

Price Discovery in Stock and Option Markets: A Portfolio Approach

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Abstract

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Keywords: Price discovery, Information share, efficient stock prices, GMM

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Abstract

In this paper, we propose a new portfolio approach to estimate Hasbrouck's (1995) information share (IS), which measures the relative contribution of one market to the variance of an efficient stock return process. Using GMM, we are able to estimate optimal weights for a portfolio of options to be used in Hasbrouck's (1995) analysis. With our dataset, IS of the option market using only ATM call options lies between 31% and 46%, while IS using a portfolio of options lies between 47% and 58%, a statistically significant increase. This finding indicates that using only one type of options, as often done in the literature, may result in an underestimated measure. We also find that as we increase the resolution of the data from 30 seconds to 15 minutes, the weight of OTM options in a portfolio increases from 18% to 32%. This result shows that the OTM option market's information takes time to be incorporated into stock prices since the information travels across stock and option markets.

1. Introduction

This paper proposes a new approach to estimate the informativeness of the option market to examine the price discovery process between stock and option markets. In particular, the information share -i.e., the variance decomposition of efficient stock prices- is investigated to answer whether using only one type of options is sufficient to represent the informativeness of the option market and whether forming a portfolio of options can improve the parameter estimation on price discovery in stock and option markets.

Chakravarty, Gulen and Mayhew (2004) use the information share (henceforth IS) proposed by Hasbrouck (1995) to examine the informativeness of the option market and show the contributions of at-the-money (henceforth ATM), in-the-money (hereafter ITM) and out-of-the-money (subsequently referred to OTM) call options to efficient stock prices. These previous studies, however, fall short in addressing the general informativeness of the option market as regards efficient stock prices.

In this paper, we propose a portfolio approach to incorporate all available information in the option market. As in Manaster and Rendleman (1982), Stephan and Whaley (1990), and Chakravarty, Gulen and Mayhew (2004), we start with implied stock prices, that is, converted option prices by an option pricing model. Then, a portfolio of implied stock returns is derived to represent the overall option market's perception of stock returns. The weight scheme used to combine the implied stock returns is derived through an iterated generalized method of moment (henceforth ITGMM). With the dataset of 58 stocks from the Bauer Research

DataSet (henceforth BRDS), we find that IS of the option market using ATM call options only lies between 31.2% and 45.6%, while IS using the option portfolio lies between 47.2% and 58.3%. We find this increase in IS to be statistically significant. This finding indicates that using only one type of options to characterize the overall option market results in underestimating the option market's role in the underlying stock price discovery. We should also note that as the resolution of the dataset increases from 30 seconds to 15 minutes, OTM option weight increases, on average, from 17.56% to 31.55%. This result reveals two things. First, the OTM option market's activity carries crucial information about future stock returns. Second, the stock price update by the OTM option market activity takes time when the information travels across stock and option markets.

This paper is organized as follows. Section 2 reviews related literature. Section 3 explains the model and the procedures used to conduct the different tests. Section 4 presents the data used in the paper. Section 5 discusses the results of the tests. Section 6 concludes the paper.

2. Literature Review

2.1 The Role of the Option Market in Price Discovery

Several papers examine the price discovery process, which is usually defined as “the dynamic process by which market prices incorporate new information” – see Yan and Zivot (2007). The main object of the price discovery analysis is to identify the primary venue where efficient price innovations occur. The quotes and trades submitted by informed traders contain vital information about securities. Therefore the market with more informative quotes and trades

contributes more to price discovery. There is a long line of papers examining whether the option market plays a role in the price discovery process of the underlying stock. The literature, however, has found mixed results regarding the option market's role in the underlying stock price discovery.

Manaster and Rendleman (1982) examine the relationship between closing stock and option prices and future stock returns. They find closing option prices contain some information regarding future stock prices. Anthony (1988) investigates whether trades in the stock and/or option market lead trades in the other market. He finds that trades in the call market lead trades in the stock market by one day. Vijh (1988) is critical of the papers, like Manaster and Rendleman (1982) and Anthony (1988), that use closing prices to examine the price discovery between stock and option markets. Vijh (1988) states that spurious results are likely since the option market closed 10 minutes later than the stock market in 1970s and 1980s.

Using intra-daily quotes, Vijh (1990) investigates option prices and option volume to examine whether there is any price discovery in the option market. He claims that price discovery in the option market is not significant since option trades have little effect on changes in option prices. Based on the finding, Vijh (1990) suggests that the information perceived by informed traders in the option market may be just a different opinion regarding the underlying stock prices. Similar findings are reported by Stephan and Whaley (1990) and Chan, Chung, and Fong (2002). Again, using intra-daily stock and option prices and volume, they both find evidence that the stock market leads the option market.

From a different angle, an event study perspective, Amin and Lee (1997) examine a proportion of long and short positions of options around earnings announcements. Amin and Lee (1997) find that option volume predicts the direction of earnings announcements. Easley, O'Hara and Srinivas (1998), relying on an asymmetric information model, study whether the option market plays any role in information dissemination. They find that signed option volume contains information regarding future stock prices. Pan and Poteshman (2006) also find that categorized option volume predicts future stock returns.

Closely related to this paper, Chakravarty, Gulen and Mayhew (2004) provide the first evidence of relative price discovery in the option market using the Hasbrouck's (1995) IS approach. Their main result provides evidence that a nontrivial amount of price discovery, around 18%, occurs in the option market. In addition, Chakravarty, Gulen and Mayhew (2004) show that the level of price discovery varies across the moneyness of the options. OTM options in their study show a higher contribution to underlying stock price discovery than ATM or ITM options. These findings support Fleming, Ostdiek, and Whaley's (1996) result that low cost in the option market attracts more informed traders regardless of the wider spread of options and higher trading cost relative to what the stock market offers.

Collver (2005) applies the methods used in Hasbrouck (1991) and Chakravarty, Gulen and Mayhew (2004) to examine the informativeness of the option market around earnings announcements. Collver (2005) finds that ATM options play a significant role in the price discovery process, but, contrary to Amin and Lee (1997), the information share of the option market around earnings

announcements is not significantly different from that during non-announcement periods.

The directional implication on whether the stock market leads the option market is inconclusive. Earlier research finds that only the stock market leads the option market, while more recent research finds that the option market is also informative regarding the stock price discovery. With their empirical result, Easley, O'Hara and Srinivas (1998) suggest that the information flow between stock and option markets may be bi-directional. Overall, Chakravarty, Gulen and Mayhew (2004) and Collver (2005) find support for Easley, O'Hara and Srinivas' (1998) study. However, the degree of relative informativeness of the option market is uncertain. The main results in both studies rely on only ATM call options.

Finally, two related papers also study price discovery with different options. Using the Kyle model-based experimental study, De Jong, Koedijk, and Schnitzlein (2006) find that price discovery occurs in both the stock and option markets, which creates feedback effects between the two markets. Based on the convergence rate of options to efficient stock prices, they claim that most of the price discovery of the option market occurs in ITM options. Pan and Poteshman (2006) find that the put-call ratio using OTM option volume has greater predictive power on future stock returns than using ITM or ATM option volume, contrary to De Jong, Koedijk, and Schnitzlein (2006)'s study.

3. Methodology and Structural Model

The previous research has shown that there is some price discovery in the option market. All prior research, however, utilizes one option per analysis and reports cross-sectionally by categorizing options along the moneyness and the type of options. Since each option is separately compared in the previous papers, we can only suspect that the total contribution of the option market to price discovery might be higher than those reported in the prior research.

In this section, we propose a new method to estimate the informativeness of the overall option market. We use multiple options simultaneously and, thus, we can incorporate all relevant information across options. To our knowledge, this is the first study to employ a portfolio of options to capture the total contribution of the option market on the price discovery of the underlying stock. The proposed method not only offers a better estimate of the informativeness of the option market, but also provides an opportunity to integrate multiple options simultaneously to characterize the information in the option market.

In addition, we modify the usual empirical approach to provide a cohesive and reliable result. In Chakravarty, Gulen and Mayhew (2004) and Collver (2005), the normality of stock price is assumed in the structural model while the lognormality of stock price is used in the empirical part. This study resolves the inconsistency found in the previous papers by assuming the lognormality of stock prices in both structural and empirical models.

The weight scheme used to form a portfolio of options can also shed some light on which option contributes the most to the price discovery of the underlying stock. Easley, O'Hara and Srinivas (1998) assume that informed traders

simultaneously trade all types of securities to maximize their profit. Therefore, each option's contribution to price discovery varies according to the tradeoff between the liquidity and the leverage of options. Black (1975) suggests that the informed trading heavily depends on the leverage of options. His claim implies that the contribution of OTM options to price discovery is the largest among options. Chakravarty, Gulen and Mayhew (2004) find that the contribution of OTM options is significantly greater than that of ATM or ITM options. Pan and Poteshman (2006) find that the put-call ratio using OTM option volume has greater predictive power on future stock returns than using ITM or ATM option volume. On the other hand, De Jong, Koedijk, and Schnitzlein (2006) find that most of the price discovery of the option market occurs in ITM options. By employing ITM, ATM, and OTM call and put options simultaneously, we are able to estimate a relative contribution of each option across the moneyness and the type of options.

3.1 Estimating the Price Discovery Process

There are two widely used techniques in the price discovery literature: the Gonzalo and Granger's (1995) approach and the Hasbrouck's (1995) information share approach.¹

Both measures are based on a vector error correction model (VECM). The Gonzalo and Granger's (1995) model is based on the idea that asset prices will

¹ The lead-lag approach is sometimes used in the price discovery literature --see Manaster and Rendleman (1982), Bhattacharya (1987), Anthony (1988), Stephan and Whale (1990), Chan, Chung and Johnson (1993), Easley, O'Hara and Srinivas (1998), and Pan and Poteshman (2006). The lead-lag approach, however, in price discovery between stock and option markets is inconclusive. It estimates causality direction, but it is unable to determine the relative roles of stock and option markets in the price discovery process.

consist of permanent and transitory components. Gonzalo and Granger (1995) regard the coefficients of the error correction term as the relative intensity of permanent stock price adjustments and utilize the intensities as a measurement of price discovery. On the other hand, the Hasbrouck's (1995) approach focuses on the variance of the permanent component in the VECM. The model measures the relative contribution of the permanent shock in its own market to the total variance of the permanent component. The market that contributes most to the total variance of the efficient price is the primary market for price discovery.

Both Gonzalo and Granger (1995) and Hasbrouck (1995) are based on the residuals from reduced-form VECMs and they offer a measure for the informativeness of a market on the efficient price process. Yan and Zivot (2007) compare both methods and find that the Gonzalo and Granger's (1995) measure is less appropriate since it contains only contemporaneous responses to transitory shocks. The Hasbrouck (1995) measure is also more popular in the price discovery literature. Based on these points, we use Hasbrouck's approach.

While it is straightforward to study the price discovery of an individual stock traded in multiple markets as in Hasbrouck (1995), it is nontrivial to examine price discovery across stock and option markets. An option price depends on multiple factors and there are multiple options for one stock, thus, the usual way of dealing with this complication is to use ATM call options for the main analysis and ITM and OTM options for a robustness check. Since ATM call options are very sensitive to underlying stock's movements and fairly liquid, it is practical to use ATM call options. However, in price discovery analysis, using only ATM call

options may lead to an incomplete result since price discovery can occur in multiple option markets concurrently. In this paper, we examine multiple options simultaneously which allows us to achieve a more comprehensive analysis regarding the option market's contribution to price discovery.

3.2 Structural Model

We construct a modified Kim and Verrecchia's (1994) and Pascual, Pascual-Fuster and Climent's (2006) model to describe the information dissemination in stock and option markets.

Assume that an unobservable efficient stock price, m_t is reflected by:

$$\frac{dm_t}{m_t} = \frac{dm_{t-1}}{m_{t-1}} + \eta_t = \frac{dm_{t-1}}{m_{t-1}} + \sum_{i=0}^n \lambda_{i,t} (v_{i,t} - E_{t-1}[v_{i,t} | \psi_t])$$

(1)

where η_t is a marginal efficient price return due to an innovation at time t and $v_{i,t}$ is a return innovation of a security traded in the i th market at time t, which is affected by the previous period's innovations in all markets with the magnitude of $\alpha_{i,j}$. We assume that $v_{i,t}$ follows a weighted AR(1) process, given by

$$v_{i,t} = \sum_{j=0}^n \alpha_{i,j} v_{j,t-1} + u_{i,t}.$$

We assume that there are $n+1$ markets trading securities whose price processes depend on the efficient price process, m_t . We assume that $u_{i,t} \sim N(0, \sigma_{ui,t}^2)$ and $v_{i,t} \sim N(0, \sigma_{vi,t}^2)$, where ψ_t represents the public information known to all markets at the beginning of time t. We also assume that $v_{i,t}$ and ψ_t

are mutually and serially uncorrelated. $\lambda_{i,t}(v_{i,t} - E_{t-1}[v_{i,t} | \psi_t])$ represents the i th market's unexpected component of the return innovation contributed to the efficient price return after the public information arrives. The parameter λ measures the magnitude of the unexpected component of the innovation, which is new to the markets. The above process satisfies the following conditions: $E[\eta_t] = 0$, $E[\eta_t^2] = \sum_{i=0}^n \sigma_{vi,t}^2 + \sigma_{ui,t}^2$ and $\exists s > 0$ such that $E[\eta_t \eta_{t-s}] = 0$. The evolution of the efficient price returns is derived by the unexpected components of the innovations from security markets.

Consider a stock and options written on the efficient stock process in the Black-Scholes/CAPM world. We assume the stock price, S_t , and the i th option price, $O_{i,t}$, follow the following processes:

$$\frac{dS_t}{S_t} = \frac{dm_t}{m_t} + e_t^P = \frac{dm_{t-1}}{m_{t-1}} + \kappa_0 v_{0,t}$$

(2)

$$\begin{aligned} \frac{dO_{i,t}}{O_{i,t}} &= f\left(\frac{dm_t}{m_t} \mid \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}\right) + e_t^i = f\left(\frac{dm_{t-1}}{m_{t-1}} \mid \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}\right) + \kappa_i' v_{i,t}' \\ &= f\left(\frac{dm_{t-1}}{m_{t-1}} \mid \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}\right) + g(v_{i,t}' \mid \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}) \end{aligned}$$

(3)

where e_t^P and e_t^i are bivariate normal variables and f and g are functionally linear.

Both the stock and the option returns are based on the efficient price return at time t . Since the efficient price return is not observable at time t , a marginal return of each market is driven by the efficient price return at time $t-1$ and its own

return innovation of $v_{i,t}$ with a magnitude of κ_i . We assume that i th market participants cannot observe the contemporaneous return innovations in other markets; therefore, each market's participants can only conjecture the security return in their own market with the consideration of possible return innovations in the other markets. The difference between $\kappa_i v_{i,t}$ and $\lambda_{i,t}(v_{i,t} - E_{t-1}[v_{i,t} | \psi_t])$ corresponds to the market friction caused by the conjectured security return. We assume that there exist proper transformation processes, f and g , so that the option return process can be expressed as a combination of the option return using only the information known at the beginning of the period, $f(\frac{dm_{t-1}}{m_{t-1}} | \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}})$ and the return innovation in the i th option market, $g(v'_{i,t} | \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}})$. The function f depends on ψ_t and $\frac{dO_{i,t-1}}{O_{i,t-1}}$, which represent the public information and the option specific information, respectively. The function g is linear on the return innovation, $v'_{i,t}$.

To examine the interaction between stock and option markets, we need to properly convert an option return to a corresponding value, which can be directly compared to a stock return. Since we assume that f and g are functionally linear, we can derive the implied stock return at time t by inverting each transformation process separately.

$$\frac{d\tilde{S}_{i,t}}{\tilde{S}_{i,t}} = f^{-1}\left(\frac{dO_{i,t}}{O_{i,t}} | \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}\right) + g^{-1}\left(\frac{dO_{i,t}}{O_{i,t}} | \psi_t, \frac{dO_{i,t-1}}{O_{i,t-1}}\right) = \frac{dm_t}{m_t} + e_t^i = \frac{dm_{t-1}}{m_{t-1}} + \kappa_i v_{i,t} \quad (4)$$

where $\tilde{S}_{i,t}$ is an implied stock price derived from the i th option market price at time t .

To identify an implied stock return perceived by all option market participants, we need to incorporate return innovations of all option markets to an implied stock return as the following:

$$\frac{d\tilde{S}_t}{\tilde{S}_t} = \frac{dm_t}{m_t} + e_t^o = \frac{dm_{t-1}}{m_{t-1}} + h(\kappa_i v_{i,t}, COV(\kappa_i v_{i,t}, \kappa_j v_{j,t}) \mid i, j = 1, \dots, n, i \neq j)$$

(5)

where h is a linear function of transformed option market innovation.

Identifying the appropriate structure of the function h is nontrivial. In this study, we empirically examine the structure of the transformation function by constructing an implied stock return portfolio. If the results of the price discovery analyses using ATM call options and a portfolio of options do not show any statistical difference, we can conclude that the option market is perfectly synchronized or price discovery occurs only in the ATM call option market. If the results are statistically different, we find evidence that using only one type of options in the price discovery analysis underestimates the informativeness of the option market.

3.3 Empirical Procedure

We apply Hasbrouck's (1995) information share approach to measure the contribution of the option market to price discovery between stock and option markets. IS derivation for the bivariate case is well explained in Hasbrouck (1995). In this section, we show the derivation of IS for the multivariate case.

Since an option return cannot be compared to a stock return directly, we follow the implied stock price approach as in Manaster and Rendleman (1982), Stephan and Whaley (1990) and Chakravarty, Gulen and Mayhew (2004). Since our data set uses American options traded in the CBOE, we employ the Roll-Geske-Whaley option pricing model to obtain implied volatility. To derive an implied stock prices, we use the binomial option pricing model on bid/ask midpoints of stocks and options as well as 30-minute lagged implied volatility as in Stephan and Whaley (1990) and Chakravarty, Gulen and Mayhew (2004). The following is an implied stock return at time t , used in the derivation of the information share:

$$\frac{d\tilde{S}_t}{\tilde{S}_t} \approx \frac{\tilde{S}_{t+1} - \tilde{S}_t}{\tilde{S}_t}$$

(6)

where $\tilde{S}_t = BiOP^{-1}(O_t | \psi_t, \sigma_{t-1})$; $BiOP$ is the binomial option pricing model; and σ_{t-1} is the 30-minute lagged implied volatility.

By using the Black-Scholes' option pricing model, Chakravarty, Gulen and Mayhew (2004) and Collver (2005) assume the log normality of stock prices. However, in their VECM, they use log returns as dependent variables, which are not stationary. To be consistent, in this paper, we use differences of log returns as dependent variables to eliminate the inconsistency between the structural model and the empirical model in Chakravarty, Gulen and Mayhew (2004) and Collver (2005).

Since a VECM can be extended to more than two variables, it is possible to obtain IS of the option market by including all options without forming a portfolio. However, a multivariate VECM method has a couple of drawbacks. First, as Yan and Zivot (2007) show, the Cholesky decomposition introduces transitory shocks to IS. Second, the exogeneity/endogeneity of the variables in a VECM system can introduce a computational problem. By forming a portfolio of implied stock returns, we can not only minimize the impact of transitory shocks on the IS but also reduce the computation time.

We propose four portfolios to conduct a comparative test on IS between ATM call options and a portfolio of options. They are an equal-weighted, a factor-weighted, and two GMM-weighted portfolios.

A. ATM call options only

If the option market is instantaneously synchronized in information dissemination or informed traders trade only in the call market, IS derived from ATM call options will be a consistent estimate.

B. Equal-weighted portfolio

If the magnitude and the size of an unexpected component of the return innovation is equivalent for each option, an equal-weighted portfolio will provide a better estimate for the informativeness of the option market.

C. Factor-weighted portfolio

Common factor analysis assumes that the variance of X in the analysis can be decomposed into a ‘common’ variance that all of the variables share and a unique variance that only variable X holds. If a common factor(s) from implied

stock returns represent the permanent component of stock returns, a factor-weighted portfolio will provide a better estimate for the informativeness of the option market.

D. GMM-weighted portfolio

The main problem in a multivariate analysis without forming a portfolio is the impact of market friction included in transitory shocks on IS. IS is a variance decomposition of a permanent component. The variance decomposition assumes the orthogonality of each variable in the VECM representation. Since most variables of interest are closely related in the price discovery analysis, the Cholesky decomposition is used to orthogonalize the variables. However, the Cholesky decomposition introduces transitory shocks to IS, which reduces the quality of the results. Since we cannot completely eliminate generic transitory shocks on IS, we try to lessen the impact of transitory shocks by selecting a weighting scheme, which minimizes the market friction caused by the conjectured security returns.

We assume that the optimal weighting scheme does not vary over a day and that stock returns and implied stock returns are normally distributed. The following equation shows the structure of a portfolio of implied stock returns:

$$\frac{d\tilde{S}_t}{\tilde{S}_t} = \sum_{i=1}^n \beta_i \frac{d\tilde{S}_{i,t}}{\tilde{S}_{i,t}} = \frac{dm_{t-1}}{m_{t-1}} + \sum_{i=1}^n \beta_i \kappa_i v_{i,t} \quad \text{where} \quad \sum_{i=1}^n \beta_i = 1 \quad \text{and} \quad t = 1, \dots, T$$

(7)

To minimize the impact of transitory shocks on IS, we directly minimize the market friction existing in the transitory shock. Ex-post, we can empirically obtain the efficient price return process using stock and option returns. The

efficient stock return process can be expressed as a function of the portfolio of implied stock returns.

$$\frac{dm_t}{m_t} = \frac{d\tilde{S}_t}{\tilde{S}_t} - e_t^o = \frac{d\tilde{S}_t}{\tilde{S}_t} + \left(\sum_{i=1}^n \lambda_{i,t} (v_{i,t} - E_{t-1}[v_{i,t} | \psi_t]) - \sum_{i=1}^n \kappa_i v_{i,t} \right)$$

(8)

where $\left(\sum_{i=1}^n \lambda_{i,t} (v_{i,t} - E_{t-1}[v_{i,t} | \psi_t]) - \sum_{i=1}^n \kappa_i v_{i,t} \right)$ is total market friction in the option market on an efficient price return.

From equation (8), we develop the moment condition, which allows us to obtain a proper weight scheme, for a portfolio of implied stock returns.

$$\frac{1}{T} \sum_{t=1}^T E \left[\left(\frac{d\tilde{S}_t}{\tilde{S}_t} - \frac{dm_t}{m_t} \right) \cdot \begin{pmatrix} \frac{d\tilde{S}_{1,t}}{\tilde{S}_{1,t}} \\ \vdots \\ \frac{d\tilde{S}_{n,t}}{\tilde{S}_{n,t}} \end{pmatrix} \right] = 0 \text{ for } \forall t=1,2,\dots,T \text{ and } n=1,\dots,n.$$

(9)

We use the implied volatility and cubed implied stock returns as instruments in the GMM estimation. In the actual estimation, we employ an iterative GMM estimation, with the Marquardt-Levenberg minimization method.

For a factor-weighted portfolio, we do not conjecture a structural model to derive an empirical application. Using the correlation among variables in the study, we extract a common factor(s) and employ normalized factor-loading as a portfolio weight. Using the Kaiser-Guttman rule and the Scree test, we find that there is only one common factor among implied stock returns.

Using the results from this section, we are able to address several issues. First, we examine the option market contribution to the price discovery process of the underlying stock; second, the relevance of including multiple options in the price discovery process; and third, the individual impact of different options in the price discovery process

4. Data

We examine trade/quotes of 58 stocks and their nearest-maturity options from Bauer Research DataSet (BRDS). BRDS contains intraday stock and option data collected from Reuters. The data cover around 60 stocks and their nearest-maturity options traded in all of the U.S. stock and option exchanges since 2004. We use quotes and trade data between April, 17, 2005, and May 16, 2005. Dividend amounts and their payout dates, size, book value, and market value are obtained from CRSP and COMPUSTAT. We use a 3-month LIBOR as the risk-free rate.

We utilize various resolutions with our data set to examine IS of the option market. Hasbrouck (1995), Chakravarty, Gulen and Mayhew (2004) and Collver (2005) use a data set with a one-second interval. However, for computational convenience, they assign the same coefficient to every 10 variables in a VECM. We use 30-second and one-, five-, 10- and 15-minute resolutions to derive IS and do not impose any constraints on coefficients in a VECM. A shorter resolution reduces the correlation in the innovation among multiple markets. However, a shorter resolution can also cause the stale price problem. The volume traded can

provide an indication of a potential stale price problem. In our data set, the average stock volume of the 58 stocks is 1,348,640, while the average option volume is 82.91 for each stock. The volume comparison confirms the findings in O'Hara (1995) that the option market is less liquid than the stock market. Using longer resolutions in the analysis, we can avoid the stale price problem.

In Table I and Table II, we provide summary statistics of the stocks and options analyzed. The daily average stock volume as a number of shares for our data set is 1,348,640, while the daily average option volume is 40.94 for call options and 41.98 for put options. As we noted before, it is clear that the stock market is much more liquid than the option market. The average daily stock spread in our data set is 0.0175, while the average option spread is 0.1052 for calls and 0.1109 for puts. Spread analysis also confirms the higher liquidity of the stock market.

Table I contains the daily averages of trading volume, bid/ask prices, trading prices, bid-ask spread, effective spread, daily realized return and daily realized volatility of stocks. Effective spread is defined as twice the absolute difference between the trade price and quote midpoint. The realized stock return is the average daily return of logged quote midpoint using BRDS. Realized stock volatility is the annualized root sum of a squared five-minute log return. The daily average stock spread and the effective spread for most of stocks are less than two cents, which shows that the stock market is very liquid. Realized volatility is measured from log stock returns with five-minute intervals, as proposed in Andersen, Bollerslev, Diebold and Labys (2001).

Table II reports the daily averages of trading volume, bid-ask spread, effective spread, moneyness, implied volatility of options as well as implied stock price. Both the spread and the effective spread of options are much larger than those of stocks, which indicates that the option market is less liquid than the stock market. While put volume is slightly larger than call volume, on average, call spreads are slightly narrower than put spreads by 0.57 cents.

We define moneyness as the ratio of the signed difference between the closing stock price and the strike price over the closing price. Since most of the options in this study are either ATM or ITM options, it is typical to observe a positive moneyness ratio. On average, the difference between average closing stock prices and average implied stock prices is quite narrow. However, individual stocks show a wide range of differences, which lies between less than -10 cents of MAR and more than 23 cents of LXX.

5. Results

5.1 Estimation of Weights

To obtain the IS of the overall option market, we need to estimate a proper weight scheme to combine implied stock returns. Using the moment condition described in Section 3.3, we derive a GMM weighting scheme as well as a factor weighting scheme for ITM, ATM and OTM call and put options. Before applying the GMM and factor analyses, we identify whether realized stock returns and implied stock returns have a unit-root problem. We also examine the correlation between the main variables and the instrumental variables used in the GMM

analysis. Table III reports the result of the Dickey-Fuller unit-root tests on stock returns and implied stock returns with three types of assumptions; zero mean, single mean and trend. The results from all three tests show that more than 99 percent of stock returns and implied stock returns in the data set do not suffer from a unit-root problem. Table IV shows the average correlations among variables used in the GMM estimation. In the GMM estimation, we use implied volatility and cubed implied stock returns as instruments. Although implied volatility is one of the crucial factors affecting option pricing, the correlation between implied volatility and implied stock returns does not appear to be strong. While ATM implied stock returns and ITM implied stock returns show a similar correlation of 0.34 with stock returns, OTM implied stock returns and stock returns show a lower correlation of less than 0.08. We should also note that the correlation of OTM implied stock returns between calls and puts is negative, which indicates that OTM option traders in the call and put markets have different perceptions regarding the underlying stock returns.

GMM weights are obtained using the moment condition in equation (9). Two GMM weighting schemes are derived by imposing different restrictions. For the first GMM weighting scheme, we assume that only buying options is allowed, which permits only non-negative weights. For the second GMM weighting scheme, we allow both buying and writing options by allowing both positive and negative weights. As a robustness check, we derive a factor weighting scheme to deal with a potential multicollinearity problem. Using common factor analysis through a maximum likelihood method with a varimax rotation, we derive factor loadings for

each implied stock return. The Kaiser-Guttman rule and the Scree test are used to confirm that there is only one common factor representing the six implied stock returns. GMM weights are obtained in such a way that an implied stock return with the least distance from an efficient stock return gets the largest weight. This ensures that a GMM weight scheme is designed to form a portfolio of implied stock returns, which minimizes the distance between a portfolio return and the efficient stock return.

Table V shows the portfolio weights for each resolution. In Panel A, the factor weights are presented. Weights vary between -10.34 and 11.16. We do not find any pattern along the different resolutions or option types. In Panel B and Panel C, the two GMM weights are presented. GMM1 weights –i.e with the assumption of no writing options- vary between 0.08 for ITM puts with a 15-minute resolution and 0.34 for OTM calls with a 15-minute resolution. GMM2 weights –i.e, with the assumption that both buying and writing options are allowed- vary between 0.06 of ITM puts with a 15-minute resolution and 0.42 of OTM puts with a 15-minute resolution. The GMM weights show that as the resolution of the dataset increases, OTM option weights increase. It also shows that OTM option weights are significantly larger than ITM or ATM option weights. These findings are consistent with the studies of Black (1975), Chakravarty, Gulen and Mayhew (2004) and Pan and Poteshman (2006). One of the interesting findings in the GMM weight analysis is that the significant weights on OTM options appear when the data set has the largest interval of 15 minutes. We believe that this is due to the market microstructure fact that it takes time to disseminate new information from

one security/market to the others. Therefore, if the resolution of the data set is too short, we may overlook the impact of new information in one security/market, which does not spread instantaneously across securities/markets. Contrary to De Jong, Koedijk, and Schnitzlein (2006), our study finds that the contribution of ITM options to price discovery is the least, regardless of the resolution used.

5.2 Contribution of Different Options to Price Discovery

With the weight estimation done, we study which option contributes the most in price discovery between stock and option markets. From the factor weight scheme, we do not find any pattern along the resolutions or option types. We do not observe a clean factor structure. Also, it is difficult to justify why and how OTM call options with 10-minute intervals contribute to the information on an efficient price return 11 times more than any other options. Based on these points, we do not use the factor weight scheme to provide an answer for which option contributes the most to price discovery. Using the GMM-weight schemes, we are able to measure the contribution of each option to price discovery. With a 30-second resolution, we find that ATM calls and puts contribute the most, and they are followed by OTM calls and puts. In the GMM1 weights, the contribution of call options is greater than that of put options regardless the resolution. In the GMM2 weights, the contribution of call options is greater than that of put options when the resolution is low. When the resolution increases, the contribution of put options to price discovery, on the other hand, increases. We also find that as the resolution increases, the contribution of OTM options increases for both GMM1

and GMM2. With a 15-minute resolution, the contribution of the OTM calls and puts exceeds 50% of the total option contribution, while the contribution of the ITM calls and puts reaches barely 17% of the total option contribution. These findings suggest the following implications. First, OTM options convey crucial information regarding the efficient stock returns. Second, the information in OTM, especially OTM put options is not instantaneously reflected across stock and option markets. Lastly, informed traders use both writing and buying options as their trading strategies.

We also conduct Wald tests on the GMM weights to test whether only ATM calls or ATM puts represent the informativeness of the overall option market. We use two types of efficient stock returns for the robustness of the tests. The efficient stock return 1 represents the estimated efficient stock returns using stock returns, ITM, ATM and OTM calls and puts. The efficient stock return 2 represents the estimated efficient stock returns using stock returns and only ATM calls. Table VI reports the result of Wald tests on GMM weights at the five percent level. It shows the percentages of stocks where the null hypotheses of equal weights are rejected. We conduct nine types of Wald tests. In Test 1 through Test 6, we investigate the informative role of individual options of ATM, ITM and OTM calls and puts. In Test 7 through Test 9, we investigate whether moneyness of options is correlated to informed trading. For Test 1 and Test 2, over 82 percent of stocks in our data set reject the null hypothesis that only ATM calls or only ATM puts should be used to form a GMM portfolio. The results are consistent regardless of the resolution of the dataset. In Test 3 and Test 5, we test whether ITM calls or

ITM puts have zero weights; we find that with a GMM1 specification, less than 31 percent of stocks reject the null hypothesis. With a GMM2 specification, up to 42 percent of stocks reject the null hypotheses. We should note that the rejection percentage increases as the resolution increases. The test results support the earlier remark that it takes time to disseminate information across stock and option markets. Between 35 to 78 percent of stocks reject the null hypothesis of Test 4 and Test 6, where we test whether OTM options convey information regarding efficient stock returns. In this case, it is very clear that as the resolution of the data set grows, the rejection rate also grows. The Wald tests more strongly reject the null hypothesis of Test 7 and Test 8 that neither the OTM calls nor puts carry any information regarding an efficient stock return. The rejection rate is lower for the case of the ITM calls and puts. The Wald tests strongly reject the null hypothesis of Test 9, showing that using only ATM calls and/or puts ignores the information present in ITM and OTM options. The rejection rates do not differ between two estimated efficient stock returns. This supports the crucial informational role of ITM and OTM options. However, the rejection rates do differ between the GMM1 and GMM2 approaches. This finding shows that information on an efficient stock return takes two routes to disseminate in the option market: both buying and writing options.

With the weight schemes, we form an equal-weighted, factor-weighted and two GMM-weighted portfolios of implied stock returns to derive IS of the option market. Table VII reports IS for each stock and for each resolution. It contains the

average IS and upper and lower bounds of IS.² Panel A to Panel E show IS for 30 seconds and one, five, 10, and 15 minutes, respectively. Panel F shows the average and upper and lower bounds of IS in our data set. The IS of the option market varies along stocks, resolutions and type of portfolios. For example, the IS of ATM call options with a 30-second resolution varies between 0.17 and 0.46. From Panel F, it is very clear that as the resolution grows, IS of the option market also grows. The difference between 30-second and 15-minute resolutions is, on average, 6.4% for the GMM1 portfolio and 14.4% for ATM calls. Also, a quick comparison of the IS between ATM calls and the others shows that utilizing multiple options in the price/return analysis provides a higher estimate on the informativeness of the option market than utilizing only one type of options.

With the IS derived above, we test whether the IS of the option market is significant. A standard t-test and a Wilcoxon signed rank-sum test show that the IS of the option market is significantly different from zero; therefore, we reject the null hypothesis that there is no contribution of option market to the price discovery process. Both a t-test and a nonparametric test have a p-value lower than 0.0001. We also test whether the IS of ATM calls truly represents the informativeness of the overall option market. For this purpose, we calculate a Wilcoxon signed rank-sum test on IS between ATM calls and the other options. Table VIII reports the result of a Wilcoxon signed rank-sum test. First, the IS of all stocks is tested for each resolution, assuming that there is no cross-sectional difference in IS among stocks. Second, a Wilcoxon signed rank-sum test is conducted for each stock for

² The Appendix provides IS' upper and lower 95% confidence intervals with a standard deviation for all resolutions.

each resolution. For the comparison purpose, Student's t-statistics are also presented. Panel A reports the nonparametric tests on IS for all resolutions. Panel B reports percentages of the nonparametric tests on each stock for each resolution that rejects the null hypothesis of no difference in means at the five percent level. From Table VIII, it is clear that there is a difference in IS between ATM calls and the portfolio approach for all resolutions. The comparison between GMM-weighted portfolios and an equal-weighted or a factor-weighted portfolio also provides statistically strong evidence that GMM-weighted portfolios offer a bigger IS than the others. The result suggests that the IS using ATM calls, an equal-weighted or a factor-weighted portfolio may not reflect the overall informativeness of the option market properly; therefore, the previously reported IS in the literature may not truly represent the true informativeness of the option market. However, we cannot generalize the biased estimation of IS to all of the stocks we examine. As we observe in Table I, it is possible that there is a cross-sectional difference in IS; for some stocks, it is still possible that only the call market conveys new information regarding underlying stock prices. To examine the IS of the option market at the individual stock level, we conduct a nonparametric test on IS for each stock. Table VIII, Panel B reports percentages of stocks that reject the null that IS of ATM calls is larger than IS of a portfolio. The result shows that the IS of an equal-weighted, a factor-weighted or a GMM-weighted portfolio is bigger than that of ATM calls only, which is consistent with our assumption. The average difference on IS between the portfolio approach and the ATM calls is always positive, which varies between 0.05 for Factor vs. ATM with a 15-minute

resolution and 0.19 for GMM1 vs. ATM with a one-minute resolution. The average mean difference is larger for the GMM approach than the equal or factor approach for all resolutions. The GMM1 portfolio provides a larger IS than ATM calls more than 45.3% of the time. The GMM2 portfolio provides a larger IS than ATM calls more than 42.6% of the time. Note that without using a sophisticated approach such as a factor analysis or a mean-variance minimization, a simple equal-weighted scheme on IS provides a better estimation of the informativeness of the option market than using ATM call options only. This shows that using only one type of options may undermine the crucial role of the option market in price discovery between stock and option markets.

We also conduct a Student's t-test and a Wilcoxon signed rank-sum test to study whether a GMM-weighted portfolio provides a better estimate of the IS than an equal-weighted or a factor-weighted portfolio. The test results using the IS of all stocks show that both GMM1 and GMM2 approaches provide a larger and better estimate than an equal-weighted or a factor-weighted portfolio. However, we want to verify the result at the individual stock level. The lower part of Panel B in Table VIII shows the percentage of stocks that reject the null hypothesis that an equal-weighted or a factor-weighted portfolio gives a larger IS estimation than the GMM1 or GMM2 approach. The rejection rates are not impressive. For the 30-second resolution, the rejection rate lies between 5.1% for GMM1 vs. Equal and 15.15% for GMM2 vs. Factor. As the resolution increases, the rejection rate also increases. For the 15-minute resolution, the rejection rate lies between 22.86% for GMM1 vs. Equal and 29.73% for GMM1 vs. Factor. In general, the rejection rate

is higher for GMM vs. Factor than GMM vs. Equal. This shows that the common factor extracted from the return series does not capture an efficient stock return process. Also, it is surprising to observe how well an equal-weighted portfolio performs in representing the informativeness of the option market. With our data set using Wilcoxon signed rank-sum tests, it is inconclusive whether the GMM approach provides a better estimate of IS than the other portfolio approaches.

5.3 Bootstrap Analysis

Given that non-normality and a limited number of observations can have a serious impact on testing, we use a bootstrapping method to resample the data and conduct a nonparametric test. We resample IS 10,000 times according to Efron's (1979) bootstrap method and perform a nonparametric test whether GMM-weighted portfolios provide higher information shares than an equal-weighted or a factor-weighted portfolio. Table IX reports the result of the bootstrapping and the nonparametric test results. With the resampled data, we derive mean, median and Bickel and Freedman's (1981) confidence intervals –i.e., an average mean difference of IS between ATM calls and a portfolio approach- for each stock. The comparison of the means between the original IS and the resampled IS shows almost no difference throughout the resolutions. Normality tests on the resampled data confirm that more than 50% of the resampled data is normally distributed. For the resolutions of 30 second and one and 10 minutes, the median of the resampled data is slightly lower than the mean of the resampled data. This indicates the distribution of the IS is right skewed with those resolutions. The nonparametric test

on the resampled data shows strong evidence that the IS using a portfolio approach outperforms IS using ATM call options. When we examine the IS of all stocks jointly, we find a statistically strong result that the IS using ATM call options is lower than the IS of the other approaches. In particular, the GMM approach performs the best among the portfolio approaches. The rejection rate from the mean comparison between ATM calls and the portfolio approaches lies between 70% and 100%. The rejection rate from the median comparison between ATM calls and the portfolio approaches lies between 69% and 98%. These findings support the hypothesis that the informativeness of the ITM and OTM option markets regarding an efficient stock return is indeed more than trivial.

Based on the results of the nonparametric tests with the bootstrap resampling, we can reject the null that an equal-weighted or a factor-weighted portfolio provides a larger IS than a GMM-weighted portfolio. Both the mean and the median of the IS comparison between a GMM approach and the others are all positive and the rejection rate is at least 63.79%. Unlike the weight scheme analysis or the IS analysis, we do not find any pattern in rejection rates along the resolution.

The nonparametric test results answer the important question whether IS using only one type of options truly represent the informativeness of the overall option market. From our analysis, it is clear that an estimate using only one type of options is biased and does not represent a true parameter of the option market. Especially for the case of IS, using only ATM calls will give a downward biased IS, which excludes the impact of OTM and ITM options on an efficient stock return.

The results also show that IS using the GMM approach performs better than other portfolios in measuring the contribution of the option market to the price discovery process.

6. Conclusion

In this paper, we propose a new portfolio approach to estimate Hasbrouck's (1995) information share (IS), which measures the relative contribution of one market to the variance of an efficient stock return process. Using GMM, we are able to estimate optimal weights for a portfolio of options to be used in Hasbrouck's (1995) analysis.

First, we estimate the information share for 58 stocks using only ATM call options as in Chakravarty, Gulen and Mayhew (2004). We find the average IS varies from 31.19% to 45.62%. Second, we use the GMM portfolio approach, and we find that the average IS of the option market lies between 47.23% and 58.34%, which suggests that the option market and the stock market are almost equally competitive in price discovery. That is, using a portfolio approach, we find that the information share of the option market is much higher than what Chakravarty, Gulen and Mayhew (2004) originally reported.

The GMM approach also offers an opportunity to examine the relative contribution of each option to price discovery. We use different options such as ITM, ATM, and OTM call and put options and provide a relative weight for each option. As in Black (1975), Chakravarty, Gulen and Mayhew (2004) and Pan and Poteshman (2006), the weight analysis shows that OTM calls and puts indeed make

a significant contribution to price discovery. The weight for OTM options lies between 16.02% and 41.77%, which is significantly higher than ITM or ATM options.

We also find strong evidence that information dissemination in the option market takes some time to spread. We classify the data set using five types of resolution: 30 second and one, five, 10 and 15 minutes. The test results show that as the resolution increases, the weight on OTM options also increases. We also find a similar phenomenon in IS. For example, the IS using a GMM approach increases from 50% to 57% as the resolution of the dataset increases from 30 seconds to 15 minutes. This finding suggests that although using data with fine intervals can prevent the impact of a serial correlation on price discovery, it might also overlook the time-taking feedback effect on price/return series.

To test whether a GMM-portfolio approach is better than simpler portfolios, we use a bootstrap. With the resampled data, we find that, on average, the mean IS using a GMM portfolio is significantly higher than the mean IS using an equal-weighted or a factor-weighted portfolio. This finding implies that with a GMM approach, we can provide a better estimate on the informativeness of the option market than any other portfolio approaches used in this study.

In this paper, we propose a portfolio approach to understand the dynamics of price discovery between stock and option markets. The portfolio approach not only enables us to examine multiple options simultaneously but also provides a better picture of the relative informational role of each option. Our findings also provide strong evidence that the informativeness of the option market is nontrivial.

Table 1: Market Summary

Ticker	Company Name	Market Value (million)	Stock Volume (thousand)	Bid Price	Ask Price	Trading Price	Stock Spread	Stock Effective Spread	Realized Stock Return	Realized Stock Volatility
AIG	AMERICAN INTERNATIONAL GROUP INC	143,868	2,077	52.64	52.62	52.61	0.0220	0.0193	0.0016	0.2944
ALL	ALLSTATE CORP	36,923	792	56.01	55.99	55.99	0.0207	0.0193	0.0025	0.2160
AMAT	APPLIED MATERIALS INC	27,304	753	15.41	15.40	15.40	0.0102	0.0218	-0.0512	1.1416
AMD	ADVANCED MICRO DEVICES INC	6,315	1,624	15.04	15.02	15.03	0.0139	0.0127	0.0004	0.3628
AMR	A M R CORP DEL	1,724	1,720	10.92	10.90	10.91	0.0172	0.0138	-0.0101	0.6889
AMZN	AMAZON COM INC	14,041	516	33.66	33.65	33.65	0.0121	0.0263	0.0420	0.8823
BAC	BANK OF AMERICA CORP	178,453	1,992	45.36	45.35	45.35	0.0162	0.0152	0.0109	0.3113
BEAS	B E A SYSTEMS INC	3,173	674	7.56	7.55	7.55	0.0103	0.0134	0.0232	0.5903
BRCM	BROADCOM CORP	9,889	493	31.52	31.51	31.53	0.0120	0.0163	0.0577	1.0533
BSX	BOSTON SCIENTIFIC CORP	24,467	1,124	29.84	29.82	29.83	0.0192	0.0169	-0.0070	0.3627
CA	COMPUTER ASSOCIATES INTL INC	15,907	945	27.65	27.64	27.64	0.0150	0.0142	-0.0018	0.2574
CMCSK	COMCAST CORP NEW	28,015	656	31.55	31.54	31.54	0.0133	0.0159	0.0031	0.2639
COF	CAPITAL ONE FINANCIAL CORP	18,456	642	72.11	72.08	72.09	0.0304	0.0290	0.0345	0.7514
CSCO	CISCO SYSTEMS INC	120,489	958	17.98	17.97	18.00	0.0101	0.0168	-0.0536	1.1188
DELL	DELL INC	95,474	594	36.90	36.89	36.90	0.0110	0.0189	0.0288	0.5879
DUK	DUKE ENERGY CORP	26,806	1,283	28.49	28.48	28.48	0.0144	0.0138	-0.0400	0.8120
EBAY	EBAY INC	24,938	516	33.23	33.22	33.24	0.0110	0.0207	0.0107	0.4037
EMC	E M C CORP MA	29,629	2,737	13.22	13.21	13.21	0.0127	0.0123	-0.0381	1.0717
ET	E TRADE FINANCIAL CORP	4,432	1,694	11.62	11.60	11.61	0.0155	0.0133	-0.0055	0.5942
FRE	FEDERAL HOME LOAN MORTGAGE CORP	43,646	737	62.16	62.13	62.14	0.0273	0.0266	0.0662	1.3043
FRX	FOREST LABS INC	12,845	883	36.43	36.41	36.42	0.0195	0.0185	-0.0202	0.6289
GE	GENERAL ELECTRIC CO	381,744	2,654	36.18	36.16	36.17	0.0134	0.0134	-0.0018	0.1872
GM	GENERAL MOTORS CORP	16,609	2,709	29.08	29.06	29.12	0.0175	0.0143	-0.0046	0.5689
HAL	HALLIBURTON COMPANY	19,117	1,002	42.22	42.20	42.21	0.0204	0.0189	0.0085	0.4000
HOG	HARLEY DAVIDSON INC	16,999	1,106	47.78	47.76	47.77	0.0206	0.0188	0.0073	0.2421

Table I continued

Ticker	Company Name	Market Value (million)	Stock Volume (thousand)	Bid Price	Ask Price	Trading Price	Stock Spread	Stock Effective Spread	Realized Stock Return	Realized Stock Volatility
HPQ	HEWLETT PACKARD CO	63,862	2,442	20.90	20.89	20.90	0.0133	0.0133	-0.0319	0.8235
IBM	INTERNATIONAL BUSINESS MACHS COR	150,374	1,326	75.35	75.32	75.33	0.0245	0.0218	0.0489	0.9934
IMCL	IMCLONE SYSTEMS INC	2,865	417	32.42	32.39	32.41	0.0309	0.0337	-0.0335	0.9507
INTC	INTEL CORP	145,257	945	24.17	24.16	24.19	0.0102	0.0188	-0.0090	0.4670
JNJ	JOHNSON & JOHNSON	199,534	1,293	68.02	68.00	68.01	0.0190	0.0171	0.0374	0.7507
JPM	JPMORGAN CHASE & CO	123,044	2,204	35.35	35.33	35.34	0.0150	0.0140	-0.0249	0.6066
KLAC	K L A TENCOR CORP	9,056	341	40.65	40.64	40.66	0.0129	0.0182	0.0076	0.3664
KO	COCA COLA CO	100,397	1,312	43.59	43.57	43.57	0.0155	0.0143	0.0013	0.1917
LXK	LEXMARK INTERNATIONAL INC NEW	10,204	818	68.78	68.75	68.77	0.0342	0.0315	0.0152	0.6307
MER	MERRILL LYNCH & CO INC	52,684	974	53.84	53.82	53.82	0.0215	0.0203	-0.0072	0.3481
MMM	3M CO	66,283	802	76.75	76.73	76.74	0.0262	0.0249	0.0134	0.4307
MO	ALTRIA GROUP INC	134,672	1,456	65.63	65.61	65.61	0.0210	0.0194	-0.0051	0.3113
MRK	MERCK & CO INC	71,494	1,757	33.79	33.77	33.78	0.0160	0.0151	-0.0292	1.2376
MS	MORGAN STANLEY DEAN WITTER & CO	62,236	1,525	50.06	50.04	50.05	0.0222	0.0220	0.0265	0.7244
MSFT	MICROSOFT CORP	262,535	1,004	25.13	25.12	25.13	0.0102	0.0182	-0.0095	0.3401
NEM	NEWMONT MINING CORP	18,827	1,151	37.80	37.78	37.80	0.0178	0.0157	0.0756	1.5352
NOK	NOKIA CORP	69,233	3,651	16.57	16.55	16.56	0.0120	0.0116	-0.0283	0.7762
ORCL	ORACLE CORP	64,210	929	11.92	11.91	11.91	0.0101	0.0143	-0.0334	0.7974
OVTI	OMNIVISION TECHNOLOGIES INC	873	451	14.51	14.49	14.51	0.0166	0.0167	0.0101	0.4108
PFE	PFIZER INC	196,316	3,269	27.60	27.58	27.59	0.0133	0.0128	0.0228	0.4804
PG	PROCTER & GAMBLE CO	134,823	1,461	54.78	54.77	54.77	0.0185	0.0170	0.0272	0.5722
QCOM	QUALCOMM INC	59,890	496	35.15	35.14	35.15	0.0115	0.0178	-0.0166	0.6209
SNDK	SANDISK CORP	5,003	466	25.16	25.15	25.16	0.0135	0.0184	0.0402	0.9930
SUNW	SUN MICROSYSTEMS INC	13,760	1,438	3.73	3.73	3.74	0.0101	0.0136	-0.0751	1.6482
TWX	TIME WARNER INC NEW	80,532	3,069	17.17	17.16	17.16	0.0137	0.0135	0.0599	1.1578

Table I continued

Ticker	Company Name	Market Value (million)	Stock Volume (thousand)	Bid Price	Ask Price	Trading Price	Stock Spread	Stock Effective Spread	Realized Stock Return	Realized Stock Volatility
TXN	TEXAS INSTRUMENTS INC	43,795	1,949	25.71	25.69	25.69	0.0152	0.0138	0.0181	0.4288
TYC	TYCO INTERNATIONAL LTD NEW	67,934	2,863	30.02	30.00	30.01	0.0158	0.0149	0.0030	0.3531
UPS	UNITED PARCEL SERVICE INC	81,905	970	71.58	71.55	71.54	0.0246	0.0241	0.0369	0.7530
USG	U S G CORP	1,436	726	42.39	42.33	42.36	0.0604	0.0518	-0.0216	0.8700
VZ	VERIZON COMMUNICATIONS INC	98,323	1,927	34.61	34.59	34.60	0.0152	0.0148	-0.0087	0.3433
WFC	WELLS FARGO & CO NEW	101,337	931	59.91	59.90	59.90	0.0176	0.0176	0.0222	0.4898
XOM	EXXON MOBIL CORP	381,500	2,422	56.71	56.69	56.69	0.0185	0.0186	-0.0051	0.3081
YHOO	YAHOO INC	46,903	554	34.84	34.83	34.84	0.0108	0.0190	-0.0168	0.5650
Mean		72,799	1,349	36.88	36.87	36.87	0.0175	0.0184	0.0030	0.6443

This table reports the summary statistics on stock market data in this study. This study uses data from BRDS, which contains intraday data on stock and option markets collected via Reuters. BRDS data starts from 2004 to current. The sample in this study covers the intraday data from April, 17, 2005, to May, 16, 2005. This table contains the daily averages of trading volume, bid/ask price, trading price, bid/ask spread, effective spread, daily realized stock returns and daily realized stock volatility for the companies in this study. Effective spread is defined as twice the absolute difference between the trade price and quote midpoint at the time when the order is received. Realized stock return is an average daily log return of quote midpoint, and realized stock volatility is an annualized root sum of squared five-minute log return using BRDS. Stock volume is measured in thousands.

Table II. Option Market Summary

Ticker	Option Volume		Option Spread		Effective Spread		Moneyness		Implied Volatility	Realized Stock Volatility	Implied Stock Price	Closing Stock Price
	Call	Put	Call	Put	Call	Put	Call	Put				
AIG	46.77	38.49	0.1244	0.1179	0.0874	0.0946	0.0473	0.0459	0.4037	0.2944	52.48	52.49
ALL	26.63	18.35	0.1193	0.1100	0.1721	0.1582	0.0461	0.0171	0.1913	0.2160	55.77	55.70
AMAT	35.58	44.74	0.0784	0.0764	0.0530	0.0552	0.0804	0.1118	0.4340	1.1416	15.29	15.29
AMD	52.62	87.43	0.0802	0.0918	0.0558	0.0578	0.0585	0.1714	0.5946	0.3628	14.80	14.83
AMR	49.39	36.58	0.1138	0.1154	0.0584	0.0751	0.2614	0.1198	0.7897	0.6889	10.69	10.58
AMZN	29.21	31.09	0.0999	0.0977	0.0675	0.0662	0.0865	0.0933	0.4542	0.8823	33.45	33.43
BAC	27.52	65.03	0.1018	0.1057	0.0778	0.0779	0.0527	0.0714	0.2825	0.3113	45.17	45.21
BEAS	54.47	87.21	0.0731	0.0818	0.0602	0.0885	0.1488	0.1458	0.6483	0.5903	7.37	7.38
BRCM	47.17	24.49	0.1100	0.1108	0.0594	0.1023	0.1554	0.0634	0.4025	1.0533	30.70	30.64
BSX	38.83	63.11	0.1280	0.1251	0.0621	0.0914	0.1000	0.1422	0.4201	0.3627	29.70	29.71
CA	24.31	10.83	0.1164	0.1146	0.0964	0.1163	0.1031	0.1312	0.4453	0.2574	27.43	27.45
CMCSK	67.64	27.44	0.1012	0.0967	0.0974	0.1552	0.0202	0.0269	0.2660	0.2639	31.58	31.60
COF	18.78	21.53	0.1248	0.1263	0.2526	0.1581	0.0242	0.0288	0.2719	0.7514	71.77	71.86
CSCO	87.52	117.97	0.0759	0.0788	0.0460	0.0493	0.1868	0.1125	0.4473	1.1188	17.74	17.73
DELL	46.39	61.93	0.0881	0.0876	0.0577	0.0736	0.0988	0.0755	0.3619	0.5879	36.25	36.25
DUK	22.26	26.68	0.1040	0.1181	0.1234	0.1181	0.0566	0.1029	0.2504	0.8120	28.66	28.65
EBAY	27.02	27.77	0.0980	0.1049	0.0611	0.0625	0.0629	0.2143	0.5927	0.4037	32.75	32.86
EMC	35.30	52.79	0.0825	0.0836	0.0518	0.0604	0.1433	0.0930	0.3579	1.0717	13.01	12.99
ET	42.41	25.94	0.0949	0.0916	0.0814	0.1082	0.0577	0.0469	0.4324	0.5942	11.46	11.47
FRE	39.03	39.08	0.1357	0.1378	0.2611	0.2003	0.0402	0.0401	0.3047	1.3043	61.79	61.82
FRX	36.58	47.56	0.1342	0.1166	0.0995	0.1489	0.1451	0.0168	0.4063	0.6289	35.99	35.97
GE	67.79	111.93	0.0909	0.0975	0.0694	0.0675	0.0999	0.0368	0.2425	0.1872	36.06	36.05
GM	32.77	28.80	0.1830	0.1725	0.0688	0.0867	0.1552	0.1024	0.4672	0.5689	28.73	28.71
HAL	29.82	25.11	0.1075	0.1115	0.1180	0.1191	0.0496	0.0630	0.3566	0.4000	42.42	42.42

Table II continued

Ticker	Option Volume		Option Spread		Effective Spread		Moneyness		Implied Volatility	Realized Stock Volatility	Implied Stock Price	Closing Stock Price
	Call	Put	Call	Put	Call	Put	Call	Put				
HOG	16.53	19.94	0.1305	0.1385	0.1053	0.1856	0.0369	0.0346	0.3159	0.2421	47.61	47.66
HPQ	46.92	92.97	0.0909	0.0946	0.0671	0.0543	0.1473	0.0292	0.6041	0.8235	20.66	20.64
IBM	25.26	23.10	0.0686	0.1289	0.0611	0.1089	-0.0194	0.0898	0.2933	0.9934	75.19	75.35
IMCL	25.23	35.15	0.1440	0.1344	0.1084	0.2136	0.1163	0.0733	0.6486	0.9507	32.16	32.08
INTC	81.05	51.81	0.0828	0.0843	0.0574	0.0546	0.0739	0.0563	0.2588	0.4670	23.90	23.91
JNJ	26.63	20.49	0.1173	0.1182	0.0685	0.1638	0.0561	0.0400	0.2214	0.7507	68.24	68.27
JPM	31.42	79.77	0.0937	0.0941	0.0699	0.0643	0.0623	0.0739	0.2610	0.6066	35.33	35.27
KLAC	39.86	32.15	0.1029	0.1034	0.0991	0.1117	0.0357	0.0867	0.4255	0.3664	40.15	40.18
KO	68.83	34.59	0.1269	0.1256	0.0755	0.0824	0.1135	0.0557	0.2448	0.1917	43.38	43.31
LXK	19.51	26.22	0.0991	0.1771	0.1251	0.3707	-0.0740	0.1308	0.4077	0.6307	69.60	69.83
MER	32.74	33.20	0.1009	0.1229	0.1256	0.1490	0.0188	0.0690	0.3293	0.3481	53.76	53.85
MMM	18.68	32.67	0.0861	0.1318	0.1257	0.1691	-0.0045	0.0727	0.2624	0.4307	76.68	76.78
MO	32.31	76.22	0.1195	0.1264	0.0972	0.0688	0.0205	0.0552	0.2937	0.3113	65.35	65.38
MRK	25.02	37.10	0.1029	0.0981	0.0589	0.1139	0.1011	0.0263	0.2997	1.2376	34.01	33.94
MS	41.08	29.39	0.0808	0.1343	0.0802	0.1026	-0.0261	0.0773	0.3867	0.7244	50.35	50.39
MSFT	78.76	70.80	0.0784	0.0800	0.0468	0.0494	0.0845	0.1522	0.2582	0.3401	25.02	24.98
NEM	34.30	28.83	0.1054	0.1121	0.0957	0.0728	0.0203	0.1309	0.4359	1.5352	38.48	38.57
NOK	41.56	33.94	0.1079	0.1104	0.0648	0.0725	0.2211	0.2351	0.3503	0.7762	16.36	16.32
ORCL	43.70	118.36	0.0671	0.0773	0.0497	0.0627	0.0587	0.1510	0.4050	0.7974	11.79	11.80
OVTI	20.46	37.85	0.1132	0.1219	0.0593	0.1199	0.1043	0.1849	0.6807	0.4108	14.22	14.24
PFE	47.41	41.81	0.0801	0.0869	0.0494	0.0536	0.1524	0.1005	0.3370	0.4804	27.43	27.37
PG	21.77	35.59	0.1053	0.1071	0.0992	0.1045	0.0326	0.0684	0.2204	0.5722	54.52	54.67
QCOM	37.00	51.97	0.0978	0.1006	0.0704	0.0712	0.1102	0.0624	0.3941	0.6209	34.94	34.84
SNDK	17.86	34.50	0.1193	0.1179	0.0762	0.0738	0.0576	0.2109	0.5393	0.9930	24.94	25.01

Table II continued

Ticker	Option Volume		Option Spread		Effective Spread		Moneyness		Implied Volatility	Realized Stock Volatility	Implied Stock Price	Closing Stock Price
	Call	Put	Call	Put	Call	Put	Call	Put				
SUNW	49.27	41.53	0.0657	0.0738	0.0475	0.0680	0.0314	0.1087	0.5983	1.6482	3.72	3.72
TWX	39.86	39.72	0.0799	0.0819	0.0534	0.0578	0.0694	0.0720	0.3599	1.1578	17.08	17.09
TXN	58.90	36.73	0.0929	0.0950	0.0621	0.0767	0.1356	0.0554	0.3546	0.4288	25.25	25.20
TYC	59.35	38.27	0.1105	0.1042	0.0784	0.0854	0.0448	0.0994	0.4162	0.3531	30.25	30.32
UPS	33.68	29.08	0.1098	0.1123	0.1478	0.1357	0.0317	0.0352	0.2805	0.7530	70.80	70.88
USG	20.73	24.53	0.2507	0.2531	0.2345	0.2079	0.0241	0.0491	0.9114	0.8700	42.24	42.25
VZ	47.85	39.34	0.0949	0.0976	0.0628	0.0818	0.0592	0.0598	0.2189	0.3433	34.52	34.51
WFC	42.34	40.94	0.1152	0.1176	0.1427	0.1265	0.0316	0.0238	0.2077	0.4898	59.72	59.82
XOM	42.11	37.67	0.1011	0.1028	0.0817	0.0926	0.0392	0.0558	0.3001	0.3081	57.42	57.44
YHOO	31.42	43.15	0.0916	0.0944	0.0550	0.0625	0.1101	0.0732	0.3629	0.5650	34.63	34.61
Mean	40.94	41.98	0.1052	0.1109	0.0886	0.1048	0.0751	0.0857	0.3915	0.6443	36.74	36.75

This table reports the summary statistics on option market data in this study. This table contains the daily averages of trading volume, option bid-ask spread, effective spread, moneyness, implied volatility and implied stock price for the companies in our sample. For comparison, the table contains the average daily closing stock prices. Moneyness is measured as a ratio of the signed difference between closing stock price and strike price over closing price. Implied volatility is measured using Roll-Geske-Whaley option pricing model, which considers the possibility of early exercise and the dividend payment before expiration date. Implied stock price is measured using the binomial tree option pricing model with 30-minute delayed implied volatility as in Chakravarty, Gulen and Mayhew (2004).

Table III. Dickey-Fuller Unit Root Test

Panel A: Test Statistics - Rho

	Stock Return	Implied Stock Return ATM Call	Implied Stock Return ITM Call	Implied Stock Return OTM Call	Implied Stock Return ATM Put	Implied Stock Return ITM Put	Implied Stock Return OTM Put
Single Mean	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9968
Trend	1.0000	0.9990	1.0000	1.0000	1.0000	1.0000	0.9989
Zero Mean	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9979

Panel B: Test Statistics - Tau

	Stock Return	Implied Stock Return ATM Call	Implied Stock Return ITM Call	Implied Stock Return OTM Call	Implied Stock Return ATM Put	Implied Stock Return ITM Put	Implied Stock Return OTM Put
Single Mean	1.0000	0.9990	1.0000	1.0000	1.0000	1.0000	0.9968
Trend	1.0000	0.9990	1.0000	1.0000	1.0000	1.0000	0.9979
Zero Mean	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9979

This table reports percentages from Dickey-Fuller tests that reject the unit root null hypothesis at the five percent level. The test is conducted every day on stock returns and six implied stock returns with 30 second resolutions. There are three types of assumptions made on the return series, which are zero mean, single mean and trend. The test results with each assumption are qualitatively similar. Panel A reports the percentages rejecting the unit root assumption using test statistics of Rho. Panel B reports the percentages rejecting the unit root assumption using test statistics of Tau.

Table IV. Correlation Analysis

		Stock Return	Implied Stock Return						Implied Volatility					
			Call			Put			Call			Put		
		ATM	ITM	OTM	ATM	ITM	OTM	ATM	ITM	OTM	ATM	ITM	OTM	
Implied Stock Return	Stock Return	1.0000	0.3441	0.3274	0.0410	0.3478	0.3571	0.0757	-0.0004	0.0000	0.0001	0.0001	-0.0004	0.0007
	ATM	1.0000	0.2644	0.0397	0.2769	0.2774	0.0516	-0.0003	0.0000	0.0001	0.0001	-0.0002	0.0005	
	Call	ITM	1.0000	0.0355	0.2576	0.2645	0.0488	-0.0003	0.0000	0.0001	0.0000	-0.0002	0.0005	
	OTM	1.0000	0.0234	0.0328	-0.2615	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001		
	ATM	1.0000	0.2853	0.0699	-0.0003	-0.0001	0.0000	0.0000	-0.0002	0.0005				
	Put	ITM	1.0000	0.0661	-0.0003	0.0000	0.0000	0.0000	-0.0003	0.0005				
	OTM	1.0000	-0.0001	0.0001	0.0000	-0.0001	0.0000	0.0000						
Implied Volatility	ATM	1.0000	0.3164	0.2670	0.7556	0.1546	0.2182							
	Call	ITM	1.0000	0.4256	0.1176	-0.0339	0.4630							
	OTM	1.0000	0.0860	0.3669	0.7008									
	ATM	1.0000	0.3088	0.0952										
	Put	ITM	1.0000	0.1917										
OTM	1.0000													

Table IV shows the correlation among stock return, implied stock returns and implied volatilities. Implied stock returns and implied volatilities are derived from six ITM, ATM, and OTM call and put options. Implied volatilities are obtained by the Roll-Geske-Whaley option pricing model. Implied stock returns are obtained using 30-minute lagged implied volatility through the binomial option pricing model.

Table V. Factor and GMM Weight Schemes

Panel A: Factor

resolution(sec)	ATM Call	OTM Call	ITM Call	ATM Put	OTM Put	ITM Put
30	0.1201	-0.1710	0.1567	0.1488	0.5632	0.1824
60	0.1386	0.3186	0.2065	0.1724	-0.0025	0.1664
300	0.2236	-6.6635	-0.4945	0.2720	6.9422	0.7202
600	-0.8663	11.1591	0.0300	0.2740	-10.3378	0.7410
900	-0.2859	1.1339	-0.1669	-0.1157	0.0611	0.3735

Panel B: GMM1

resolution(sec)	ATM Call	OTM Call	ITM Call	ATM Put	OTM Put	ITM Put
30	0.2133	0.1602	0.1451	0.1808	0.1708	0.1298
60	0.1816	0.2077	0.1399	0.1565	0.1897	0.1245
300	0.1390	0.2839	0.1348	0.1260	0.2102	0.1061
600	0.1200	0.3248	0.1114	0.0970	0.2673	0.0794
900	0.1228	0.3354	0.0882	0.1040	0.2711	0.0784

Panel C: GMM2

resolution(sec)	ATM Call	OTM Call	ITM Call	ATM Put	OTM Put	ITM Put
30	0.2072	0.1882	0.1361	0.1710	0.1826	0.1149
60	0.1714	0.2380	0.1245	0.1422	0.2173	0.1066
300	0.1427	0.3087	0.1107	0.1280	0.2194	0.0905
600	0.1157	0.3266	0.1038	0.1291	0.2453	0.0795
900	0.0946	0.2377	0.0800	0.1115	0.4177	0.0586

This table reports the weight schemes for implied stock returns with five types of resolutions; 30 seconds and one, five, 10 and 15 minutes. The weights are obtained through common factor analysis and an iterated generalized method of moments (ITGMM) estimation. For a factor weight, a maximum likelihood method with a varimax rotation is used to extract a common factor. GMM 1 weight assumes that only buying options is allowed, while GMM 2 assumes that both buying and writing options are allowed. The moment condition used in ITGMM is the following:

$$g(w) = \frac{1}{T} \sum_{t=1}^T \left(\sum_{i=1}^6 w_i \frac{dIS_{i,t}}{IS_{i,t}} - \frac{dm_t}{m_t} \right) \cdot \left(\frac{dIS_{1,t}}{IS_{1,t}} \dots \frac{dIS_{6,t}}{IS_{6,t}} \right)' \quad \text{where } w = (w_1, \dots, w_6) ; w_i \text{ is a}$$

weight for the i th implied stock return; $\frac{dIS_{i,t}}{IS_{i,t}}$ is the i th implied stock return; $\frac{dm_t}{m_t}$ is an

efficient stock return at time t , empirically estimated through a VAR model; $i = 1, \dots, 6$ indicates ATM call, OTM call, ITM call, ATM put, OTM put and ITM put, respectively. Panel A presents factor weight schemes, and Panel B and Panel C present GMM weight schemes for five resolutions.

Table VI. Wald Test on GMM Weights

Panel A: GMM1 with efficient stock return 1

resolution(sec)	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
30	0.9391	0.9388	0.2373	0.4263	0.2488	0.4553	0.6132	0.5826	0.8336
60	0.9443	0.9427	0.2830	0.5322	0.2522	0.5481	0.5832	0.7014	0.8676
300	0.9053	0.9062	0.3078	0.6778	0.2757	0.6567	0.5920	0.8926	0.9670
600	0.8737	0.8632	0.2525	0.6777	0.2228	0.6697	0.4635	0.9065	0.9533
900	0.8193	0.8681	0.2212	0.7067	0.2082	0.6656	0.4433	0.8909	0.9497

Panel B: GMM2 with efficient stock return 1

resolution(sec)	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
30	0.9281	0.9469	0.1854	0.3490	0.1760	0.3917	0.5031	0.5398	0.8240
60	0.9454	0.9391	0.2308	0.4532	0.1815	0.4758	0.4853	0.6752	0.8796
300	0.9134	0.9276	0.3017	0.6245	0.2538	0.5857	0.5515	0.8858	0.9677
600	0.8773	0.8906	0.3526	0.6454	0.3285	0.6182	0.5955	0.9170	0.9706
900	0.8647	0.8700	0.4218	0.7215	0.3992	0.6764	0.7029	0.9335	0.9891

Panel C: GMM1 with efficient stock return 2

resolution(sec)	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
30	0.8711	0.8844	0.1582	0.4550	0.1003	0.4904	0.4530	0.5909	0.6513
60	0.8582	0.8645	0.1649	0.5688	0.1039	0.5704	0.3954	0.7068	0.7146
300	0.8781	0.8910	0.1643	0.6978	0.1013	0.6916	0.3568	0.9193	0.9383
600	0.8491	0.8611	0.1663	0.6916	0.1388	0.6984	0.3016	0.9205	0.9529
900	0.8601	0.8282	0.1935	0.7044	0.1361	0.6621	0.3333	0.9214	0.9548

Panel D: GMM2 with efficient stock return 2

resolution(sec)	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
30	0.8446	0.8801	0.1011	0.3452	0.0501	0.3889	0.2888	0.5520	0.7017
60	0.8657	0.8877	0.0850	0.4470	0.0504	0.4460	0.2246	0.6635	0.7810
300	0.9001	0.9254	0.1888	0.6496	0.1449	0.6159	0.3606	0.8898	0.9459
600	0.9082	0.9163	0.2850	0.7169	0.2760	0.6718	0.5217	0.9232	0.9653
900	0.8795	0.8874	0.4072	0.7775	0.3656	0.6897	0.6671	0.9389	0.9837

Table VI reports percentages of Wald tests on ITGMM weights that reject the null hypothesis at the five percent level. There are nine Wald tests with two types of permanent stock returns. Efficient stock return 1 is obtained by using stock returns and all six implied stock returns through a VAR. Efficient stock return 2 is obtained by using

stock returns and implied stock returns only from ATM call options through a VAR. Wald tests with efficient stock return 2 are conducted to examine whether using implied stock returns from all six options does affect the derivation and significance of GMM weight schemes in the analysis. GMM1 represents weight schemes with the assumption that only buying options is allowed. GMM2 represents weight schemes with the assumption that both buying and writing options are allowed.

Test 1 investigates whether only ATM call in option markets conveys information regarding efficient stock return; $H_0 : w_1 = 1, H_1 : w_i = 0, i = 2, \dots, 6$.

Test 2 investigates whether only an ATM put in option markets conveys information regarding efficient stock returns; $H_0 : w_4 = 1, H_1 : w_i = 0, i = 1, 2, 3, 5, 6$.

Test 3 investigates whether an ITM call conveys any information regarding efficient stock returns; $H_0 : w_3 = 0, H_1 : w_3 \neq 0$.

Test 4 investigates whether an OTM call conveys any information regarding efficient stock returns; $H_0 : w_2 = 0, H_1 : w_2 \neq 0$.

Test 5 investigates whether an ITM put conveys any information regarding efficient stock returns; $H_0 : w_6 = 0, H_1 : w_6 \neq 0$.

Test 6 investigates whether an OTM put conveys any information regarding efficient stock returns; $H_0 : w_5 = 0, H_1 : w_5 \neq 0$.

Test 7 investigates whether ITM option returns convey any information regarding efficient stock returns; $H_0 : w_3 = w_6 = 0, H_1 : w_3 \text{ and or } w_6 \neq 0$.

Test 8 investigates whether OTM option returns convey any information regarding efficient stock returns; $H_0 : w_2 = w_5 = 0, H_1 : w_2 \text{ and or } w_5 \neq 0$.

Test 9 investigates whether only ATM calls and puts convey information regarding efficient stock returns; $H_0 : w_2 = w_3 = w_5 = w_6 = 0, H_1 : w_2, w_3, w_5 \text{ and or } w_6 \neq 0$.

w_1, w_2, w_3, w_4, w_5 and w_6 represent weights on an ATM call, OTM call, ITM call, ATM put, OTM put and ITM put, respectively.

Table VII. Summary Statistics on the Information Share of the Option Market

Panel A: 30-Second Resolution

Ticker	ATM Call			Equal			Factor			GMM1			GMM2		
	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
AIG	0.423	0.221	0.322	0.623	0.340	0.482	0.734	0.160	0.447	0.563	0.387	0.475	0.587	0.306	0.446
ALL	0.534	0.318	0.426	0.604	0.561	0.582	0.612	0.266	0.439	0.605	0.576	0.590	0.534	0.415	0.474
AMAT	0.280	0.191	0.235	0.383	0.249	0.316	0.482	0.244	0.363	0.513	0.400	0.456	0.474	0.363	0.419
AMD	0.322	0.257	0.289	0.505	0.385	0.445	0.455	0.412	0.433	0.541	0.368	0.455	0.546	0.366	0.456
AMR	0.288	0.168	0.228	0.380	0.255	0.318	0.386	0.277	0.331	0.526	0.312	0.419	0.549	0.340	0.444
AMZN	0.375	0.183	0.279	0.623	0.479	0.551	0.657	0.379	0.518	0.749	0.538	0.644	0.750	0.594	0.672
BAC	0.299	0.075	0.187	0.483	0.377	0.430	0.585	0.315	0.450	0.611	0.410	0.511	0.538	0.342	0.440
BEAS	0.443	0.363	0.403	0.417	0.367	0.392	0.276	0.167	0.222	0.473	0.350	0.411	0.504	0.356	0.430
BRCM	0.331	0.156	0.243	0.481	0.428	0.455	0.474	0.323	0.399	0.728	0.381	0.554	0.743	0.377	0.560
BSX	0.299	0.186	0.242	0.592	0.483	0.537	0.475	0.239	0.357	0.570	0.393	0.482	0.594	0.399	0.497
CA	0.333	0.234	0.284	0.490	0.432	0.461	0.586	0.551	0.568	0.628	0.438	0.533	0.624	0.419	0.521
CMCSK	0.357	0.269	0.313	0.508	0.322	0.415	0.447	0.239	0.343	0.676	0.381	0.529	0.663	0.359	0.511
COF	0.569	0.134	0.352	0.784	0.456	0.620	0.821	0.151	0.486	0.679	0.418	0.549	0.666	0.470	0.568
CSCO	0.348	0.357	0.352	0.632	0.547	0.589	0.453	0.433	0.443	0.643	0.518	0.580	0.638	0.460	0.549
DELL	0.227	0.159	0.193	0.454	0.375	0.414	0.474	0.185	0.329	0.538	0.235	0.386	0.506	0.230	0.368
DUK	0.402	0.321	0.361	0.528	0.389	0.459	0.518	0.258	0.388	0.541	0.289	0.415	0.498	0.255	0.376
EBAY	0.391	0.110	0.251	0.513	0.398	0.455	0.671	0.064	0.367	0.650	0.269	0.460	0.582	0.182	0.382
EMC	0.345	0.294	0.320	0.506	0.423	0.464	0.443	0.295	0.369	0.628	0.543	0.585	0.651	0.490	0.570
ET	0.412	0.322	0.367	0.493	0.366	0.430	0.369	0.308	0.338	0.551	0.541	0.546	0.457	0.360	0.408
FRE	0.515	0.222	0.369	0.717	0.510	0.613	0.750	0.239	0.494	0.663	0.657	0.660	0.630	0.594	0.612
FRX	0.382	0.310	0.346	0.631	0.524	0.577	0.633	0.261	0.447	0.535	0.465	0.500	0.459	0.361	0.410
GE	0.469	0.200	0.335	0.494	0.438	0.466	0.440	0.325	0.383	0.488	0.419	0.454	0.507	0.481	0.494
GM	0.448	0.400	0.424	0.491	0.472	0.481	0.530	0.384	0.457	0.386	0.332	0.359	0.376	0.270	0.323
HAL	0.490	0.187	0.339	0.564	0.433	0.499	0.645	0.216	0.431	0.760	0.443	0.602	0.730	0.397	0.564
HOG	0.413	0.189	0.301	0.699	0.384	0.542	0.666	0.172	0.419	0.775	0.533	0.654	0.726	0.460	0.593
HPQ	0.327	0.172	0.249	0.417	0.261	0.339	0.510	0.399	0.455	0.519	0.260	0.389	0.526	0.271	0.398
IBM	0.476	0.206	0.341	0.551	0.327	0.439	0.735	0.161	0.448	0.698	0.409	0.554	0.620	0.267	0.443
IMCL	0.455	0.290	0.372	0.691	0.440	0.565	0.597	0.263	0.430	0.642	0.501	0.571	0.554	0.431	0.493
INTC	0.368	0.235	0.302	0.360	0.243	0.302	0.385	0.252	0.319	0.470	0.287	0.378	0.463	0.272	0.368
JNJ	0.513	0.398	0.455	0.530	0.415	0.473	0.667	0.415	0.541	0.670	0.462	0.566	0.770	0.556	0.663
JPM	0.423	0.195	0.309	0.497	0.333	0.415	0.376	0.300	0.338	0.604	0.327	0.466	0.594	0.290	0.442
KLAC	0.361	0.164	0.263	0.542	0.238	0.390	0.609	0.130	0.369	0.642	0.375	0.508	0.636	0.331	0.483
KO	0.358	0.229	0.293	0.531	0.422	0.477	0.660	0.558	0.609	0.550	0.394	0.472	0.558	0.343	0.451
LXK	0.291	0.262	0.276	0.565	0.526	0.545	0.719	0.270	0.495	0.632	0.522	0.577	0.687	0.362	0.525
MER	0.336	0.163	0.250	0.564	0.468	0.516	0.707	0.261	0.484	0.730	0.493	0.612	0.663	0.437	0.550
MMM	0.561	0.124	0.342	0.635	0.312	0.474	0.804	0.156	0.480	0.696	0.323	0.510	0.718	0.316	0.517
MO	0.528	0.363	0.446	0.796	0.406	0.601	0.691	0.159	0.425	0.668	0.522	0.595	0.556	0.373	0.464
MRK	0.365	0.189	0.277	0.386	0.282	0.334	0.568	0.223	0.396	0.569	0.312	0.441	0.594	0.367	0.480
MS	0.435	0.185	0.310	0.420	0.228	0.324	0.580	0.158	0.369	0.717	0.560	0.639	0.648	0.440	0.544
MSFT	0.360	0.267	0.313	0.473	0.310	0.392	0.540	0.403	0.472	0.579	0.414	0.497	0.517	0.380	0.448
NEM	0.470	0.276	0.373	0.311	0.309	0.310	0.444	0.255	0.350	0.460	0.331	0.395	0.434	0.213	0.324
NOK	0.278	0.162	0.220	0.467	0.345	0.406	0.544	0.332	0.438	0.654	0.598	0.626	0.463	0.335	0.399
ORCL	0.304	0.308	0.306	0.507	0.327	0.417	0.311	0.282	0.297	0.459	0.423	0.441	0.535	0.411	0.473
OVTI	0.289	0.257	0.273	0.501	0.397	0.449	0.427	0.280	0.353	0.410	0.237	0.323	0.380	0.221	0.301
PFE	0.336	0.272	0.304	0.433	0.313	0.373	0.402	0.295	0.348	0.641	0.442	0.541	0.617	0.392	0.504
PG	0.212	0.128	0.170	0.521	0.370	0.445	0.629	0.189	0.409	0.636	0.334	0.485	0.606	0.278	0.442
QCOM	0.445	0.203	0.324	0.600	0.374	0.487	0.617	0.324	0.470	0.780	0.347	0.563	0.765	0.355	0.560
SNDK	0.306	0.200	0.253	0.456	0.244	0.350	0.512	0.219	0.366	0.592	0.319	0.455	0.612	0.380	0.496
SUNW	0.323	0.228	0.276	0.415	0.366	0.390	0.366	0.292	0.329	0.425	0.277	0.351	0.301	0.199	0.250
TWX	0.366	0.252	0.309	0.615	0.466	0.541	0.645	0.474	0.559	0.640	0.465	0.552	0.648	0.443	0.546
TXN	0.352	0.222	0.287	0.546	0.382	0.464	0.654	0.506	0.580	0.616	0.354	0.485	0.661	0.399	0.530
TYC	0.445	0.403	0.424	0.612	0.426	0.519	0.557	0.298	0.428	0.607	0.400	0.504	0.599	0.370	0.484
UPS	0.456	0.227	0.342	0.338	0.243	0.291	0.771	0.170	0.471	0.597	0.339	0.468	0.615	0.309	0.462
USG	0.411	0.341	0.376	0.676	0.301	0.488	0.620	0.356	0.488	0.563	0.296	0.430	0.563	0.296	0.430
VZ	0.478	0.414	0.446	0.401	0.167	0.284	0.545	0.243	0.394	0.538	0.289	0.413	0.512	0.274	0.393
WFC	0.461	0.220	0.341	0.626	0.497	0.562	0.692	0.278	0.485	0.469	0.368	0.419	0.389	0.402	0.396
XOM	0.301	0.146	0.224	0.614	0.377	0.495	0.582	0.223	0.403	0.691	0.454	0.573	0.601	0.395	0.498
YHOO	0.395	0.231	0.313	0.614	0.362	0.488	0.445	0.287	0.366	0.727	0.493	0.610	0.672	0.378	0.525

Panel B: One-Minute Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
AIG	0.495	0.197	0.346	0.621	0.362	0.491	0.835	0.150	0.492	0.563	0.506	0.534	0.579	0.451	0.515
ALL	0.528	0.352	0.440	0.661	0.444	0.553	0.623	0.215	0.419	0.570	0.602	0.586	0.540	0.504	0.522
AMAT	0.344	0.212	0.278	0.509	0.298	0.404	0.444	0.181	0.313	0.515	0.489	0.502	0.590	0.533	0.561
AMD	0.285	0.202	0.243	0.470	0.345	0.407	0.424	0.288	0.356	0.604	0.331	0.468	0.612	0.386	0.499
AMR	0.330	0.126	0.228	0.311	0.268	0.290	0.260	0.194	0.227	0.684	0.508	0.596	0.649	0.446	0.547
AMZN	0.495	0.222	0.358	0.614	0.388	0.501	0.643	0.373	0.508	0.657	0.421	0.539	0.533	0.316	0.425
BAC	0.371	0.132	0.251	0.454	0.354	0.404	0.427	0.176	0.301	0.591	0.256	0.424	0.684	0.342	0.513
BEAS	0.411	0.314	0.362	0.427	0.266	0.346	0.362	0.192	0.277	0.544	0.426	0.485	0.541	0.450	0.495
BRCM	0.520	0.245	0.382	0.526	0.371	0.449	0.553	0.175	0.364	0.728	0.438	0.583	0.713	0.355	0.534
BSX	0.332	0.154	0.243	0.620	0.409	0.515	0.441	0.178	0.309	0.630	0.364	0.497	0.643	0.443	0.543
CA	0.434	0.312	0.373	0.660	0.497	0.578	0.502	0.435	0.468	0.559	0.410	0.485	0.672	0.535	0.604
CMCSK	0.408	0.321	0.365	0.578	0.389	0.483	0.505	0.300	0.403	0.740	0.389	0.565	0.624	0.261	0.443
COF	0.725	0.123	0.424	0.732	0.356	0.544	0.864	0.111	0.487	0.677	0.442	0.559	0.675	0.477	0.576
CSCO	0.211	0.239	0.225	0.667	0.375	0.521	0.386	0.145	0.265	0.830	0.596	0.713	0.802	0.657	0.729
DELL	0.313	0.167	0.240	0.502	0.377	0.439	0.513	0.248	0.380	0.792	0.323	0.558	0.725	0.282	0.503
DUK	0.414	0.311	0.362	0.535	0.374	0.454	0.558	0.246	0.402	0.689	0.363	0.526	0.632	0.356	0.494
EBAY	0.522	0.178	0.350	0.556	0.324	0.440	0.847	0.075	0.461	0.741	0.493	0.617	0.700	0.547	0.623
EMC	0.383	0.292	0.337	0.524	0.379	0.451	0.372	0.204	0.288	0.633	0.461	0.547	0.614	0.397	0.505
ET	0.394	0.317	0.356	0.585	0.441	0.513	0.485	0.286	0.385	0.532	0.554	0.543	0.520	0.480	0.500
FRE	0.596	0.137	0.367	0.706	0.369	0.537	0.707	0.225	0.466	0.567	0.402	0.484	0.633	0.412	0.522
FRX	0.439	0.344	0.391	0.545	0.448	0.496	0.716	0.328	0.522	0.631	0.594	0.612	0.534	0.477	0.506
GE	0.606	0.224	0.415	0.537	0.426	0.481	0.419	0.272	0.346	0.620	0.526	0.573	0.608	0.511	0.559
GM	0.480	0.403	0.441	0.489	0.368	0.428	0.573	0.320	0.446	0.518	0.296	0.407	0.532	0.258	0.395
HAL	0.643	0.148	0.395	0.598	0.344	0.471	0.714	0.196	0.455	0.656	0.478	0.567	0.715	0.522	0.619
HOG	0.527	0.175	0.351	0.685	0.374	0.529	0.750	0.212	0.481	0.735	0.543	0.639	0.669	0.374	0.521
HPQ	0.386	0.201	0.293	0.386	0.223	0.304	0.426	0.241	0.334	0.581	0.293	0.437	0.584	0.280	0.432
IBM	0.630	0.238	0.434	0.650	0.288	0.469	0.858	0.121	0.489	0.654	0.385	0.520	0.672	0.310	0.491
IMCL	0.553	0.327	0.440	0.535	0.415	0.475	0.583	0.253	0.418	0.644	0.547	0.596	0.593	0.544	0.568
INTC	0.494	0.272	0.383	0.369	0.190	0.279	0.499	0.191	0.345	0.458	0.376	0.417	0.484	0.280	0.382
JNJ	0.419	0.222	0.321	0.607	0.260	0.433	0.847	0.174	0.511	0.692	0.387	0.539	0.694	0.488	0.591
JPM	0.525	0.204	0.364	0.618	0.324	0.471	0.536	0.362	0.449	0.684	0.335	0.509	0.638	0.323	0.481
KLAC	0.471	0.237	0.354	0.498	0.241	0.369	0.608	0.105	0.357	0.660	0.481	0.571	0.612	0.454	0.533
KO	0.452	0.234	0.343	0.531	0.182	0.357	0.465	0.388	0.426	0.645	0.454	0.549	0.647	0.507	0.577
LXK	0.326	0.216	0.271	0.617	0.432	0.524	0.768	0.171	0.470	0.641	0.526	0.583	0.517	0.385	0.451
MER	0.434	0.173	0.304	0.604	0.457	0.530	0.786	0.215	0.501	0.623	0.444	0.534	0.639	0.378	0.509
MMM	0.574	0.135	0.354	0.590	0.254	0.422	0.815	0.111	0.463	0.680	0.249	0.464	0.712	0.244	0.478
MO	0.650	0.376	0.513	0.832	0.441	0.637	0.790	0.179	0.485	0.629	0.577	0.603	0.539	0.429	0.484
MRK	0.391	0.180	0.285	0.439	0.242	0.340	0.746	0.209	0.478	0.614	0.208	0.411	0.651	0.256	0.454
MS	0.566	0.229	0.397	0.554	0.296	0.425	0.787	0.174	0.481	0.733	0.485	0.609	0.614	0.376	0.495
MSFT	0.412	0.295	0.353	0.541	0.340	0.441	0.576	0.288	0.432	0.547	0.319	0.433	0.513	0.378	0.445
NEM	0.520	0.243	0.381	0.291	0.301	0.296	0.438	0.130	0.284	0.414	0.243	0.328	0.417	0.168	0.292
NOK	0.311	0.161	0.236	0.410	0.230	0.320	0.383	0.282	0.333	0.579	0.450	0.514	0.563	0.462	0.513
ORCL	0.166	0.195	0.180	0.439	0.318	0.378	0.393	0.217	0.305	0.495	0.434	0.464	0.498	0.433	0.465
OVTI	0.297	0.287	0.292	0.457	0.386	0.422	0.427	0.269	0.348	0.575	0.306	0.441	0.511	0.318	0.415
PFE	0.210	0.135	0.172	0.401	0.376	0.388	0.572	0.277	0.424	0.657	0.416	0.537	0.642	0.385	0.513
PG	0.289	0.098	0.193	0.627	0.421	0.524	0.779	0.183	0.481	0.759	0.392	0.575	0.769	0.407	0.588
QCOM	0.518	0.167	0.342	0.660	0.328	0.494	0.673	0.189	0.431	0.707	0.442	0.574	0.699	0.424	0.561
SNDK	0.374	0.193	0.283	0.564	0.290	0.427	0.642	0.227	0.434	0.740	0.382	0.561	0.621	0.305	0.463
SUNW	0.305	0.272	0.289	0.319	0.264	0.291	0.205	0.183	0.194	0.533	0.493	0.513	0.576	0.521	0.548
TWX	0.341	0.205	0.273	0.528	0.342	0.435	0.613	0.408	0.510	0.721	0.544	0.633	0.628	0.512	0.570
TXN	0.367	0.205	0.286	0.657	0.322	0.490	0.457	0.337	0.397	0.790	0.389	0.589	0.768	0.403	0.585
TYC	0.406	0.301	0.354	0.663	0.351	0.507	0.660	0.158	0.409	0.686	0.306	0.496	0.671	0.280	0.476
UPS	0.518	0.286	0.402	0.459	0.236	0.348	0.782	0.165	0.473	0.576	0.262	0.419	0.607	0.290	0.448
USG	0.413	0.310	0.362	0.697	0.268	0.483	0.685	0.272	0.479	0.571	0.401	0.486	0.583	0.347	0.465
VZ	0.462	0.367	0.414	0.598	0.317	0.458	0.600	0.263	0.432	0.509	0.342	0.425	0.526	0.387	0.456
WFC	0.560	0.274	0.417	0.586	0.480	0.533	0.687	0.312	0.499	0.462	0.504	0.483	0.494	0.591	0.543
XOM	0.517	0.163	0.340	0.646	0.236	0.441	0.795	0.187	0.491	0.588	0.437	0.513	0.747	0.458	0.602
YHOO	0.414	0.170	0.292	0.681	0.358	0.519	0.653	0.347	0.500	0.653	0.530	0.592	0.707	0.522	0.614

Panel C: Five-Minute Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
AIG	0.554	0.203	0.379	0.737	0.278	0.507	0.907	0.124	0.515	0.685	0.354	0.520	0.724	0.353	0.539
ALL	0.780	0.263	0.521	0.571	0.436	0.504	0.786	0.272	0.529	0.457	0.437	0.447	0.733	0.507	0.620
AMAT	0.426	0.214	0.320	0.633	0.190	0.411	0.568	0.287	0.428	0.597	0.270	0.433	0.653	0.428	0.541
AMD	0.489	0.199	0.344	0.638	0.244	0.441	0.624	0.123	0.374	0.634	0.369	0.501	0.676	0.445	0.561
AMR	0.561	0.149	0.355	0.541	0.302	0.421	0.629	0.385	0.507	0.572	0.315	0.443	0.591	0.422	0.506
AMZN	0.655	0.215	0.435	0.613	0.427	0.520	0.621	0.295	0.458	0.626	0.465	0.546	0.654	0.574	0.614
BAC	0.692	0.134	0.413	0.729	0.330	0.530	0.665	0.382	0.523	0.792	0.433	0.612	0.655	0.486	0.571
BEAS	0.559	0.392	0.476	0.592	0.309	0.451	0.448	0.215	0.332	0.766	0.585	0.676	0.826	0.602	0.714
BRCM	0.547	0.128	0.338	0.572	0.411	0.491	0.802	0.463	0.632	0.611	0.439	0.525	0.672	0.444	0.558
BSX	0.540	0.247	0.393	0.800	0.355	0.578	0.606	0.108	0.357	0.650	0.421	0.535	0.688	0.436	0.562
CA	0.710	0.229	0.470	0.746	0.318	0.532	0.663	0.419	0.541	0.691	0.295	0.493	0.810	0.409	0.609
CMCSK	0.482	0.259	0.370	0.752	0.356	0.554	0.608	0.268	0.438	0.638	0.450	0.544	0.644	0.515	0.580
COF	0.857	0.094	0.476	0.832	0.252	0.542	0.910	0.134	0.522	0.662	0.454	0.558	0.665	0.469	0.567
CSCO	0.426	0.269	0.348	0.488	0.526	0.507	0.527	0.300	0.414	0.519	0.523	0.521	0.749	0.565	0.657
DELL	0.470	0.108	0.289	0.584	0.426	0.505	0.828	0.406	0.617	0.629	0.431	0.530	0.650	0.507	0.578
DUK	0.458	0.375	0.416	0.788	0.390	0.589	0.847	0.168	0.508	0.629	0.534	0.581	0.737	0.599	0.668
EBAY	0.629	0.067	0.348	0.570	0.338	0.454	0.861	0.174	0.517	0.584	0.539	0.561	0.670	0.537	0.604
EMC	0.575	0.280	0.428	0.707	0.391	0.549	0.745	0.343	0.544	0.719	0.415	0.567	0.693	0.523	0.608
ET	0.495	0.243	0.369	0.641	0.319	0.480	0.593	0.211	0.402	0.577	0.419	0.498	0.672	0.449	0.560
FRE	0.730	0.184	0.457	0.696	0.405	0.550	0.846	0.287	0.566	0.692	0.656	0.674	0.745	0.509	0.627
FRX	0.649	0.148	0.398	0.583	0.451	0.517	0.707	0.132	0.420	0.669	0.404	0.537	0.632	0.474	0.553
GE	0.661	0.199	0.430	0.697	0.389	0.543	0.673	0.378	0.526	0.615	0.396	0.506	0.631	0.507	0.569
GM	0.578	0.377	0.477	0.600	0.325	0.463	0.650	0.297	0.473	0.632	0.409	0.521	0.709	0.470	0.589
HAL	0.728	0.155	0.442	0.622	0.350	0.486	0.854	0.282	0.568	0.654	0.401	0.528	0.718	0.446	0.582
HOG	0.658	0.154	0.406	0.740	0.247	0.493	0.795	0.132	0.463	0.758	0.270	0.514	0.848	0.355	0.602
HPQ	0.603	0.175	0.389	0.614	0.262	0.438	0.741	0.290	0.515	0.740	0.224	0.482	0.770	0.279	0.524
IBM	0.767	0.178	0.472	0.742	0.330	0.536	0.856	0.160	0.508	0.759	0.410	0.585	0.706	0.336	0.521
IMCL	0.739	0.149	0.444	0.695	0.456	0.575	0.802	0.187	0.495	0.712	0.552	0.632	0.735	0.552	0.644
INTC	0.593	0.214	0.404	0.602	0.221	0.412	0.538	0.304	0.421	0.580	0.445	0.513	0.526	0.498	0.512
JNJ	0.632	0.354	0.493	0.730	0.457	0.593	0.839	0.217	0.528	0.621	0.465	0.543	0.745	0.434	0.589
JPM	0.769	0.143	0.456	0.747	0.341	0.544	0.587	0.293	0.440	0.688	0.491	0.589	0.684	0.443	0.563
KLAC	0.666	0.164	0.415	0.603	0.307	0.455	0.773	0.139	0.456	0.601	0.423	0.512	0.710	0.409	0.559
KO	0.507	0.155	0.331	0.752	0.402	0.577	0.588	0.294	0.441	0.786	0.480	0.633	0.815	0.444	0.630
LXK	0.470	0.241	0.355	0.596	0.458	0.527	0.758	0.343	0.551	0.571	0.408	0.489	0.598	0.471	0.534
MER	0.588	0.245	0.416	0.645	0.398	0.522	0.782	0.065	0.424	0.646	0.332	0.489	0.687	0.413	0.550
MMM	0.737	0.124	0.430	0.640	0.336	0.488	0.873	0.100	0.486	0.715	0.305	0.510	0.742	0.187	0.464
MO	0.611	0.328	0.469	0.847	0.361	0.604	0.805	0.154	0.479	0.626	0.499	0.563	0.686	0.552	0.619
MRK	0.552	0.204	0.378	0.625	0.382	0.504	0.605	0.237	0.421	0.601	0.309	0.455	0.804	0.386	0.595
MS	0.654	0.290	0.472	0.694	0.296	0.495	0.794	0.252	0.523	0.596	0.565	0.581	0.632	0.434	0.533
MSFT	0.483	0.193	0.338	0.568	0.235	0.402	0.534	0.182	0.358	0.759	0.371	0.565	0.698	0.409	0.554
NEM	0.737	0.226	0.482	0.512	0.298	0.405	0.778	0.184	0.481	0.578	0.368	0.473	0.735	0.414	0.575
NOK	0.396	0.181	0.288	0.651	0.290	0.471	0.663	0.219	0.441	0.773	0.482	0.628	0.782	0.648	0.715
ORCL	0.271	0.259	0.265	0.581	0.325	0.453	0.418	0.190	0.304	0.572	0.392	0.482	0.643	0.476	0.559
OVTI	0.334	0.168	0.251	0.551	0.370	0.461	0.633	0.355	0.494	0.593	0.293	0.443	0.625	0.422	0.523
PFE	0.339	0.210	0.275	0.612	0.314	0.463	0.530	0.255	0.392	0.568	0.526	0.547	0.716	0.466	0.591
PG	0.516	0.106	0.311	0.613	0.403	0.508	0.786	0.186	0.486	0.719	0.516	0.617	0.605	0.441	0.523
QCOM	0.804	0.117	0.461	0.823	0.249	0.536	0.686	0.169	0.428	0.800	0.366	0.583	0.795	0.363	0.579
SNDK	0.387	0.205	0.296	0.730	0.269	0.500	0.688	0.159	0.424	0.597	0.584	0.591	0.675	0.614	0.644
SUNW	0.437	0.334	0.386	0.472	0.201	0.337	0.504	0.327	0.416	0.742	0.420	0.581	0.750	0.486	0.618
TWX	0.529	0.208	0.368	0.730	0.394	0.562	0.750	0.216	0.483	0.875	0.450	0.662	0.852	0.506	0.679
TXN	0.671	0.191	0.431	0.725	0.388	0.557	0.718	0.322	0.520	0.697	0.416	0.557	0.800	0.545	0.672
TYC	0.544	0.337	0.440	0.747	0.324	0.535	0.850	0.203	0.526	0.630	0.291	0.461	0.674	0.413	0.543
UPS	0.598	0.222	0.410	0.538	0.179	0.358	0.820	0.171	0.496	0.665	0.224	0.445	0.723	0.228	0.475
USG	0.617	0.339	0.478	0.746	0.267	0.507	0.730	0.232	0.481	0.697	0.312	0.504	0.722	0.272	0.497
VZ	0.517	0.306	0.412	0.792	0.238	0.515	0.608	0.180	0.394	0.666	0.397	0.531	0.686	0.348	0.517
WFC	0.699	0.243	0.471	0.716	0.380	0.548	0.848	0.177	0.513	0.669	0.439	0.554	0.803	0.301	0.552
XOM	0.655	0.096	0.376	0.713	0.239	0.476	0.909	0.052	0.480	0.790	0.254	0.522	0.723	0.422	0.572
YHOO	0.616	0.180	0.398	0.829	0.304	0.567	0.734	0.408	0.571	0.887	0.429	0.658	0.821	0.441	0.631

Panel D: Ten-Minute Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
AIG	0.606	0.234	0.420	0.769	0.258	0.513	0.852	0.111	0.482	0.725	0.283	0.504	0.670	0.289	0.479
ALL	0.720	0.296	0.508	0.621	0.505	0.563	0.577	0.441	0.509	0.686	0.576	0.631	0.767	0.603	0.685
AMAT	0.492	0.182	0.337	0.702	0.184	0.443	0.708	0.231	0.470	0.734	0.329	0.532	0.682	0.434	0.558
AMD	0.656	0.105	0.380	0.709	0.313	0.511	0.781	0.293	0.537	0.710	0.480	0.595	0.744	0.505	0.625
AMR	0.677	0.245	0.461	0.576	0.336	0.456	0.543	0.275	0.409	0.498	0.521	0.509	0.638	0.479	0.558
AMZN	0.721	0.149	0.435	0.662	0.430	0.546	0.719	0.319	0.519	0.621	0.496	0.558	0.567	0.502	0.535
BAC	0.775	0.180	0.478	0.692	0.438	0.565	0.709	0.357	0.533	0.630	0.467	0.548	0.678	0.469	0.573
BEAS	0.659	0.380	0.519	0.616	0.358	0.487	0.506	0.112	0.309	0.723	0.566	0.645	0.812	0.570	0.691
BRCM	0.635	0.132	0.384	0.608	0.392	0.500	0.714	0.351	0.532	0.716	0.390	0.553	0.589	0.377	0.483
BSX	0.660	0.185	0.423	0.815	0.321	0.568	0.543	0.163	0.353	0.673	0.460	0.567	0.610	0.470	0.540
CA	0.824	0.266	0.545	0.722	0.490	0.606	0.829	0.527	0.678	0.689	0.532	0.610	0.764	0.657	0.710
CMCSK	0.670	0.272	0.471	0.751	0.379	0.565	0.703	0.377	0.540	0.792	0.441	0.616	0.777	0.612	0.695
COF	0.782	0.225	0.504	0.854	0.267	0.561	0.893	0.092	0.493	0.824	0.361	0.593	0.779	0.303	0.541
CSCO	0.536	0.295	0.416	0.617	0.480	0.548	0.567	0.267	0.417	0.652	0.582	0.617	0.751	0.621	0.686
DELL	0.575	0.124	0.349	0.590	0.367	0.479	0.702	0.216	0.459	0.672	0.431	0.552	0.589	0.515	0.552
DUK	0.469	0.245	0.357	0.637	0.402	0.519	0.817	0.182	0.500	0.646	0.539	0.593	0.580	0.451	0.516
EBAY	0.696	0.136	0.416	0.672	0.227	0.450	0.809	0.154	0.482	0.703	0.417	0.560	0.618	0.444	0.531
EMC	0.591	0.218	0.405	0.759	0.460	0.609	0.661	0.410	0.535	0.737	0.612	0.675	0.740	0.598	0.669
ET	0.549	0.282	0.416	0.712	0.311	0.512	0.555	0.294	0.425	0.645	0.392	0.518	0.598	0.353	0.475
FRE	0.766	0.160	0.463	0.724	0.292	0.508	0.779	0.265	0.522	0.643	0.569	0.606	0.804	0.463	0.634
FRX	0.617	0.230	0.423	0.582	0.384	0.483	0.687	0.240	0.464	0.619	0.274	0.446	0.642	0.376	0.509
GE	0.686	0.246	0.466	0.768	0.342	0.555	0.707	0.543	0.625	0.730	0.408	0.569	0.747	0.427	0.587
GM	0.606	0.372	0.489	0.705	0.394	0.549	0.678	0.341	0.510	0.724	0.381	0.553	0.697	0.423	0.560
HAL	0.783	0.138	0.461	0.747	0.275	0.511	0.797	0.227	0.512	0.747	0.454	0.600	0.755	0.538	0.647
HOG	0.778	0.120	0.449	0.723	0.323	0.523	0.869	0.077	0.473	0.693	0.506	0.599	0.826	0.488	0.657
HPQ	0.664	0.213	0.439	0.748	0.344	0.546	0.769	0.252	0.510	0.740	0.451	0.596	0.815	0.375	0.595
IBM	0.689	0.283	0.486	0.752	0.401	0.577	0.886	0.166	0.526	0.702	0.393	0.547	0.775	0.402	0.589
IMCL	0.778	0.181	0.480	0.710	0.443	0.576	0.819	0.167	0.493	0.743	0.531	0.637	0.760	0.451	0.606
INTC	0.689	0.206	0.447	0.667	0.170	0.419	0.597	0.227	0.412	0.564	0.439	0.502	0.752	0.468	0.610
JNJ	0.582	0.327	0.455	0.691	0.410	0.550	0.860	0.215	0.538	0.593	0.571	0.582	0.695	0.427	0.561
JPM	0.933	0.167	0.550	0.726	0.399	0.562	0.665	0.313	0.489	0.808	0.429	0.618	0.746	0.502	0.624
KLAC	0.788	0.205	0.497	0.599	0.388	0.494	0.786	0.051	0.418	0.607	0.471	0.539	0.782	0.380	0.581
KO	0.516	0.157	0.337	0.760	0.376	0.568	0.693	0.549	0.621	0.677	0.436	0.557	0.681	0.605	0.643
LXK	0.594	0.350	0.472	0.676	0.464	0.570	0.694	0.384	0.539	0.695	0.457	0.576	0.622	0.468	0.545
MER	0.641	0.264	0.453	0.689	0.310	0.499	0.829	0.149	0.489	0.691	0.454	0.572	0.772	0.434	0.603
MMM	0.770	0.161	0.465	0.665	0.366	0.516	0.845	0.126	0.486	0.763	0.232	0.497	0.715	0.233	0.474
MO	0.662	0.311	0.487	0.815	0.336	0.575	0.817	0.140	0.479	0.846	0.412	0.629	0.796	0.465	0.631
MRK	0.627	0.373	0.500	0.652	0.310	0.481	0.511	0.238	0.374	0.552	0.442	0.497	0.713	0.431	0.572
MS	0.665	0.363	0.514	0.706	0.281	0.494	0.693	0.294	0.494	0.741	0.531	0.636	0.770	0.463	0.617
MSFT	0.572	0.238	0.405	0.679	0.284	0.482	0.691	0.233	0.462	0.672	0.363	0.517	0.687	0.341	0.514
NEM	0.759	0.162	0.461	0.591	0.321	0.456	0.754	0.278	0.516	0.657	0.397	0.527	0.610	0.360	0.485
NOK	0.587	0.215	0.401	0.729	0.402	0.565	0.570	0.305	0.437	0.848	0.475	0.661	0.771	0.595	0.683
ORCL	0.402	0.252	0.327	0.783	0.240	0.511	0.635	0.229	0.432	0.784	0.388	0.586	0.643	0.445	0.544
OVTI	0.507	0.240	0.374	0.685	0.349	0.517	0.776	0.338	0.557	0.687	0.346	0.517	0.625	0.426	0.525
PFE	0.459	0.283	0.371	0.636	0.322	0.479	0.778	0.353	0.565	0.727	0.521	0.624	0.765	0.516	0.640
PG	0.577	0.203	0.390	0.707	0.408	0.558	0.725	0.255	0.490	0.731	0.390	0.561	0.791	0.406	0.598
QCOM	0.788	0.151	0.470	0.733	0.338	0.536	0.711	0.263	0.487	0.766	0.427	0.597	0.763	0.496	0.629
SNDK	0.547	0.134	0.341	0.726	0.255	0.491	0.661	0.234	0.448	0.738	0.469	0.603	0.616	0.348	0.482
SUNW	0.490	0.343	0.417	0.629	0.311	0.470	0.456	0.258	0.357	0.774	0.473	0.624	0.796	0.392	0.594
TWX	0.614	0.205	0.409	0.698	0.339	0.518	0.792	0.368	0.580	0.687	0.570	0.628	0.797	0.567	0.682
TXN	0.726	0.135	0.431	0.738	0.435	0.586	0.905	0.639	0.772	0.806	0.460	0.633	0.773	0.530	0.652
TYC	0.620	0.343	0.481	0.785	0.328	0.556	0.862	0.283	0.572	0.735	0.510	0.622	0.726	0.536	0.631
UPS	0.691	0.225	0.458	0.636	0.319	0.477	0.804	0.174	0.489	0.682	0.320	0.501	0.785	0.326	0.556
USG	0.649	0.284	0.466	0.795	0.152	0.474	0.744	0.217	0.480	0.650	0.265	0.457	0.625	0.291	0.458
VZ	0.590	0.300	0.445	0.795	0.319	0.557	0.565	0.286	0.426	0.693	0.448	0.571	0.691	0.414	0.553
WFC	0.683	0.217	0.450	0.707	0.423	0.565	0.858	0.210	0.534	0.782	0.420	0.601	0.700	0.423	0.562
XOM	0.691	0.137	0.414	0.681	0.273	0.477	0.839	0.229	0.534	0.766	0.577	0.671	0.756	0.408	0.582
YHOO	0.795	0.115	0.455	0.784	0.338	0.561	0.703	0.536	0.619	0.766	0.425	0.595	0.674	0.370	0.522

Panel E: Fifteen-Minute Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
AIG	0.712	0.201	0.457	0.710	0.337	0.524	0.862	0.078	0.470	0.825	0.330	0.577	0.684	0.352	0.518
ALL	0.654	0.310	0.482	0.662	0.526	0.594	0.753	0.254	0.503	0.600	0.406	0.503	0.777	0.544	0.660
AMAT	0.562	0.223	0.393	0.748	0.188	0.468	0.722	0.274	0.498	0.647	0.507	0.577	0.818	0.409	0.614
AMD	0.702	0.180	0.441	0.686	0.372	0.529	0.712	0.214	0.463	0.687	0.627	0.657	0.721	0.502	0.611
AMR	0.671	0.279	0.475	0.723	0.254	0.488	0.591	0.313	0.452	0.781	0.542	0.661	0.711	0.473	0.592
AMZN	0.774	0.129	0.451	0.644	0.465	0.554	0.695	0.316	0.506	0.692	0.502	0.597	0.780	0.563	0.672
BAC	0.818	0.135	0.476	0.831	0.244	0.538	0.600	0.316	0.458	0.640	0.502	0.571	0.717	0.446	0.581
BEAS	0.641	0.394	0.518	0.691	0.425	0.558	0.514	0.440	0.477	0.629	0.567	0.598	0.759	0.557	0.658
BRCM	0.644	0.145	0.394	0.604	0.440	0.522	0.745	0.235	0.490	0.755	0.340	0.547	0.665	0.347	0.506
BSX	0.748	0.188	0.468	0.850	0.287	0.569	0.586	0.188	0.387	0.611	0.415	0.513	0.691	0.499	0.595
CA	0.724	0.246	0.485	0.608	0.334	0.471	0.747	0.508	0.627	0.708	0.552	0.630	0.832	0.583	0.708
CMCSK	0.700	0.345	0.523	0.814	0.334	0.574	0.815	0.396	0.605	0.751	0.314	0.532	0.843	0.459	0.651
COF	0.823	0.127	0.475	0.833	0.182	0.507	0.848	0.134	0.491	0.787	0.276	0.531	0.655	0.359	0.507
CSCO	0.570	0.337	0.454	0.574	0.560	0.567	0.613	0.243	0.428	0.622	0.532	0.577	0.809	0.567	0.688
DELL	0.614	0.174	0.394	0.649	0.388	0.519	0.784	0.346	0.565	0.754	0.324	0.539	0.830	0.503	0.666
DUK	0.535	0.285	0.410	0.719	0.479	0.599	0.783	0.237	0.510	0.734	0.457	0.595	0.705	0.471	0.588
EBAY	0.769	0.201	0.485	0.614	0.362	0.488	0.772	0.166	0.469	0.580	0.444	0.512	0.664	0.409	0.536
EMC	0.744	0.312	0.528	0.763	0.320	0.541	0.676	0.336	0.506	0.785	0.370	0.578	0.712	0.390	0.551
ET	0.638	0.260	0.449	0.664	0.314	0.489	0.621	0.245	0.433	0.507	0.450	0.479	0.531	0.293	0.412
FRE	0.909	0.115	0.512	0.678	0.462	0.570	0.804	0.272	0.538	0.732	0.491	0.612	0.736	0.403	0.569
FRX	0.628	0.241	0.435	0.649	0.524	0.587	0.681	0.290	0.485	0.709	0.472	0.590	0.669	0.452	0.561
GE	0.693	0.302	0.497	0.733	0.354	0.544	0.700	0.332	0.516	0.721	0.540	0.630	0.673	0.428	0.550
GM	0.604	0.302	0.453	0.707	0.395	0.551	0.774	0.378	0.576	0.702	0.400	0.551	0.614	0.262	0.438
HAL	0.765	0.167	0.466	0.680	0.341	0.511	0.808	0.313	0.560	0.647	0.318	0.483	0.642	0.263	0.452
HOG	0.731	0.173	0.452	0.807	0.250	0.528	0.766	0.198	0.482	0.832	0.407	0.620	0.755	0.327	0.541
HPQ	0.765	0.218	0.492	0.674	0.180	0.427	0.638	0.366	0.502	0.629	0.221	0.425	0.579	0.266	0.422
IBM	0.759	0.264	0.511	0.620	0.439	0.529	0.814	0.243	0.528	0.665	0.383	0.524	0.712	0.214	0.463
IMCL	0.674	0.257	0.465	0.610	0.479	0.545	0.631	0.360	0.496	0.706	0.527	0.616	0.765	0.305	0.535
INTC	0.765	0.186	0.475	0.779	0.186	0.483	0.548	0.300	0.424	0.666	0.337	0.502	0.776	0.483	0.630
JNJ	0.798	0.331	0.564	0.677	0.508	0.593	0.853	0.400	0.627	0.775	0.502	0.639	0.816	0.535	0.675
JPM	0.834	0.121	0.477	0.867	0.353	0.610	0.661	0.315	0.488	0.838	0.345	0.591	0.626	0.302	0.464
KLAC	0.723	0.264	0.493	0.614	0.353	0.483	0.657	0.179	0.418	0.474	0.504	0.489	0.572	0.378	0.475
KO	0.648	0.138	0.393	0.766	0.436	0.601	0.594	0.558	0.576	0.738	0.394	0.566	0.844	0.518	0.681
LXK	0.589	0.366	0.478	0.679	0.352	0.515	0.752	0.323	0.538	0.681	0.426	0.553	0.728	0.526	0.627
MER	0.702	0.255	0.479	0.651	0.444	0.548	0.684	0.264	0.474	0.813	0.236	0.524	0.695	0.291	0.493
MMM	0.771	0.168	0.470	0.639	0.464	0.552	0.819	0.171	0.495	0.726	0.298	0.512	0.778	0.301	0.540
MO	0.717	0.300	0.509	0.674	0.446	0.560	0.850	0.176	0.513	0.637	0.468	0.552	0.705	0.479	0.592
MRK	0.662	0.215	0.438	0.696	0.293	0.494	0.632	0.231	0.432	0.811	0.598	0.704	0.677	0.531	0.604
MS	0.753	0.227	0.490	0.663	0.346	0.505	0.699	0.308	0.503	0.837	0.324	0.581	0.659	0.335	0.497
MSFT	0.557	0.138	0.347	0.709	0.298	0.504	0.505	0.426	0.465	0.665	0.579	0.622	0.667	0.398	0.533
NEM	0.817	0.183	0.500	0.488	0.332	0.410	0.807	0.110	0.458	0.650	0.300	0.475	0.694	0.410	0.552
NOK	0.530	0.079	0.304	0.776	0.269	0.523	0.749	0.299	0.524	0.679	0.472	0.576	0.677	0.499	0.588
ORCL	0.588	0.303	0.445	0.663	0.291	0.477	0.664	0.253	0.458	0.648	0.356	0.502	0.632	0.477	0.554
OVTI	0.594	0.195	0.395	0.687	0.321	0.504	0.789	0.401	0.595	0.715	0.538	0.627	0.765	0.395	0.580
PFE	0.539	0.187	0.363	0.542	0.393	0.468	0.547	0.306	0.427	0.599	0.590	0.594	0.783	0.576	0.679
PG	0.621	0.137	0.379	0.721	0.355	0.538	0.728	0.267	0.498	0.709	0.268	0.488	0.639	0.273	0.456
QCOM	0.830	0.125	0.478	0.738	0.290	0.514	0.668	0.198	0.433	0.825	0.346	0.586	0.718	0.514	0.616
SNDK	0.608	0.147	0.377	0.688	0.347	0.518	0.848	0.246	0.547	0.693	0.494	0.593	0.765	0.506	0.635
SUNW	0.575	0.370	0.472	0.775	0.306	0.540	0.476	0.281	0.378	0.782	0.585	0.683	0.640	0.384	0.512
TWX	0.797	0.192	0.494	0.737	0.340	0.539	0.730	0.366	0.548	0.780	0.476	0.628	0.754	0.438	0.596
TXN	0.717	0.192	0.455	0.700	0.466	0.583	0.842	0.521	0.681	0.746	0.442	0.594	0.721	0.478	0.599
TYC	0.581	0.258	0.419	0.631	0.461	0.546	0.870	0.199	0.534	0.724	0.457	0.590	0.889	0.394	0.642
UPS	0.780	0.288	0.534	0.591	0.320	0.456	0.714	0.283	0.499	0.772	0.272	0.522	0.685	0.398	0.541
USG	0.640	0.251	0.446	0.788	0.209	0.498	0.680	0.277	0.478	0.588	0.404	0.496	0.689	0.357	0.523
VZ	0.591	0.271	0.431	0.655	0.377	0.516	0.612	0.303	0.458	0.848	0.487	0.668	0.581	0.304	0.442
WFC	0.860	0.135	0.497	0.703	0.300	0.502	0.786	0.198	0.492	0.848	0.191	0.520	0.844	0.383	0.614
XOM	0.642	0.203	0.422	0.689	0.304	0.496	0.907	0.148	0.527	0.801	0.425	0.613	0.885	0.392	0.638
YHOO	0.714	0.083	0.398	0.818	0.222	0.520	0.801	0.453	0.627	0.674	0.341	0.507	0.785	0.522	0.653

Panel F: Summary of Information Share

Resolution (sec)		ATM Call			Equal			Factor			GMM1			GMM2		
		Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share	Upper Bound	Lower Bound	Info Share
30	Mean	0.387	0.237	0.312	0.531	0.377	0.454	0.561	0.280	0.421	0.603	0.406	0.504	0.580	0.364	0.472
	Std	0.320	0.286	0.274	0.346	0.340	0.316	0.343	0.322	0.285	0.327	0.373	0.307	0.339	0.369	0.314
60	Mean	0.441	0.231	0.336	0.556	0.341	0.448	0.596	0.229	0.413	0.629	0.422	0.525	0.618	0.405	0.512
	Std	0.332	0.282	0.329	0.152	0.322	0.285	0.338	0.291	0.246	0.334	0.381	0.287	0.318	0.381	0.306
300	Mean	0.585	0.213	0.399	0.667	0.335	0.501	0.712	0.238	0.475	0.665	0.416	0.541	0.708	0.450	0.579
	Std	0.336	0.277	0.230	0.318	0.335	0.216	0.310	0.315	0.221	0.326	0.363	0.239	0.309	0.372	0.257
600	Mean	0.653	0.227	0.440	0.702	0.346	0.524	0.724	0.273	0.498	0.705	0.448	0.576	0.714	0.453	0.583
	Std	0.338	0.284	0.216	0.303	0.343	0.187	0.308	0.335	0.218	0.307	0.376	0.226	0.311	0.367	0.261
900	Mean	0.691	0.221	0.456	0.696	0.355	0.526	0.716	0.289	0.503	0.706	0.431	0.568	0.717	0.421	0.569
	Std	0.317	0.281	0.197	0.311	0.344	0.172	0.314	0.345	0.216	0.307	0.375	0.232	0.303	0.354	0.260

This table reports the summary statistics on the information share of the option market. It provides InfoS for 30-second and one-, five-, 10-, and 15- minute resolutions using ATM call implied stock returns, an equal-weighted, a factor-weighted, a GMM1-weighted and a GMM2-weighted portfolio. The table contains the average and upper and lower bounds of daily InfoS for each stock. InfoS is measured every day using option and stock mid-quotes from BRDS dating between April 17, 2005 and May 16, 2005. Panels A to E report the results with 30-second and one-, five-, ten-, and fifteen-minute resolutions, respectively. Panel F reports the average of upper and lower bounds of InfoS for all 58 stocks as well as the average InfoS for all five resolutions. InfoS is defined as a relative contribution of one market to the total variance of an efficient stock return process. It is obtained through a VECM:

$$\begin{pmatrix} \Delta \frac{dS_{t-1}}{S_{t-1}} \\ \Delta \frac{dIS_{t-1}}{IS_{t-1}} \end{pmatrix} + \mathbf{A}_2 \begin{pmatrix} \Delta \frac{dS_{t-2}}{S_{t-2}} \\ \Delta \frac{dIS_{t-2}}{IS_{t-2}} \end{pmatrix} + \dots + \mathbf{A}_M \begin{pmatrix} \Delta \frac{dS_{t-M}}{S_{t-M}} \\ \Delta \frac{dIS_{t-M}}{IS_{t-M}} \end{pmatrix} + \gamma(z_{t-1} - m) + \mathbf{v}_t. \text{ With the VECM,}$$

we derive a VMA model such as $\begin{pmatrix} \Delta \frac{dS_t}{S_t} \\ \Delta \frac{dIS_t}{IS_t} \end{pmatrix} = \mathbf{v}_t + \Psi_1 \mathbf{v}_{t-1} + \Psi_2 \mathbf{v}_{t-2} + \Psi_3 \mathbf{v}_{t-3} + \dots$ for

$$\forall t \in \{1, \dots, T\}. \text{ Here, we finally obtain InfoS for the } i\text{th market as } InfoS_{i,t} = \frac{\Psi_i^2 \Omega_{i,i}}{\Psi \Omega \Psi'},$$

where $\Omega = \begin{pmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{pmatrix}$ is a variance-covariance matrix of $\mathbf{v}_t = (v_{S,t}, v_{IS,t})'$.

Table VIII. Wilcoxon Signed Rank-Sum Test

Panel A: All

resolution tests pairs	30				60				300			
	signed		student's t		signed		student's t		signed		student's t	
	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Equal vs. ATM	100221.00	<.0001	12.34	<.0001	86911.50	<.0001	10.70	<.0001	103372.50	<.0001	11.71	<.0001
Fctr vs. ATM	84591.00	<.0001	9.36	<.0001	73036.50	<.0001	7.53	<.0001	75354.50	<.0001	8.20	<.0001
GMM1 vs. ATM	135595.50	<.0001	17.18	<.0001	133350.00	<.0001	16.99	<.0001	126355.50	<.0001	14.87	<.0001
GMM2 vs. ATM	113863.00	<.0001	13.90	<.0001	121545.50	<.0001	15.25	<.0001	143750.50	<.0001	18.07	<.0001
GMM1 vs. Equal	45864.00	<.0001	4.51	<.0001	72976.50	<.0001	7.86	<.0001	48225.50	<.0001	5.00	<.0001
GMM1 vs. Fctr	59803.00	<.0001	7.00	<.0001	87919.50	<.0001	10.88	<.0001	63102.50	<.0001	6.80	<.0001
GMM2 vs. Equal	19322.00	0.0270	1.50	0.1340	53933.50	<.0001	5.82	<.0001	82233.50	<.0001	9.14	<.0001
GMM2 vs. Fctr	37722.00	<.0001	4.33	<.0001	75854.50	<.0001	9.10	<.0001	86320.50	<.0001	10.09	<.0001

Panel A continued

resolution tests pairs	600				900			
	signed		student's t		signed		student's t	
	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Equal vs. ATM	93161.50	<.0001	10.46	<.0001	90368.00	<.0001	9.54	<.0001
Fctr vs. ATM	53028.50	<.0001	6.34	<.0001	44760.00	<.0001	5.24	<.0001
GMM1 vs. ATM	119362.50	<.0001	14.83	<.0001	102537.50	<.0001	12.30	<.0001
GMM2 vs. ATM	113997.50	<.0001	14.14	<.0001	101881.00	<.0001	12.34	<.0001
GMM1 vs. Equal	60535.50	<.0001	7.30	<.0001	45796.00	<.0001	5.22	<.0001
GMM1 vs. Fctr	73100.50	<.0001	8.53	<.0001	57572.00	<.0001	6.61	<.0001
GMM2 vs. Equal	61493.50	<.0001	6.88	<.0001	47219.00	<.0001	5.57	<.0001
GMM2 vs. Fctr	69475.50	<.0001	8.33	<.0001	60645.00	<.0001	7.08	<.0001

Panel B: Stock (percentages of tests that reject the null hypothesis)

resolution tests pairs	30				60				300			
	% of rejecting null signed	student's	mean	negative mean	% of rejecting null signed	student's	mean	negative mean	% of rejecting null signed	student's	mean	negative mean
Equal vs. ATM	34.00%	40.00%	0.1417	13.79%	28.57%	30.61%	0.1123	10.34%	32.69%	34.62%	0.1015	10.34%
Fctr vs. ATM	41.67%	35.42%	0.1080	17.24%	36.36%	29.55%	0.0764	17.24%	33.33%	25.00%	0.0757	17.24%
GMM1 vs. ATM	53.70%	62.96%	0.1909	6.90%	53.57%	58.93%	0.1914	8.62%	45.28%	45.28%	0.1413	8.62%
GMM2 vs. ATM	56.00%	62.00%	0.1590	13.79%	52.83%	60.38%	0.1784	1.72%	59.65%	61.40%	0.1801	1.72%
GMM1 vs. Equal	5.13%	7.69%	0.0492	32.76%	19.57%	23.91%	0.0791	34.48%	15.79%	21.05%	0.0398	34.48%
GMM1 vs. Fctr	12.82%	28.21%	0.0830	32.76%	32.61%	39.13%	0.1150	24.14%	15.91%	25.00%	0.0656	24.14%
GMM2 vs. Equal	5.71%	11.43%	0.0173	39.66%	10.00%	10.00%	0.0661	17.24%	20.83%	14.58%	0.0785	17.24%
GMM2 vs. Fctr	15.15%	15.15%	0.0510	43.10%	26.67%	28.89%	0.1020	13.79%	26.00%	28.00%	0.1044	13.79%

Panel B continued

resolution tests pairs	600				900			
	% of rejecting null signed	student's	mean	negative mean	% of rejecting null signed	student's	mean	negative mean
Equal vs. ATM	26.53%	34.69%	0.0840	15.52%	35.42%	31.25%	0.0693	17.24%
Fctr vs. ATM	12.50%	20.00%	0.0585	31.03%	14.29%	17.14%	0.0461	39.66%
GMM1 vs. ATM	50.94%	54.72%	0.1366	8.62%	48.98%	51.02%	0.1088	15.52%
GMM2 vs. ATM	40.74%	42.59%	0.1437	6.90%	47.62%	50.00%	0.1183	27.59%
GMM1 vs. Equal	13.64%	15.91%	0.0526	24.14%	28.57%	22.86%	0.0395	39.66%
GMM1 vs. Fctr	26.67%	28.89%	0.0782	22.41%	27.03%	29.73%	0.0627	36.21%
GMM2 vs. Equal	14.63%	14.63%	0.0597	29.31%	23.68%	23.68%	0.0491	34.48%
GMM2 vs. Fctr	20.93%	20.93%	0.0852	25.86%	20.93%	25.58%	0.0722	25.86%

Table VIII presents the result of a Wilcoxon signed rank-sum nonparametric test and a t test on InfoS. The test is conducted to examine whether there is a difference in InfoS between two portfolios. For example, Equal vs. ATM represents a test on InfoS with the null hypothesis that InfoS of ATM calls is bigger than InfoS of an equal-weighted portfolio at the five percent level. Panel A describes test statistics and p-value of the parametric and nonparametric test on InfoS of all stocks. Panel B reports percentages of stocks that reject the null hypothesis. In Panel B, the percentages of stocks that show a difference in InfoS between two portfolios are reported.

Table IX. Wilcoxon Signed Rank-Sum Test with Bootstrapping

Panel A: statistics with mean

resolution pairs	30					60				
	mean	confidence interval		% of normality	% of rejecting null	mean	confidence interval		% of normality	% of rejecting null
		p 2.5	p 95.7				p 2.5	p 95.7		
Equal vs. ATM	0.1417	-0.0209	0.3049	58.62%	91.38%	0.1122	-0.0360	0.2600	48.28%	89.66%
Fctr vs. ATM	0.1079	-0.0554	0.2688	51.72%	89.66%	0.0764	-0.0664	0.2165	72.41%	81.03%
GMM1 vs. ATM	0.1908	0.0345	0.3468	58.62%	96.55%	0.1914	0.0354	0.3459	58.62%	96.55%
GMM2 vs. ATM	0.1590	-0.0014	0.3215	63.79%	93.10%	0.1784	0.0166	0.3394	58.62%	93.10%
GMM1 vs. Equal	0.0492	-0.1062	0.2027	62.07%	74.14%	0.0792	-0.0596	0.2175	68.97%	84.48%
GMM1 vs. Fctr	0.0829	-0.0836	0.2480	63.79%	81.03%	0.1150	-0.0305	0.2598	58.62%	89.66%
GMM2 vs. Equal	0.0173	-0.1494	0.1825	70.69%	60.34%	0.0661	-0.0897	0.2218	58.62%	70.69%
GMM2 vs. Fctr	0.0511	-0.1154	0.2165	67.24%	65.52%	0.1019	-0.0528	0.2544	68.97%	82.76%

Panel A continued

resolution pairs	300					600				
	mean	confidence interval		% of normality	% of rejecting null	mean	confidence interval		% of normality	% of rejecting null
		p 2.5	p 95.7				p 2.5	p 95.7		
Equal vs. ATM	0.1016	-0.0188	0.2217	51.72%	89.66%	0.0840	-0.0266	0.1934	63.79%	87.93%
Fctr vs. ATM	0.0757	-0.0505	0.2023	68.97%	87.93%	0.0584	-0.0643	0.1828	56.90%	75.86%
GMM1 vs. ATM	0.1413	0.0071	0.2726	65.52%	96.55%	0.1366	0.0069	0.2660	60.34%	96.55%
GMM2 vs. ATM	0.1801	0.0394	0.3190	50.00%	100.00%	0.1438	0.0000	0.2871	58.62%	98.28%
GMM1 vs. Equal	0.0397	-0.0717	0.1499	60.34%	74.14%	0.0526	-0.0478	0.1546	65.52%	84.48%
GMM1 vs. Fctr	0.0657	-0.0694	0.1982	70.69%	77.59%	0.0782	-0.0493	0.2045	44.83%	86.21%
GMM2 vs. Equal	0.0785	-0.0432	0.1981	55.17%	89.66%	0.0598	-0.0635	0.1827	53.45%	77.59%
GMM2 vs. Fctr	0.1044	-0.0405	0.2484	55.17%	89.66%	0.0854	-0.0573	0.2281	46.55%	84.48%

Panel A continued

resolution		900			
pairs	mean	confidence interval		% of normality	% of rejecting null
		p 2.5	p 95.7		
Equal vs. ATM	0.0694	-0.0315	0.1677	68.97%	91.38%
Fctr vs. ATM	0.0461	-0.0732	0.1677	67.24%	70.69%
GMM1 vs. ATM	0.1089	-0.0133	0.2304	50.00%	91.38%
GMM2 vs. ATM	0.1185	-0.0138	0.2489	58.62%	84.48%
GMM1 vs. Equal	0.0396	-0.0667	0.1448	53.45%	67.24%
GMM1 vs. Fctr	0.0628	-0.0680	0.1925	62.07%	75.86%
GMM2 vs. Equal	0.0491	-0.0740	0.1708	48.28%	72.41%
GMM2 vs. Fctr	0.0724	-0.0693	0.2124	60.34%	82.76%

Panel B: statistics with median

resolution		30				60				
pairs	median	confidence interval		% of normality	% of rejecting null	median	confidence interval		% of normality	% of rejecting null
		p 2.5	p 95.7				p 2.5	p 95.7		
Equal vs. ATM	0.1296	-0.0625	0.3601	100.00%	86.21%	0.1016	-0.0807	0.3060	100.00%	86.21%
Fctr vs. ATM	0.1094	-0.0748	0.3153	100.00%	87.93%	0.0804	-0.0760	0.2452	100.00%	84.48%
GMM1 vs. ATM	0.1722	-0.0066	0.4038	100.00%	96.55%	0.1869	-0.0072	0.4146	100.00%	94.83%
GMM2 vs. ATM	0.1362	-0.0326	0.3534	100.00%	89.66%	0.1707	-0.0252	0.3876	100.00%	93.10%
GMM1 vs. Equal	0.0518	-0.1029	0.2301	100.00%	82.76%	0.0768	-0.0765	0.2365	100.00%	84.48%
GMM1 vs. Fctr	0.0696	-0.1287	0.3195	100.00%	74.14%	0.1038	-0.0595	0.3121	100.00%	82.76%
GMM2 vs. Equal	0.0267	-0.1779	0.2252	100.00%	68.97%	0.0641	-0.1175	0.2513	100.00%	79.31%
GMM2 vs. Fctr	0.0377	-0.1384	0.2552	100.00%	67.24%	0.0959	-0.0703	0.2989	100.00%	82.76%

Panel B continued

resolution		300				600				
pairs	median	confidence interval		% of	% of	median	confidence interval		% of	% of
		p 2.5	p 95.7	normality	rejecting null		p 2.5	p 95.7	normality	rejecting null
Equal vs. ATM	0.1025	-0.0451	0.2546	100.00%	93.10%	0.0881	-0.0645	0.2290	100.00%	89.66%
Fctr vs. ATM	0.0699	-0.0690	0.2299	100.00%	84.48%	0.0516	-0.0911	0.2059	100.00%	75.86%
GMM1 vs. ATM	0.1396	-0.0279	0.3216	100.00%	93.10%	0.1282	-0.0304	0.3087	100.00%	93.10%
GMM2 vs. ATM	0.1801	-0.0038	0.3736	100.00%	98.28%	0.1413	-0.0496	0.3449	100.00%	96.55%
GMM1 vs. Equal	0.0360	-0.0866	0.1672	100.00%	75.86%	0.0416	-0.0727	0.1726	100.00%	82.76%
GMM1 vs. Fctr	0.0706	-0.1104	0.2461	100.00%	82.76%	0.0750	-0.0803	0.2542	100.00%	81.03%
GMM2 vs. Equal	0.0787	-0.0654	0.2323	100.00%	87.93%	0.0605	-0.0892	0.2224	100.00%	79.31%
GMM2 vs. Fctr	0.1069	-0.0849	0.3022	100.00%	87.93%	0.0782	-0.1029	0.2823	100.00%	77.59%

Panel B continued

resolution		900			
pairs	median	confidence interval		% of	% of
		p 2.5	p 95.7	normality	rejecting null
Equal vs. ATM	0.0766	-0.0534	0.1988	100.00%	87.93%
Fctr vs. ATM	0.0425	-0.0931	0.1869	100.00%	68.97%
GMM1 vs. ATM	0.1060	-0.0499	0.2798	100.00%	82.76%
GMM2 vs. ATM	0.1274	-0.0649	0.3057	100.00%	79.31%
GMM1 vs. Equal	0.0418	-0.0970	0.1741	100.00%	65.52%
GMM1 vs. Fctr	0.0625	-0.1072	0.2308	100.00%	63.79%
GMM2 vs. Equal	0.0553	-0.1185	0.2205	100.00%	63.79%
GMM2 vs. Fctr	0.0812	-0.1221	0.2722	100.00%	77.59%

Table IX presents the Wilcoxon signed rank-sum nonparametric test results on the resampled InfoS using a bootstrapping method. InfoS is resampled 10,000 times to estimate mean, median and confidence intervals of InfoS for each resolution. A mean indicates a resampled mean difference in InfoS of 58 stocks. The table also reports percentages of stocks that reject the null hypothesis that InfoS of ATM calls is larger than InfoS of a portfolio approach and the null hypothesis that InfoS of a equal-weighted or a factor-weighted is larger than a GMM1-weighted or a GMM2-weighted portfolio at the five percent level. The bootstrap resampling is conducted based on Efron's (1979) nonparametric bootstrap method, and confidence interval is derived using Bickel and Freedman's (1981) approach.

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APPENDIX

Upper and lower 95% confidence intervals and standard deviation of Information Share for each resolution

Panel A: Thirty Seconds Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
AIG	0.477	0.167	0.301	0.631	0.332	0.291	0.550	0.344	0.201	0.629	0.321	0.299	0.577	0.316	0.253
ALL	0.555	0.297	0.251	0.757	0.407	0.341	0.572	0.305	0.259	0.775	0.405	0.360	0.671	0.278	0.382
AMAT	0.383	0.087	0.288	0.437	0.195	0.235	0.484	0.241	0.236	0.633	0.280	0.343	0.592	0.245	0.337
AMD	0.402	0.176	0.219	0.602	0.289	0.305	0.610	0.256	0.344	0.576	0.333	0.237	0.579	0.333	0.238
AMR	0.346	0.110	0.230	0.496	0.139	0.347	0.490	0.173	0.308	0.601	0.238	0.352	0.636	0.269	0.357
AMZN	0.393	0.165	0.222	0.693	0.409	0.276	0.692	0.344	0.338	0.802	0.485	0.308	0.840	0.504	0.327
BAC	0.251	0.123	0.121	0.623	0.237	0.362	0.633	0.267	0.344	0.666	0.356	0.291	0.602	0.278	0.303
BEAS	0.557	0.250	0.299	0.580	0.204	0.366	0.330	0.114	0.210	0.571	0.251	0.311	0.597	0.263	0.325
BRCM	0.359	0.128	0.225	0.640	0.270	0.360	0.593	0.204	0.378	0.697	0.412	0.277	0.705	0.416	0.281
BSX	0.371	0.114	0.250	0.723	0.351	0.362	0.522	0.191	0.321	0.654	0.310	0.334	0.674	0.320	0.344
CA	0.452	0.115	0.328	0.622	0.301	0.312	0.733	0.404	0.320	0.696	0.370	0.316	0.682	0.361	0.312
CMCSK	0.485	0.140	0.324	0.579	0.251	0.307	0.509	0.178	0.310	0.698	0.380	0.299	0.665	0.349	0.296
COF	0.456	0.247	0.203	0.744	0.495	0.243	0.576	0.396	0.176	0.703	0.394	0.301	0.728	0.408	0.311
CSCO	0.557	0.148	0.397	0.753	0.425	0.319	0.637	0.249	0.377	0.778	0.424	0.344	0.737	0.406	0.322
DELL	0.309	0.076	0.227	0.583	0.246	0.327	0.459	0.200	0.252	0.513	0.259	0.247	0.496	0.240	0.249
DUK	0.552	0.171	0.371	0.635	0.282	0.344	0.524	0.252	0.264	0.555	0.275	0.273	0.525	0.228	0.289
EBAY	0.355	0.146	0.204	0.636	0.275	0.352	0.427	0.307	0.117	0.594	0.326	0.261	0.523	0.242	0.273
EMC	0.496	0.143	0.344	0.668	0.261	0.397	0.552	0.185	0.357	0.778	0.393	0.374	0.767	0.373	0.383
ET	0.527	0.208	0.311	0.588	0.271	0.308	0.483	0.194	0.281	0.708	0.384	0.314	0.580	0.237	0.334
FRE	0.496	0.241	0.248	0.765	0.462	0.295	0.609	0.380	0.222	0.794	0.525	0.262	0.776	0.448	0.319
FRX	0.517	0.175	0.321	0.727	0.428	0.281	0.568	0.326	0.227	0.682	0.319	0.341	0.594	0.227	0.344
GE	0.453	0.217	0.212	0.673	0.258	0.375	0.600	0.166	0.392	0.669	0.238	0.389	0.714	0.273	0.398
GM	0.585	0.263	0.303	0.665	0.297	0.345	0.632	0.281	0.330	0.530	0.189	0.320	0.482	0.165	0.297
HAL	0.467	0.210	0.250	0.677	0.320	0.347	0.551	0.310	0.234	0.759	0.487	0.265	0.729	0.444	0.277
HOG	0.431	0.171	0.253	0.672	0.411	0.254	0.529	0.308	0.215	0.800	0.508	0.285	0.743	0.443	0.293
HPQ	0.325	0.173	0.148	0.514	0.164	0.340	0.653	0.257	0.385	0.516	0.236	0.272	0.532	0.236	0.288
IBM	0.462	0.220	0.236	0.583	0.295	0.279	0.535	0.361	0.169	0.708	0.399	0.301	0.590	0.297	0.285
IMCL	0.515	0.229	0.268	0.713	0.417	0.278	0.517	0.343	0.163	0.736	0.406	0.310	0.673	0.312	0.339
INTC	0.469	0.135	0.313	0.455	0.148	0.288	0.459	0.178	0.263	0.551	0.205	0.325	0.548	0.187	0.339
JNJ	0.643	0.268	0.365	0.643	0.302	0.332	0.667	0.415	0.245	0.714	0.418	0.288	0.822	0.505	0.308
JPM	0.453	0.165	0.271	0.587	0.243	0.323	0.493	0.183	0.291	0.626	0.305	0.302	0.594	0.289	0.286
KLAC	0.360	0.165	0.189	0.503	0.276	0.221	0.463	0.275	0.183	0.655	0.361	0.286	0.642	0.325	0.308
KO	0.446	0.141	0.296	0.645	0.309	0.327	0.818	0.401	0.406	0.610	0.308	0.294	0.608	0.269	0.330
LXK	0.410	0.143	0.260	0.726	0.365	0.351	0.603	0.386	0.211	0.724	0.430	0.286	0.690	0.360	0.321
MER	0.370	0.129	0.235	0.689	0.343	0.337	0.616	0.352	0.256	0.736	0.434	0.294	0.700	0.336	0.355
MMM	0.433	0.252	0.176	0.601	0.347	0.247	0.549	0.412	0.134	0.634	0.385	0.242	0.642	0.391	0.244
MO	0.610	0.282	0.319	0.714	0.488	0.220	0.538	0.312	0.219	0.775	0.414	0.351	0.650	0.278	0.362
MRK	0.426	0.128	0.290	0.470	0.198	0.264	0.537	0.255	0.274	0.585	0.296	0.280	0.630	0.330	0.292
MS	0.418	0.203	0.209	0.466	0.183	0.275	0.461	0.276	0.180	0.788	0.489	0.291	0.708	0.380	0.319
MSFT	0.460	0.167	0.275	0.590	0.193	0.373	0.661	0.282	0.356	0.642	0.292	0.328	0.615	0.232	0.359
NEM	0.537	0.210	0.318	0.436	0.184	0.245	0.496	0.203	0.286	0.520	0.270	0.243	0.451	0.197	0.247
NOK	0.352	0.088	0.256	0.532	0.280	0.245	0.570	0.306	0.257	0.829	0.423	0.395	0.600	0.198	0.391
ORCL	0.495	0.118	0.367	0.562	0.272	0.282	0.471	0.122	0.339	0.646	0.237	0.398	0.670	0.276	0.383
OVTI	0.434	0.113	0.312	0.627	0.271	0.346	0.539	0.168	0.362	0.483	0.164	0.310	0.460	0.142	0.309
PFE	0.476	0.132	0.335	0.554	0.192	0.352	0.525	0.172	0.343	0.717	0.365	0.343	0.687	0.322	0.355
PG	0.227	0.114	0.110	0.631	0.260	0.360	0.547	0.271	0.268	0.631	0.339	0.283	0.575	0.309	0.260
QCOM	0.437	0.211	0.219	0.665	0.309	0.345	0.625	0.316	0.301	0.698	0.429	0.261	0.690	0.430	0.253
SNBK	0.406	0.100	0.298	0.499	0.202	0.289	0.504	0.227	0.269	0.596	0.314	0.275	0.648	0.344	0.296
SUNW	0.425	0.127	0.290	0.558	0.222	0.327	0.524	0.135	0.378	0.526	0.176	0.340	0.382	0.118	0.257
TWX	0.435	0.182	0.246	0.721	0.360	0.350	0.732	0.386	0.337	0.711	0.394	0.308	0.694	0.398	0.288
TXN	0.417	0.156	0.254	0.636	0.293	0.334	0.756	0.404	0.342	0.643	0.327	0.307	0.691	0.369	0.314

Panel A contributed

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
TYC	0.606	0.242	0.329	0.700	0.337	0.328	0.565	0.290	0.249	0.668	0.340	0.296	0.640	0.328	0.282
UPS	0.469	0.215	0.247	0.450	0.132	0.309	0.564	0.377	0.182	0.607	0.329	0.271	0.607	0.317	0.282
USG	0.515	0.237	0.271	0.604	0.373	0.225	0.602	0.374	0.222	0.545	0.314	0.225	0.545	0.314	0.225
VZ	0.656	0.236	0.394	0.408	0.159	0.234	0.544	0.243	0.283	0.597	0.229	0.345	0.581	0.205	0.352
WFC	0.479	0.202	0.260	0.736	0.387	0.328	0.579	0.391	0.176	0.581	0.268	0.294	0.563	0.235	0.307
XOM	0.301	0.146	0.150	0.641	0.349	0.285	0.524	0.281	0.236	0.709	0.436	0.266	0.663	0.333	0.321
YHOO	0.463	0.164	0.280	0.638	0.337	0.282	0.549	0.184	0.343	0.748	0.472	0.259	0.682	0.368	0.294

Panel B: One Minute Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
AIG	0.497	0.195	0.294	0.624	0.359	0.257	0.572	0.413	0.155	0.675	0.393	0.274	0.652	0.378	0.267
ALL	0.571	0.309	0.246	0.706	0.400	0.287	0.520	0.319	0.189	0.747	0.425	0.302	0.723	0.321	0.377
AMAT	0.420	0.136	0.277	0.519	0.288	0.224	0.423	0.202	0.215	0.684	0.321	0.353	0.762	0.361	0.389
AMD	0.371	0.115	0.240	0.569	0.246	0.304	0.524	0.189	0.314	0.600	0.351	0.233	0.686	0.374	0.293
AMR	0.348	0.108	0.217	0.481	0.098	0.345	0.367	0.087	0.253	0.757	0.359	0.359	0.731	0.319	0.372
AMZN	0.509	0.208	0.293	0.639	0.363	0.269	0.663	0.352	0.302	0.692	0.386	0.298	0.598	0.251	0.338
BAC	0.319	0.184	0.131	0.574	0.234	0.330	0.448	0.154	0.286	0.528	0.319	0.203	0.673	0.353	0.311
BEAS	0.518	0.207	0.302	0.496	0.197	0.291	0.406	0.148	0.251	0.671	0.299	0.362	0.687	0.304	0.373
BRCM	0.517	0.248	0.253	0.619	0.278	0.320	0.510	0.218	0.274	0.724	0.442	0.264	0.683	0.385	0.279
BSX	0.361	0.125	0.229	0.654	0.375	0.272	0.429	0.190	0.233	0.654	0.340	0.306	0.706	0.379	0.318
CA	0.559	0.187	0.362	0.734	0.423	0.302	0.632	0.305	0.318	0.649	0.321	0.319	0.779	0.429	0.340
CMCSK	0.533	0.196	0.328	0.646	0.321	0.316	0.597	0.208	0.378	0.710	0.440	0.263	0.597	0.324	0.265
COF	0.509	0.339	0.166	0.656	0.432	0.217	0.540	0.434	0.103	0.691	0.427	0.257	0.716	0.436	0.272
CSCO	0.379	0.072	0.277	0.693	0.349	0.311	0.405	0.126	0.252	0.860	0.566	0.265	0.875	0.584	0.263
DELL	0.371	0.109	0.255	0.593	0.285	0.299	0.517	0.244	0.266	0.699	0.417	0.274	0.645	0.361	0.276
DUK	0.528	0.196	0.323	0.601	0.307	0.286	0.521	0.283	0.232	0.663	0.389	0.266	0.637	0.351	0.278
EBAY	0.491	0.209	0.265	0.563	0.316	0.232	0.519	0.404	0.108	0.722	0.512	0.197	0.739	0.508	0.217
EMC	0.506	0.168	0.317	0.649	0.254	0.372	0.434	0.143	0.273	0.722	0.372	0.329	0.661	0.350	0.292
ET	0.499	0.212	0.279	0.641	0.385	0.249	0.515	0.256	0.251	0.720	0.365	0.345	0.677	0.324	0.343
FRE	0.464	0.270	0.188	0.664	0.411	0.246	0.536	0.396	0.136	0.625	0.343	0.274	0.666	0.379	0.280
FRX	0.534	0.249	0.278	0.656	0.337	0.311	0.649	0.395	0.248	0.760	0.464	0.288	0.695	0.317	0.368
GE	0.539	0.292	0.240	0.665	0.298	0.356	0.510	0.181	0.321	0.737	0.409	0.319	0.745	0.374	0.361
GM	0.603	0.280	0.303	0.616	0.240	0.353	0.622	0.271	0.329	0.578	0.236	0.320	0.550	0.241	0.290
HAL	0.489	0.302	0.181	0.613	0.330	0.276	0.556	0.354	0.196	0.690	0.444	0.239	0.745	0.492	0.246
HOG	0.470	0.232	0.231	0.642	0.416	0.220	0.572	0.390	0.177	0.783	0.496	0.279	0.657	0.386	0.264
HPQ	0.397	0.190	0.195	0.475	0.133	0.321	0.503	0.165	0.317	0.593	0.280	0.294	0.584	0.280	0.285
IBM	0.558	0.311	0.240	0.582	0.356	0.220	0.555	0.423	0.129	0.642	0.397	0.238	0.632	0.350	0.275
IMCL	0.578	0.302	0.269	0.609	0.341	0.261	0.489	0.347	0.138	0.700	0.491	0.203	0.722	0.414	0.300
INTC	0.547	0.218	0.320	0.373	0.186	0.182	0.461	0.230	0.225	0.569	0.264	0.297	0.510	0.254	0.248
JNJ	0.443	0.199	0.229	0.572	0.294	0.260	0.591	0.430	0.151	0.694	0.384	0.291	0.768	0.415	0.331
JPM	0.486	0.242	0.238	0.615	0.328	0.279	0.603	0.296	0.299	0.673	0.346	0.318	0.649	0.313	0.326
KLAC	0.481	0.227	0.247	0.471	0.267	0.198	0.439	0.274	0.160	0.721	0.421	0.292	0.709	0.358	0.341
KO	0.532	0.154	0.328	0.497	0.217	0.242	0.609	0.231	0.327	0.761	0.373	0.336	0.806	0.380	0.369
LXK	0.435	0.106	0.308	0.682	0.366	0.297	0.545	0.394	0.141	0.730	0.437	0.275	0.612	0.290	0.303
MER	0.439	0.168	0.263	0.666	0.395	0.263	0.616	0.385	0.224	0.639	0.429	0.204	0.649	0.368	0.272
MMM	0.441	0.268	0.169	0.546	0.298	0.241	0.510	0.415	0.093	0.563	0.366	0.191	0.589	0.366	0.217
MO	0.654	0.371	0.275	0.724	0.549	0.171	0.584	0.385	0.193	0.767	0.439	0.320	0.664	0.304	0.350
MRK	0.420	0.150	0.263	0.472	0.209	0.255	0.578	0.377	0.196	0.508	0.314	0.189	0.568	0.339	0.223
MS	0.525	0.270	0.248	0.547	0.303	0.237	0.570	0.391	0.174	0.728	0.490	0.232	0.627	0.362	0.258
MSFT	0.504	0.203	0.293	0.635	0.246	0.378	0.588	0.277	0.302	0.588	0.236	0.342	0.584	0.264	0.311
NEM	0.517	0.245	0.264	0.400	0.192	0.202	0.388	0.181	0.201	0.457	0.200	0.250	0.404	0.180	0.218
NOK	0.372	0.099	0.256	0.456	0.184	0.255	0.475	0.191	0.267	0.712	0.317	0.370	0.728	0.298	0.403
ORCL	0.312	0.049	0.256	0.532	0.225	0.299	0.434	0.177	0.250	0.615	0.314	0.293	0.647	0.284	0.353
OVTI	0.445	0.139	0.297	0.599	0.244	0.345	0.510	0.186	0.314	0.604	0.277	0.318	0.602	0.227	0.364
PFE	0.281	0.063	0.205	0.584	0.193	0.367	0.601	0.248	0.331	0.711	0.362	0.328	0.688	0.339	0.328
PG	0.265	0.122	0.139	0.686	0.362	0.315	0.579	0.383	0.191	0.711	0.440	0.264	0.725	0.451	0.267
QCOM	0.446	0.239	0.201	0.642	0.346	0.288	0.539	0.323	0.209	0.719	0.410	0.300	0.730	0.405	0.316
SNDK	0.419	0.148	0.264	0.598	0.256	0.332	0.567	0.301	0.259	0.690	0.431	0.252	0.592	0.334	0.250
SUNW	0.400	0.177	0.210	0.438	0.145	0.275	0.328	0.059	0.252	0.743	0.283	0.432	0.769	0.327	0.415
TWX	0.399	0.147	0.236	0.601	0.268	0.312	0.648	0.373	0.258	0.801	0.465	0.315	0.758	0.382	0.352
TXN	0.421	0.150	0.264	0.641	0.339	0.294	0.572	0.223	0.340	0.753	0.470	0.275	0.730	0.462	0.260
TYC	0.536	0.171	0.342	0.665	0.349	0.296	0.517	0.300	0.203	0.633	0.359	0.258	0.607	0.345	0.246
UPS	0.533	0.270	0.256	0.498	0.198	0.292	0.547	0.399	0.143	0.525	0.313	0.206	0.593	0.303	0.282
USG	0.462	0.262	0.194	0.588	0.377	0.205	0.547	0.411	0.133	0.595	0.378	0.211	0.572	0.359	0.207
VZ	0.611	0.218	0.382	0.600	0.315	0.277	0.568	0.296	0.265	0.594	0.256	0.329	0.649	0.264	0.374
WFC	0.562	0.272	0.282	0.675	0.391	0.275	0.585	0.413	0.167	0.630	0.351	0.271	0.677	0.387	0.282
XOM	0.471	0.208	0.256	0.567	0.316	0.244	0.585	0.397	0.182	0.650	0.376	0.267	0.750	0.454	0.288
YHOO	0.404	0.180	0.218	0.662	0.377	0.277	0.642	0.358	0.276	0.762	0.465	0.289	0.802	0.467	0.326

Panel C: Five Minutes Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
AIG	0.482	0.275	0.201	0.605	0.409	0.191	0.562	0.469	0.090	0.607	0.432	0.170	0.678	0.399	0.271
ALL	0.592	0.451	0.133	0.609	0.399	0.197	0.647	0.411	0.222	0.590	0.304	0.268	0.776	0.464	0.293
AMAT	0.475	0.165	0.301	0.513	0.310	0.198	0.547	0.308	0.232	0.569	0.297	0.264	0.705	0.377	0.319
AMD	0.441	0.247	0.189	0.568	0.314	0.247	0.461	0.286	0.170	0.652	0.351	0.294	0.740	0.382	0.348
AMR	0.463	0.247	0.210	0.586	0.257	0.319	0.698	0.316	0.371	0.608	0.279	0.320	0.680	0.332	0.338
AMZN	0.528	0.342	0.180	0.633	0.407	0.220	0.602	0.314	0.281	0.647	0.445	0.196	0.712	0.516	0.190
BAC	0.509	0.317	0.186	0.621	0.438	0.178	0.619	0.428	0.185	0.722	0.502	0.214	0.696	0.445	0.243
BEAS	0.630	0.321	0.300	0.596	0.306	0.282	0.428	0.235	0.188	0.808	0.543	0.258	0.843	0.586	0.250
BRCM	0.443	0.232	0.206	0.584	0.399	0.179	0.762	0.503	0.252	0.608	0.443	0.161	0.669	0.447	0.216
BSX	0.508	0.278	0.224	0.672	0.483	0.183	0.451	0.263	0.183	0.689	0.381	0.299	0.714	0.410	0.295
CA	0.587	0.352	0.228	0.640	0.425	0.209	0.717	0.365	0.342	0.614	0.372	0.235	0.723	0.496	0.221
CMCSK	0.518	0.222	0.288	0.636	0.473	0.158	0.564	0.312	0.245	0.660	0.427	0.227	0.707	0.453	0.247
COF	0.530	0.421	0.106	0.592	0.492	0.097	0.585	0.460	0.122	0.657	0.460	0.192	0.658	0.475	0.178
CSCO	0.499	0.197	0.294	0.649	0.366	0.275	0.571	0.256	0.307	0.672	0.370	0.293	0.776	0.538	0.232
DELL	0.382	0.196	0.182	0.625	0.385	0.233	0.754	0.480	0.266	0.645	0.416	0.223	0.697	0.460	0.230
DUK	0.577	0.255	0.313	0.675	0.503	0.167	0.589	0.426	0.158	0.705	0.458	0.241	0.820	0.516	0.296
EBAY	0.441	0.255	0.180	0.552	0.356	0.191	0.607	0.427	0.175	0.697	0.426	0.263	0.753	0.455	0.290
EMC	0.568	0.287	0.273	0.715	0.382	0.324	0.691	0.398	0.285	0.719	0.414	0.297	0.749	0.460	0.281
ET	0.499	0.239	0.253	0.605	0.356	0.242	0.477	0.328	0.145	0.628	0.368	0.253	0.701	0.420	0.273
FRE	0.541	0.372	0.164	0.645	0.455	0.185	0.657	0.475	0.177	0.758	0.590	0.163	0.761	0.493	0.260
FRX	0.490	0.307	0.177	0.628	0.407	0.215	0.512	0.328	0.179	0.649	0.425	0.218	0.700	0.407	0.285
GE	0.542	0.317	0.219	0.661	0.425	0.230	0.714	0.337	0.368	0.641	0.371	0.263	0.725	0.413	0.304
GM	0.623	0.331	0.284	0.591	0.334	0.251	0.575	0.372	0.198	0.666	0.375	0.283	0.742	0.437	0.296
HAL	0.493	0.391	0.099	0.572	0.400	0.168	0.678	0.458	0.214	0.631	0.424	0.201	0.699	0.465	0.228
HOG	0.481	0.331	0.145	0.601	0.386	0.210	0.512	0.414	0.096	0.640	0.388	0.245	0.726	0.478	0.241
HPQ	0.473	0.306	0.163	0.586	0.290	0.289	0.620	0.410	0.205	0.590	0.373	0.211	0.655	0.393	0.254
IBM	0.547	0.398	0.144	0.597	0.476	0.117	0.543	0.473	0.068	0.663	0.506	0.152	0.604	0.438	0.161
IMCL	0.514	0.374	0.135	0.687	0.463	0.218	0.532	0.457	0.073	0.734	0.531	0.198	0.775	0.512	0.257
INTC	0.537	0.270	0.259	0.513	0.310	0.198	0.568	0.275	0.285	0.657	0.369	0.280	0.655	0.369	0.278
JNJ	0.647	0.339	0.300	0.686	0.501	0.180	0.608	0.448	0.156	0.672	0.414	0.251	0.721	0.458	0.255
JPM	0.544	0.368	0.171	0.663	0.426	0.230	0.569	0.310	0.251	0.718	0.461	0.250	0.680	0.447	0.227
KLAC	0.515	0.316	0.194	0.518	0.391	0.123	0.555	0.357	0.192	0.636	0.388	0.242	0.704	0.415	0.281
KO	0.471	0.191	0.273	0.670	0.484	0.181	0.601	0.281	0.312	0.751	0.515	0.230	0.740	0.519	0.214
LXK	0.522	0.189	0.324	0.641	0.413	0.222	0.608	0.494	0.110	0.622	0.357	0.257	0.666	0.402	0.257
MER	0.533	0.300	0.227	0.593	0.451	0.137	0.497	0.350	0.142	0.594	0.384	0.203	0.676	0.424	0.245
MMM	0.500	0.360	0.136	0.568	0.409	0.155	0.516	0.457	0.057	0.604	0.416	0.182	0.551	0.377	0.169
MO	0.559	0.379	0.175	0.670	0.538	0.129	0.534	0.425	0.106	0.684	0.442	0.236	0.757	0.481	0.268
MRK	0.512	0.244	0.261	0.638	0.370	0.261	0.512	0.329	0.178	0.599	0.312	0.279	0.730	0.460	0.263
MS	0.558	0.386	0.168	0.589	0.401	0.183	0.615	0.432	0.178	0.701	0.461	0.233	0.683	0.383	0.292
MSFT	0.471	0.205	0.259	0.529	0.274	0.248	0.465	0.251	0.209	0.684	0.445	0.233	0.713	0.394	0.311
NEM	0.586	0.377	0.203	0.529	0.281	0.241	0.584	0.377	0.201	0.580	0.366	0.208	0.679	0.470	0.203
NOK	0.438	0.139	0.291	0.611	0.331	0.273	0.571	0.312	0.251	0.778	0.477	0.293	0.860	0.570	0.282
ORCL	0.436	0.094	0.333	0.610	0.297	0.305	0.427	0.182	0.238	0.637	0.327	0.302	0.736	0.383	0.344
OVTI	0.356	0.146	0.205	0.612	0.309	0.294	0.658	0.330	0.319	0.557	0.328	0.223	0.653	0.394	0.251
PFE	0.413	0.136	0.269	0.605	0.321	0.277	0.549	0.235	0.306	0.700	0.394	0.298	0.735	0.447	0.280
PG	0.400	0.222	0.173	0.617	0.399	0.212	0.546	0.426	0.117	0.737	0.497	0.234	0.673	0.374	0.290
QCOM	0.526	0.395	0.127	0.617	0.454	0.159	0.531	0.324	0.201	0.685	0.481	0.199	0.705	0.453	0.245
SNDK	0.393	0.200	0.188	0.627	0.372	0.248	0.535	0.312	0.217	0.738	0.443	0.287	0.781	0.508	0.265
SUNW	0.553	0.218	0.325	0.470	0.203	0.260	0.595	0.236	0.349	0.735	0.427	0.300	0.753	0.483	0.262
TWX	0.495	0.241	0.247	0.691	0.433	0.251	0.600	0.366	0.227	0.779	0.546	0.227	0.802	0.555	0.240
TXN	0.555	0.307	0.241	0.652	0.461	0.186	0.667	0.373	0.286	0.658	0.455	0.197	0.762	0.583	0.175
TYC	0.617	0.264	0.343	0.639	0.432	0.201	0.610	0.442	0.163	0.558	0.363	0.191	0.678	0.409	0.262
UPS	0.490	0.329	0.157	0.450	0.266	0.179	0.529	0.462	0.065	0.539	0.350	0.184	0.551	0.399	0.147
USG	0.560	0.397	0.158	0.572	0.441	0.127	0.535	0.428	0.104	0.577	0.432	0.141	0.586	0.408	0.173
VZ	0.585	0.238	0.337	0.603	0.426	0.172	0.494	0.295	0.193	0.652	0.411	0.234	0.658	0.376	0.274
WFC	0.566	0.376	0.185	0.633	0.464	0.164	0.575	0.450	0.121	0.649	0.469	0.175	0.654	0.467	0.182
XOM	0.464	0.287	0.173	0.575	0.377	0.193	0.503	0.457	0.045	0.639	0.405	0.227	0.728	0.416	0.303
YHOO	0.502	0.294	0.202	0.631	0.503	0.125	0.732	0.410	0.314	0.714	0.602	0.109	0.754	0.509	0.238

Panel D: Ten Minutes Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
AIG	0.514	0.326	0.184	0.599	0.428	0.167	0.556	0.407	0.144	0.607	0.400	0.201	0.606	0.352	0.248
ALL	0.578	0.439	0.130	0.650	0.475	0.164	0.621	0.397	0.210	0.749	0.513	0.222	0.792	0.578	0.200
AMAT	0.468	0.206	0.254	0.548	0.338	0.204	0.580	0.359	0.215	0.672	0.391	0.273	0.707	0.409	0.289
AMD	0.477	0.283	0.182	0.631	0.391	0.225	0.652	0.422	0.216	0.739	0.452	0.269	0.780	0.469	0.292
AMR	0.590	0.332	0.250	0.591	0.321	0.262	0.601	0.216	0.374	0.650	0.369	0.273	0.701	0.415	0.278
AMZN	0.531	0.339	0.187	0.645	0.448	0.191	0.646	0.393	0.246	0.635	0.482	0.149	0.647	0.423	0.218
BAC	0.530	0.426	0.101	0.640	0.489	0.147	0.653	0.413	0.233	0.678	0.419	0.252	0.690	0.457	0.226
BEAS	0.686	0.353	0.323	0.613	0.360	0.246	0.394	0.223	0.166	0.789	0.500	0.281	0.806	0.575	0.224
BRCM	0.476	0.291	0.180	0.569	0.431	0.135	0.675	0.390	0.278	0.618	0.488	0.126	0.628	0.338	0.283
BSX	0.520	0.325	0.190	0.646	0.490	0.152	0.449	0.257	0.187	0.702	0.431	0.264	0.716	0.364	0.343
CA	0.659	0.430	0.223	0.698	0.515	0.178	0.845	0.511	0.325	0.722	0.499	0.217	0.811	0.610	0.195
CMCSK	0.607	0.335	0.264	0.637	0.493	0.139	0.689	0.392	0.288	0.720	0.512	0.203	0.802	0.588	0.208
COF	0.554	0.453	0.098	0.595	0.527	0.066	0.519	0.467	0.051	0.684	0.502	0.177	0.643	0.440	0.197
CSCO	0.559	0.272	0.279	0.671	0.426	0.238	0.570	0.263	0.299	0.769	0.464	0.297	0.826	0.546	0.273
DELL	0.427	0.272	0.151	0.576	0.382	0.189	0.591	0.327	0.257	0.668	0.436	0.226	0.698	0.406	0.285
DUK	0.494	0.220	0.266	0.597	0.442	0.150	0.583	0.417	0.162	0.696	0.489	0.201	0.681	0.351	0.321
EBAY	0.495	0.337	0.154	0.544	0.356	0.183	0.576	0.387	0.184	0.707	0.413	0.286	0.704	0.359	0.336
EMC	0.531	0.279	0.245	0.756	0.463	0.285	0.685	0.386	0.291	0.801	0.543	0.251	0.807	0.511	0.288
ET	0.518	0.314	0.198	0.613	0.410	0.197	0.502	0.347	0.150	0.643	0.394	0.242	0.620	0.331	0.281
FRE	0.562	0.364	0.192	0.590	0.426	0.159	0.580	0.464	0.114	0.698	0.514	0.179	0.751	0.516	0.229
FRX	0.501	0.346	0.150	0.591	0.375	0.210	0.578	0.349	0.222	0.556	0.337	0.213	0.610	0.408	0.197
GE	0.576	0.356	0.214	0.645	0.465	0.175	0.776	0.474	0.294	0.702	0.436	0.259	0.738	0.436	0.294
GM	0.620	0.357	0.256	0.657	0.442	0.209	0.603	0.416	0.182	0.662	0.443	0.213	0.707	0.413	0.286
HAL	0.508	0.414	0.092	0.556	0.467	0.087	0.612	0.413	0.193	0.671	0.529	0.139	0.757	0.536	0.215
HOG	0.519	0.378	0.132	0.615	0.431	0.172	0.513	0.434	0.073	0.711	0.488	0.209	0.743	0.571	0.162
HPQ	0.524	0.353	0.167	0.653	0.439	0.209	0.594	0.426	0.163	0.727	0.464	0.256	0.728	0.462	0.259
IBM	0.573	0.399	0.163	0.638	0.516	0.114	0.592	0.461	0.123	0.627	0.468	0.149	0.737	0.440	0.279
IMCL	0.525	0.435	0.087	0.656	0.497	0.155	0.531	0.454	0.075	0.749	0.525	0.218	0.723	0.488	0.228
INTC	0.559	0.335	0.218	0.524	0.314	0.204	0.527	0.297	0.223	0.648	0.356	0.283	0.757	0.463	0.286
JNJ	0.639	0.271	0.345	0.631	0.469	0.152	0.621	0.455	0.155	0.701	0.463	0.224	0.698	0.424	0.258
JPM	0.606	0.495	0.108	0.638	0.487	0.146	0.634	0.344	0.282	0.720	0.517	0.198	0.764	0.484	0.273
KLAC	0.557	0.436	0.118	0.552	0.435	0.114	0.490	0.346	0.141	0.654	0.424	0.223	0.695	0.467	0.222
KO	0.460	0.214	0.239	0.650	0.485	0.161	0.777	0.464	0.305	0.688	0.426	0.255	0.796	0.490	0.298
LXK	0.658	0.285	0.363	0.662	0.477	0.180	0.629	0.449	0.175	0.684	0.468	0.210	0.710	0.381	0.320
MER	0.552	0.353	0.194	0.571	0.427	0.140	0.561	0.417	0.140	0.716	0.429	0.279	0.758	0.449	0.300
MMM	0.522	0.409	0.106	0.595	0.436	0.149	0.513	0.459	0.051	0.588	0.407	0.170	0.568	0.380	0.177
MO	0.547	0.426	0.114	0.625	0.525	0.093	0.539	0.419	0.113	0.720	0.540	0.169	0.714	0.545	0.159
MRK	0.620	0.381	0.233	0.609	0.353	0.249	0.465	0.283	0.177	0.633	0.360	0.265	0.698	0.446	0.245
MS	0.603	0.426	0.172	0.583	0.405	0.173	0.606	0.381	0.219	0.755	0.518	0.231	0.744	0.489	0.247
MSFT	0.563	0.247	0.307	0.607	0.357	0.243	0.561	0.364	0.192	0.654	0.380	0.267	0.646	0.381	0.258
NEM	0.551	0.370	0.176	0.560	0.351	0.203	0.580	0.452	0.125	0.650	0.405	0.238	0.632	0.338	0.285
NOK	0.533	0.269	0.257	0.706	0.425	0.274	0.567	0.308	0.251	0.788	0.535	0.246	0.841	0.526	0.306
ORCL	0.492	0.161	0.322	0.612	0.411	0.195	0.556	0.308	0.242	0.703	0.469	0.227	0.704	0.384	0.311
OVTI	0.516	0.231	0.277	0.635	0.399	0.230	0.673	0.441	0.226	0.616	0.417	0.194	0.666	0.384	0.274
PFE	0.532	0.209	0.314	0.620	0.338	0.275	0.700	0.431	0.262	0.758	0.490	0.260	0.775	0.505	0.263
PG	0.476	0.305	0.166	0.654	0.461	0.187	0.571	0.409	0.158	0.663	0.458	0.199	0.747	0.450	0.289
QCOM	0.522	0.417	0.102	0.617	0.454	0.158	0.558	0.416	0.138	0.706	0.487	0.213	0.744	0.515	0.222
SNDK	0.426	0.256	0.166	0.599	0.382	0.212	0.556	0.339	0.212	0.718	0.489	0.222	0.642	0.323	0.310
SUNW	0.600	0.233	0.356	0.623	0.316	0.298	0.511	0.203	0.299	0.757	0.490	0.259	0.735	0.454	0.273
TWX	0.528	0.290	0.232	0.649	0.388	0.253	0.703	0.457	0.239	0.770	0.487	0.275	0.809	0.556	0.246
TXN	0.525	0.337	0.182	0.665	0.508	0.152	0.893	0.651	0.235	0.733	0.534	0.194	0.768	0.535	0.226
TYC	0.642	0.321	0.312	0.641	0.471	0.165	0.662	0.482	0.175	0.721	0.523	0.193	0.734	0.528	0.201
UPS	0.552	0.365	0.182	0.584	0.371	0.208	0.523	0.455	0.066	0.598	0.403	0.190	0.682	0.430	0.245
USG	0.553	0.379	0.163	0.522	0.425	0.091	0.520	0.441	0.074	0.533	0.382	0.141	0.555	0.361	0.183
VZ	0.596	0.295	0.293	0.637	0.477	0.156	0.546	0.305	0.235	0.701	0.440	0.253	0.690	0.416	0.267
WFC	0.521	0.379	0.138	0.632	0.498	0.130	0.593	0.475	0.115	0.713	0.521	0.187	0.708	0.476	0.226
XOM	0.501	0.326	0.170	0.554	0.400	0.149	0.609	0.459	0.146	0.775	0.568	0.202	0.714	0.450	0.257
YHOO	0.536	0.373	0.158	0.608	0.514	0.091	0.780	0.459	0.313	0.685	0.505	0.176	0.675	0.369	0.298

Panel E: Ten Minutes Resolution

Ticker	ATM Call			Equal-weighted			Factor			GMM1			GMM2		
	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V	Upper CI	Lower CI	STDE V
AIG	0.545	0.369	0.171	0.607	0.440	0.162	0.522	0.419	0.100	0.686	0.483	0.197	0.681	0.425	0.248
ALL	0.536	0.428	0.102	0.665	0.523	0.134	0.591	0.416	0.163	0.608	0.368	0.225	0.812	0.513	0.280
AMAT	0.523	0.263	0.252	0.572	0.365	0.201	0.621	0.375	0.239	0.762	0.490	0.264	0.823	0.520	0.294
AMD	0.549	0.332	0.211	0.619	0.439	0.175	0.587	0.339	0.241	0.760	0.512	0.241	0.795	0.472	0.314
AMR	0.595	0.356	0.233	0.579	0.398	0.176	0.619	0.286	0.324	0.772	0.488	0.276	0.717	0.459	0.251
AMZN	0.533	0.370	0.158	0.650	0.459	0.185	0.643	0.369	0.267	0.677	0.525	0.147	0.802	0.588	0.209
BAC	0.526	0.426	0.098	0.593	0.482	0.109	0.579	0.338	0.235	0.715	0.413	0.293	0.724	0.426	0.289
BEAS	0.662	0.374	0.280	0.654	0.463	0.186	0.575	0.379	0.190	0.715	0.480	0.228	0.756	0.560	0.191
BRCM	0.470	0.318	0.148	0.600	0.443	0.152	0.604	0.376	0.221	0.615	0.451	0.159	0.615	0.401	0.208
BSX	0.573	0.363	0.204	0.640	0.497	0.140	0.502	0.272	0.223	0.688	0.328	0.350	0.854	0.502	0.342
CA	0.589	0.381	0.202	0.594	0.347	0.240	0.794	0.461	0.325	0.733	0.463	0.262	0.779	0.612	0.162
CMCSK	0.662	0.383	0.271	0.638	0.510	0.124	0.710	0.501	0.203	0.688	0.441	0.240	0.735	0.565	0.166
COF	0.507	0.443	0.062	0.557	0.458	0.096	0.514	0.468	0.045	0.588	0.480	0.105	0.593	0.392	0.196
CSCO	0.592	0.315	0.269	0.692	0.442	0.243	0.576	0.279	0.289	0.712	0.424	0.280	0.824	0.582	0.235
DELL	0.493	0.295	0.193	0.599	0.438	0.157	0.699	0.432	0.259	0.593	0.412	0.176	0.802	0.550	0.244
DUK	0.549	0.270	0.271	0.668	0.530	0.133	0.603	0.418	0.180	0.692	0.510	0.177	0.720	0.477	0.236
EBAY	0.580	0.390	0.179	0.596	0.380	0.203	0.572	0.366	0.193	0.639	0.381	0.242	0.668	0.350	0.298
EMC	0.639	0.416	0.217	0.664	0.418	0.239	0.661	0.351	0.302	0.698	0.416	0.274	0.684	0.394	0.283
ET	0.548	0.349	0.194	0.577	0.401	0.172	0.491	0.376	0.113	0.574	0.383	0.186	0.520	0.304	0.210
FRE	0.587	0.437	0.146	0.626	0.514	0.109	0.617	0.459	0.153	0.772	0.558	0.208	0.745	0.505	0.234
FRX	0.524	0.346	0.174	0.681	0.493	0.183	0.570	0.401	0.164	0.677	0.471	0.201	0.635	0.418	0.212
GE	0.583	0.412	0.167	0.621	0.467	0.149	0.660	0.372	0.280	0.812	0.479	0.324	0.707	0.383	0.315
GM	0.581	0.325	0.250	0.652	0.450	0.197	0.659	0.493	0.162	0.647	0.399	0.241	0.560	0.263	0.288
HAL	0.516	0.416	0.097	0.574	0.448	0.122	0.683	0.437	0.239	0.557	0.379	0.174	0.568	0.360	0.202
HOG	0.504	0.399	0.103	0.606	0.450	0.152	0.536	0.429	0.104	0.710	0.579	0.128	0.647	0.428	0.213
HPQ	0.584	0.399	0.180	0.535	0.319	0.210	0.634	0.370	0.257	0.602	0.322	0.272	0.611	0.308	0.294
IBM	0.588	0.434	0.150	0.589	0.469	0.117	0.568	0.489	0.076	0.646	0.346	0.291	0.551	0.308	0.236
IMCL	0.531	0.399	0.128	0.616	0.473	0.139	0.539	0.453	0.084	0.720	0.544	0.172	0.643	0.454	0.184
INTC	0.594	0.357	0.230	0.568	0.398	0.165	0.574	0.275	0.290	0.638	0.385	0.246	0.703	0.412	0.284
JNJ	0.687	0.442	0.238	0.659	0.526	0.130	0.737	0.516	0.215	0.657	0.471	0.180	0.732	0.468	0.257
JPM	0.544	0.411	0.130	0.687	0.534	0.149	0.618	0.359	0.251	0.745	0.474	0.263	0.671	0.345	0.317
KLAC	0.553	0.433	0.116	0.547	0.419	0.125	0.508	0.328	0.175	0.592	0.418	0.169	0.625	0.351	0.267
KO	0.500	0.286	0.207	0.673	0.529	0.139	0.761	0.391	0.360	0.722	0.440	0.275	0.748	0.601	0.143
LXK	0.620	0.336	0.276	0.594	0.436	0.154	0.615	0.460	0.151	0.661	0.439	0.215	0.785	0.482	0.295
MER	0.534	0.424	0.107	0.595	0.500	0.092	0.566	0.383	0.178	0.554	0.379	0.171	0.591	0.371	0.213
MMM	0.525	0.414	0.108	0.629	0.475	0.151	0.528	0.462	0.064	0.576	0.448	0.125	0.636	0.444	0.186
MO	0.575	0.443	0.128	0.621	0.499	0.119	0.574	0.451	0.120	0.601	0.434	0.162	0.737	0.493	0.237
MRK	0.548	0.329	0.213	0.605	0.383	0.216	0.527	0.336	0.185	0.764	0.641	0.119	0.750	0.467	0.275
MS	0.563	0.417	0.141	0.562	0.447	0.112	0.584	0.423	0.156	0.725	0.494	0.225	0.611	0.318	0.286
MSFT	0.441	0.254	0.182	0.610	0.397	0.207	0.614	0.317	0.288	0.742	0.497	0.239	0.705	0.368	0.327
NEM	0.570	0.430	0.136	0.540	0.281	0.252	0.539	0.378	0.156	0.579	0.282	0.289	0.651	0.362	0.282
NOK	0.428	0.181	0.240	0.636	0.409	0.220	0.622	0.427	0.190	0.738	0.367	0.360	0.738	0.428	0.301
ORCL	0.603	0.287	0.308	0.559	0.394	0.160	0.555	0.362	0.188	0.613	0.358	0.248	0.743	0.400	0.333
OVTI	0.502	0.287	0.209	0.623	0.385	0.232	0.725	0.466	0.252	0.709	0.546	0.159	0.722	0.416	0.298
PFE	0.485	0.241	0.237	0.571	0.365	0.200	0.583	0.270	0.304	0.691	0.442	0.242	0.872	0.585	0.280
PG	0.444	0.314	0.127	0.631	0.445	0.181	0.584	0.411	0.169	0.573	0.376	0.192	0.635	0.425	0.205
QCOM	0.529	0.427	0.096	0.599	0.428	0.160	0.551	0.315	0.222	0.708	0.526	0.171	0.755	0.482	0.257
SNDK	0.462	0.292	0.166	0.611	0.424	0.182	0.644	0.449	0.189	0.707	0.422	0.277	0.783	0.545	0.231
SUNW	0.662	0.283	0.369	0.659	0.422	0.230	0.540	0.216	0.315	0.782	0.522	0.253	0.661	0.361	0.291
TWX	0.604	0.385	0.213	0.669	0.408	0.254	0.693	0.403	0.281	0.755	0.504	0.244	0.727	0.464	0.256
TXN	0.561	0.348	0.207	0.653	0.513	0.136	0.817	0.546	0.263	0.809	0.520	0.281	0.771	0.534	0.230
TYC	0.557	0.282	0.267	0.659	0.433	0.220	0.596	0.473	0.121	0.718	0.510	0.202	0.775	0.578	0.192
UPS	0.613	0.455	0.154	0.541	0.370	0.166	0.528	0.469	0.058	0.637	0.434	0.197	0.655	0.400	0.247
USG	0.528	0.363	0.161	0.553	0.443	0.107	0.523	0.434	0.087	0.581	0.412	0.165	0.642	0.404	0.232
VZ	0.572	0.291	0.273	0.603	0.430	0.168	0.593	0.322	0.264	0.826	0.576	0.242	0.513	0.264	0.242
WFC	0.554	0.441	0.110	0.567	0.437	0.126	0.575	0.409	0.161	0.583	0.413	0.165	0.801	0.570	0.224
XOM	0.513	0.332	0.177	0.586	0.407	0.174	0.573	0.482	0.089	0.718	0.504	0.208	0.679	0.503	0.171
YHOO	0.480	0.316	0.159	0.575	0.465	0.107	0.736	0.518	0.212	0.620	0.411	0.203	0.756	0.557	0.194