Fake News

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Abstract

This analysis uses Twitter stock and options prices sampled at a 30 second frequency around the fake news announcement, of a bid for a controlling stake in Twitter stock, to investigate whether price discovery is made in the stock or option markets. We find reaction to the fake news occurred in the stock market, and the option market reacted with a delay. This differs from many analyses of actual news events, which found informed traders prefer the options market, and information from their trades then leaks into the stock market. We conclude uninformed traders, and those aware of the hoax, prefer to trade in stock over option markets. This result has implications for isolating informed trading around actual news events.

Introduction

In cases of actual news releases of a takeover, there may be both informed and noise traders bidding for shares. However, these cases of fake news are interesting because they cause pure noise trading. So by watching the reaction of the market to fake news, we can assess the effect of noise trading, uncluttered by simultaneous effects of informed trading. In the recent past we've witnessed other tender offer hoaxes such as American Airlines, Rocky Mountain Chocolate, and Avon amongst others that were unsophisticated tender filings where investors recognized the hoax before the target of the hoax could make

Table 1: Timeline of the fake news announcement. Times are accurate to the minute.

11:36	Fake Bloomberg website appears online.
11:39	First known tweet by @openOutcrier.
11:40	Carl Quintanilla tweets about takeover.
11:44	First article posted that news is a possible hoax.
11:45	Bloomberg news spokesman says story is fake
11:51	Bloomberg news spokesman reiterated story is fake.

an announcement. The most recent case of Avon, as in prior hoaxes, trading was suspeneded during the information discovery. The Twitter hoax is vastly different in that information discovery and the medium for the hoax all reacted via Twitter! Therefore, a very clear record of events from the tender announcement till the hoax was avowed, and importantly trading was not suspended as in the case of Avon.

Series of events

At approximately 11:39 am on Tuesday July 14 2015 Twitter common stock jumped nearly 8 percent on news of a $31 billion bid for the company. The news was posted on the website http://bloomberg.market, which was made to look much like the Bloomberg News website (http://bloomberg.com). Within one minute Carl Quintanilla of CNBC and many others tweet on the takeover bid. Approximately five minutes after Quinanilla's tweet, Ty Trippet of Bloomberg News tweets that the bloomberg.market site is a hoax and the market reacts.

The domain bloomberg.market was registered the previous Friday (7/10/2015), and the identity of the registrant is unknown. The news release on bloomberg.market also made mistakes such as misspelling former Twitter CEO Richard Costolo's name. By late afternoon, the bloomberg.market site had been removed with the message "account suspended" being posted.

Literature Review

Equities or options? This long running question of where does price discovery occurs is hotly debate in the finance literature and the resulting studies tend to only contribute more questions than at inception.

Financial theory states that in a friction-less efficient market, price discovery will occur in equities and the option price is a subsequent function of the underlying asset that provides no information—that is the option is redundant. However, a great number of studies posit that there are rational well informed traders who may at times employ options to optimize wealth (Black and Scholes 1973; Black 1975; Amin and Lee 1997; Jayaraman, Frye, and Sabherwal 2001; Ni, Pan, and Poteshman 2008). These informed traders exist due to market inefficiencies and it is thought that their actions in either equity or derivative markets signal information on future price movements to the uninformed (Chakravarty, Gulen, and Mayhew 2004). When markets are incomplete informed traders may be motivated to bypass equity markets to trade in options due to financial leverage exposure and lower transaction cost *vis-a-vis* short-sale costs as well as long equity purchase (Black 1975; Easley, O'hara, and Srinivas 1998). If informed traders provide information on future price movements, then where do informed traders prefer to use their information? That is, where do informed traders trade? And correspondingly, where do uniformed traders respond to new information? To date, we are unaware of any prior studies that assess hoaxes to understand the trading methods of uninformed and informed traders.

The extant literature of informed and uninformed trades can be summarized into two streams; models of information based trading and empirical investigation of trades made by informed investors. The prior provide motivation and rational for informed trading in option markets, where options are non-redundant. The latter assess the process of price discovery or the information signaling of option volume relative to equity.

Models of information based trading

Models of information based trading are consistent in proposing that the venue of informed trading is subject to the depth and liquidity of option market as well as the underlying asset, such that thin or non-existent option markets motivate informed trading in stock (Glosten and Milgrom 1985; Biais and Hillion 1994; Easley, O'hara, and Srinivas 1998; John et al. 2003; Easley et al. 2008; Takayama 2013). An interesting point noted by Biais and Hillion (1994) is that option provides a greater number of trading strategies and the information content of option trades may seem enigmatic to the uniformed, naturally lending to noise. Biais and Hillion also note that the option may subsequently "reduce the informational efficiency of the market." Other issues of noise purposeful hindering information flow have been described in Kyle's (1985) model of insider trading as well as Collin-Dufresne and Fos (2012). Like Kyle, Collin-Dufresne and Fos posit that informed traders will prefer to trade when noise traders are more active to obscure their actions subsequently concealing their private information. Collin-Dufresne and Fos (2015) review trades made by 13D filers finding that these informed traders prefer to purchase during high volume sessions, thereby concealing their activities within noise. Similar findings trade concealment have also been noted in options markets (Anand and Chakravarty 2007). Berkman, Kock, and Westerholm (2014) report that informed investor will also trade through their children's accounts to conceal their activities. This evidence suggests that those with private information follows noise to stay private in equity markets as well as employ varying option strategies to create a subterfuge, these finding highlight some of the difficulty in separating noise from trades that may actually inform. These points also highlight the importance of identifying events where noise trading is unlikely to occur, such as in the case of the Twitter hoax.

Empirical research

The venue of price discovery is examined as a pointer of where informed traders choose trade, such that investors with superior information may prefer to invest in options or the underlying asset. This branch of the literature is plagued by the ambiguity of uniformed noise that has the potential to be spuriously interpreted as evidence of informed trading. The majority of empirical studies admittedly note that investors and market makers trade options for non-information based motivations (e.g. hedging, transaction costs, or liquidity), thus impacting net option volume (Pan and Poteshman 2006; Ni, Pan, and Poteshman 2008; Hu 2014).

Lead-lag information

A substantial amount of research has investigated the possibility of option volume as a leading indicator of equity price vector. Technological and data improvements have evolved this area of study from daily close data to intraday measurements. In the interest of brevity, we focus on the contemporary. The majority of these studies center on scheduled events such as earnings announcements, few others explore trades preceding mergers and acquisitions (unscheduled).

Investigating the relationship between the change in price as well as volume of equities and options, Stephan and Whaley (1990) note that stock price tends to lead the options market by as much as fifteen minutes and stock volume leads by approximately the same amount. Chan, Chang, and Johnson (1993) explore the findings of Stephan and Whaley reporting that the stock market lead disappears when the mid-point spread of bid/ask are used in-place of transaction values, noting that "their results can be explained as spurious leads induced by infrequent trading of options." Chan, Chang, and Johnson conclude that neither leads. Amin and Lee (1997) note that option buy/sell activity foreshadows subsequent news. Option trading signals earning news with faster more informed trading. Perhaps explaining some of the conflicting results, Chakravarty, Gulen, and Mayhew (2004) find evidence of price discovery in both equities and options. They report that 17 percent of price discovery takes place in option markets and out-of-the-money options convey slightly more information than at-the-money. With regard to the size of the trade, Lee and Yi (2001) note the small informed traders tend to act in option markets whereas large traders will trade equities. As entering (exiting) a large equity position may require a considerable amount of time to prevent price run up (down), a short-lived event would create exposure to any position that would take time to back out from.

Ni, Pan, and Poteshman (2008) explore the volume of options prior to earnings announcements relative to future stock volatility. Their analysis reveals that the net demand for option volatility of non-market makers is positively related to future volatility of the underlying asset. It is their interpretation that informed investors trade on volatility information in option markets. This report is analogous to prior studies that link the volatility implied by option price to future volatility of the underlying asset, though this study extending the private information content of the implied volatility (Christensen and Prabhala 1998; Ederington and Guan 2002; Busch, Christensen, and Nielsen 2011). Testing takeover announcements, Cao, Chen, and Griffen (2005) find the option volume is an indicator of future equity return. If there are a sizeable amount of informed parties prior to the Twitter hoax, we should expect to observe an increase in implied volatility prior to a stock price increase. Jayaraman, Frye, and Sabherwal (2001) and Chesney, Crameri, and Mancini (Chesney, Crameri, and Mancini 2014) both note that option volume increases prior to known M&A activity. Therefore if the Twitter hoax is known prior to the event, then we should expect to see an increase in option volume and price. However, if informed investors are very few or there are none trading on the information, then we expect to see no abnormal action in the option market for Twitter stock prior to the event.

1 Data

Our data set consists of TWTR stock and options prices sampled at 30 second intervals over the July 14 2015 trading day. For each interval we have open, high, low, close, volume, and the volume-weighted average price. The options in the data set are both calls and puts for the following 2015 expiration dates: July 17; July 24; July 31; August 7. Our set contains option prices for each strike price ranging from 33 to 41.5 at 0.50 intervals.

For each option, we first remove any 30 second interval in which there was no trading in the option. This removed a large proportion of intervals for the options which had a greater tenor and were further away from the at-the-money option.

For each option we then merge the volume-weighted average option prices for the intervals with trades with the corresponding volume-weighted average price of TWTR stock in that interval. Then for each interval (and each option) we calculated the option's implied volatility using the function impliedVolatility() for the implied volatility of an American option assuming an underlying geometric Brownian motion process, in the QuantLib C++ quantitative finance library.

At this point, for each expiration date we have time series of implied volatility for each stock price (and for both calls and puts). This is 36 implied volatility time series for each expiration, and 144 series over all expiration dates. Of course, some time series have more data points than others.

Then given an expiration date and option type (call or put), we take the average implied volatility over each 30 second interval across those options which had trading in that interval. This gives us, for each expiration date, a time series of call and put option implied volatilities. This is a total of 8 time series of option implied volatilities over July 14 (sampled at 30 second intervals).

2 Methods and Results

We must be careful if averaging option prices or implied volatilities across strike prices. Every option series has 30 second intervals in which there was no trading in the option. Therefore if averaging across options, and one option does not have trading in that interval, we have two choices. First, we could leave the option without trading in that interval out of the average. However, since prices and even implied volatilities (due to the well-known implied volatility smile) are different across strikes, this would cause a change in the time series, which would bias in favor of a changepoint in that interval.

Alternatively, we could drop any 30 second interval in which there was no trading *in any* of the options in our average. However, this would increase the number of dropped intervals in our time series, further complicating the changepoint analysis.

Ultimately, we prefer to average over a set of individual options with the fewest intervals with no trading, and conduct the changepoint analysis on this series. This created a bias in favor of changepoints in the implied volatility analysis. For robustness, we will also estimate changepoints in option series where we use the EM algorithm to fit option prices and volatilities to gaps in trading.

The July 17 call options had the most volume throughout the fake news event. Among the July 17 calls, the 36, 36.5, 37, 37.5, and 38 strike prices were the most active. We therefore averaged implied volatility across these options.

A time-series chart of the implied volatility series and TWTR stock price is in the figure below. We have also put an interactive Javascript chart with TWTR stock price, as well as implied volatility averages for all options by maturity and type, online here (requires a modern browser such as Google Chrome with Javascript enabled): Interactive Chart

Table 2: Changepoints in the Realized Volatility series. Realized volatility is calculated as the square of TWTR's log returns over each 30 second interval. The realized volatility is then annualized. The implied volatility is annualized. The table contains the beginning of the 30 second interval at which the changepoint took place, as well as the volatility level at that changepoint in parentheses following the time.

	Realized Volatility		
Changepoint	Mean	Variance	Mean/Variance
1	11:37:30 (51.76%)	9:56:30 (80.41%)	9:56:30 (80.41%)
2	11:39:00 (108.98%)	11:37:30 (51.76%)	11:37:30 (51.76%)
3	11:49:00 (187.87%)	11:39:00 (108.98%)	11:49:00 (187.86%)
4	12:16:00 (66.95%)	12:00:00 (126.89%)	12:00:00 (126.89%)
5		12:12:30 (62.01%)	12:16:00 (66.95%)

2.1 Changepoint Analysis

We can model volatility over July 14 as:

$$V_t = \mu_t + e_t, \quad e_t \sim N(0, \sigma_t^2) \tag{1}$$

where V_t is a particular measure of volatility (realized or implied). Under the null hypothesis we have $\mu_0 = \mu_t, \sigma_0^2 = \sigma_t^2, \forall t$. We can then test alternative hypotheses of shifts in both components of the parameter vector $(\mu, \sigma^2)'$ or shifts in individual components.

We'll first tests for shifts in parameters using the Bin Segmentation method of Scott and Knott (1974) with an MBIC penalty (Zhang and Siegmund 2007). To do so we make use of the `changepoint` (2014) R package. The results are robust to the use of alternative segmentation methods, such as Segmented Neighborhoods (Auger and Lawrence 1989). Note, all segmentation methods used allow for the estimation of multiple unknown changepoints.

Comparing changepoints in the mean only, we see four changepoints for the realized volatility series, and no changepoints for the implied volatility series. Interestingly, at 11:39:30 the implied volatility dropped to 30.93%, which is the lowest implied volatility of the day. This is due to the stock price dramatically increasing on the fake news, and the option price reacting with a delay. This initial spike downward, likely offset some of the subsequent increase in implied volatility, driving the lack of a changepoint in the implied volatility

Table 3: Changepoints in the Implied Volatility series. Implied volatility was calculated as an average of the implied volatilities for the July 17 calls with 36, 36.5, 37, 37.5, and 38 strike prices. The implied volatilities were calculated with the QuantLib function impliedVolatility() for the implied volatility of an American Option on a stock following a geometric Brownian motion price process. The implied volatility is annualized. The table contains the beginning of the 30 second interval at which the changepoint took place, as well as the volatility level at that changepoint in parentheses following the time.

	Implied Volatility		
Changepoint	Mean	Variance	Mean/Variance
1		10:25:00 (42.14%)	10:14:00 (42.27%)
2		11:39:00 (42.53%)	11:39:00 (42.53%)
3		11:43:30 (54.25%)	11:51:00 (52.94%)
4		11:49:00 (56.10%)	12:04:30 (46.65%)
5		12:02:30 (47.09%)	14:16:00 (46.40%)

mean.

[Place Figures About Here: Presently Placed After the References]

Regarding the 4 mean changepoints in the realized volatility series, the first changepoint was an increase in volatility to 51.76% at 11:37:30. This is about one and a half minutes after the fake Bloomberg website containing the hoax takeover story appeared on the web, and a full minute and a half before the first known tweet about the fake news. The second changepoint occurred 11:39:00 when volatility increased to an average of 108.98%. This is contemporaneous with the first tweet on the news by @openOutcrier. The last changepoint increase took place at 11:49:00 to 187.87%. This volatility is due to the large negative returns that occurred after the 11:45 Bloomberg News announcement that the story was fake.

The results of tests for a change in the variance, and both mean and variance, of the two volatility series paints a similar picture. The stock price reacts to the news more quickly than option prices. This is evidence that price discovery around the fake news announcement occurred in the stock market. Moreover, because the increase in the stock price preceded the first tweet, this may be considered evidence that those informed about the fake news chose to make use of their knowledge in the stock rather than option market.

3 Conclusion

This study documents the trading activities of investors during the faked news of a tender offer for Twitter. This setting of fake news offeres a unique opportunity to examine trading based purely on noise, whereas prior studies suffer from the simultaneous effects of informed and uninformed trading taking place. The Twitter hoax is special in that information discovery and the hoax were all announced on Twitter, providing a very clear record of events. And unlike prior hoaxes such as Avon, trading was not suspended. To our knowledge we are the first to study such an event free of confounding trades.

Employing price data on the stock and options for TWTR, we identify that noise traders first responded by trading in equities that brought about a decline in the implied volatility. We also observe that there is a delayed reaction in the option price. Overall, we find that the stock price reacts to the news faster than option prices. This is evidence that price discovery around the fake news announcement occurred in the stock market. Moreover, because the increase in the stock price preceded the first tweet, this may be considered evidence that those informed about the fake news chose to make use of their knowledge in the stock rather than option market. This observation is consistent with Stephan and Whaley (1990) who report that stock price leads options and Chakravarty, Gulen, and Mayhew (2004) find evidence of price discovery in equities. Our findings suggest that noise traders first choose to participate in equities over options. We find no evidence of implied volatility or option price preceding equity.

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List of Figures

Figure 1: July 17 Call Implied Volatility and TWTR Stock price.

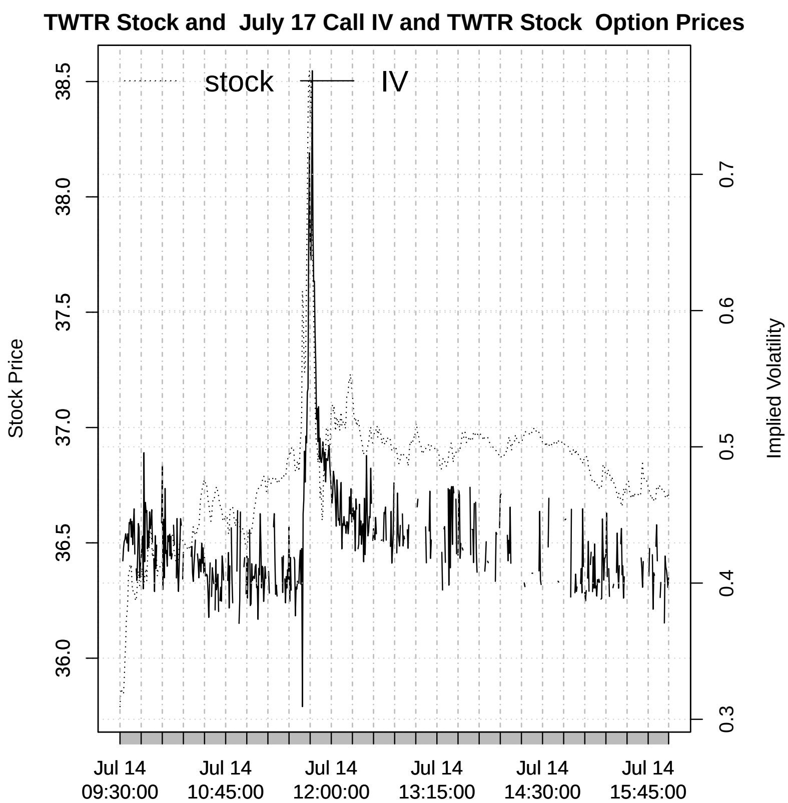

Figure 2: Realized volatility series with changes allowed in the mean only.

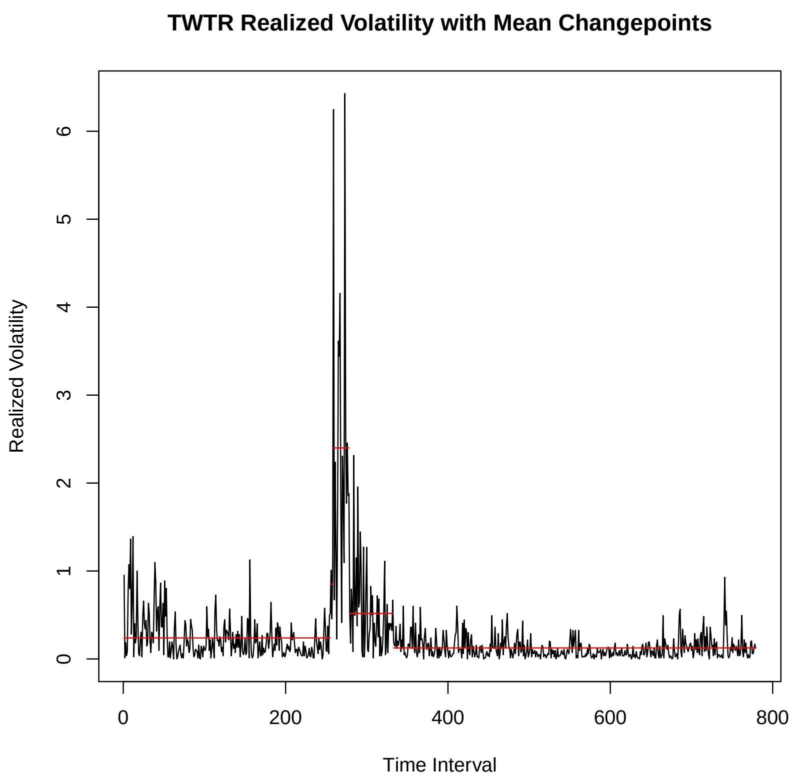

Figure 3: Realized volatility series with changes allowed in the variance only.

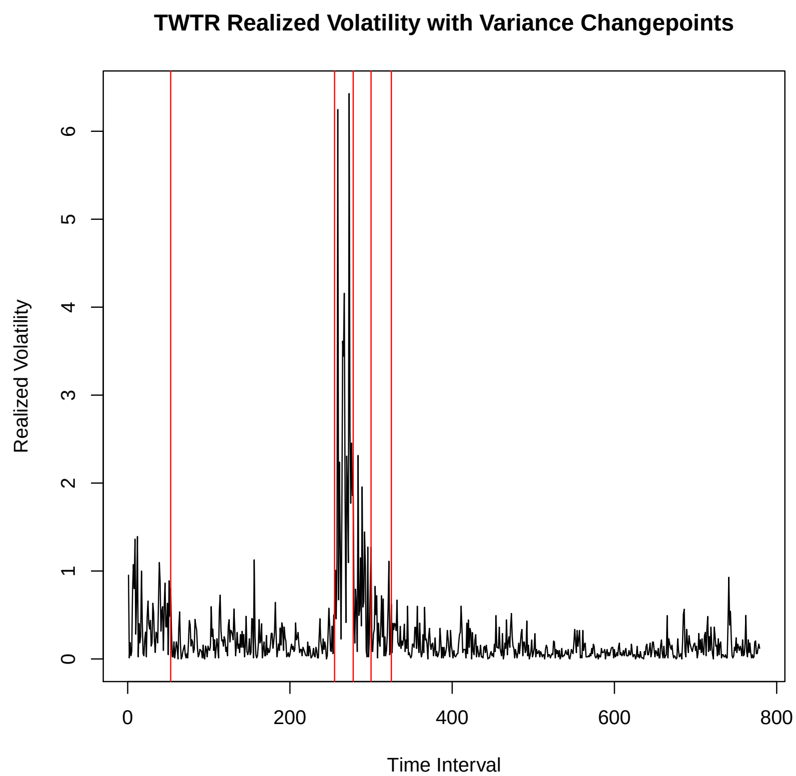

Figure 4: Realized volatility series with changes allowed in both the mean and variance.

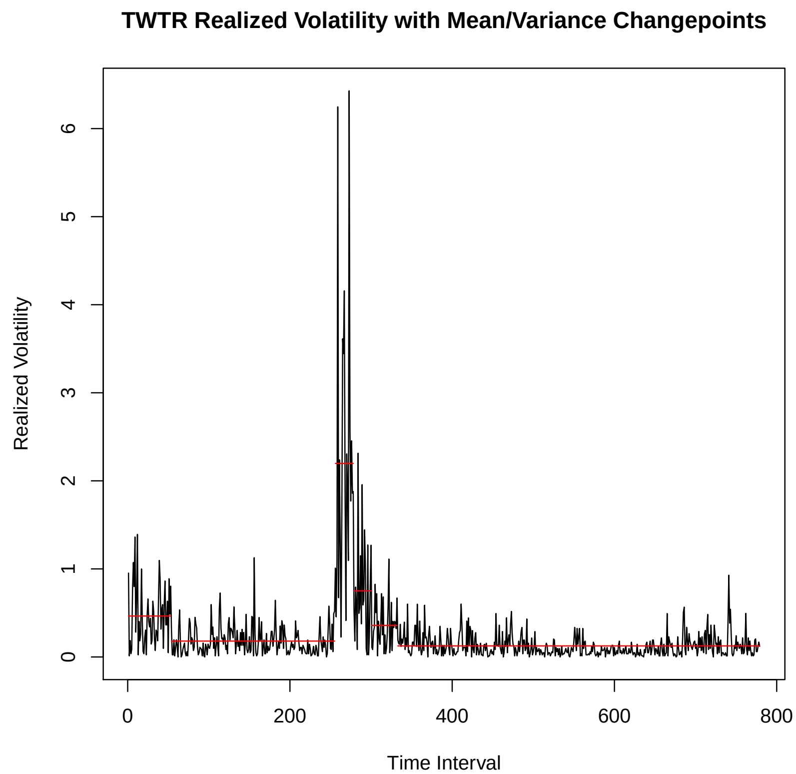

Figure 5: Implied volatility series with changes allowed in the mean only.

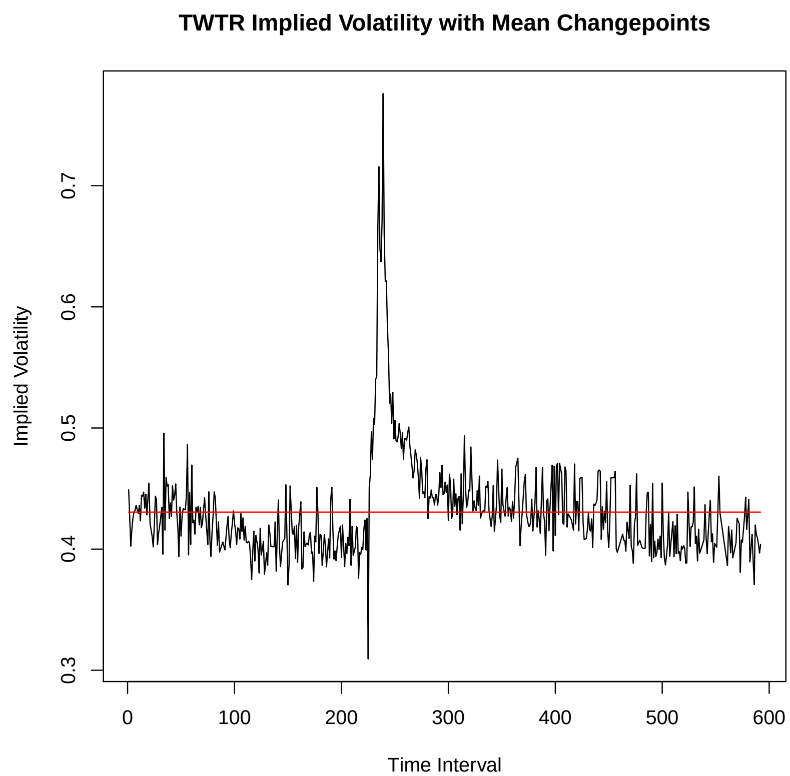

Figure 6: Implied volatility series with changes allowed in the variance only.

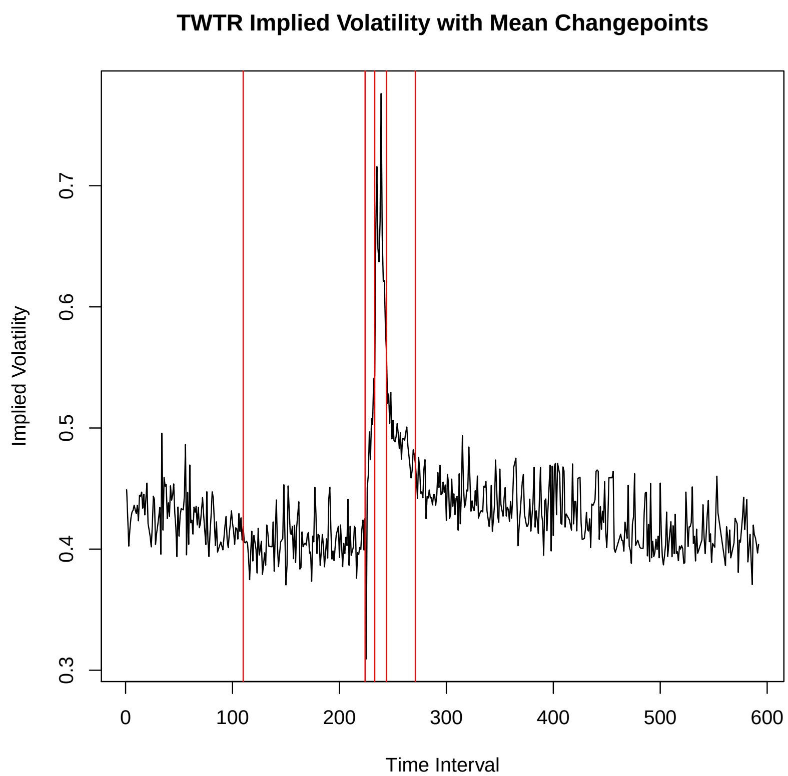

Figure 7: Implied volatility series with changes allowed in both the mean and variance.