$\Delta BRH_{1,t}$	**3.531**	**2**	2.838	1	4.568	1	3.867	1
$\Delta BRH_{2,t}$	**0.568**	**3**	**0.798**	**3**	**0.611**	**3**	**0.838**	**2**
$\Delta BRH_{3,t}$	0.147	1	0.201	0	0.164	1	0.210	0
$\Delta BRH_{4,t}$	0.214	1	0.384	0	0.273	1	0.449	1
$\Delta BRH_{5,t}$	-0.027	1	0.088	0	0.012	0	0.138	0
$\Delta CRH_{1,t}$	8.331	1	**-4.331**	**3**	8.386	1	**-4.081**	**3**
$\Delta CRH_{2,t}$	0.141	1	**0.603**	**2**	0.089	1	**0.563**	**2**
$\Delta CRH_{3,t}$	0.099	0	**0.677**	**2**	0.022	0	**0.655**	**2**
$\Delta CRH_{4,t}$	0.133	1	**0.224**	**3**	0.083	0	**0.252**	**2**
$\Delta CRH_{5,t}$	**0.140**	**2**	**0.142**	**3**	0.085	1	**0.182**	**2**

Note: This table reports a summary of the impact of changes in the order book height during the pre-opening (order book evolution) on opening returns and returns innovations. The stocks are categorized into two main groups. A stocks represents the three most active stocks and B stocks represents the three least active of the six stocks studied. The table reports the average coefficient value (Avg. Coef.) and the number of significant coefficient at the five percent level of significance for both group of stocks. The coefficient values are scaled by a multiple of 100 for better presentation in the table.

Table 15
Model Fit Statistics for Order Book Evolution Regressions

Panel A. Relative Depth Evolution

	BOV		MLC		HSB	
	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$
Adj. R^2	1.58	1.99	3.68	5.29	5.78	18.45
F-stat.	2.34	2.7	4.24	5.74	5.74	18.49
P-val.	0	0	0	0	0	0
AR Lags	3	-	6	-	8	-

	MSI		MIA		IHI	
	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$
Adj. R^2	8.64	12.5	9.95	11.45	13.65	16.52
F-stat.	5.38	7.59	4.99	5.67	8.81	10.77
P-val.	0	0	0	0	0	0
AR Lags	6	-	2	-	2	-

Panel B. Relative Height Evolution

	BOV		MLC		HSB	
	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$
Adj. R^2	9.54	9.52	24.58	25.66	13.03	25.76
F-stat.	9.79	9.76	28.69	30.33	12.58	27.81
P-val.	0	0	0	0	0	0
AR Lags	3		6		8	

	MSI		MIA		IHI	
	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$	(ε_t^*)	$(r_{1,t})$
Adj. R^2	21.5	26.1	23.7	25.47	34.47	37.28
F-stat.	13.7	17.3	12.21	13.33	26.98	30.35
P-val.	0	0	0	0	0	0
AR Lags	6		2		2	

Note: This table reports the model fit statistics for the impact of order book height and depth evolution during the pre-opening on opening return and return innovations. The statistics include the adjusted R^2 (Adj. R^2), the F-statistic (F-stat.) and its associated probability value (P-val.) and the number of lags included in the autoregressive model (AR Lags) used to capture the return innovations. The adjusted R^2 is reported in percentages.

Table 16
Order Book Evolution Information

	Opening Return Innovations (ε_t^*)				Opening Returns ($r_{1,t}$)			
Relative Depth	**A Stocks**		**B Stocks**		**A Stocks**		**B Stocks**	
Steps (j)	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***
$j = 0$	1.120		6.411		5.484		9.270	
$j = 1$	1.826	0.706	7.993	1.583	6.518	1.035	10.677	1.408
$j = 2$	2.249	0.423	8.693	0.700	7.067	0.549	11.397	0.719
$j = 3$	2.429	0.180	9.475	0.782	7.240	0.172	12.210	0.813
$j = 4$	3.154	0.725	10.117	0.642	7.835	0.595	12.985	0.775
$j = 5$	3.703	0.549	10.747	0.630	8.578	0.743	13.471	0.486
Relative Height								
Steps (j)	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***
$j = 0$	1.120		6.411		5.484		9.270	
$j = 1$	3.609	2.489	9.662	3.252	8.519	3.035	12.727	3.457
$j = 2$	13.148	9.538	16.616	6.954	18.074	9.555	19.627	6.900
$j = 3$	13.825	0.678	20.441	3.825	18.695	0.621	23.232	3.605
$j = 4$	14.379	0.553	24.021	3.580	19.284	0.589	26.922	3.690
$j = 5$	15.667	1.289	26.543	2.522	20.312	1.028	29.601	2.678

Note: This table reports the average adjusted R^2 and the changes in the average adjusted R^2 when the relative depth and height at steps one to five are incorporated in the model. Essentially, we estimate the regression for each stock without incorporation of the relative depth or height and measure the adjusted R^2 then recursively add relative depth and height from steps 1 to 5 and measuring the change in the adjusted R^2 in the resulting regressions. The average adjusted R^2 (Avg. Adj. R^2) and the percentage change in the adjusted R^2 (Change (%)) is calculated for both A stocks and B stocks.

Table 17

Impact of the Opening Order Book on Opening Return Innovations (ε_t^*)

Panel A	**BOV**		**MLC**		**HSB**		**MSI**		**MIA**		**IHI**	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	**-0.0020**	-4.00	**-0.0015**	-2.05	**-0.0023**	-3.74	-0.0009	-1.10	**-0.0013**	-2.19	**-0.0046**	-5.46
$r_{2,t-1}$	0.0113	0.71	**-0.0804**	-5.25	**-0.1054**	-6.21	**-0.1501**	-5.25	**-0.1708**	-6.39	**-0.2018**	-8.24
DL_t^B	**0.0046**	8.06	**0.0062**	7.36	**0.0060**	8.76	**0.0099**	7.82	**0.0071**	7.97	**0.0121**	10.55
DL_t^S	**-0.0015**	-2.42	**-0.0039**	-4.49	**-0.0025**	-3.31	**-0.0073**	-5.63	**-0.0035**	-3.76	**-0.0048**	-3.91
DC_t^B	**0.0073**	8.61	**0.0106**	9.30	**0.0112**	10.62	**0.0152**	6.55	**0.0098**	6.12	**0.0228**	12.54
DC_t^S	**-0.0059**	-5.98	**-0.0060**	-5.16	**-0.0025**	-2.01	**-0.0097**	-3.33	**-0.0040**	-2.37	**-0.0100**	-4.09
$RD_{1,t}^T$	-0.0001	-0.31	0.0007	1.29	0.0002	0.45	**0.0020**	2.15	0.0012	1.74	**0.0018**	2.00
$RD_{2,t}^T$	-0.0001	-0.18	0.0004	0.84	**0.0016**	3.32	0.0014	1.64	0.0004	0.59	0.0014	1.65
$RD_{3,t}^T$	0.0004	1.08	0.0005	1.05	0.0004	0.89	**0.0019**	2.17	0.0011	1.56	0.0001	0.14
$RD_{4,t}^T$	0.0005	1.46	-0.0003	-0.76	**0.0011**	2.38	0.0008	0.93	**0.0014**	2.08	0.0012	1.26
$RD_{5,t}^T$	-0.0005	-1.40	0.0007	1.61	-0.0002	-0.51	-0.0001	-0.08	-0.0003	-0.45	0.0007	0.83
$RH_{1,t}^T$	-0.0026	-0.53	0.0323	0.68	**0.0051**	2.18	**0.0098**	2.55	**0.0133**	3.11	**0.0132**	1.99
$RH_{2,t}^T$	**-0.0020**	-5.03	**-0.0041**	-8.98	**-0.0015**	-3.18	**-0.0039**	-4.64	**-0.0048**	-6.92	**-0.0056**	-6.52
$RH_{3,t}^T$	-0.0004	-1.03	0.0002	0.51	-0.0002	-0.42	-0.0006	-0.86	-0.0004	-0.63	**-0.0038**	-4.99
$RH_{4,t}^T$	-0.0002	-0.69	-0.0004	-0.95	0.0001	0.35	**-0.0017**	-2.26	-0.0008	-1.28	-0.0004	-0.64
$RH_{5,t}^T$	0.0001	0.38	**0.0011**	2.63	-0.0005	-1.35	0.0007	0.95	0.0009	1.65	-0.0005	-0.83
Panel B												
Adj. R2		0.21		0.31		0.20		0.25		0.31		0.39
F-stat.		**31.05**		**55.67**		**27.82**		**22.58**		**23.94**		**44.62**
Prob.		0.00		0.00		0		0		0		0
AR Lags		3		6		8		6		2		1

Note: This table reports the regression estimates of the relative height and depth from one to five steps away from the top of the opening order book in determining opening return innovations. Panel A reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilized in this analysis. Panel B reports the adjusted R-square (Adj. R^2), F-statistic (F-stat.) and related probability (P-val.) for all six stocks and the number of autoregressive lags used to generate the return innovation series. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 18
Impact of the Overnight Order Book on Opening Returns ($r_{1,t}$)

Panel A	**BOV**		**MLC**		**HSB**		**MSI**		**MIA**		**IHI**	
Variable	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***	***Coef.***	***t-Stat.***
α_0	-0.0006	-1.61	-0.0010	-1.00	0.0004	0.53	**-0.0024**	-3.07	**-0.0011**	-2.13	**-0.0031**	-3.76
$r_{2,t-1}$	-0.0084	-0.18	**-0.1183**	-4.24	**-0.2848**	-6.60	**-0.2211**	-5.97	**-0.1982**	-3.78	**-0.2469**	-6.25
DL_t^B	**0.0052**	10.94	**0.0066**	5.99	**0.0064**	9.58	**0.0108**	6.79	**0.0071**	7.65	**0.0122**	10.48
DL_t^S	**-0.0017**	-3.06	**-0.0037**	-3.58	**-0.0031**	-3.98	**-0.0077**	-4.41	**-0.0035**	-3.77	**-0.0045**	-3.57
DC_t^B	**0.0084**	6.21	**0.0112**	5.30	**0.0170**	8.44	**0.0169**	5.47	**0.0097**	5.09	**0.0229**	9.97
DC_t^S	**-0.0058**	-3.40	**-0.0060**	-3.37	-0.0032	-1.91	**-0.0101**	-2.96	**-0.0043**	-2.06	**-0.0097**	-5.06
$RD_{1,t}^T$	-0.0002	-0.31	0.0006	0.97	-0.0003	-0.38	**0.0019**	2.06	0.0012	1.77	**0.0020**	2.26
$RD_{2,t}^T$	-0.0002	-0.38	0.0004	0.79	**0.0017**	3.04	0.0009	1.34	0.0003	0.51	0.0010	1.05
$RD_{3,t}^T$	0.0002	0.40	0.0002	0.49	**0.0013**	2.56	0.0013	1.49	0.0010	1.37	0.0003	0.32
$RD_{4,t}^T$	0.0006	1.56	-0.0006	-1.36	**0.0016**	3.22	0.0010	1.09	**0.0015**	2.35	0.0014	1.77
$RD_{5,t}^T$	-0.0001	-0.30	0.0007	1.79	0.0005	0.97	0.0001	0.08	-0.0002	-0.35	0.0008	0.94
$RH_{1,t}^T$	-0.0042	-1.62	0.0637	0.70	0.0043	1.88	**0.0127**	2.43	0.0126	1.61	0.0134	1.16
$RH_{2,t}^T$	**-0.0022**	-4.04	**-0.0045**	-7.21	**-0.0014**	-2.09	**-0.0044**	-5.19	**-0.0050**	-5.79	**-0.0062**	-6.98
$RH_{3,t}^T$	-0.0006	-1.26	-0.0002	-0.46	**-0.0011**	-2.10	-0.0017	-1.88	-0.0005	-0.69	**-0.0044**	-5.40
$RH_{4,t}^T$	-0.0005	-1.16	-0.0005	-1.04	-0.0003	-0.57	**-0.0025**	-3.14	-0.0007	-0.84	-0.0006	-1.04
$RH_{5,t}^T$	0.0000	-0.08	**0.0012**	2.55	-0.0006	-1.61	0.0003	0.34	0.0010	1.73	-0.0005	-0.93
Panel B												
Adj. R^2		0.23		0.3431		0.38		0.31		0.34		0.43
F-stat.		**35.01**		**63.11**		**67.00**		**30.76**		**26.52**		**53.36**
P-val.		0.00		0.00		0.00		0.00		0.00		0.00

Note: This table reports the regression estimates of the relative height and depth from one to five steps away from the top of the opening order book in determining opening return. Panel A reports the coefficients (coef.) and t-statistic (t-stat.) for the six stocks utilised in this analysis. The t-statistic is calculated using the Newey-West heteroskedasticity and autocorrelation consistent standard errors. Panel B reports the adjusted R-square (Adj. R^2), F-statistic (F-stat.) and related probability (P-val.) for all six stocks. The coefficients highlighted in bold are significant at the five percent level of significance.

Table 19
Impact of Opening Order Book Results Summary

	Opening Return Innovations (ε_t^*)				Opening Return ($r_{1,t}$)			
Panel A.	**A Stocks**		**B Stocks**		**A Stocks**		**B Stocks**	
Variable	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***	***Avg. Coefs.***	***No. Sig.***
α_0	**-0.192**	**3**	**-0.225**	**2**	-0.042	0	**-0.219**	**3**
$r_{2,t-1}$	**-5.817**	**2**	**-17.425**	**3**	**-13.714**	**2**	**-22.205**	**3**
DL_t^B	**0.561**	**3**	**0.975**	**3**	**0.607**	**3**	**1.003**	**3**
DL_t^S	**-0.263**	**3**	**-0.520**	**3**	**-0.285**	**3**	**-0.524**	**3**
DC_t^B	**0.967**	**3**	**1.594**	**3**	**1.221**	**3**	**1.649**	**3**
DC_t^S	**-0.481**	**3**	**-0.791**	**3**	**-0.499**	**2**	**-0.800**	**3**
$RD_{1,t}^T$	0.026	0	**0.166**	**2**	0.007	0	**0.173**	**2**
$RD_{2,t}^T$	0.063	1	0.104	0	0.062	1	0.075	0
$RD_{3,t}^T$	0.043	0	0.103	1	0.058	1	0.086	0
$RD_{4,t}^T$	0.044	1	0.114	1	0.054	1	0.128	1
$RD_{5,t}^T$	-0.002	0	0.014	0	0.037	0	0.022	0
$RH_{1,t}^T$	1.158	1	**1.210**	**3**	2.129	0	1.291	1
$RH_{2,t}^T$	**-0.255**	**3**	**-0.473**	**3**	**-0.267**	**3**	**-0.519**	**3**
$RH_{3,t}^T$	-0.012	0	-0.160	1	-0.061	1	-0.217	1
$RH_{4,t}^T$	-0.017	0	-0.096	1	-0.041	0	-0.126	1
$RH_{5,t}^T$	0.025	1	0.038	0	0.017	1	0.024	0
Panel B.								
Steps (j)	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***	***Avg. Adj. R^2***	***Change (%)***
$j = 0$	21.862		27.806		28.696		31.285	
$j = 1$	21.866	0.004	27.938	0.132	28.752	0.056	31.440	0.155
$j = 2$	23.658	1.792	30.702	2.763	30.844	2.092	34.643	3.203
$j = 3$	23.670	0.011	31.469	0.767	31.122	0.278	35.659	1.016
$j = 4$	23.803	0.133	31.658	0.189	31.438	0.316	36.068	0.408
$j = 5$	23.935	0.132	31.647	-0.011	31.575	0.138	36.060	-0.007

Note: This table reports a summary of the impact of the opening order book on opening returns and returns innovations. The t-statistic for coefficients in the opening returns regressions are based on the Newey-West heteroskedasticity and autocorrelation consistent standard errors. The stocks are categorized into two main groups. A stocks represents the three most active stocks and B stocks represents the three least active of the six stocks studied. Panel A reports the average coefficient value (Avg. Coef.) and the number of significant coefficient at the five percent level of significance for both group of stocks. The coefficient values are scaled by a multiple of 100 for better presentation in the table. Panel B reports the finding about the information below the top of the order book. Essentially, we estimate the regression for each stock without incorporation of the relative depth or height and measure the adjusted R^2 then recursively add relative depth and height from steps 1 to 5 and measuring the change in the adjusted R^2 in the resulting regressions. The average adjusted R^2 (Avg. Adj. R^2) and the percentage change in the adjusted R^2 (Change (%)) is calculated for both A stocks and B stocks.