A Cross-Country Model for the Influence of the Pre-Trade Transparency on Market Liquidity and Price Volatility

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The aim of this article is to empirically examine the dynamic relationship between the pre-trade transparency (PTT) and various liquidity and volatility features of the market. The majority of previous literature has described such relationships but the available empirical studies to date have produced inconsistent results. In order to investigate further the relationships between these interconnections, we carry out a system of simultaneous equations that relates a set of liquidity and volatility indicators with three different PTT dimensions, given a series of control variables. We make a cross-country comparison, using a sample of 223 stocks, selected from the equity divisions of 14 stock exchanges, with order driven features or hybrid.

We consider different expressions of market liquidity, partially taken from the existing literature (volume and bid-ask spread) and partially our own defined parameters (new orders on a one minute basis), together with different measures of price volatility: the traditional realized variance and our own defined measure of intra-minute price volatility.

As far as the PTT is concerned, we split the overall information displayed to investors via electronic trading platforms into three dimensions, as introduced by Lucarelli, Mazzoli and Rothfeld [2007]: the identification of the trader that sends the order to the market (PTT1), the desegregation of price levels (PTT2), and the number of price levels displayed in the order book (PTT3).

The control variables refer to some share-specific characteristics together with some general stock market and country features. The first two sets of variables are different for each stock considered, while the following refer to general market/national data which are the same for all stocks belonging to a specific stock exchange, or country. In particular, we refer to:

- the overall current mood of traders, an important feature due to the highly emotional behavior of investors;
- share-specific features, mainly related to the economic fundamentals of the issuing firms;
- stock exchange features connected with the characteristics of the stock market where a share is listed;
- country features, in terms of the national economic and technological development;
- market transparency, in this article identified with PTT dimensions.

The main contribution of this article relies on the wide cross-country comparisons of the PTT stock markets levels, based on a cross-section approach, rather than on a time series structure that characterizes previous studies. The analysis of each PTT dimension, as mentioned above, adds important value to the results of earlier studies. Moreover, we use an interconnected set of market liquidity and price volatility indicators, through a system of simultaneous equations, exploiting tick by tick data.

The remainder of the article is organized as follows: first there is a short review of the literature concerning, on one hand, the PTT relationship with liquidity and volatility and, on the other hand, some drivers of market liquidity and price volatility. Then we carry out the empirical analysis, providing a description of the data and the variables used in our estimation. The final two sections summarize the main results and provide some concluding remarks.

LITERATURE REVIEW

The existing literature we are interested in defines and measures the liquidity and price volatility of equity markets. For the latter, there is a mild consensus agreeing to the use of realized variance as an easy measure of price volatility, even if some authors are still improving the definition of more appropriate volatility indicators. Besides, liquidity is easy to define but difficult to measure. For example liquidity indicators can be divided into two broad categories: trade-based and order-based. Trade-based measures used in literature include trading value, trading volume, number of trades and turnover that is the value of shares traded divided by market capitalization. Order-based measures consist of the relative bid-ask spread and order depth, that is the total volume of all orders in the book divided by the shares on issue (Aitken and Comerton-Forde [2003]). Nevertheless, Aitken and Winn [1997] report that literature contains at least 68 measures of liquidity, thus witnessing that there is little agreement on the best measure to use. Moreover, Aitken and Comerton-Forde [2003] find little correlation between the two categories, showing that the choice of liquidity measure may affect the results.

The economic determinants of liquidity and volatility can be divided into at least five categories: the current mood of traders; the share-specific features; the stock exchange features; the country features and, finally, the level of market transparency. Moreover, volatility and liquidity are shown to be strictly connected to each other.

In general, trader emotional behavior determines the current mood of a share and influences its liquidity and volatility. Chordia, Roll, and Subrahmanyam [2001], among others, study the relationship between order imbalance and changes in liquidity. They find that excess sell orders have an impact on the increased volumes that is four times that of excess buy orders. This is consistent with the emotional reaction of traders to a bearish situation in the market. Moreover they demonstrate a positive relationship between order imbalance and price volatility. This relationship is particularly strong in the case of sell pressure.

With reference to the link between firm-specific characteristics and the liquidity and volatility features of equity markets, Wahal [1997] claims that firms with larger market capitalization tend to attract more market makers than small capitalization firms do. As a consequence, the competition among market makers increases the liquidity of the market as witnessed by lower bid-ask spreads. Moreover, some literature reports on the relationship between earnings announcements and the liquidity of the market (Morse [1981] Verrecchia and Kim [1991]; Karpoff [1986]; Lee, Mucklow and Ready [1993]). These contributions show that volume is largely influenced by firm performance news. The relationship seems to be stronger in the presence of bad news, suggesting that investors trade more aggressively when the company is not doing well (Lakhal [2004]). As far as the volatility is concerned, Cohen, Ness, Okuda, Schwartz and Whitcomb [1976] argue that the fundamentals of a stock are strictly and negatively connected to its price volatility in the market.

The relationship between liquidity and stock exchange features has attracted lots of research. For example, Li [2007] finds that the stock market capitalization to GDP ratio positively reacts to the level of trading activity (market total value traded to GDP ratio); the level of trading activity, instead, decreases when the correlation of the market with the MSCI world portfolio increases. Moreover, Cohen, Ness, Okuda, Schwartz and Whitcomb [1976] observe that the "thinner" a country is in terms of a low market capitalization and low floating supply, the higher the level of price volatility.

For the national economic development, Engel and Rangel [2005] find that volatility is positively associated to a country's GDP, together with uncertainty about inflation and interest rates. Furthermore, Shah and Thomas [2001] provide a positive relationship between the electronic development of a country and the volume of its stock market and suggest electronic development as a way to obtain securities market liquidity in small countries.

A stream of other studies focuses on how the level of pre-trade information disclosed in each stock exchange influences the liquidity and volatility of that market. Comerton-Forde, Frino and Mollica [2005] study the impact of order anonymity upon the liquidity of the Paris, Tokyo, and Korea Stock Exchanges. In particular, Paris and Tokyo introduced anonymity in 2001 and 2003 respectively, while Korea removed anonymity in 1999. Liquidity is measured through the bid-ask spread. The results provide evidence that anonymity has impacts upon liquidity. In particular, Paris and Tokyo, show higher liquidity (lower bid-ask spread) after 2001 and 2003 while Korea reduces its level of attractiveness toward investors after becoming more transparent. Similarly, Simaan, Weaver, and Whitcomb [2003] measure the impact of different levels of PTT upon the behavior of market makers in the NASDAQ Stock Exchange. They demonstrate that, as market makers prefer being anonymous, a higher level of PTT reduces their competition and so reduces liquidity in the market as measured by larger bid-ask spreads. Madhavan, Porter, and Weaver [2005] analyze the Toronto Stock Exchange, examining its transition from floor to electronic trading. They show that, contrary to the common presumption among policy makers and regulators, greater transparency might not increase market quality; instead, they document increases in execution costs and volatility and a reduction in market maker profits that upholds their opposition to any increase in transparency. Instead, Bohemer, Saar, and Yu [2005] show that disclosing more information about limit orders in the order book enhances liquidity and reduces volatility. Focault, Moinas, and Theissen [2007] analyze changes in liquidity and volatility in the Euronext Paris Stock Exchange after the transition to an anonymous order book, and they find that the bid-ask spread decreases significantly, increasing liquidity. They also find that this reduction in the spread can be considered a predictor of a future decrease in volatility even if, after the transition to anonymity, these results appear less clear.

Most of the literature supports a positive relationship between liquidity and price volatility. Karpoff [1987] surveys more than 18 studies about volume-volatility and finds that most of the studies show a positive correlation, while Gallant, Rossi, and Tauchen [1992] point out that much of this literature focuses on the contemporaneous relationship without examining any causality. More recent papers address the causality examining the dynamic relationship between stock volume, stock returns, and price volatility. Yet, despite their main use of the same methodology (Granger causality test), their findings are still contradictory. Naes and Skjeltorp [2006] find a positive simultaneous relationship between number of trades, average value of trades, and price volatility based on tick by tick dataset of stocks traded on the Oslo Stock Exchange. Nevertheless, they overlook the causality among the three variables. Chen, Firth, and Rui [2001] make use of daily stock data on nine national markets between the 1973 and 2000 and find that volume Granger causes volatility and also the opposite, thus making it impossible to understand the drivers. Lee and Riu [2002] apply the Granger causality test on daily data from three stock exchanges (New York, London, and Tokyo) and observe a positive correlation between price volatility and trading volume without finding any clear causality. Rashid [2007] uses the same method on daily data and observes a causal relationship from price volatility to trading volume for the whole observation period (from 2001 to 2006). Finally, Darrat, Zhong, and Cheng [2007] apply the Granger causality test to tick by tick data on the NYSE and find that trading volume Granger causes price volatility.

THE MODEL

Preliminary Setup

Our analysis focuses on the major 14 North-American and European stock exchanges: the Toronto Stock Exchange, the New York Stock Exchange (NYSE), the NASDAQ, the London Stock Exchange, Euronext (Paris, Amsterdam, Brussels and Lisbon), the Deutsche Bourse (Xetra), the Madrid Stock Exchange, Borsa Italia, the Stockholm Stock Exchange, the Copenhagen Stock Exchange, and the Helsinki Stock Exchange. The sampled shares belong to the main equity indexes of the above mentioned stock exchanges, which are TSX Composite Index, All NYSE, Nasdaq100, FTSE100, CAC40, AEX, BEL20, PSI30, DAX30, All Madrid, S&P/MIB, OMX Stockholm30, OMX Copenhagen20 and All Helsinki, respectively[1].

Given the huge number of stocks available, within each stock index, we choose to select as representative the most liquid shares; so we select the 10 shares with the largest monthly average trading volume ($\overline{V}$) and the

10 shares with the lowest average monthly turnover ratio ($\overline{r}$), both evaluated for the period between November 2005 and November 2006.

The turnover ratio $\overline{r}$ informs about the number of days it takes for every stock in the index to trade all of its floating shares, as follows:

$$\overline{r} = \frac{\overline{f} \cdot \overline{s}}{\overline{v}} \tag{1}$$

where $\overline{s}$ is the monthly average of the issued shares and $\overline{f}$ is the free float rate.

In this context, the total amount of sampled shares should be 280, 20 stocks for each market; nevertheless, at the end of the observation period we restrict the sample to 223 stocks for two reasons: firstly, sometimes stocks showing the highest volume inside the index coincide with those having the lowest turnover (higher velocity); secondly, we excluded observations corresponding to missing data, caused by holidays or other extraordinary events (see Appendix 2).

The Data Set

The data set is made up of tick by tick data of quotes and volumes for each stock, from the Digital Data Exchange (DDE) function of Realtick® Trading Platform. The sample period available goes from November 29, 2006, to December 20, 2006, and from January 8, 2007, to January 26, 2007. Within these periods, we download tick by tick data from the opening to the closing time of each stock exchange[2]. The final data set contains more than 120 million observations and has to be managed through specific queries based on the Structured Query Language (SQL) Software.

Finally, the control variables have been obtained from the Thompson Financial DataStream software, from the OECD Database, and from the World Federation of Exchanges.

The Variables

The aim of this article is to test whether the PTT affects the volatility and the liquidity of a stock exchange, hence our attention is focused upon the existence of any dynamic (causal) relationship between some liquidity and volatility variables, given a set of controls. We use a system of simultaneous equations in which, for the i-th share, y_i represents the vector ($n \times 1$) of endogenous variables, while the k-dimensional vector z_i includes all the exogenous or explanatory variables.

Given the total amount of the trading minutes M, the total number of trading days D, the endogenous variables vector y_i, for the i-th stock is

$$y_i' = [v_i \quad q_i \quad s_i \quad m_i \quad \sigma_i]' \tag{2}$$

The $n = 5$ elements being calculated as follows:

1. the average trading volume (v_i)

$$v_i = \frac{1}{10000}\frac{1}{DM}\sum_{d=1}^{D}\sum_{m=1}^{M} V_{idm} \tag{3}$$

where V_{idm} is the volume of share i observed at the m-th minute on day d. 10000 represents a scale factor;

2. the average of new orders (q_i)

$$q_i = \frac{1}{100}\frac{1}{DM}\sum_{d=1}^{D}\sum_{m=1}^{M} Q_{idm} \tag{4}$$

where Q_{idm} is the orders' number of shares i observed at the m-th minute on day d. This number includes both the bid orders and the ask orders. 100 is the scale factor;

3. the relative bid-ask spread (S_i)

$$s_i = \frac{1}{DM}\sum_{d=1}^{D}\sum_{m=1}^{M} \frac{\overline{A}_{idm} - \overline{B}_{idm}}{\frac{1}{2}(\overline{A}_{idm} + \overline{B}_{idm})} \tag{5}$$

where $\overline{A}_{idm}$ is the intra-minute (or tick by tick) average of the ask prices and $\overline{B}_{idm}$ is the intra-minute average of the bid prices;

4. the intra-minute volatility (m_i)

$$m_i = \frac{1}{DM}\sum_{d=1}^{D}\sum_{m=1}^{M}\left[\frac{H_{idm} - L_{idm}}{\frac{1}{2}(H_{idm} + L_{idm})} - \frac{|C_{idm} - O_{idm}|}{\frac{1}{2}(C_{idm} + O_{idm})}\right] \tag{6}$$

where H_{idm}, L_{idm}, O_{idm} and C_{idm} are the respective high, low, open, and close prices on a one minute basis; it is very easy to show that this volatility index is positive by definition.

5. the realized variance (σ_i) as the average of the daily volatility (h_d)

$$\sigma_i = \frac{1}{D}\sum_{d=1}^{D} h_d \qquad (7)$$

where h_d is defined as the second sample moment of the intra-minute return evaluated using closing prices

$$h_d = \frac{1}{M-1}\sum_{m=2}^{M}\left[\ln(C_{idm}) - \ln(C_{id,m-1})\right]^2$$

The k-dimensional vector z_i, containing all the exogenous variables, described in Exhibit 1, is partitioned as

$$z_i' = \begin{bmatrix} \underset{(1\times m)}{x_i'} & \vdots & \underset{(1\times r)}{p_i'} & \vdots & \underset{(1\times q)}{d_i'} \end{bmatrix} \qquad (8)$$

where $k = m + r + q$.

The vector x_i contains all the control variables of our model related to the current mood, the share-specific features, the stock market features, and the country features, respectively. The vector p_i holds the PTT indicators. The vector d_i includes the dummy variables which are equal to one when an outlier occurs in the specified market. From Exhibit 1 it is straightforward evident that in our model $m = 11$, $r = 3$, and $q = 9$, therefore $k = 23$.

More precisely, PTT indicators contained in the vector p_i consist in the average score assigned to each PTT dimension as in Lucarelli, Mazzoli, and Rothfeld [2007]. These scores have been obtained through a cross-country recognition of the pre-trade transparency levels actually disclosed to stock market participants, as shown in Exhibit 2. This exhibit refers to two different investor categories: the partially informed traders, on the one hand, and the fully informed traders, on the other. The first one includes those retail traders who generally find it convenient to buy a limited amount of pre-trade information, whose fees are lower and coherent with the scale of their trading activity. The second category of traders refers to institutional investors together with the retail traders able to afford the (higher) fees requested to buy all the (public) pre-trade information a stock exchange spreads among market participants.[3] Each pre-trade transparency level is scored assigning 0 to the lowest level of PTT and 1 to the highest, as described in Exhibit 3. In order to obtain the average PTT score, for each stock exchange, we weight the PTT scores of partially and fully informed traders by a coefficient indicating the relevance of their respective trading activity (see Lucarelli, Mazzoli, and Rothfeld [2007]).

The System

Our model consists of a standard system of simultaneous equations, whose structural form for the i-th share is

$$\begin{aligned} B'\gamma_i &= \mu + \Lambda' z_i + \varepsilon_i \\ B'\gamma_i &= \mu + \Gamma' x_i + \Theta' p_i + \Phi' d_i + \varepsilon_i \end{aligned} \qquad (9)$$

where γ_i and z_i are the vectors defined in the immediately preceding subsections, μ is the n-dimensional vector of constant terms, and $\varepsilon_i \sim i.i.d.(0, \Sigma)$ is the vector of the error terms. The matrices B' and Λ' contain the $(n \times n)$ and $(n \times k)$ coefficients respectively.

As Equation (8) shows, the vector z_i is partitioned into two different blocks, hence matrix Λ' can also be written as follows:

$$\Lambda' = \begin{bmatrix} \underset{(n\times m)}{\Gamma'} & \vdots & \underset{(n\times r)}{\Theta'} & \vdots & \underset{(n\times q)}{\Phi'} \end{bmatrix}$$

Considering the triple (B, Λ, Σ) and the n-dimensional vector of constants μ, the total amount of parameters to be estimated in the structural form would be $n + n\,(n + k) + 0.5n\,(n + 1) = 155$.

The identification problem that arises in the simultaneous equation setup is solved by imposing some restrictions. In our system some normalization and some exclusion constraints are set; the former restriction imposes the diagonal of the matrix B' to become a vector of ones and has the advantage that it expresses each element of γ_i as a function of the other endogenous variables and of all the exogenous variables. The latter restriction, its use suggested by economic theory and by the proper use of the dummy variables, sets some

Exhibit 1
The Exogenous Variables

	Name	Variable	Description
	Current mood:		
	versus	vs_i	number of bid offers on the total number of bid/ask offers
	beta	β_i	covariance of the stock compared to its national stock index volatility
	Share-specific features:		
	free-float	ff_i	free float rate
	real capitalization	rk_i	total amount of issued stocks/1000
	ROE	roe_i	return on equity
x_i	*Stock market features:*		
	listed companies	n_i	number of listed companies/100
	market free-float	mf_i	average free-float rate of the listed companies
	market capitalization	mk_i	stock market capitalization/1 million
	market correlation	ρ_i	stock index correlation
	Country features:		
	country GDP	gdp_i	GDP/1 million
	electronic development	e_i	internet users per 1000 inhabitants
	Pre-trade transparency indicators:		
	first PTT dimension	$PTT1_i$	average score assigned to traders' identification
p_i	second PTT dimension	$PTT2_i$	average score assigned to orders' desegregation
	third PTT dimension	$PTT3_i$	average score assigned to number of levels
	Dummies:		
		$lisb3$	Pararede
		$lse11$	Vodafone
		$madr3$	Jazztel, Banco Santander Central Hispanico
		$mil11$	Alitalia
d_i		$nas11$	Apple, Research In Motion
		$sto11$	Ericsson
		$sto4$	Assa Abloy 'B', Atlas Copco 'A', Sandvik
		$sto5$	Atlas Copco 'A', Sandvik
		$usa11$	Sun Microsystems

parameters to zero. The constrained structural form is provided by Equation (11) in Appendix 1.

From the structural form of Equation (9), the identification process requires that both the order condition and the rank condition should be satisfied; the first is a necessary although not generally a sufficient condition, and it requires that in each equation the number of excluded explanatory variables should be at least as great as the number of the included endogenous variables. As Equation (11) shows, the exclusion restrictions imposed in the matrix Φ' satisfy such condition, and this allows us to estimate a model in which almost all the parameters in Γ' are free. In particular, with this set of restrictions, the first two rows in Γ' are non-zero, hence some variables in y_i can be expressed as a linear function of y_i itself and of the entire x_i. Moreover, the constraints imposed to Φ' allow us to use a matrix Θ' in which all parameters are free. In this case, there are no constraints regarding the impact of PTTs in our system.

These constraints also guarantee that the rank condition is satisfied. The rank condition, which represents a sufficient condition for identification, is satisfied if the restrictions imposed upon the structural form allow one

EXHIBIT 2
Cross-Country Survey of PTT

Stock Exchange	Partially informed traders			Fully informed traders		
	PTT1	PTT2	PTT3	PTT1	PTT2	PTT3
Madrid SE	no	no	5	no	yes	20
Borsa Italia	no	no	5	no	yes	all
Copenhagen SE	no	no	5	no	no	20
Euronext Amsterdam	no	no	5	no	yes	all
Euronext Brussels	no	no	5	no	yes	all
Euronext Lisbon	no	no	5	no	yes	all
Euronext Paris	no	no	5	no	yes	all
Helsinki SE	no	no	5	no	no	20
London SE	with code	yes	all	with code	yes	all
NASDAQ	yes	yes	all	yes	yes	all
NYSE	yes	yes	all	yes	yes	all
Stockholm SE	no	no	5	no	no	20
Toronto SE	yes	yes	all	yes	yes	all
Xetra	no	no	10	no	no	all

Source: Lucarelli, Mazzoli and Rothfeld (2007).

EXHIBIT 3
PTT Dimensions Scoring

PTT1: Traders' identification		PTT2: Orders desegregation		PTT3: Number of visible levels	
Identification	Score	Desegregation	Score	Price levels	Score
Yes	1	Yes	1	5	0.25
No	0	No	0	10	0.5
with code	0.75			20	0.75
				all	1

to express any condition in terms of both the parameters belonging to (B, Λ, Σ) and the parameters of the reduced form (Π, Ω), with $\Omega = Var(u_t)$ and $u_t = (B')^{-1}\varepsilon_t$. It takes the equation $\Pi B = \Lambda$ into account, where Π' is taken from the reduced form of Equation (9)

$$y_t = c + \Pi' z_t + u_t \tag{10}$$

where $c = (B')^{-1}\mu$, $\Pi' = (B')^{-1}\Lambda'$ and $u_t = (B')^{-1}\varepsilon_t$.

The estimation method used is the Full Information Maximum Likelihood model (FIML) that requires iterative computations but has the property to yield consistent and asymptotically efficient and normally distributed estimates of the matrices B', Γ', Φ', and Σ (see, for example, Davidson and Mackinnon [1993]). Exhibit 4 reports the FIML estimation of the structural form (9). Two Stage Least Squared (2SLS) and Three Stage Least Squares (3SLS) methods are also carried out: the diagnostics related to 2SLS and 3SLS do not highlight evidence of overidentification and the estimates are quite similar to those obtained with FIML.[4]

DISCUSSION OF THE MAJOR FINDINGS

Our findings are shown in Exhibit 4 and appear coherent with part of the previous literature: PTT increases liquidity and reduces volatility. The system shows dynamic (causal) relationships between the three PTT dimensions and some endogenous variables.

The traders' identification (PTT1) negatively affects the intra-minute volatility (from Equation 4), and it produces higher trading volumes as shown in Equation 1, whereas Equation 2 shows its positive influence on the

EXHIBIT 4

FIML Estimation of the System

var.	coeff.	s.e.	t-stat	p-val
Equation 1 - dependent	variable: υ_i			
μ_1	5.0403	1.9569	2.5760	0.0100**
q_i	0.4002	0.2385	1.6780	0.0934*
s_i	0.0008	0.0038	0.2170	0.8281
m_i	-0.0030	0.0052	-0.5700	0.5685
σ_i	0.1216	0.1508	0.8060	0.4201
υs_i	-24.6434	4.5967	-5.3610	0.0000***
β_i	0.3123	0.1673	-1.8670	0.0619*
ff_i	0.4628	0.5866	0.7890	0.4301
rk_i	0.9146	0.0568	16.0880	0.0000***
roe_i	-0.0086	0.0033	-2.6100	0.0091***
n_i	-0.5608	0.5930	-0.9460	0.3443
mf_i	8.1988	3.1654	2.5900	0.0096***
mk_i	-0.1251	0.1107	-1.1300	0.2584
ρ_i	-1.9313	1.5971	-1.2090	0.2266
gdp_i	-0.1505	0.1153	-1.3050	0.1920
e_i	-1.4396	2.2258	-0.6470	0.5178
$PTT1_i$	4.4030	2.6560	1.6580	0.0974*
$PTT2_i$	1.7628	0.9655	1.8260	0.0679*
$PTT3_i$	0.0289	2.5030	0.0120	0.9908
$mil1$	9.7548	1.6087	6.0640	0.0000***
$sto1$	20.8107	1.5480	13.4440	0.0000***
$lse1$	30.1385	1.5806	19.0680	0.0000***
$usa1$	9.5104	1.7487	5.4390	0.0000***
Equation 2 - dependent	variable: q_i			
μ_2	0.5634	0.7168	0.7860	0.4319
υ_i	-0.0073	0.0157	-0.4640	0.6426
s_i	-0.0006	0.0014	-0.4290	0.6676
m_i	-0.0001	0.0019	-0.0360	0.9711
σ_i	-0.0226	0.0549	-0.4120	0.6803
υs_i	-2.5916	1.7412	-1.4880	0.1366
β_i	0.2353	0.0560	4.2020	0.0000***
ff_i	0.9507	0.1990	4.7770	0.0000***
rk_i	0.0792	0.0257	3.0840	0.0020***
roe_i	0.0004	0.0012	0.2920	0.7702
n_i	-0.3202	0.2163	-1.4800	0.1388
mf_i	-3.2404	1.2003	-2.7000	0.0069***
mk_i	-0.2077	0.0345	-6.0280	0.0000***
ρ_i	0.9781	0.6132	1.5950	0.1107
gdp_i	0.2796	0.0317	8.8140	0.0000***
e_i	1.0358	0.8644	1.1980	0.2308
$PTT1_i$	1.1371	0.9842	1.1550	0.2479
$PTT2_i$	0.5938	0.3620	1.6410	0.1009
$PTT3_i$	1.3281	0.9183	1.4460	0.1481
$usa1$	-2.1910	0.6107	-3.5880	0.0003***
$nas2$	4.9598	0.4331	11.4520	0.0000***
Equation 3 - dependent	variable: s_i			
μ_3	90.1025	12.2813	7.3370	0.0000***
q_i	-3.0959	1.5459	-2.0030	0.0452**
υ_i	-0.0818	0.2525	-0.3240	0.7459
m_i	-0.0118	0.0433	-0.2730	0.7850
σ_i	0.1307	1.2483	0.1050	0.9166
n_i	6.9807	4.9134	1.4210	0.1554
mf_i	71.7637	25.4996	2.8140	0.0049***
mk_i	1.0320	0.8695	1.1870	0.2352
ρ_i	-53.4744	13.3735	-3.9990	0.0001***
gdp_i	-1.3366	0.8569	-1.5600	0.1188
e_i	-86.7018	17.1833	-5.0460	0.0000***
$PTT1_i$	42.0698	21.6187	1.9460	0.0517*
$PTT2_i$	-1.4783	7.2396	-0.2040	0.8382
$PTT3_i$	-99.9189	19.8071	-5.0450	0.0000***
$madr3$	141.5230	9.7093	14.5760	0.0000***
$lisb3$	394.6820	13.4881	29.2610	0.0000***

var.	coeff.	s.e.	t-stat	p-val
Equation 4 - dependent	variable: m_i			
μ_4	10.9091	3.2290	3.3780	0.0007***
υ_i	0.1175	0.0735	1.5990	0.1098
q_i	0.5505	0.3963	1.3890	0.1649
s_i	-0.0030	0.0065	-0.4610	0.6447
υs_i	-20.9393	7.3173	-2.8620	0.0042***
β_i	0.2160	0.2829	0.7630	0.4452
ff_i	-0.0924	0.9822	-0.0940	0.9251
rk_i	-0.1577	0.1182	-1.3350	0.1820
roe_i	-0.0131	0.0056	-2.3300	0.0198**
n_i	3.9172	0.7882	4.9700	0.0000***
mf_i	3.1688	2.6702	1.1870	0.2353
mk_i	0.1743	0.1422	1.2260	0.2203
gdp_i	0.7805	0.1820	4.2900	0.0000***
$PTT1_i$	-14.7391	3.2543	-4.5290	0.0000***
$PTT2_i$	4.5985	1.2152	3.7840	0.0002***
$PTT3_i$	-8.2311	3.5024	-2.3500	0.0188**
$mil1$	5.7455	2.7112	2.1190	0.0341**
$usa1$	8.5620	2.9504	2.9020	0.0037***
$madr3$	13.2359	1.9916	6.6460	0.0000***
$sto4$	374.617	2.6741	140.093	0.0000***
$sto5$	-370.376	3.1991	-115.770	0.0000***
Equation 5 - dependent	variable: σ_i			
μ_5	0.4346	0.2144	2.0270	0.0427**
υ_i	-0.0025	0.0047	-0.5320	0.5949
q_i	0.0085	0.0246	0.3470	0.7286
s_i	0.0011	0.0004	2.8360	0.0046***
υs_i	-0.4939	0.4849	-1.0190	0.3084
β_i	-0.0177	0.0183	-0.9690	0.3327
ff_i	-0.0067	0.0648	-0.1030	0.9177
rk_i	-0.0008	0.0078	-0.0970	0.9228
roe_i	-0.0004	0.0004	-1.0370	0.2997
n_i	0.0168	0.0520	0.3230	0.7468
mf_i	0.1082	0.1752	0.6180	0.5368
mk_i	0.0021	0.0090	0.2320	0.8165
gdp_i	-0.0089	0.0115	-0.7770	0.4373
$PTT1_i$	0.2230	0.2152	1.0360	0.3000
$PTT2_i$	-0.0900	0.0799	-1.1260	0.2602
$PTT3_i$	-0.4059	0.2299	-1.7660	0.0775*
$sto4$	8.0570	0.1072	75.1850	0.0000***

Convergence achieved after 12 iterations

Log-likelihood $= -1934.51$

Log determinant of cross-equation covariances for residuals = 3.1639

* indicates statistical significance at the 10% level,

** indicates statistical significance at the 5% level,

*** indicates statistical significance at the 1% level.

bid-ask spread. The identification of the counterpart leads to a reduction of the information asymmetries that affect stock markets. We may argue that this is particularly appreciated by retail traders, who could be induced to trade more and to be more confident (trades increase and volatility decreases). Nevertheless, higher levels of transparency may be displeased by market makers who generally prefer to be anonymous as highlighted by Simaan, Weaver, and Whitcomb [2003].

Orders desegregation (PTT2) clearly contributes to the enhancement of market activity in terms of both liquidity and volatility. In particular, Equations 1 and 2 show that PTT2 positively affects the traded volume (v_i) and the orders (q_i), even if in the latter case the relationship has a statistical significance of 10.09%. Equation 4 highlights that orders desegregation has a positive effect on the intra-minute measure of volatility (m_i).

The number of price levels (PTT3) increases liquidity and reduces price volatility. Equation 3 shows that PTT3 negatively affects the bid-ask spread, whereas Equations 4 and 5, respectively, prove that it negatively influences both the intra-minute and the realized variance.

Moreover, our analysis shows that some endogenous inter-connections exist and they are sensitive measures as pointed out by Aitken and Comerton-Fords [2003]: on one hand, our innovative measure of liquidity (q_i) positively influences trading volumes (see Equation 1) and it decreases the bid-ask spread, as shown in Equation 3. This allows us to argue that this measure is an important driver of the trading activity, as proved also in Chordia, Roll, and Subrahrmanyam [2001].

On the other hand, our system shows a dynamic (causal) relationship between liquidity and volatility. Results differ for the liquidity/volatility measures. Equation 4 shows that a higher volume (v_i) increases the intra-minute volatility[5] (m_i). This is coherent with the contributions of Karpoff [1987] and Gallant, Rossi, and Tauchen [1992]. Besides, Equation 5 highlights that a lower (higher) bid-ask spread (s_i) reduces (increases) the realized variance. So, when liquidity is measured by the volume, it enhances the short-term measure of volatility (the intra-minute volatility); when it is expressed by the bid-ask spread, liquidity brakes volatility in terms of realized variance (σ_i).

Considering all the exogenous variables different from PTT indicators, the versus component of the current mood confirms the previous findings of Chordia, Roll, and Subrahmanyam [2001], who show a positive influence of the selling pressure upon the trading activity. This is witnessed by the negative relationship between versus (vs_i) and trading volume (v_i). Moreover, in Equation 4 we find that the selling pressure brings about higher intra-minute volatility. Our analysis also points out that the beta (β_i) of the stock positively affects the orders (q_i), while it has a negative effect upon the trading volume (v_i). This suggests that traders show interest for aggressive shares, when quoting (larger q_i), but they are more cautious when trading them (lower v_i).

The results about the share-specific features are coherent with the findings from the previous studies. We find that the real capitalization of a stock (rk_i) and its free-float rate (ff_i) increase the liquidity as in Wahal [1997]. On one hand, larger real capitalization produces higher volumes and more frequent orders; on the other hand, higher free-float rates induce larger orders. In fact, it is well known that large and public companies are often the target of traders, both retail and institutional (Barber and Odean [2007]). Moreover, we find that the ROE (roe_i) is negatively related to both volume and volatility. This result supports that volume is influenced by firm economic fundamentals (ROE, EBITDA, etc). In fact, Equation 1 provides evidence that in the case of a low ROE, investors could trade more aggressively thus also increasing volatility, as in Cohen, Ness, Okuda, Schwartz, and Whitcomb [1976].

The stock market variables reveal no relevant results in favor of the country features. In this case we confirm the findings of Engel and Rangel [2005], showing that the GDP fosters volatility, even if their research refers to a different time-horizon. In our analysis gdp_i reflects national peculiarities, and it reveals some U.S. stock exchange anomalies, in terms of short-term order intensity (q_i) and riskiness (m_i). Finally, Equation 3 shows the negative relationship between e_i and s_i: the electronic development of a country is assumed as a proxy of investors' attitude to use technological devices in the stock exchanges, and it is proved being a catalyst of liquidity, as in Shah and Thomas [2001].

CONCLUDING REMARKS

The key objective of this article is to investigate the dynamic relationships between the pre-trade transparency and the stock market quality through cross-country comparisons. Starting from the previous findings of

Lucarelli, Mazzoli, and Rothfeld [2007], our analysis basically consists of the application of a wide range of control variables used in the model. Specifically, we estimate a system of simultaneous equations in order to investigate how the PTT affects the traditional and innovative indicators of liquidity and price volatility.

Our work confirms the results of previous studies maintaining that PTT is a driver of liquidity and a brake upon price volatility. Our contribution enhances the existing findings by considering the three dimensions of PTT. PTT3, the order book depth, is the indicator showing the clearest effects, enhancing the liquidity, through a decrease in the bid-ask spread, and reducing both the intra-minute and the daily volatility. PTT2, the order desegregation, stimulates the market activity, through trades, quotes, and intra-minute volatility. This last relationship may be mainly due to an indirect effect of PTT2, because it is proved to influence the traded volume and the latter affects the intra-minute volatility. PTT1, the traders' identification, brings about a reduction of the intra-minute volatility and an increase of the trading volume on the one hand, while it enlarges the bid-ask spread on the other. These findings confirm that the microstructure of a stock exchange influences its market quality, in terms of liquidity and volatility. Thus, from the institutional point of view, pre-trade transparency can be customized by regulatory authorities to control both the liquidity and the price volatility of a stock exchange.

Further research will be addressed to enhancing our model exploiting the recent reshaping of the Italian PTT regulation, taking also the time-series framework into account.

APPENDIX 1

The Structural Model

$$\begin{bmatrix} 1 & \beta_{1,2} & \beta_{1,3} & \beta_{1,4} & \beta_{1,5} \\ \beta_{21} & 1 & \beta_{2,3} & \beta_{2,4} & \beta_{2,5} \\ \beta_{3,1} & \beta_{3,2} & 1 & \beta_{3,4} & \beta_{,35} \\ \beta_{4,1} & \beta_{4,2} & \beta_{4,3} & 1 & 0 \\ \beta_{5,1} & \beta_{5,2} & \beta_{5,3} & 0 & 1 \end{bmatrix} \begin{bmatrix} v_1 \\ q_i \\ s_i \\ m_i \\ \sigma_i \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \end{bmatrix}$$

$$+ \begin{bmatrix} \gamma_{1,1} & \gamma_{1,2} & \gamma_{1,3} & \gamma_{1,4} & \gamma_{1,5} & \gamma_{1,6} & \gamma_{1,7} & \gamma_{1,8} & \gamma_{1,9} & \gamma_{1,10} & \gamma_{1,11} \\ \gamma_{2,1} & \gamma_{2,2} & \gamma_{2,3} & \gamma_{2,4} & \gamma_{2,5} & \gamma_{2,6} & \gamma_{2,7} & \gamma_{2,8} & \gamma_{2,9} & \gamma_{2,10} & \gamma_{2,11} \\ 0 & 0 & 0 & 0 & 0 & \gamma_{3,6} & \gamma_{3,7} & \gamma_{3,8} & \gamma_{3,9} & \gamma_{3,10} & \gamma_{3,11} \\ \gamma_{4,1} & \gamma_{4,2} & \gamma_{4,3} & \gamma_{4,4} & \gamma_{4,5} & \gamma_{4,6} & \gamma_{4,7} & \gamma_{4,8} & 0 & 0 & \gamma_{4,11} \\ \gamma_{5,1} & \gamma_{5,2} & \gamma_{5,3} & \gamma_{5,4} & \gamma_{5,5} & \gamma_{5,6} & \gamma_{5,7} & \gamma_{5,8} & 0 & 0 & \gamma_{5,11} \end{bmatrix} \begin{bmatrix} vs_1 \\ \beta_i \\ ff_i \\ rk_i \\ roe_i \\ n_i \\ mf_i \\ mk_i \\ \rho_i \\ e_i \\ gdp_i \end{bmatrix}$$

$$+ \begin{bmatrix} \theta_{1,1} & \theta_{1,2} & \theta_{1,3} \\ \theta_{2,1} & \theta_{2,2} & \theta_{3,3} \\ \theta_{3,1} & \theta_{3,2} & \theta_{3,3} \end{bmatrix} \begin{bmatrix} PTT\ 1i \\ PTT\ 2i \\ PTT\ 3i \end{bmatrix} + \begin{bmatrix} 0 & \phi_{1,2} & 0 & \phi_{1,4} & 0 & \phi_{1,6} & 0 & 0 & \phi_{1,9} \\ 0 & 0 & 0 & 0 & \phi_{2,5} & 0 & 0 & 0 & \phi_{2,9} \\ \phi_{3,1} & 0 & \phi_{3,3} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \phi_{4,3} & \phi_{4,4} & 0 & 0 & \phi_{4,7} & \phi_{4,8} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \phi_{5,7} & 0 & 0 \end{bmatrix} \begin{bmatrix} lisb3 \\ lse11 \\ madr3 \\ mil11 \\ nas11 \\ sto11 \\ sto4 \\ sto5 \\ usa11 \end{bmatrix} + \varepsilon_i \quad (11)$$

APPENDIX 2

List of the Sample Shares

Stock Exchange	Company name	Symbol	t	v
Euronext Amsterdam	ABN AMRO HOLDING	AABA.AMS		x
Euronext Amsterdam	AEGON	AGN.AMS	x	x
Euronext Amsterdam	AHOLD KON.	AH.AMS	x	x
Euronext Amsterdam	ASML HOLDING	ASML.AMS	x	x
Euronext Amsterdam	HAGEMEYER	HGM.AMS		x
Euronext Amsterdam	ING GROEP CERTS.	INGA.AMS	x	x
Euronext Amsterdam	KPN KON	KPN.AMS		x
Euronext Amsterdam	PHILIPS ELTN.KON	PHIA.AMS	x	x
Euronext Amsterdam	ROYAL DUTCH SHELL A	RDSA.AMS	x	x
Euronext Amsterdam	REED ELSEVIER	REN.AMS	x	
Euronext Amsterdam	TNT	TNT.AMS	x	
Euronext Amsterdam	UNILEVER CERTS.	UNA.AMS		x
Euronext Amsterdam	VEDIOR	VDOR.AMS	x	
Euronext Amsterdam	WOLTERS KLUWER	WKL.AMS	x	
BORSAITALIA	AUTOGRILL	AGL.MIL	x	
BORSAITALIA	AUTOSTRADE	AUTO.MIL	x	
BORSAITALIA	ALITALIA	AZA.MIL	x	x
BORSAITALIA	BULGARI	BUL.MIL	x	
BORSAITALIA	CAPITALIA	CAP.MIL		x
BORSAITALIA	ENEL	ENEL.MIL		x
BORSAITALIA	ENI	ENI.MIL		x
BORSAITALIA	FIAT	F.MIL	x	x
BORSAITALIA	FASTWEB	FWB.MIL	x	
BORSAITALIA	MEDIOLANUM	MED.MIL	x	
BORSAITALIA	PIRELLI	PC.MIL		x
BORSAITALIA	SEAT PAGINE GIALLE	PG.MIL		x
BORSAITALIA	SAIPEM	SPM.MIL	x	
BORSAITALIA	STMICROELECTRONICS	STM.MIL	x	
BORSAITALIA	TELECOM ITALIA	TIT.MIL	x	x
BORSAITALIA	TERNA	TRN.MIL		x
Euronext Bruxelles	AGFA GEVAERT	AGFB.BRU	x	x
Euronext Bruxelles	BARCO NEW	BAR.BRU	x	
Euronext Bruxelles	BEKAERT	BEKB.BRU	x	
Euronext Bruxelles	BELGACOM	BELG.BRU	x	
Euronext Bruxelles	DELHAIZE	DELB.BRU	x	x
Euronext Bruxelles	DEXIA	DEXB.BRU		x
Euronext Bruxelles	FORTIS	FORB.BRU		x
Euronext Bruxelles	GBL NEW	GBLB.BRU	x	x
Euronext Bruxelles	KBC GROUPE	KBC.BRU	x	x
Euronext Bruxelles	MOBISTAR	MOBB.BRU	x	x
Euronext Bruxelles	OMEGA PHARMA	OME.BRU	x	x
Euronext Bruxelles	SOLVAY	SOLB.BRU	x	
Euronext Bruxelles	UCB	UCB.BRU	x	x
Euronext Bruxelles	UMICORE	UMI.BRU	x	x
Copenhagen Stock Exchange	BANG & OLUFSEN ‘B’	BOB.CPH	x	
Copenhagen Stock Exchange	CARLSBERG ‘B’	CARLB.CPH	x	x
Copenhagen Stock Exchange	COLOPLAST ‘B’	COLOB.CPH	x	

Appendix 2 (Continued)

Stock Exchange	Companyname	Symbol	t	v
Copenhagen Stock Exchange	DANSKEBANK	DANSKE.CPH		x
Copenhagen Stock Exchange	DANISCO	DCO.CPH	x	x
Copenhagen Stock Exchange	DSV 'B'	DSV.CPH	x	
Copenhagen Stock Exchange	OSTASIATISKE KOM	EAC.CPH	x	x
Copenhagen Stock Exchange	GN STORE NORD	GN.CPH	x	x
Copenhagen Stock Exchange	GROUP 4 SECURICOR	GR4SEC.CPH	x	x
Copenhagen Stock Exchange	LUNDBECK	LUN.CPH	x	
Copenhagen Stock Exchange	AP MOLLER MAERSK 'B'	MAERSKB.CPH	x	
Copenhagen Stock Exchange	NOVO NORDISK 'B'	NOVOB.CPH		x
Copenhagen Stock Exchange	TRYGVESTA	TRYG.CPH		x
Copenhagen Stock Exchange	VESTAS WIND SYSTEMS	VWS.CPH	x	x
Helsinki Stock Exchange	ELISA	ELI1V.HEL	x	x
Helsinki Stock Exchange	ELCOTEQ SE	ELQAV.HEL	x	
Helsinki Stock Exchange	METSO	MEO1V.HEL	x	x
Helsinki Stock Exchange	M REAL 'B'	MRLBV.HEL	x	x
Helsinki Stock Exchange	NOKIA	NOK1V.HEL	x	x
Helsinki Stock Exchange	OUTOKUMPU 'A'	OTE1V.HEL	x	x
Helsinki Stock Exchange	PERLOS	POS1V.HEL	x	x
Helsinki Stock Exchange	SAMPO 'A'	SAMAS.HEL	x	x
Helsinki Stock Exchange	STORA ENSO 'R'	STERV.HEL	x	x
Helsinki Stock Exchange	TIETOENATOR	TIE1V.HEL	x	x
Helsinki Stock Exchange	UPM KYMMENE	UPM1V.HEL	x	x
Euronext Lisbon	BANCO ESPR.SANTO	BES.LIS		x
Euronext Lisbon	BANIF 'R'	BNF.LIS	x	
Euronext Lisbon	BANCO BPI	BPI.LIS		x
Euronext Lisbon	BRISA AUTO ESTRADAS PRIV	BRI.LIS	x	x
Euronext Lisbon	COFINA	CFN.LIS	x	
Euronext Lisbon	CIMPOR	CPR.LIS		x
Euronext Lisbon	MOTA ENGIL SGPS	EGL.LIS	x	x
Euronext Lisbon	IMPRESA SGPS	IPR.LIS	x	x
Euronext Lisbon	NOVABASE	NBA.LIS	x	
Euronext Lisbon	PARAREDE	PAD.LIS	x	x
Euronext Lisbon	PORTUGAL TELECOM SGPS	PTC.LIS	x	x
Euronext Lisbon	PORTUCEL EMPRESA	PTI.LIS		x
Euronext Lisbon	SOARES DA COSTA	SCOAE.LIS	x	x
Euronext Lisbon	SEMAPA	SEM.LIS	x	
Euronext Lisbon	SONAE SGPS	SON.LIS	x	x
London Stock Exchange	ANTOFAGASTA	ANTO.LSE	x	
London Stock Exchange	BARCLAYS	BARC.LSE		x
London Stock Exchange	BRITISH ENERGY	BGY.LSE	x	
London Stock Exchange	BP	BP.LSE		x
London Stock Exchange	BRITISH SKY BCAST	BSY.LSE	x	
London Stock Exchange	BT GROUP	BT.A.LSE		x
London Stock Exchange	MAN GROUP	EMG.LSE	x	
London Stock Exchange	HOME RETAIL GROUP	HOME.LSE	x	
London Stock Exchange	HSBCHDG.	HSBA.LSE		x
London Stock Exchange	ITV	ITV.LSE		x
London Stock Exchange	KAZAKHMYS	KAZ.LSE	x	
London Stock Exchange	LEGAL & GENERAL	LGEN.LSE		x
London Stock Exchange	LLOYDS TSB GROUP	LLOY.LSE		x

APPENDIX 2 *(Continued)*

Stock Exchange	Company name	Symbol	t	v
London Stock Exchange	NEXT	NXT.LSE	x	
London Stock Exchange	OLD MUTUAL	OML.LSE		x
London Stock Exchange	TESCO	TSCO.LSE		x
London Stock Exchange	VEDANTA RESOURCES	VED.LSE	x	
London Stock Exchange	VODAFONE GROUP	VOD.LSE		x
London Stock Exchange	XSTRATA	XTA.LSE	x	
Madrid Stock Exchange	AVANZIT	AVZ.MAD	x	x
Madrid Stock Exchange	BBV ARGENTARIA	BBVA.MAD		x
Madrid Stock Exchange	INBESOS	BES.MAD	x	
Madrid Stock Exchange	PULEVA BIOTECH	BIO.MAD	x	
Madrid Stock Exchange	GRUPO INMOCARAL	CAR.MAD	x	
Madrid Stock Exchange	ERCROS	ECR.MAD	x	x
Madrid Stock Exchange	ENDESA	ELE.MAD		x
Madrid Stock Exchange	IBERIA	IBLA.MAD		x
Madrid Stock Exchange	JAZZTEL	JAZ.MAD	x	x
Madrid Stock Exchange	CORP.MAPFRE ‘R’	MAP.MAD	x	
Madrid Stock Exchange	DURO FELGUERA	MDF.MAD	x	
Madrid Stock Exchange	BANCO POPULAR ESPANOL	POP.MAD		x
Madrid Stock Exchange	REPSOL YPF	REP.MAD		x
Madrid Stock Exchange	SNIACE	SNC.MAD	x	
Madrid Stock Exchange	SERVICE POINT SOLUTIONS	SPS.MAD	x	
Madrid Stock Exchange	TELEFONICA	TEF.MAD		x
Madrid Stock Exchange	TABLEROS DE FIBRAS	TFI.MAD	x	
Madrid Stock Exchange	BNC.SANTANDER CTL.HISP.	XSBP.MAD		x
NASDAQ	APPLE COMPUTER	AAPL	x	x
NASDAQ	APPLIED MATS.	AMAT		x
NASDAQ	BROADCOM ‘A’	BRCM	x	
NASDAQ	CHECKFREE	CKFR	x	
NASDAQ	CISCO SYSTEMS	CSCO		x
NASDAQ	DELL	DELL		x
NASDAQ	EBAY	EBAY		x
NASDAQ	GOOGLE ‘A’	GOOG	x	
NASDAQ	INTEL	INTC		x
NASDAQ	INTUITIVE SURGICAL	ISRG	x	
NASDAQ	MARVELL TECH. GROUP	MRVL	x	
NASDAQ	MICROSOFT	MSFT		x
NASDAQ	NVIDIA	NVDA	x	
NASDAQ	ORACLE	ORCL		x
NASDAQ	RESEARCH IN MOTION	RIMM	x	
NASDAQ	SEPRACOR	SEPR	x	
NASDAQ	SIRIUS SATELLITE RADIO	SIRI		x
NASDAQ	SANDISK	SNDK	x	
NASDAQ	SUN MICRO SYSTEMS	SUNW		x
NASDAQ	YAHOO	YHOO		x
NYSE	ADVANCED MICRO DEVC.	AMD		x
NYSE	BIG LOTS	BIG	x	
NYSE	BO WATER	BOW	x	
NYSE	CLEVELAND CLIFFS	CLF	x	
NYSE	DIAMOND OFFS.DRL.	DO	x	
NYSE	FURNITURE BRANDS INTL.	FBN	x	

APPENDIX 2 *(Continued)*

Stock Exchange	Company name	Symbol	t	v
NYSE	GENERAL ELECTRIC	GE		x
NYSE	GAME STOP	GME	x	
NYSE	MOTOROLA	MOT		x
NYSE	MEDICIS PHARMS.'A'	MRX	x	
NYSE	NCI BUILDING SYS.	NCS	x	
NYSE	NORTEL NETWORKS	NT		x
NYSE	PFIZER	PFE		x
NYSE	RYERSON	RYI	x	
NYSE	SPRINT NEXTEL	S		x
NYSE	AT&T	T		x
NYSE	TITANIUM METALS	TIE	x	
NYSE	TIME WARNER	TWX		x
NYSE	EXXON MOBIL	XOM		x
Euronext Paris	ACCOR	AC.PAR	x	
Euronext Paris	CREDIT AGRICOLE	ACA.PAR		x
Euronext Paris	ALSTOM	ALO.PAR	x	
Euronext Paris	BNP PARIBAS	BNP.PAR		x
Euronext Paris	CAP GEMINI	CAP.PAR	x	
Euronext Paris	AXA	CS.PAR		x
Euronext Paris	EADS	EAD.PAR	x	x
Euronext Paris	TOTAL	FP.PAR		x
Euronext Paris	FRANCE TELECOM	FTE.PAR		x
Euronext Paris	MICHELIN	ML.PAR	x	
Euronext Paris	PPR	PP.PAR	x	
Euronext Paris	RENAULT	RNO.PAR	x	
Euronext Paris	SANOFI AVENTIS	SAN.PAR		x
Euronext Paris	STMICROELECTRONICS	STM.PAR	x	x
Euronext Paris	SUEZ	SZE.PAR		x
Euronext Paris	THOMSON	TMS.PAR	x	
Euronext Paris	PEUGEOT	UG.PAR	x	
Euronext Paris	VIVENDI	VIV.PAR		x
Stockholm Stock Exchange	ABB (OME)	ABB.STO		x
Stockholm Stock Exchange	ASSA ABLOY 'B'	ASSAB.STO	x	
Stockholm Stock Exchange	ATLAS COPCO 'A'	ATCOA.STO	x	x
Stockholm Stock Exchange	BOLIDEN	BOL.STO	x	x
Stockholm Stock Exchange	ELECTROLUX 'B'	ELUXB.STO	x	
Stockholm Stock Exchange	ENIRO	ENRO.STO	x	
Stockholm Stock Exchange	ERICSSON 'B'	ERICB.STO		x
Stockholm Stock Exchange	HENNES & MAURITZ 'B'	HMB.STO		x
Stockholm Stock Exchange	SANDVIK	SAND.STO	x	x
Stockholm Stock Exchange	SECURITAS 'B'	SECUB.STO	x	x
Stockholm Stock Exchange	TELE2 'B'	TEL2B.STO	x	x
Stockholm Stock Exchange	TELIASONERA	T LSN.STO x		x
Stockholm Stock Exchange	VOLVO 'B'	VOLVB.STO	x	
Toronto Stock Exchange	ABITIBI CONSOLIDATED	A.CAT	x	
Toronto Stock Exchange	BARRICK GOLD	ABX.CAT		x
Toronto Stock Exchange	ACE AVTN.HDG.'B' VTG.	ACE.B.CAT	x	
Toronto Stock Exchange	ALGOMA STL.	AGA.CAT	x	
Toronto Stock Exchange	BOMBARDIER 'B'	BBD.B.CAT		x
Toronto Stock Exchange	ENCANA	ECA.CAT		x

APPENDIX 2 *(Continued)*

Stock Exchange	Company name	Symbol	t	v
Toronto Stock Exchange	ELDORADO GOLD	ELD.CAT		x
Toronto Stock Exchange	GOLDCORP	G.CAT	x	x
Toronto Stock Exchange	HUDBAY MINERALS	HBM.CAT	x	
Toronto Stock Exchange	NOVA CHEMS.	NCX.CAT	x	
Toronto Stock Exchange	NORTEL NETWORKS	NT.CAT		x
Toronto Stock Exchange	SILVER WHEATON	SLW.CAT	x	
Toronto Stock Exchange	TALISMAN EN.	TLM.CAT		x
Toronto Stock Exchange	UTS ENERGY	UTS.CAT		x
Toronto Stock Exchange	YAMANA GOLD	YRI.CAT	x	
XETRA	ADIDAS	ADS.ETR	x	
XETRA	ALTANA	ALT.ETR	x	
XETRA	ALLIANZ	ALV.ETR		x
XETRA	BAYER	BAY.ETR		x
XETRA	COMMERZBANK	CBK.ETR		x
XETRA	DEUTSCHE BANK	DBK.ETR		x
XETRA	DAIMLERCHRYSLER	DCX.ETR		x
XETRA	DEUTSCHE POST	DPW.ETR		x
XETRA	DEUTSCHE TELEKOM	DTE.ETR	x	x
XETRA	LINDE	LIN.ETR	x	
XETRA	MAN	MAN.ETR	x	
XETRA	METRO	MEO.ETR	x	
XETRA	MUENCHENER RUCK.	MUV2.ETR	x	
XETRA	SIEMENS	SIE.ETR		x
XETRA	THYSSENKRUPP	TKA.ETR	x	x
XETRA	TUI	TUI1.ETR	x	x
XETRA	VOLKSWAGEN	VOW.ETR	x	

Tickers:

t - turnover sampled shares.

v - volume sampled shares.

ENDNOTES

The authors are grateful to the participants in the Liquidity Session of the MFA 2008, San Antonio - Texas, for comments received. In particular, we are grateful to Melanie Cao (York University) for her advice provided as discussant.

[1]Source for the data: Thompson DataStream.

[2]For the North American markets we are forced to select just a few hours of the day, as they are featured by a higher level of ticks; in particular, we sample data starting from 9:30 AM, 12:00 PM, and 3:00 PM, downloading the maximum amount of data Realtick® that DDE memory can bear. This way, even if the data sheet is not able to contain all the data for the day, we are able to observe differences between the markets at specific time points.

[3]See Lucarelli, Mazzoli, and Rothfeld [2007].

[4]All these estimates are available upon request from the authors.

[5]In this case, even if the p-value is 10.98% we do not reject this relationship.

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