Exchange Traded Barrier Option and Volume-Synchronized Probability of Informed Trading: Evidence from Hong Kong

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Abstract

We study the validity of the *Volume-Synchronized Probability of Informed Trading* (VPIN) metric to measure the order toxicity around the mandatory call event of Callable Bull/Bear Contract (CBBC). The high VPIN around mandatory call events indicate that large volume imbalance exists and it predict the high risk in the market. This study provides evidences that the first direct evidence of application of VPIN outside the US market.

Key words: Order toxicity, Volume-Synchronized Probability of Informed Trading, Callable Bull/Bear Contract, Mandatory Call Event

1. Introduction

Understanding of trading behavior of high frequency financial markets has become increasingly important. In despite of repeated episodes of liquidity events, such as the Flash Crash of May 6, 2010, our understanding of risks associated with liquidity provision is still very limited. One of many reasons is the lack of appropriate measures of risks of liquidity provision in a high frequency setting. Recent studies (Easley et al., 2011 2012a, 2012b) develop a measure of this risks, the Volume-Synchronized Probability of Informed Trading (VPIN) metric based on a model of time-varying arrival rate of informed and uninformed traders (Easley, Engle, O'Hara and Wu, 2008). Andersen and Bondarenko (2013), however, dispute Easley et al. empirical findings and question the validity of measuring order toxicity by VPIN.[1] Most of these studies examine the validity of VPIN around specific events like the Flash Crash. In this paper, we use a unique dataset of exchange-traded callable contracts in HK and investigate the validity of VPIN as a measure of order toxicity.

Hong Kong Stock Exchange (HKSE) launched callable bull/bear contract (CBBC) product since June 12th, 2006. CBBC consist of Callable Bull Contract (BULL) and Callable Bear Contract (BEAR)[2] is a structured derivative product which mostly issued by investment banks. The CBBC must be terminated immediately at any time prior to expiry if the underlying asset's price reaches the call price. CBBC is similar to exchange-traded contracts, with a barrier price that if touched, will trigger the

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[1] Easley et al (2013) further the debate in their logic behind the VPIN metric.

[2] A Bull contract is similar to a call warrant with underlying stock price *S*, maturity date *T*, strike price *X*, and barrier *H*, where $S > H \geq X$. If the contract is not called back before time *T*, it matures with a payoff of $S_T - X$. But if the underlying stock price decreases so that S_t = H for any $t < T$, then it triggers the MCE at time *t*. The contract is then settled with a residual value equals max[$M - X$, 0], where *M* is the settlement price, which is the lowest price of the underlying stock price until the end of the *next* trading session after the MCE. The Bear contract is defined as the opposite manner.

Mandatory Call Event (MCE) such that the issue would terminate immediately. The MCE may have large impact to underlying stocks, due to the sheer amount of related shares and hedged positions that has to be re-winded in a short period of time. Therefore, it is interesting to explore whether CBBC related events such as the MCE, issuance and expiration matters, and how they affect the informed trading activities in the stock market.

The MCEs of CBBCs can be valid experiments to test the validity of VPIN. Firstly, when the underlying stock price is close enough to the barrier price, information of the stock price are no longer the major factor that drives the stock price. The issuers of CBBCs can secure their profits by knocking-out these CBBCs prior to the expiry, so they have the incentives to trade the underlying stock until the price hitting the barrier. Speculators in the market may also observe the barrier prices of CBBCs and trade to the barrier. This barrier price creates a magnet effect as discuss in Cho et al. (2003) and Lei (2013), and during this period, the incentives of speculation are larger than trading with information. Furthermore, the timing of MCE is unknown, and this can occur anytime within the continuous trading session. Thus, we expect that there are higher risks of liquidity provision around the MCE, that is, higher order flow toxicity as measured by VPIN.

The exchange-traded barrier options have become very popular in Hong Kong and around the world[3]. During 2006-2010, there are 19,318 CBBCs are issued, with a total issued amount of HKD 1,358 billion (approx. USD 174 billion). The recent amount of CBBC issuance exceeds that of the exchange-traded derivative warrants.

[3] Hong Kong is one of the first countries to launch exchange-trading of CBBCs in 2006, followed by Taiwan, which launched them on 8 July 2011 with trading rapidly increasing. Similar products have been traded off-market in the UK, Germany, Australia, New Zealand, Switzerland, Italy, Korea and Singapore.

The market turnover of CBBCs as a percentage of the total market in 2009 reached 10.86%, which surpassed the 10.72% of DWs. The monthly market share of CBBCs and DWs constitutes about 25% of the total market turnover throughout the 2006-2010. The success of CBBCs provides a unique opportunity to explore order flow toxicity around the MCE.

We find that the order toxicity significantly increase at the moment that triggers the MCE. The toxicity continues to increase for a short period of time after the MCE, and then returns to normal level eventually. The results are consistent when we separate CBBCs to Bull and Bear Contracts, and also with a various sets of parameters for VPIN. Besides, our analysis also shows that there are substantial amount of uninformed trading activities around the day of MCE, suggesting speculation related to the underlying assets. This study provides evidences that the VPIN is a valid measure the order toxicity and CBBC can influence the informed trading of the underlying asset.

We contribute to the literature in the following ways. Different from prior studies that use Flash Crash of the US as the main event, we validate the application of VPIN using the unique settings of CBBC listed in HK stock market. Our analysis suggests that VPIN can be calculated continually to measure market order toxicity. We show that the measure could be useful in much smaller events compared to the Flash Crash. Also, VPIN can be applied to the intraday settings and detect trading imbalances in shorter duration compared to PIN[4]. We also reveal that there are speculation activities

[4] Even though it seems plausible to put PIN in an intraday setting, the large amount of non-convergence in the estimations render high-frequency trading analysis with PIN infeasible.

around CBBC MCE. Our evidences will contribute to the literature of price discovery process related to exchange-trade options.

The most related paper is Lei (2013), he finds substantial amount of price reversal after MCEs in intraday results and also significant abnormal trading volumes of the underlying assets surrounding the CBBCs events. However, the abnormal trading volumes in that paper may not be able to identify risk of liquidity provision, since volumes only capture increase in trading activities but not trading imbalances.

This paper is organized as follows. The next section briefly reviews the previous evidences of PIN and relative developments about the impact of derivatives, and our hypothesis. Section 3 describes the PIN (Easley et al, 1996) and VPIN (Easley et al, 2012) methods which measure the risk brought along by the informed traders. Section 4 describes the data we used and the required data processing in this paper and discusses the model to test the hypotheses. Section 5 discusses the results. Finally, we summarize our findings in Section 6.

2. Literature Review and hypothesis

One of the most influential models to measure PIN is built by Easley, Kiefer, O'Hara and Paperman (1996)[5] (EKOP hereafter) which has been expanded by Easley, Hvidkjaer and O'Hara (2002) and Easley et al (2008). EKOP model needs only daily buy orders and sell orders which are sufficient in the most likelihood equations to

[5] Researchers normally think Easley et al (1996) established the theoretical foundations of PIN. Such as Tay, Ting, Tse and Warachke (2009) , Yan and Zhang (2012), etc.

estimate the parameter vector using. The PIN then can be derived by the parameter vector. Some literatures also build other models to estimate the PIN. For example, Nyholm (2002) develop a model based on trade-indicator regression framework (e.g. Glosten 1987; Easley and O'Hara 1987; Huang and Stoll 1997) to analysis the trading activities. Tay, Ting, Tse and Warachke (2009) estimates the PIN use the ratio of informed trades to the total trades applying transaction durations. Easley, de Prado and O'Hara (2012) use Volume-Synchronized Probability of Informed Trading (VPIN) to enhances the explain power in a high frequency world. Though they calculate PIN in different methods, they still have something in common. All the methods need securities' trading data to deduce the informed trading. Thus, PIN cannot be estimated directly, but still can be worked out using mathematic or technical means.

In prior literatures, the effect of derivatives has been widely studied. Though CBBC has not been researched directly, similar literatures are also significant. Lots of papers document the price effect and volatility effect of derivatives. Conrad (1989) finds that optioned stock have a permanent price enhance. Ni, Pearson and Poteshman (2005) document that option trading changes the prices of underlying stocks. Additionally, some literatures also explore the effect around the derivatives' issuance and expiration. Detemple and Jorion (1990), Bansal, Pruitt and Wei(1989) find a positive price effect when option issuing. However, the result conflicts when study option expiration. Studies such as Bhattacharya (1987) and Pope and Yadav (1992) document the negative effect when option expires. Other literatures, such as Klemkosky (1978) and

Cinar and Vu (1987) have not found any single change in abnormal price and abnormal return. These literatures show that derivatives have impacts on underlying stocks.

Above studies, though examine the derivatives' impact, the effect of CBBC on the market haven't been studied. Also, few literatures show how derivatives' trading activity can influence the informed traders. Chan and Wei (2001) document that hedging effect created by the merchant banks can lead to buying pressure. However, it is unclear that how the effect can influence informed traders or uninformed traders or both. The role of informed traders and uninformed traders is a bone of contention. Some literatures suggest that price moving is induced by informed traders who hold the private information and uninformed traders are liquidity traders (such as Easley et al, 1996, 2008, 2012, Nyholm, 2002, Romer, 1993). And other papers argue that uninformed traders can also cause price movement and investors bear "noise trader risk" (such as Sias et al, 2001 and De Long et al 1990). Cutler et al (1989) suggest that uniformed traders are purely trend-followers with extrapolative expectations. Delong et al (1990) define the noise traders' demand as a function of sentiment, fads, social trends and other random variables. This paper, therefore, tries to fill the gaps using intraday trading data to track the trading behavior closely. We focus on the CBBC traded in Hong Kong to try to find evidence that how CBBC can influence the investors' trading behavior in market.

This article studies the probability of informed trading around CBBC activities such as issuance, expiration and MCE. PIN is significant low around issuance and MCE. However, it does not necessarily mean the risk for small or individual investors is lower because PIN measures the interaction between the whole arrival rate of informed traders and uninformed traders. Traders come from small investors make up only a small portion of the trades in the market. Small investors are vulnerable group compared with other large market powers in the market. Therefore, we further investigate the risk for investors after issue the CBBC using VPIN metric In this paper.

2.1. Hypothesis

Solt et al (1988) and De Bondt (1993) find that retail stock speculators trade based with extrapolative expectations which are mainly based on the past returns, and they exhibit to be tendency followers. Speculators may ask for a higher return if the market is not satisfactory. Many orders caused by the retail speculators come into the market with the same price direction would increase the volume imbalance and trigger the Mandatory Call Event. Informed traders who achieve the information that speculator would enter into the market could also enter into the market expecting make a positive profit. This situation would enlarge the volatility and makes the market more risky. We can observe this change in intra-day level using VPIN metric and predict the short-term risk in the market as VPIN is calculated based on the volume imbalance.

We conjecture that VPIN is higher around MCE.

H1: VPIN is higher around the MCE.

3. VPIN

3.1 *Volume-Synchronized Probability of Informed Trading* (VPIN)

Based on volume imbalance and trading intensity, Easley et al (2012) produce VPIN method to overcome the drawbacks met in high frequency market applying PIN. This volume-based method fits the high frequency market well and can update in volume-time rather than clock time. This change makes the investor access to market information more efficiently and timely.

Instead of looking at the number of buy and sell orders, VPIN method pay close attention to the trade volume. This method wants to explore the information from the trade intensity caused by informed or uninformed traders. VPIN measures the volume imbalance and predicts the short-term risk such as high volatility or large price changes.

To apply VPIN method, we should exogenously define the equal volume buckets with size V. Then put the sequential trades into these buckets. If the volume is larger than the bucket size V, then put the extra volume into the next bucket until all the volume has categorized. At last, we discard the last bucket if its volume is less than V. One of the most important issues is how to classify the volume into buy initiated or sell initiated. We will discuss this issue in section 5.

After above preparation, VPIN can calculate as

$$\text{VPIN} = \frac{\sum_{\tau=1}^{n} |V_\tau^S - V_\tau^B|}{nV} \qquad (8)$$

Where $\tau = 1, \ldots n$ is the index of equal volume buckets; V is the size for each bucket; V_τ^S and V_τ^B is the buy initiated volume in bucket τ and $V_\tau^S + V_\tau^B = V$.

Easley et al (2008, 2012) demonstrate the consistency between PIN and VPIN. Easley et al (2008) show that the expected trade imbalance is $\text{E}[|V_\tau^S - V_\tau^B|] \approx \alpha\mu$ and expected arrival rate of total trades is $\text{E}[V_\tau^S + V_\tau^S] = V$. VPIN is the average trade imbalance over *n* buckets.

So, $\text{VPIN} = \frac{\alpha\mu}{\alpha\mu+2\varepsilon} = \frac{\alpha\mu}{\text{V}} = \frac{\sum_{\tau=1}^{n}|V_\tau^S - V_\tau^B|}{nV}$

We need to choose the amount of volume V in each bucket and the number of buckets n to calculate the VPIN[6]. Following Easley et al (2012), we choose V as one-fiftieth of the average daily volume and n=50. Thus average one day volume can estimate a

6 For more about how to calculate VPIN, Please see appendix I

daily VPIN. When bucket 51 is filled, we could drop bucket 1 and calculate a new VPIN using bucket 2 to bucket 51. We can find that updating the VPIN using volume-time is more convenient than clock time and can detect the information more efficient and accurate by observe the volume arrival velocity. Easley et al (2012), also demonstrate the stability of a wide selection of V and n.

3.2 Applicability in order-driven systems

Prior studies focus on the quote-driven markets where market makers provide bid-ask prices in the market to supply liquidity such as the New York Stock Exchange (NYSE). Investors submit their orders based on market makers' bid-bid price. Easley et al (1996, 2012) develop their PIN and VPIN metric based on the mechanism in quote-driven market. However, bid-ask spread is not unique in quote-driven market (Brockman and Chung, 1999; Huang, 2004, Ahn et al, 2002). There are similarities between order-driven market making and quote-driven market marking. There are no market makers in order-driven market. However, order-driven system could be viewed as a platform where all traders in order-driven market supply the liquidity by submit their orders. Spread is determined by the difference of price between the lowest sell order and highest buy order. In this sense, the PIN and VPIN metric is also valid in order-driven market. Some literatures have studied the probability of informed trading in order-driven market, such as Ma et al, 2001. In this paper, we would like to further study the probability of informed trading using both PIN and

VPIN metric to test the market behavior when Callable Bull/Bear Contracts exist and measure the risk after around Callable Bull/Bear Contracts MCE.

4. Data and methodology

4.1 Data

The intraday data used in this paper come from the trade record of HKSE. We choose all the CBBC exist during January, 2008 to September 30, 2009. We keep only the CBBC whose underlying assets are stocks. Then, 3136 CBBC and 36 underlying stocks[7] satisfy our criteria.

4.1.2 Data processing

In a high frequency market, Easley et al (2011) argue that, information can be arise for a number of reasons such as stock returns or elements related to systemic or portfolio-based effect. This broader definition indicates information event may happen during the day. In this sense, we try to adjust the EKOP model established by Easley et al (1996) to make the PIN estimators more suitable for investors to deal with high frequency trading. By subdividing the daily trading and derive a PIN estimator every day for each stocks, it can greatly relieve the timeliness problem and can be

[7] There 3136 CBBC exist during January 1, 2008 to September 30, 2009, see Table 1

easily analyzed with other daily variables.

We keep all the assumptions in the standard PIN approach but make some adjustments. We subdivide every trading day into several intraday periods, each contains trades for ten minutes.[8] Instead of assuming that information events take place at the beginning of the trading day, we assume the events will occur before each time period. Using the buy and sell orders in each period and put them into equation (6), we can get the daily PIN estimators for each stocks by equation (7). We estimate daily PIN for all the 36 underlying stocks. We expect to find some empirical results to examine the hypotheses.

Easley et al (1996) document that all trades occurring within five seconds of each other at the same time and no intervening quote revision should collapse into one trade. We use volume-based average price and quotes for the trades occurring at the same second but different in price or quotes.

To estimate the daily PIN, we need the buy orders and sell orders for each intraday period. We apply Lee and Read (1991) method[9] to classify the buy orders and sell orders. Two tests are used in their method, thus, Quote Test and Tick Test. When using Quote Test, orders are classified in buys if trading price is higher than the midpoint of

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[8] Also, we have tried five minutes or other time buckets. Finally we choose ten minutes as it can guarantee the orders in each bucket are not too small.

[9] Lee and Read (1991) and Easley (1996) mention this method may misclassifies some trades. But it is a standard that can works reasonably well.

current bid-ask quotes. If the trading price is below the midpoint, we classify it in sells. We use Tick Test if Quote Test fails as trading price may equal with the midpoint. If trading price is higher than last trading price, it is classified as buys. If trading price is lower than last trading price, it is classified as sells. If they are equal, we compare the trading price with additional price lags until we classify all the trades. Follow Lee and Read (1991)'s suggestion, we apply the 5-second rule to match the time between quotes and trades. Thus, bid-ask quotes should have existed five seconds when used. We can derive the parameter vectors and daily PIN using the number of buy orders and sell orders in each buckets. We also apply the filters introduced by Brown, Hillegeist and Lo (2004) to eliminate the extreme parameter estimates. (1) if $50\varepsilon > \mu$ or $50\mu > \varepsilon$ (2)if $\alpha < 0.02$ or $\alpha > 0.98$ $(3) if\ \delta < 0.02\ or\ \delta > 0.98 \quad and\ \ (4) if\ min(\varepsilon, \mu) < 1$

Bulk classification (Easley et al, 2012) is used to classify buy initiated or sell initiated volume in each bucket when calculate VPIN. Bulk classification needs to gather the traders in an interval (for example, one minute bars), then classify buy or sell volume using standardized price change between the beginning and the end of the interval. Let

$$V_\tau^B = \sum_{i=t(\tau-1)+1}^{t(\tau)} V_i \cdot Z(\frac{P_i - P_{i-1}}{\sigma_{\Delta P}})$$

$$V_\tau^S = \sum_{i=t(\tau-1)+1}^{t(\tau)} V_i \cdot \left[1 - Z(\frac{P_i - P_{i-1}}{\sigma_{\Delta P}})\right] = V - V_\tau^B$$

Where $t(\tau)$ is the last time bar in the τ volume bucket, Z is the cumulative distribution function (CDF) of the standard normal distribution, and $\sigma_{\Delta P}$ is the estimate of the standard derivation of price changes between time bars. Then volume imbalance in bucket τ is $|V_{\tau}^{B} - V_{\tau}^{S}|$. If price does not change during the bucket, then volume is equally split and volume imbalance equal to zero.

After classifying the buy or sell volumes in every buckets, we can estimate a VPIN every moving *n* buckets (50 buckets for example) as described in equation 8. VPIN is use to perform a deeper analysis on the impact of market around the exact time at which CBBC is called back.

4.2 Methodology

Following regression is used to test CBBC's impact on the probability of informed trading.

$$\mathrm{PIN} = \alpha + \beta_1\mathrm{Bull} + \beta_2\mathrm{Bear} + \beta_3\mathrm{Bullevent}_i + \beta_4\mathrm{Bearevent}_i + \beta_5\mathrm{Bullexistevent}_i + \beta_6\mathrm{Bearexistevent}_i + \beta_7\mathrm{Spread} + \beta_6\mathrm{Volume} + \mathrm{error}$$

where Bull, Bear are the number of Callable Bull contracts and the number of Callable Bear Contracts, respectively; Spread is the percentage spread and Volume is the daily volume which take the natural logarithm.

We study whether the CBBC quantity can influence the probability of informed trading. We then further focus on the effect associated with events of CBBC issuance, expiration and MCE on the PIN. In the regression, Bullevent contains three conditions, thus, Callable Bull Contract issuance, expiration and MCE. Bearevent also contain Callable Bear Contract issuance, expiration and MCE. Bullexistevent and Bearexistevent are dummy variables which equal to 1 if any condition happens while bull or bear exist. Spread and Volume are control variables.

Percentage spread is calculated using the method documented in McInish and Wood (1992). First, we calculate percentage spread for each quotation i occurs at time t.

$$\mathrm{SPREAD}_{i,t} = \frac{Ask_{i,t} - Bid_{i,t}}{(Ask_{i,t} + Bid_{i,t})/2}$$

Where $Ask_{i,t}$ and $Bid_{i,t}$ are ask and bid price at time t. Then, we can use a time-weighted method to aggregate the percentage spread to get the daily percentage spread.

$$\mathrm{SPREAD} = \sum_{i=1}^{I} \frac{D_i}{T} SPREAD_{i,t}$$

Where D_i represent the duration of quotation i in seconds. T and I is the total number of seconds and total number of quotations for any trading day, respectively.

We conjecture that CBBC MCE or other event could have a longer time effect on the investor behavior because of information leakage effect and information effect. So, we observe the PIN, arrival rate of informed traders and arrival rate of uninformed traders during the estimation window [-15, 15] for each CBBC and compare it with their average level in 30 days before and 30 days ([-30, 30]) after the event such as issuance, expiration and MCE. Thus, we can get a close look at the change around the events. We can also study whether arrival rate of informed or uninformed trades change during the estimation window.

This paper further investigates the VPIN to study the risk around CBBC MCE. We calculate VPIN using bulk classification of one-minute bars. The amount of volume V in each bucket is one-fiftieth of the average daily volume and each moving 50 buckets can calculate a VPIN. We also present the VPIN calculated by different bucket volume V and different number of bucket n. By studying VPIN around the moment CBBC callback, we could find any change or fluctuation in intra-day level. This help to analyze the investors' behavior before and after the CBBC callback.

5. Result and analysis

5.1 Summary statistic

Table 1 shows that 1656 Bulls and 1474 Bears are issued for 36 underlying stocks during January, 2008 to September 30, 2009. 907 Bulls and 1028 Bears are called back and 227 Bulls and 143 Bears expired during this period. The number of CBBC call back is much more than the CBBC expiration. It indicates that most CBBC is call back before expiration. It is interesting to find that though the number of bear issuance is less than the bull issuance, the number of bear MCE is larger than bull MCE. It shows Bear is much vulnerable to call back after issue. The possible reason is that company will take actions to prevent their stock price dropping if their stock stays in a low price and release favorable information to spur the share price to rise. If informed traders achieve this favorable information, they will buy the shares and push up the price which could trigger the Mandatory Call Event.

[Table 1 about here]

Table 2 presents the summary statistic related with PIN and VPIN. Panel A reports the summary statistic of the parameter estimates in EKOP model along with the summary of percentage spread and daily volume. After data filtering, 11184 observations are valid in our sample. The mean probability of events happening (α) is 0.3227. We can also note that the probability of the event being bad news (δ) is 0.4779 which indicates there will be almost an equal chance of bad news or good news occurs. The arrival rate of informed trade (μ) and arrival rate of uninformed traders (ε) are 41.46 and 31.45 respectively. As show in equation (7), PIN can be calculated by the parameter estimates. The mean of the daily PIN is 0.1642 and the minimum daily PIN is 0.042 while the maximum daily PIN is 0.4850.

[Table 2 about here]

As described in Section 3, we define bucket volume as one-fiftieth of the average daily volume and each moving 50 buckets can calculate one VPIN. Table 2 Panel B reports the summary statistic of VPIN and describes the detail bucket information. We can find some consistency between volume-time and clock-time. Bucket duration 4.88 minutes is about one-fiftieth of the average VPIN duration. Most notably is the feather of VPIN duration. The average VPIN duration is 243.98 minutes. However, the time range needed to calculate one VPIN is from one second to 1461.95 minutes. Such a wide large indicates that there should be a great volume fluctuation in the market. It also demonstrates the rationality of using VPIN metric in volume-time to measure the risk of informed trading based on volume imbalance.

Prior studies, such as Easley et al (1996), document that probability of informed trading is lower for high volume stocks. Thus, we conjecture that PIN and VPIN varies in lower volume-level of stocks. We divided the underlying stocks into nine groups by the average daily volume, each contains four stocks. The estimated parameters by volume deciles are presented in table 3.

[Table 3 about here]

Average daily volume increases as decile ascends from 1 to 9. We can find that the probability of event (α), and the Probability of Informed Trading (PIN) and Volume-Synchronized Probability of Informed Trading (VPIN) are obvious lower for Decile 9. The probability of event occurring, the Probability of Informed Traders and Volume-Synchronized Probability of Informed Trading are 10.72%, 18.81% and 21.46% lower than the full sample for decile 9. It indicates the overall risk of frequently traded stocks is lower. However, PIN and VPIN show no obvious difference for relatively lower volume deciles. The result is consistent with the finding in Easley et al (1996). Both of the arrival rates of informed traders and uninformed traders increase as volume decile ascends. The high arrival rate and low PIN and VPIN for high volume deciles confirm the result found in Easley et al (1996).

5.2 VPIN around MCE

To further investigate the risk existed around MCE, we calculate the *volume-synchronized probability of informed trading* (VPIN). VPIN heralds the short-term risk. High VPIN indicates high volume imbalance and predict the high risk and volatility in the market.

Table 4 displays the mean moving VPIN for the volume buckets around the MCE. VPIN significantly increase around CBBC MCE from Bucket -3 to Bucket 7, Most of them are significant at 1% level. The crucial MCE moment embeds in the Bucket 0. It shows the VPIN at Bucket 0 is 0.1640, which is remarkable increasing comparing with 0.1574 at Bucket -1. The increment 0.00658 is much higher than other increments. As 50 volume buckets is needed to calculate VPIN, so Bucket 0 is removed after Bucket 50. We could observe a significant decreasing around Bucket 50. Significantly diminishing lasts from Bucket 47 to Bucket 55 and then return to normal. VPIN shrinks by 0.004158 or 2.43% at Bucket 50 comparing with pervious bucket. It indicates that there should be a great volume imbalance and volume intensity around Bucket 0, or MCE moment. It also heralds high volatility and risk in the market. The result supports the hypothesis that VPIN is higher around the MCE.

The results are similar after dividing CBBC into Callable Bull Contracts and Callable Bear Contracts. VPIN increase 0.006521 and 0.006630 at Bucket 0 to 0.1604 and 0.1672 for Callable Bull Contracts and Callable Bear Contracts respectively, comparing it with previous Bucket. And, VPIN decrease 0.003839 and 0.004439 at Bucket 50 to 0.1674 and 0.1667 for Callable Bull Contracts and Callable Bear Contracts respectively, comparing it with Bucket 49. The increments is significant different from 0 around MCE or Bucket 50. It demonstrates the high risk at Bucket 0 and its surrounding periods.

We conjecture that high volume intensity is continuing even after MCE. If high volume intensity only comes at bucket 0, then the highest VPIN should appears at bucket 25. However, we could observe the VPIN still increases after MCE in Table 4 and from Figure 2 Panel A (a) we note that the highest VPIN appears after bucket 25. It presents that the high intensity could go on even though CBBC is called back. It seems that speculators and other manipulators have made up their mind to push the CBBC MCE and input large number of orders in the market which need a longer time to trade.

[Table 4 about here]

Easley et al (2012) documents that their results are robust by difference choice of bucket volume size (*V*) and bucket number (*n*) needed to calculate VPIN. Figure 2 presents the VPIN is high consistency even though change the bucket volume size and bucket number. VPIN continues to rise around Bucket 0 and falling when Bucket 0 is excluded. VPIN gradually return to normal level after *n* buckets. As intensive trades still come into the market after MCE, the highest VPIN then occurs immediately after *n/2* buckets. These results confirm our findings that there are large order imbalance around the MCE and the risk is higher. Investors should take note of this situation to prevent possible loss.

[Figure 2 about here]

5.3 Regressions

We perform regression analyses to test the effect of CBBC activities on the probability of informed trading. Table 5 shows the regression results. Panel A shows probability of informed trading significantly declines when CBBC existence. The coefficient of Bull and Bear is -0.0007 and -0.0010 respectively and both of them significant at 1% level. Integrating the number of callable bull contracts and the number of callable bear contracts in one regression, the coefficients are lower but still very significant. This result supports our hypothesis 1.3 that the probability of informed trading is lower when CBBC exist.

A deeper analysis of CBBC introduction, MCE and expiration is showed in Panel B to Panel D. Panel B presents the change of probability of informed trading on the day CBBC listing. Though the result is not significant, we could find some characteristics in these regressions. The signs of all four variables about CBBC listing are negative. It indicates that the probability of informed trading is lower on the day of CBBC listing. Panel C and Panel D do not provide an explicit result how probability of informed trading changes on the day of CBBC MCE and CBBC expiration. It is no surprise that PIN has not change much when CBBC expiration as we discuss that CBBC expiration could not cause any market shift. However, a weak significant impact is also found on the day CBBC listing and CBBC MCE.

In the regressions from Panel B to Panel C, we only provide some evidences focusing on the day of CBBC listing, expiration and MCE. Maybe that is why the results do not meet our expectation. A further study is needed by extending the investigating period around these CBBC activities.

[Table 5 about here]

5.5 CBBC MCE

Table 6 display the PIN, arrival rate of informed traders and arrival rate of uninformed traders in the event window [-15, 15] around CBBC MCE date. We compare them with each underlying stocks' 61 days ([-30, 30] days around MCE date) average PIN, arrival rate of informed traders and arrival rate of uninformed traders, respectively, and label their mean-comparison test statistics. Panel A shows probability of informed trading is significant lower after Callable Bull/Bear contract MCE. It presents a continuous significant lower than the average PIN with at 1% level from day -1 to day 2. The probability of informed trading on the MCE day is 0.1397, which is much lower than the average 0.1443. Panel B presents that the probability of informed trading is relatively stationary around Callable Bull Contract MCE than the performance around Callable Bear Contract MCE in Panel C. Probability of informed trading is relative lower around Callable Bull contract MCE, but it is not as significant as callable bear contract MCE. Probability of informed trading is significant falling until 4 days after Callable Bear Contract MCE. It is consistent with hypothesis 2.1 that PIN is lower around the day of MCE.

Arrival rate of informed traders gradually increase before CBBC MCE and reach to the highest point on the MCE day. Arrival rate of informed traders on the MCE date increase 31.54% comparing to the average arrival rate 57.10. Arrival rate of informed traders is 68.73 on the Callable Bull Contract call back date, which is 26.53% higher than the average level. It increases more on the Callable Bear Contract call back date, which is 80.80, increase 35.57% than the average arrival rate of 59.60.

The problem is how these traders know the CBBC wound call back and come into the market at that time. Before CBBC MCE, no one knows whether or when would CBBC MCE. Informed traders cannot get any more information from the issuers who conduct hedge activities. Because arrival rate of uninformed traders induced by issuers' hedge activities always exist and informed traders must have taken it into consideration. Also, issuers seem to conduct hedge activities passively according to the market situation. We conjecture that uniformed traders manipulated by another kind of market power enter into the market and lead to CBBC MCE. It is speculators who premeditate to rig the market and deliberate leak the information to expand the market influence.

Hedge and re-hedge activities play an important role on the value of PIN when

CBBCs exist. CBBC expiration is more controllable than CBBC MCE for the issuer. The issuer can adjust their position of underlying stock according current price with the assumption that CBBC would expire at a certain time. So hedge activities exist all the time and less action is needed when CBBC is expired. However, Adjusting hedge position is more dubious when CBBC MCE as underlying stock price and volume could fluctuate violently. The issuers must adjust their hedge position accordingly and should take further action to hedge loss after CBBC MCE. They should re-hedge and be unwinding all their hedged positions of underlying stocks after confirming the residual value of the CBBC in two trading session or one day. Intensive arrival rate of uninformed traders by the hedge activities should appear one day after CBBC MCE.

However, as Panel A shows, the highest uninformed traders occurs on the MCE date but not one day later. Comparing with day 1, arrival rate of uniformed trader is 17.81% higher on the MCE day. This increment is caused by the speculators as our analysis. The arrival rate of uninformed traders is 12.27% higher than one day after Callable Bull Contract MCE and is 20.21% higher than the average 41.72. Also, it is 22.17% higher than one day after Callable Bear Contract MCE and is 35.89% higher than the average 46.47. The result shows that speculators is more likely appears when Callable Bear MCE.

For individual investors, it is still risky for them to enter into the market though the probability of informed trading is lower around the CBBC MCE. As the market is controlled by the large market participants, such as informed traders (most of them are large shareholders), issuers, and speculators, small investors are hardly to make profit.

[Table 6 about here]

6. Conclusion

We could find that risk always exit for small investors along with CBBC activities. However, PIN shows a relatively low value and this is misleading for small investors because PIN method does not measure the risk of small investors separately. If small investor could not realize the behavior in the market, they could face a huge loss. It seems that VPIN is a good measurement to detect the liquidity risk for small investors. Our results Policy makers should establish corresponding regulations to protect small investors when they allow launching Callable Bull/Bear Contract or other exchange traded barrier options.

Our finding in this paper suggests that CBBC activities have significant impact to the investors' trading behavior. Investors' trading behavior is more complicated after launching CBBC. Investors may trade in the market defensively, such as hedge activities. Also, investors would take positive action to meet their sentiments. For example, speculators would manipulate the underlying stock price to knock out the CBBC. This study provides evidences that how CBBC can influence the trading behavior in market and provide some references to investors. These evidences will contribute to the literatures of price discovery process and investors' trading behavior related to exchange-trade options.

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Tables and Figures

Table 1: CBBC information for each underlying stocks

This table displays the distribution of CBBC classified by underlying stocks. 36 underlying stocks and 3136 CBBC exist, among which 3130 CBBC are new issued, during January 1, 2008 to September 30, 2009. The sample covers all the CBBC which issue, call back and expire during this period.

Stock code	Bull issuance	Bear issuance	Bull MCE	Bear MCE	Bull expiration	Bear expiration
1	34	22	15	10	3	2
5	180	158	101	87	10	46
11	26	18	16	9	1	6
13	22	14	10	7	5	4
16	52	49	23	34	9	3
358	32	20	14	12	0	0
386	58	50	25	34	11	2
388	185	214	99	174	25	5
390	4	2	3	2	1	0
688	10	11	1	6	1	0
700	5	5	0	5	0	0
728	25	11	14	6	3	0
762	9	7	3	3	0	0
813	15	15	9	7	0	0
857	90	78	56	60	19	7
883	77	77	44	60	18	4
939	63	72	26	53	19	8
941	165	151	108	93	24	25
998	2	0	2	0	0	0
1088	34	23	20	15	3	2
1171	3	0	3	0	0	0
1186	7	1	5	1	0	0
1398	49	51	22	35	12	7
1800	17	13	9	10	5	3
1898	24	13	15	9	1	0
1919	25	22	16	10	0	0
2318	37	28	20	22	5	0
2328	4	0	4	0	0	0
2388	16	8	8	5	0	0
2600	28	17	18	9	0	0

2628	239	229	133	188	39	13
2777	15	14	9	4	0	0
2899	5	0	5	0	0	0
3328	27	16	15	13	2	0
3968	50	46	30	32	5	5
3988	22	19	6	13	6	1
Total	1656	1474	907	1028	227	143
	3130		1935		370	

Table 2: Summary statistic

This table provides the summary statistic related with PIN and VPIN. Panel A presents the summary statistic of parameter estimates in EKOP model along with the percentage spread and daily volume. The parameter α is the probability of events occurring, δ is the probability that the event is bad news, μ and ε is are the arrival rate of informed traders and arrival rate of uninformed traders, PIN is the probability of informed trading. The table also shows the statistic of percentage spread and daily volume. Panel B presents the summary statistic related with VPIN. Bucket volume is one-fiftieth of the average daily volume, Bucket duration is the duration of the beginning to the end of the bucket, VPIN duration is the time period from the first bucket to the fiftieth bucket, VPIN is *Volume-Synchronized Probability of Informed Trading* defined by Easley et al (2011). Bulk classification, one minute bars is used to classify the buy-initiated traders or sell-initiated traders.

Panel A: Summary statistic related with PIN

Parameter	Number	Mean	Std. Dev.	Minimum	Medium	Maximum
α	11184	0.3227	0.1484	0.0821	0.2998	0.9744
δ	11184	0.4779	0.2187	0.0203	0.4859	0.9778
μ	11184	41.46	28.20	5.35	33.81	410.22
ε	11184	31.45	18.34	3.85	26.97	224.00
PIN	11184	0.1642	0.0526	0.0420	0.1580	0.4850
Percentage spread (10^{-3})	11184	1.8223	0.7602	0.5609	1.7041	7.6973
Daily volume (10^{3})	11184	67948	112094	546	29445	1568239

Panel B: Summary statistic related with VPIN

Parameter	Number	Mean	Std. Dev.	Min	Max
Bucket volume (10^{3})	769950	1576.43	2252.41	64.07	8787.39
Bucket duration (minutes)	769950	4.88	6.82	0	392
VPIN duration (minutes)	769950	243.98	131.86	0	1461.95
VPIN	769950	0.1943	0.0904	0	1.0000

Table 3: Summary parameters of EKOP model and VPIN by volume decile

This table presents the mean of the parameter estimates by volume decile for total 36 stocks in our samples. Each decile contains 4 stocks. Average daily volume increase as decile ascends from decile 1 to decile 9. The second column and third column show the probability of information event (α) and probability of that event is bad news (δ). The fourth and fifth column show the mean of arrival rate of informed traders (μ) and the arrival rate of uninformed trader (ε) respectively. And the last two columns show the Probability of Informed Trading (PIN) and Volume-Synchronized Probability of Informed Trading (VPIN).

Parameter	α	δ	μ	ε	PIN	VPIN
full sample	0.3227	0.4779	41.46	31.45	0.1642	0.1943
Decile 1	0.3351	0.4689	30.34	21.55	0.1788	0.1920
Decile 2	0.3319	0.4650	39.96	30.53	0.1692	0.2013
Decile 3	0.3513	0.4940	38.89	29.67	0.1740	0.1832
Decile 4	0.3164	0.4737	43.35	32.68	0.1637	0.1960
Decile 5	0.3405	0.4671	33.27	24.64	0.1763	0.2150
Decile 6	0.3194	0.5029	37.21	28.39	0.1631	0.2043
Decile 7	0.3407	0.4790	36.84	28.25	0.1743	0.2049
Decile 8	0.2731	0.4901	55.09	40.88	0.1383	0.1992
Decile 9	0.2881	0.4619	63.19	50.77	0.1333	0.1526

Table 4: VPIN around CBBC MCE

This table displays the moving mean VPIN, the changes comparing with the previous VPIN and its mean-comparison test statistics between this increment and 0 ten volume buckets before and sixty volume buckets after Mandatory Call Event (MCE). VPIN is *volume-synchronized probability of informed trading* defined in Easley et al (2012). Callable Bull/Bear Contract (CBBC) call back at Bucket 0. Bucket volume size V equals one-fiftieth of the average daily volume, and every moving 50 buckets is needed when calculate VPIN. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

	Full Sample			BULL			BEAR		
Bucket/VPIN number	Mean VPIN	Mean VPIN change	t statistic	Mean VPIN	Mean VPIN change	t-statistic	Mean VPIN	Mean VPIN change	t-statistic
-10	0.154866	-0.000093	-0.53	0.151973	-0.000097	-0.31	0.157419	-0.000090	-0.48
-9	0.154582	-0.000284	-1.93*	0.151772	-0.000201	-0.79	0.157061	-0.000358	-2.21**
-8	0.154527	-0.000055	-0.4	0.151689	-0.000083	-0.43	0.157031	-0.000030	-0.15
-7	0.154203	-0.000324	-1.84*	0.151298	-0.000392	-1.47	0.156766	-0.000265	-1.13
-6	0.154194	-0.000009	-0.04	0.151118	-0.000179	-0.79	0.156908	0.000142	0.43
-5	0.154270	0.000076	0.42	0.151180	0.000061	0.22	0.156997	0.000089	0.37
-4	0.154443	0.000173	1.17	0.151527	0.000348	1.52	0.157016	0.000019	0.1
-3	0.154967	0.000524	3.33***	0.151829	0.000302	1.41	0.157736	0.000720	3.16***
-2	0.156025	0.001058	6.07***	0.152432	0.000602	2.46**	0.159195	0.001459	5.93***
-1	0.157436	0.001411	7.6***	0.153833	0.001401	4.93***	0.160616	0.001421	5.83***
0 (MCE)	0.164015	0.006579	26.47***	0.160354	0.006521	16.86***	0.167245	0.006630	20.71***
1	0.165737	0.001722	8.86***	0.161978	0.001624	5.17***	0.169054	0.001809	7.57***
2	0.167589	0.001852	9.02***	0.164109	0.002131	6.14***	0.170661	0.001606	6.82***
3	0.168753	0.001163	6.71***	0.164920	0.000811	3.44***	0.172135	0.001474	5.87***
4	0.169167	0.000414	2.49**	0.165408	0.000488	1.83*	0.172483	0.000349	1.68*

5	0.169643	0.000476	3.01***	0.165763	0.000355	1.47	0.173067	0.000583	2.79***
6	0.170215	0.000572	4.07***	0.166313	0.000549	2.45**	0.173659	0.000592	3.36***
7	0.170556	0.000340	2.25**	0.166755	0.000442	1.74*	0.173909	0.000250	1.44
8	0.170733	0.000178	1.29	0.167074	0.000319	1.39	0.173962	0.000053	0.33
9	0.170896	0.000162	1.18	0.167041	-0.000033	-0.15	0.174297	0.000335	2**
10	0.170835	-0.000061	-0.49	0.167095	0.000054	0.28	0.174135	-0.000162	-0.99
11-39	…	…	…	…	…	…	…	…	…
40	0.173993	0.000385	3.09***	0.172414	0.000509	2.7***	0.175382	0.000276	1.67*
41	0.174446	0.000453	3.07***	0.172810	0.000396	2.33**	0.175885	0.000503	2.16**
42	0.174466	0.000020	0.16	0.173100	0.000290	1.62	0.175667	-0.000218	-1.31
43	0.174550	0.000085	0.69	0.173161	0.000061	0.36	0.175772	0.000105	0.6
44	0.174780	0.000229	1.68*	0.173666	0.000506	2.33**	0.175759	-0.000014	-0.08
45	0.174719	-0.000060	-0.43	0.173712	0.000045	0.22	0.175606	-0.000153	-0.79
46	0.174697	-0.000023	-0.18	0.174040	0.000328	1.71*	0.175274	-0.000332	-1.91*
47	0.174432	-0.000265	-1.93*	0.174175	0.000135	0.77	0.174657	-0.000616	-2.98***
48	0.173612	-0.000819	-5.55***	0.173656	-0.000519	-2.36**	0.173574	-0.001083	-5.46***
49	0.171184	-0.002429	-14.34***	0.171285	-0.002371	-9.98***	0.171095	-0.002479	-10.32***
50	0.167025	-0.004158	-22.77***	0.167446	-0.003839	-16.51***	0.166656	-0.004439	-16.12***
51	0.164088	-0.002937	-17.05***	0.164369	-0.003077	-13.23***	0.163842	-0.002814	-11.21***
52	0.162619	-0.001469	-9.83***	0.162975	-0.001394	-6.25***	0.162305	-0.001536	-7.63***
53	0.161678	-0.000964	-6.86***	0.162216	-0.000808	-4.18***	0.161205	-0.001101	-5.46***
54	0.161234	-0.000475	-3.27***	0.161809	-0.000474	-2.5**	0.160729	-0.000475	-2.2**
55	0.160929	-0.000305	-2**	0.161527	-0.000282	-1.41	0.160404	-0.000326	-1.44
56	0.160726	-0.000202	-1.55	0.161474	-0.000053	-0.28	0.160070	-0.000333	-1.86*
57	0.160461	-0.000265	-1.99**	0.161152	-0.000322	-1.6	0.159854	-0.000216	-1.22
58	0.160478	0.000025	0.2	0.161147	0.000011	0.06	0.159892	0.000038	0.22

59	0.160366	-0.000105	-0.62	0.161092	-0.000039	-0.21	0.159731	-0.000162	-0.6
60	0.160519	0.000153	1.1	0.161483	0.000392	1.86*	0.159674	-0.000056	-0.3

Table 5: Regression Analysis

This table presents the linear regression aimed to find the influence of CBBC activities on the probability of informed trading. According to the regression model in section 4, Panel A reports the regression result of daily PIN on the quantity of CBBC existence. Variable "Bull" is the number of callable bull contracts exists on that day and variable "Bear" is the number of callable bear contracts exists on that day. Panel B displays the result adding the condition whether any new CBBC list on that day. "CBBC list while Bull existence" and "CBBC list while Bear existence" are dummy variables which equal to 1 if any CBBC lists on that day while bull existence and bear existence respectively. Panel C displays the result adding the condition whether any CBBC MCE on that day. "CBBC MCE while Bull existence" and "CBBC MCE while Bear existence" are dummy variables which equal to 1 if any CBBC MCE on that day while bull existence and bear existence respectively. Panel D displays the result adding the condition whether any CBBC expires on that day. "CBBC expiration while Bull existence" and "CBBC expiration while Bear existence" are dummy variables which equal to 1 if any CBBC expires on that day while bull existence and bear existence respectively. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Panel A: CBBC existence

	(1)	(2)	(3)
Independent Variables	Daily PIN	Daily PIN	Daily PIN
Bull	-0.0007***		-0.0003***
	(-13.9707)		(-3.9762)
Bear		-0.0010***	-0.0006***
		(-14.6919)	(-6.0128)
Daily volume	-0.0152***	-0.0151***	-0.0150***
	(-36.5271)	(-36.4281)	(-36.1670)
Percentage spread	11.1211***	11.4040***	11.0040***
	(16.0984)	(16.6946)	(15.9475)
Constant	0.4086***	0.4071***	0.4067***
	(60.9787)	(60.7463)	(60.7035)
Observations	11,184	11,184	11,184
R-squared	0.1369	0.1384	0.1397

Table 5 -Continued

Panel B: CBBC listing

Independent Variables	(1) Daily PIN	(2) Daily PIN	(3) Daily PIN
Bull	-0.0006***		-0.0003***
	(-11.3480)		(-3.5916)
Bear		-0.0009***	-0.0006***
		(-11.5268)	(-5.1790)
Number of Bull list	-0.0025		-0.0023
	(-1.6073)		(-1.4499)
Number of Bear list		-0.0007	-0.0002
		(-0.4352)	(-0.0885)
CBBC list while Bull existence	-0.0047**		-0.0013
	(-2.0684)		(-0.2802)
CBBC list while Bear existence		-0.0057**	-0.0022
		(-2.4100)	(-0.4503)
Daily volume	-0.0151***	-0.0151***	-0.0150***
	(-36.3830)	(-36.3579)	(-36.0900)
Percentage spread	11.0110***	11.3258***	10.9440***
	(15.9403)	(16.5772)	(15.8485)
Constant	0.4081***	0.4070***	0.4065***
	(60.9282)	(60.7351)	(60.6829)
Observations	11,184	11,184	11,184
R-squared	0.1384	0.1394	0.1406

Table 5 -Continued

Panel C: CBBC MCE

Independent Variables	(1) Daily PIN	(2) Daily PIN	(3) Daily PIN
Bull	-0.0006***		-0.0003***
	(-12.6199)		(-3.8513)
Bear		-0.0009***	-0.0006***
		(-13.1101)	(-5.7983)
Number of Bull MCE	0.0007		0.0026
	(0.3420)		(1.0282)
Number of Bear MCE		0.0011	0.0025
		(0.7058)	(1.2666)
CBBC MCE while Bull existence	-0.0059**		-0.0083
	(-2.4861)		(-1.5810)
CBBC MCE while Bear existence		-0.0057**	0.0007
		(-2.2423)	(0.1286)
Daily volume	-0.0150***	-0.0150***	-0.0149***
	(-36.0088)	(-36.0664)	(-35.7470)
Percentage spread	10.9729***	11.2943***	10.8725***
	(15.8428)	(16.4928)	(15.7116)
Constant	0.4069***	0.4060***	0.4054***
	(60.4688)	(60.3811)	(60.2919)
Observations	11,184	11,184	11,184
R-squared	0.1375	0.1389	0.1402

Table 5 -Continued

Panel D: CBBC expiration

Independent Variables	(1) Daily PIN	(2) Daily PIN	(3) Daily PIN
Bull	-0.0007***		-0.0003***
	(-13.5710)		(-3.9158)
Bear		-0.0010***	-0.0006***
		(-14.3400)	(-6.0143)
Number of Bull expiration	0.0028		0.0028
	(0.7473)		(0.7015)
Number of Bear expiration		0.0028	0.0032
		(0.7163)	(0.7580)
CBBC expiration while Bull existence	-0.0031		-0.0317
	(-0.5075)		(-0.8877)
CBBC expiration while Bear existence		-0.0044	0.0267
		(-0.8802)	(0.7640)
Daily volume	-0.0152***	-0.0151***	-0.0150***
	(-36.5129)	(-36.3704)	(-36.1430)
Percentage spread	11.1199***	11.3899***	11.0020***
	(16.0951)	(16.6651)	(15.9414)
Constant	0.4086***	0.4070***	0.4066***
	(60.9551)	(60.6855)	(60.6664)
Observations	11,184	11,184	11,184
R-squared	0.1369	0.1385	0.1397

Table 6: Daily PIN around CBBC MCE

This table shows the underlying stocks' mean daily PIN, arrival rate of informed traders (μ) and arrival rate of uninformed traders (ε) during the event window, which contains 15 days before 15 days after CBBC MCE date. Alongside of these values, mean-comparison test statistics are presented comparing with each underlying stock's 61 days' ([-30, 30]) average PIN, arrival rate of informed traders (μ) and arrival rate of uninformed traders (ε), respectively. Panel A presents the daily PIN around MCE for the whole Callable Bull/Bear Contract sample, Panel B presents the daily PIN during the period of Callable Bull Contract MCE, and Panel C presents the daily PIN during the period of Callable Bear Contract MCE. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Panel A: Daily PIN around the period of Callable Bull/Bear Contract MCE.

Event day/Window	Mean Daily PIN	t-statistic	Mean μ	t-statistic	Mean ε	t-statistic
-15	0.1420	-1.82*	58.12	0.920	45.42	1.66*
-14	0.1435	-0.62	57.16	0.060	44.25	0.01
-13	0.1462	1.55	56.02	-0.920	43.67	-0.85
-12	0.1424	-1.58	58.95	1.540	44.90	0.95
-11	0.1446	0.23	58.93	1.490	45.01	1.13
-10	0.1431	-0.87	55.85	-1.20	44.26	0.03
-9	0.1458	1.08	56.65	-0.410	43.38	-1.42
-8	0.1471	2.11**	56.07	-0.910	43.18	-1.58
-7	0.1471	2.18**	54.30	-2.91***	42.36	-3.24***
-6	0.1464	1.55	54.80	-2.15**	42.87	-2.18**
-5	0.1445	0.16	56.41	-0.620	43.95	-0.42
-4	0.1416	-2.18**	56.66	-0.370	43.81	-0.69
-3	0.1440	-0.24	58.39	1.080	43.51	-1.13
-2	0.1478	2.51**	58.23	0.890	44.15	-0.13
-1	0.1400	-3.41***	59.45	2.02**	46.35	3.17***
0	0.1397	-3.74***	75.11	10.99***	57.01	14.01***
1	0.1398	-3.77***	61.63	4.09***	48.39	6.18***
2	0.1392	-4.21***	58.60	1.450	46.05	2.8***
3	0.1426	-1.33	58.17	1.010	45.67	2.17**
4	0.1420	-1.75*	54.74	-2.47**	43.84	-0.66
5	0.1437	-0.42	56.24	-0.80	44.87	0.96
6	0.1421	-1.73*	56.02	-0.960	44.63	0.58
7	0.1434	-0.71	56.03	-0.980	43.56	-1.04
8	0.1438	-0.35	56.71	-0.330	42.99	-2.04**
9	0.1455	0.9	56.25	-0.780	43.82	-0.65
10	0.1452	0.64	58.42	1.030	44.02	-0.35
11	0.1445	0.19	56.30	-0.660	43.83	-0.62
12	0.1449	0.46	56.51	-0.540	43.65	-0.95

13	0.1466	1.67*	57.64	0.470	44.04	-0.29
14	0.1469	1.92*	54.59	-2.34**	43.66	-0.87
15	0.1417	-1.97**	58.48	1.140	45.82	2.12**

Note: 1935 Callable Bull/Bear Contracts MCE during Jan 1st, 2008 to Sep 30th, 2009. Mean of each underlying stock's average PIN during the period [-30, 30] around the MCE date for these 1935 Callable Bull/Bear Contracts is 0.1443, mean of each underlying stock's average arrival informed traders and uninformed traders during the period [-30, 30] around the MCE date for these 1935 Callable Bull/Bear contracts are 57.10 and 44.24 respectively.

Table 6 -Continued

Panel B: Daily PIN around the period of Callable Bull Contract MCE

Event day/Window	Mean Daily PIN	t-statistic	Mean μ	t-statistic	Mean ε	t-statistic
-15	0.1420	-2.71***	52.47	-1.340	40.61	-1.2
-14	0.1439	-1.86*	50.41	-2.99***	40.25	-1.72*
-13	0.1478	0.34	52.79	-0.960	40.05	-2.07**
-12	0.1442	-1.59	52.68	-1.140	40.47	-1.51
-11	0.1474	0.11	54.35	0.020	42.05	0.28
-10	0.1450	-1.11	53.62	-0.440	41.81	0.05
-9	0.1488	0.81	52.69	-1.050	40.66	-1.27
-8	0.1490	0.89	51.21	-2.15**	39.92	-2.15**
-7	0.1508	1.94*	51.20	-2.19**	39.61	-2.53**
-6	0.1517	2.28**	49.58	-3.43***	39.13	-2.91***
-5	0.1478	0.38	50.87	-2.46**	39.46	-2.55**
-4	0.1471	-0.01	51.54	-1.93*	40.94	-0.87
-3	0.1461	-0.55	53.00	-0.920	39.90	-2.16**
-2	0.1547	3.23***	54.43	0.050	39.19	-3.03***
-1	0.1451	-1.03	54.50	0.110	40.69	-1.25
0	0.1437	-1.9*	68.73	6.66***	50.15	7.35***
1	0.1476	0.26	59.80	3.16***	44.67	3.01***
2	0.1467	-0.24	57.59	2.02**	43.69	1.91*
3	0.1483	0.6	54.04	-0.210	42.17	0.48
4	0.1485	0.67	52.13	-1.510	40.56	-1.36
5	0.1492	1	55.56	0.680	42.75	0.99
6	0.1446	-1.29	56.77	1.280	42.37	0.61
7	0.1450	-1.1	53.88	-0.290	42.40	0.64
8	0.1470	-0.09	56.74	1.250	42.33	0.59
9	0.1488	0.78	56.03	0.970	43.36	1.48
10	0.1481	0.47	56.38	1.010	41.72	-0.04
11	0.1482	0.51	56.22	0.970	41.79	0.03
12	0.1486	0.71	51.49	-2.04**	41.40	-0.4
13	0.1472	0.02	54.65	0.180	41.51	-0.24
14	0.1492	1.02	51.13	-2.14**	40.34	-1.5
15	0.1455	-0.82	55.67	0.740	42.57	0.75

Note: 907 Callable Bull Contracts MCE during Jan 1st, 2008 to Sep 30th, 2009. Mean of each underlying stock's average PIN during the period [-30, 30] around the MCE date for these 907 Callable Bull Contracts is 0.1472, mean of each underlying stock's average arrival informed traders and uninformed traders during the period [-30, 30] around the MCE date for these 907 Callable Bull contracts are 54.32 and 41.72 respectively.

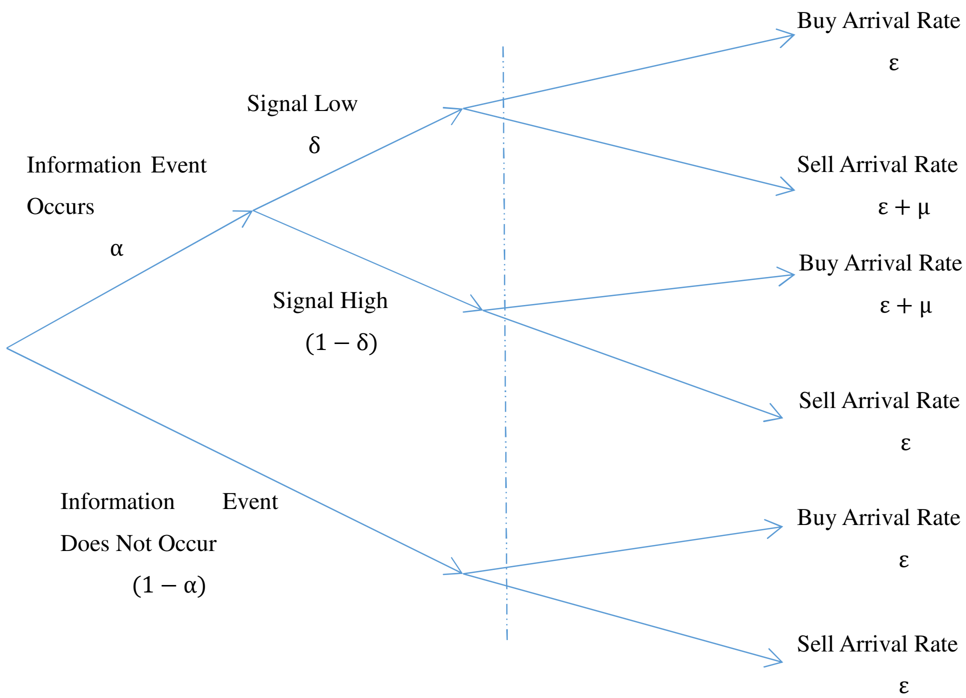
Table 6-Continued

Panel C: Daily PIN around the period of Callable Bear Contract MCE

Event day/Window	Mean Daily PIN	t-statistic	Mean μ	t-statistic	Mean ε	t-statistic
-15	0.1420	0.14	63.07	2.06**	49.63	3.13***
-14	0.1432	0.78	63.07	2.1**	47.75	1.51
-13	0.1449	1.79*	58.84	-0.45	46.84	0.37
-12	0.1408	-0.61	64.43	2.63***	48.78	2.22**
-11	0.1422	0.24	62.93	1.97**	47.61	1.27
-10	0.1415	-0.13	57.81	-1.32	46.41	-0.07
-9	0.1431	0.73	60.15	0.37	45.78	-0.82
-8	0.1455	2.1**	60.37	0.47	46.07	-0.4
-7	0.1437	1.15	57.06	-1.97**	44.81	-2.13**
-6	0.1416	-0.08	59.45	-0.09	46.19	-0.33
-5	0.1415	-0.15	61.34	1.06	47.95	1.48
-4	0.1367	-3.06***	61.23	0.91	46.36	-0.13
-3	0.1421	0.2	63.21	1.95*	46.74	0.29
-2	0.1417	-0.01	61.63	1.17	48.59	2.04**
-1	0.1354	-3.97***	63.87	2.73***	51.41	5.11***
0	0.1362	-3.41***	80.80	8.81***	63.15	12.4***
1	0.1329	-5.84***	63.26	2.59***	51.69	5.74***
2	0.1327	-5.97***	59.47	-0.1	48.10	1.98**
3	0.1377	-2.3**	61.67	1.31	48.62	2.26**
4	0.1366	-3.19***	56.91	-2.14**	46.56	0.1
5	0.1392	-1.53	56.81	-2.22**	46.63	0.19
6	0.1399	-1.09	55.40	-3.22***	46.52	0.05
7	0.1420	0.14	57.83	-1.14	44.54	-2.29**
8	0.1411	-0.33	56.68	-2.03**	43.54	-3.68***
9	0.1428	0.56	56.44	-2.35**	44.22	-2.97***
10	0.1426	0.47	60.17	0.36	46.00	-0.57
11	0.1414	-0.19	56.37	-2.19**	45.60	-0.98
12	0.1417	-0.03	60.90	0.83	45.61	-0.99
13	0.1461	2.35**	60.27	0.45	46.27	-0.22
14	0.1448	1.69*	57.62	-1.3	46.58	0.12
15	0.1384	-1.97**	60.92	0.82	48.64	2.18**

Note: 1028 Callable Bear Contracts MCE during Jan 1st, 2008 to Sep 30th, 2009. Mean of each underlying stock's average PIN during the period [-30, 30] around the MCE date for these 1028 Callable Bear Contracts is 0.1418, mean of each underlying stock's average arrival informed traders and uninformed traders during the period [-30, 30] around the MCE date for these 1028 Callable Bear contracts are 59.60 and 46.47 respectively.

Figure 1: Trading process in EKOP model.

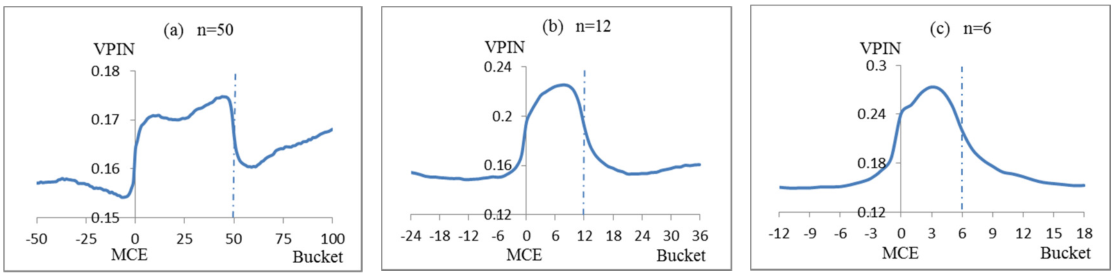


Note: α is the probability of an information event, δ is the probability that this information event is bad news, μ is arrival rate of informed traders, ε is arrival rate of uninformed traders.

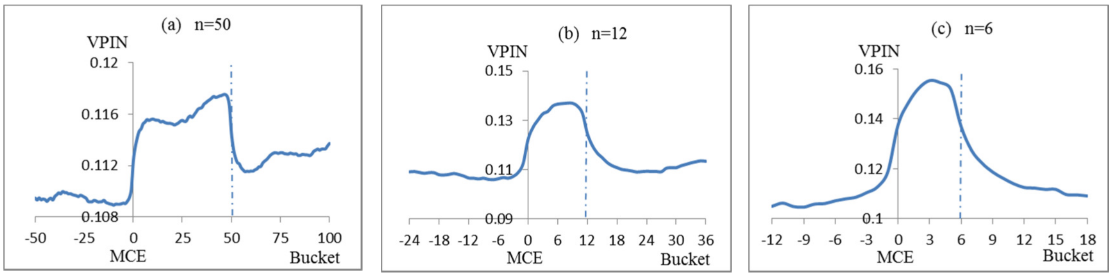
Figure 2: VPIN around MCE.

This figure shows the moving *volume-synchronized probability of informed trading* (VPIN) of the underlying stocks around the MCE moment calculated by different bucket volume size (*V*), different number of buckets (*n*) and different time bars. Bucket volume size for Panel A and Panel B is 1/50 of the average daily volume, and for Panel C is 1/250 of the average daily volume. Bulk classification is used to processing all the trading data. Panel A uses 1 minute bars while Panel B and Panel C use 10 second bars. MCE occurs at bucket 0.

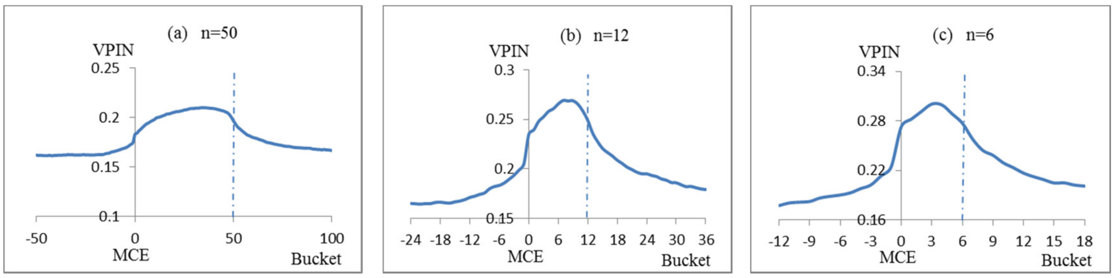
Panel A: VPIN around MCE: *V*=1/50 average daily volume, 1 minute bars



Panel B: VPIN around MCE: *V*=1/50 average daily volume, 10 second bars



Panel C: VPIN around MCE: *V*=1/250 average daily volume, 10 second bars



Appendix I: Calculate VPIN

This appendix shows the procedure to calculate Volume-Synchronized Probability of Informed Trading (VPIN) by Easley (2012).

To calculate VPIN, we need the following variables:

T_ω: Time of the trade

P_ω: Price at which securities were traded

V_ω: Volume exchanged

$V_{\tau i}$: Volume in i th one minute bar included in bucket τ

$\sigma_{\Delta P}$: The estimate of the standard derivation of price changes between time bars.

V: Volume in each bucket.

n: Buckets used to calculate VPIN.

Note: V and n can be determined by user.

Procedure:

1. Sort transactions by time ascending: $T_{\omega+1} \geq T_\omega, \forall \omega$.
2. Expand the number of observations by repeating each observation P_ω as many times as V_ω. This generates a total of $\mathrm{W} = \sum_\omega V_\omega$ observations.
3. Initiate $\tau = 0$
4. Add one unit to τ
5. If $W < \tau V$, jump to step 10 (Not enough observations in this bucket)
6. $\forall \mathrm{i} \in [(\tau - 1)V + 1, \tau V]$, classify each transaction as buy or sell initiated:
   a. Classify the transaction in buy initiated using
   $$V_\tau^S = \sum_{i=t(\tau-1)+1}^{t(\tau)} V_i \cdot Z\left(\frac{P_i - P_{i-1}}{\sigma_{\Delta P}}\right)$$
   b. And, classify the transaction in sell initiated.
   $$V_\tau^S = \sum_{i=t(\tau-1)+1}^{t(\tau)} V_i \cdot \left[1 - Z\left(\frac{P_i - P_{i-1}}{\sigma_{\Delta P}}\right)\right] = V - V_\tau^B$$
7. Define V_τ^B as the number of volume in buy initiated and V_τ^S as the number of volume in sell initiated. Obvious, $\mathrm{V} = V_\tau^B + V_\tau^S$
8. Loop to step 5
9. Set $L = \tau - 1$ (the last bucket is empty or has not enough observation, thus $V_\tau^B + V_\tau^S < V$)
10. For $n \leq j \leq N$, calculate $\mathrm{VPIN}_j = \frac{\sum_{\tau=j-n+1}^{j} |V_\tau^B - V_\tau^S|}{\sum_{\tau=j-n+1}^{j} (V_\tau^B + V_\tau^S)}$

Appendix II: Stock included in Sample

This table shows the stocks used in this paper. Thirty-six stocks are selected as they are the underlying stocks of CBBCs. Average daily volume, average daily percentage spread, average daily orders, average daily PIN and average VPIN from January 1, 2008 to September 30, 2009 are presented. All these variables are calculated using the intra-day data from the trade record of HKSE.

Code	Identity	Company name	Average daily volume (10^3)	average daily percentage spread (10^{-3})	Average daily orders	Average daily PIN	Average VPIN
1	2155010	Cheung Kong (Holdings) Ltd.	6082	1.2608	2367	0.1715	0.1929
5	2034010	HSBC Holdings plc	28616	0.904	9958	0.1356	0.1071
11	2114010	Hang Seng Bank Ltd.	3203	0.9426	3709	0.1821	0.1977
13	2278010	Hutchison Whampoa Ltd.	8498	1.2917	2940	0.1634	0.1932
16	2133010	Sun Hung Kai Properties Ltd.	8605	1.1717	3067	0.1654	0.1864
358	3033010	Jiangxi Copper Co. Ltd. 'H'	31826	1.8902	3922	0.1755	0.2015
386	1009240	China Petroleum & Chemical Corporation 'H'	178450	1.8248	7575	0.1389	0.1987
388	1007640	Hong Kong Exchanges and Clearing Ltd.	10275	0.8823	7476	0.1490	0.1852
390	1152790	China Railway Group Ltd. 'H'	45395	2.0132	4491	0.1686	0.2461
688	2611010	China Overseas Land & Investment Ltd.	37353	1.7097	3736	0.1821	0.2188
700	1035730	Tencent Holdings Ltd.	4496	1.2985	2972	0.1972	0.1844
728	1020510	China Telecom Corporation Ltd. 'H'	143629	2.8267	4981	0.1572	0.2175
762	1007590	China Unicom (Hong Kong) Ltd.	33427	1.799	3257	0.1832	0.2087
813	1074200	Shimao Property Holdings Ltd.	20390	2.1637	2936	0.2019	0.2314
857	1006930	PetroChina Co. Ltd. 'H'	170720	1.6279	7985	0.1309	0.1803

Appendix II-Continued

Code	Identity	Company name	Average daily volume (10^3)	average daily percentage spread (10^{-3})	Average daily orders	Average daily PIN	Average VPIN
883	1011060	CNOOC Ltd.	122989	1.6624	7754	0.1335	0.1949
939	1058240	China Construction Bank Corporation 'H'	422515	1.9763	13518	0.1332	0.0850
941	3078010	China Mobile Ltd.	30708	0.8346	10376	0.1309	0.1738
998	1108220	China CITIC Bank Corporation Ltd. 'H'	49206	2.9335	2602	0.2110	0.2290
1088	1050050	China Shenhua Energy Co. Ltd. 'H'	29937	1.7914	5541	0.1570	0.1992
1171	1000010	Yanzhou Coal Mining Co. Ltd. 'H'	29713	2.1307	2919	0.1821	0.2097
1186	1174780	China Railway Construction Corporation Ltd. 'H'	23806	2.0139	3773	0.1897	0.2362
1398	1084380	Industrial and Commercial Bank of China Ltd. 'H'	408867	2.1777	13863	0.1245	0.1959
1800	1091300	China Communications Construction Co. Ltd.	43395	1.6733	4762	0.1498	0.1867
1898	1091310	China Coal Energy Co. Ltd. 'H'	40408	1.9494	4290	0.1639	0.1912
1919	1051020	China COSCO Holdings Co. Ltd. 'H'	57621	1.9968	6301	0.1632	0.1940
2318	1036030	Ping An Insurance (Group) Co. of China Ltd. 'H'	16695	1.2875	5369	0.1565	0.2022
2328	1027530	PICC Property and Casualty Co. Ltd. 'H'	37242	2.592	3031	0.1827	0.2278
2388	1018580	BOC Hong Kong (Holdings) Ltd.	24217	1.6273	3890	0.1717	0.1880
2600	1013210	Aluminum Corporation of China Ltd. 'H'	59077	2.0877	4842	0.1604	0.1918
2628	1029020	China Life Insurance Co. Ltd. 'H'	84239	1.869	11028	0.1303	0.2043
2777	1051860	Guangzhou R&F Properties Co., Ltd. 'H'	25662	2.0343	3886	0.1869	0.2075
2899	1029180	Zijin Mining Group Co., Ltd. 'H'	41823	2.3405	3728	0.1690	0.1933
3328	1050580	Bank of Communications Co., Ltd. 'H'	72190	1.7627	5295	0.1598	0.2049
3968	1080540	China Merchants Bank Co., Ltd.	38632	1.7648	5450	0.1560	0.2046
3988	1071410	Bank of China Ltd.	439369	3.3842	9465	0.1353	0.1308