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BANK STOCK AND OPTION TRANSMISSIONS IN FINANCIAL CRISIS

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ABTRACT

We investigate bank stock and option transmissions during the financial crisis in 2008. Contemporaneous and lagged-one stock order imbalances have a significant impact on option returns. A time-varying GARCH model is employed to confirm the results. We develop an imbalance-based call (put) trading strategy that buys the call (put) if the previous day's stock imbalance is positive, and sells the stock if the previous day's stock imbalance is negative. The empirical results do not show a positive premium, which implies market efficiency between option and stock markets in financial crisis.

JEL: G01, G14, G21

KEYWORDS: Order Imbalance, Market Efficiency, Investment Bank, Commercial Bank, Financial Crisis, Option

INTRODUCTION

In 2008, the subprime crisis in U.S. spilled over and became the catalyst for a much broader global financial crisis. Intervention by the Treasury and the Federal Reserve in the financial markets was intend to avoid broader spillovers to other markets and sectors of the economy. An extensive literature about financial contagion in financial crisis examines the consequences for cross-nation contagion (e.g. Aloui et al., 2011; Baur, 2012). Less is known about the spillovers from stock markets to option markets in U.S. Because the financial sector is most vulnerable and subject to inside information during financial crisis, we examine the transmission from stock markets to option markets in U.S. banking sector around the financial crisis. That is, we use daily data of the financial sector in the U.S. during financial crisis in 2008 to examine the market efficiency between option and stock markets.

Choy and Wei (2012) argue that abnormal option turnovers and abnormal stock returns are significantly related (positively for calls and negatively for puts) around earnings announcements. Once they control for pre-announcement returns, the pre-announcement turnovers no longer predicts post-announcement returns. Hence, option trading doesn't appear to be driven by information around earnings announcements. Nevertheless, Hu (2014) decompose stock order imbalance into the option-induced imbalance and the imbalance independent of option trading activities. He finds that stock exposure imbalance induced by option transactions has strong predictive power of stock returns, while the independent stock order imbalance has a transitory price impact but shows no significant predictive ability for stock returns on the next day. We further explore whether the stock order imbalance has influence on option returns.

Lamoureux and Lastrapes (1990) employ a time-varying Autoregressive Conditional Heteroskedasticity (ARCH) model to test the relation between daily stock returns and trading volume and show that trading volume is a significant explanatory variable on the variance of daily returns. Gallant et al. (1992) shows that correlation between conditional volatility and volume is positive. Moreover, larger price movements are followed by higher trading volumes. Thus, we use a GARCH model to examine the relation between volatility, order imbalance, and return around financial crisis.

We find that contemporaneous stock imbalances have a significant impact on option returns, and lagged-one imbalances also have a significantly positive impact on call but not on put. Conditional on contemporaneous imbalance, the impact of lagged-one imbalance on call return is still positive. Employing a time-varying GARCH model based on the argument of a volatile market in financial crisis, we find that volatility plays an important role in the return-order imbalance relation. Moreover, we develop an imbalance-based call (put) trading strategy that buys the call (put) if the previous day's stock imbalance is positive, and sells the stock if the previous day's stock imbalance is negative. This trading strategy does not outperform the original buy and hold return.

The remainder of this paper is organized as follows. In the literature review section, we present the related literature. The data and methodology section describes the data and defines the variables. In results and discussion section, we show the regression results and discussions. Finally, the conclusion comments section provides our conclusion and suggestion.

LITERATURE REVIEW

Chordia et al. (2002) document that market order imbalances, defined as aggregated daily market purchase orders less sell orders, are positively autocorrelated. Therefore, investors continue buying or selling for a period, suggesting that traders are herding, or splitting large orders over time. Chordia and Subrahmanyam (2004) study the relation between stock order imbalances and daily returns of individual stocks. Price pressures caused by autocorrelated imbalances cause a positive relation between lagged imbalances and returns. Informed traders can use the imbalance-based trading strategies to yield statistically significant returns.

Instead of trading stocks, informed traders may trade options for the following reasons. First, greater leverage, lower transaction costs and built-in downside protection may attract informed traders to participate in the option market (e.g. Chakravarty et al., 2004). Second, investors who only have private information about the volatility of underlying security price could bet on such volatility in the option market (e.g. Ni et al., 2008). Third, the option market provides strategic flexibility to informed traders because they can trade contracts on the same underlying security but with different exercise prices and maturities (Kaul et al., 2004). On the contrary, lower liquidity may discourage informed traders from trading options (Vijh, 1990). Overall, Easley et al. (1998) indicated that informed traders may simultaneously trade in options and underlying stock markets. Further, Chakravarty et al. (2004) and Kaul et al. (2004) suggest that informed traders would trade-off between options leverage and the transaction costs associated with options liquidity.

Although there is informed trading in the option market, it does not necessarily imply that there is no market efficiency, because option volume is not publicly observable. Information-based models proposed by Easley et al. (1998) imply that prices react immediately to public information contained in the trading process but adjust slowly to the private information possessed by informed traders. Vega (2006) shows that not all information acquisition variables have the same effect on the market's efficiency. Cao and Wei (2010) find that information asymmetry is greater for options than for the underlying stocks, implying that the options market is a more efficient venue for informed traders.

DATA AND METHODOLOGY

We choose the largest nine investment and commercial banks to represent the U.S. banking sector, with a sample from June 1, through December 31, 2008. We collect intraday data from NYSE TAQ (Trade and Automated Quotations) and daily data from Option Metrics. Sample stocks and options are included or excluded in our samples according to the following criteria. First, all objective included in our sample must be large investment banks and commercial banks in the U.S., including Goldman Sachs, Merrill Lynch, Citi Group, Morgan Stanley, JP Morgan, Bank of America, Wells Fargo, American Express and Lehman Brothers. Second, all objectives whose transaction data are not available in both NYSE TAQ and Option Metrics are excluded from our samples. Third, to avoid noise trading, we delete those transaction recorded within the first 90 seconds after the market opens.

We employ Lee and Ready (1991) trade assignment algorithm to determine whether it is buyer-initiated or seller-initiated transaction. The average return of call options is -452.48%, with a median of -288.80%. The standard deviation of call option returns is 529.40%, with a maximum value is 68.35% and the minimum is -2393.52%. On the other hand, the average return of puts is -10.52%, with a median of 11.56%. The standard deviation of put option returns is 250.38%, with a maximum of 351.98% and minimum of 1068.90%.

We employ a time-varying GARCH model to re-examine the above relations based on the argument that volatility might play an important role in financial crisis.

$$R_t = \alpha + \beta^* OI_t + \varepsilon_t \qquad \varepsilon_t \mid \Omega_t \sim N(0, h_t) \qquad h_t = A + B\ h_{t-1} + C\ \varepsilon_{t-1}^2 \tag{1}$$

Where R_t is the return at time t, and is defined as ln (Pt/Pt-1). OI_t denotes the explanatory variable of order imbalance. β is the coefficient describing the impact of the order imbalance on option return. ε_t is the residual value of the option return at time t. h_t is the conditional variance at time t. Ω_{t-1} is the information set in at time t.

To investigate volatility-order imbalance relation, we use another GARCH model.

$$R_t = \alpha + \varepsilon_t\ , \qquad \varepsilon_t \mid \Omega_t \sim N(0, h_t)\ ,\ h_t = A + B\ h_{t-1} + C\ \varepsilon_{t-1}^2 + \gamma\, OI_t \tag{2}$$

Where R_t is the return at time t, and is defined as ln (Pt/Pt-1). OI_t denotes the explanatory variable of order imbalance. ε_t is the residual value of the stock return at time t. h_t is the conditional variance at time t. Ω_{t-1} is the information set in at time t. γ is the coefficient describing the impact of the order imbalance on volatility of the return.

RESULTS AND DISCUSSION

Chordia and Subrahmanyam (2004) propose that lagged stock order imbalances are positively related to stock returns. We investigate unconditional return-order imbalance relation by regressing option return on five lagged stock imbalances. We expect the relation between call (put) option returns and stock order imbalance is po6sitive (negative). The results are presented in Table 1.

At the 5% significant level, the positive and significant percent of lagged-one imbalance is 21.0%, while the negative and significant one is null. Surprisingly, there is no significant relation between lagged-one imbalance and put return. The empirical result of call options is consistent with Chordia and Subrahmanyam (2004), while put option results show a totally different picture. A possible explanation is as follows. First of all, we find an asymmetric return pattern in option, namely, there is no upper limit for a long option.

Table 1: Unconditional Lagged Return-Order Imbalance Relation

	Positive	Positive and Significant	Negative and Significant
Panel A: Call			
OI_{t-1}	82.72%	21.0%	0.0%
OI_{t-2}	33.33%	2.5%	4.9%
OI_{t-3}	75.31%	2.5%	0.0%
OI_{t-4}	16.05%	3.7%	16.0%
OI_{t-5}	33.33%	0.0%	18.5%
Panel B: Put			
OI_{t-1}	44.44%	0.0%	0.0%
OI_{t-2}	71.60%	3.7%	0.0%
OI_{t-3}	33.33%	0.0%	1.2%
OI_{t-4}	88.89%	8.6%	3.7%
OI_{t-5}	43.21%	7.4%	0.0%

This table shows the regression estimates of lagged order imbalances on the current stock return of the individual stock. Panels A and B present the results in call and put options respectively. "Significant" denotes significance at the 5% level.

During financial crises, markets tend to be more volatile. Investors are prone to long a call instead of writing a call. In addition, market makers react in a different ways to a positive or a negative imbalance. Market makers with call options tend to have a stronger reaction on a positive than a negative imbalance. On the other hand, market makers with put options are prone to overreact more to a negative than a positive imbalance. Secondly, market participants show a pessimistic attitude toward the financial sector in financial crises. Market makers tend to keep a high level inventory of puts. When a large negative order imbalance shows up, option market makers interpret it as a noise trade. Therefore, from a daily perspective, market makers are reluctant to lower bid-ask spreads on put options in the following period to accommodate a negative imbalance. On the other hand, market makers with put option are short call option. When a large positive order imbalance appears, market makers tend to interpret it as a discretionary trade. Therefore, market makers are eager to raise bid-ask spreads on calls.

We also examine conditional return-order imbalance through a contemporaneous imbalance and four lags of order imbalances. The empirical result is exhibited in Table 2. At the 5% significant level, the positive and significant percent of contemporaneous and lagged-one imbalance are 76.5% and 24.7% respectively. We conclude that contemporaneous relations between imbalances and returns confirms both inventory and asymmetric information effects of price formation. However, our empirical results are inconsistent with Chordia and Subrahmanyam (2004), which predict a reversal return-lagged imbalance relation. There is a possible explanation: When a large positive imbalance appears, option market makers tend to interpret it as a discretionary trade and rush to raise bid-ask immediately because markets are in a panic. Nonetheless, they quickly find themselves overreacted. Therefore, they slow the price adjustments.

Table 2: Conditional Lagged Return-Order Imbalance Relation

	Positive	Positive and Significant	Negative and Significant
Panel A: Call			
OI_t	100.00%	76.5%	0.0%
OI_{t-1}	90.12%	24.7%	0.0%
OI_{t-2}	28.40%	3.7%	8.6%
OI_{t-3}	59.26%	1.2%	0.0%
OI_{t-4}	33.33%	3.7%	13.6%
Panel B: Put			
OI_t	0.0%	0.0%	82.7%
OI_{t-2}	25.93%	0.0%	0.0%
OI_{t-3}	74.07%	2.5%	0.0%
OI_{t-4}	43.21%	0.0%	1.2%
OI_{t-5}	70.37%	7.4%	3.7%

This table shows the regression estimates of current and lagged order imbalances on the current stock return of the individual stock. Panels A and B present the results in call and put options respectively. "Significant" denotes significance at the 5% level.

As for put options, the negative and significant percent of contemporaneous and lagged-one imbalances are 82.7% and 0% at the 5% significant level. One possible explanation is that, during a severe financial crisis with a pessimistic environment, market makers regard large negative imbalance as noise trading. Therefore, market makers in the option market lower quotes of put options to manage inventory levels in the same trading day, and do not further adjust quotes significantly to react to imbalances of the last trading day.

Does volatility play a role in return-order imbalance relation, especially in a financial turbulence? We employ a time-varying GARCH model to capture time-variant properties in the return-order imbalance relation. Table 3 presents the results that the positive and significant percent of calls is 79.0% and the negative and significant percent of puts is 81.5% at 5% significant level. These results reconfirm the return-order imbalance relation. If option markets are efficient, there should be no significant GARCH relation between stock order imbalances and option returns in financial crisis.

Table 3: Dynamic Return-Order Imbalance GARCH (1,1) Relation

	Percent	Percent Positive and Significant	Percent Negative and Significant
Call	95.1%	79.0%	0.00%
Put	4.9%	1.2%	81.5%

This table shows the regression estimates of the equation. $R_t = \alpha + \beta^* OI_t + \varepsilon_t \quad \varepsilon_t \mid \Omega_t \sim N(0, h_t) \quad h_t = A + B\ h_{t-1} + C\ \varepsilon_{t-1}^2$ *where R_t is the return in period t, and is defined as $\ln(P_t/P_{t-1})$, OI_t is the order imbalance, ε_t is the residual value of the stock return in period t, Ω_{t-1} is the information set in period t-1. "Significant" denotes significant at the 5% level.*

We take a further step to examine volatility-order imbalance relation through a time-varying GARCH model. The empirical results are exhibited in Table 4. The prior belief is that the larger order imbalance is associated with the higher volatility. Nonetheless, the imbalance impact on volatility is not what we had thought. For call, we document that the positive and significant percent is 33.3% and negative and significant percent is 32.1% at 5% significant level respectively. For put, we find that the positive and significant percent is 33.3% and negative and significant percent is 33.3% at 5% significant level respectively. It implies that market makers have sufficient inventories to mitigate option market volatility.

Table 4: Dynamic Volatility-Order Imbalance GARCH (1,1) Relation

Panel A: By Option Type			
	Percent	**Percent Positive and Significant**	**Percent Negative and Significant**
Call	50.6%	33.3%	32.1%
Put	45.7%	33.3%	33.3%
Panel B: By Bank			
γ	**Percent**	**Percent Positive and Significant**	**Percent Negative and Significant**
AXP	38.9%	33.3%	11.1%
BAC	22.2%	11.1%	55.6%
C	88.9%	77.8%	0.0%
GS	27.8%	22.2%	55.6%
JPM	16.7%	11.1%	50.0%
LEH	50.0%	5.6%	27.8%
MER	72.2%	50.0%	22.2%
MS	16.7%	11.1%	72.2%
WFC	100.0%	77.8%	0.0%

This table shows the regression estimates of the equation. $R_t = \alpha + \varepsilon_t \;, \varepsilon_t \mid \Omega_{t-1} \sim N(0, h_t),\ h_t = A + Bh_{t-1} + C\varepsilon_{t-1}^2 + \gamma^* OI_t$ *where R_t is the return in period t, and OI_t is the order imbalance ε_t is the residual value of the stock return in period t, Ω_{t-1} is the information set in period t-1. Panel A presents the results by option type and Panel B shows the results by bank. "Significant" denotes significant at the 5% level.*

We further regroup our sample into nine small groups according to their institution to demonstrate market maker behaviors in different option markets. The results show variable abilities of market makers in different markets. We find the positive and significant percent is 77.8%, 50.0%, and 77.8% at 5% significant level on Citi (C), Merrill Lynch (MER), and Wells Fargo (WFC). This result implies that market makers are poor at mitigating volatility in these markets. The empirical results are consistent with the intuition that these three financial institutions are deeply involved in the financial crisis. On the other hand, we show the negative and significant percent is 55.6%, 50.0%, and 72.2% in options of Bank of America (BAC), JP Morgan (JPM), and Morgan Stanley (MS) respectively.

To test spillover efficiency, we develop an order imbalance-based trading strategy. In our sample period, the average return on calls is -452.5%, while that on puts is 82.23%. We implement our imbalance-based trading strategy as following. First, we trim 90% noisy trades on liquidity on a daily bases. Then we long a call when a positive stock order imbalance appears and long a put when a negative imbalance appears. We hold the position until reversal appears. The performance is exhibited in Panel A of Table 5. Through this trading strategy, the returns are -179.56% and -26.42% for calls and puts respectively. At the 1% significant level, the return of trading strategy for calls is significantly negative, whereas the return of trading strategy for puts is insignificant negative. This result is self-explained in the financial crisis. Panel B shows the return of imbalance-based trading strategy for calls is significantly lower than open-to-close returns at the

1% significant level. In Panel C, we find significant differences in returns between the two strategies at the 1% significant level.

Table 5: Trading Profit under the Basis of Quote price

Panel A: Returns Compared with Zero		
	P-value	
Call	0.0001***	
Put	0.1041***	
Panel B: Returns Compared with Returns of Buy-and-hold Strategy		
	Mean Original	P-value
Original open-to-close return	-0.1050	
Call Return of strategy	-1.7956	0.0001***
Put Return of strategy	-0.2642	0.2273
Panel C: Differences in Returns between Two Strategies		
P-value	Mean	Two-tail P-value
Call return of strategy	-1.7956	0.0001***
Put return of strategy	-0.2642	

This table shows the trading profit under the quote price. We long a call when a positive stock order imbalance appears and long a put on a negative one. We hold the position until reversal shows up. Panel A presents the p-values to be used to examine whether the return of imbalance-based trading strategy is positive. Panel B shows the p-values to be used to explore whether the return of imbalance-based trading strategy is higher than open-to-close return. Panel C exhibits the p-values to be used to examine whether there is no difference in return between two strategies.

CONCLUDING COMMENTS

An extensive literature about financial contagion in financial crises examines the consequences across nations. Less is known about the spillovers from stock markets to option markets in the U.S. Since financial sector is most vulnerable and subject to inside information during financial crises, we focus on bank stocks and option transmissions during the financial crisis of 2008. From daily trading of nine leading banks in the U.S. from June 1, 2008 to December 31, 2008, we first examine the relations between returns and lagged order imbalances by using an OLS model. We find that lagged imbalance is a good predictor of calls, which is consistent with Chordia and Subrahmanyam (2004). We examine the role of volatility on return-order imbalance relations in financial crisis and find that the relations are significant. From a volatility-order imbalance GARCH model, we argue that market makers are capable of mitigating volatility. After examining relations among returns, order imbalance, and volatility, we develop an imbalance-based trading strategy. Our strategy suggests longing a call (put) if the previous day's stock imbalance is positive, and selling a stock if the previous day's stock imbalance is negative. We document that imbalance-based trading strategies on call options cannot beat the market. It implies market efficiency on bank stocks and option transmissions.

This paper focuses on the impact of stock order imbalances on option returns in financial crisis. Future research could examine the influence of option order imbalances on stock returns to enrich the literature.

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