# GROWING PRESENCE OF REAL OPTIONS IN GLOBAL FINANCIAL MARKETS

# RESEARCH IN FINANCE

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# GROWING PRESENCE OF REAL OPTIONS IN GLOBAL FINANCIAL MARKETS

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# CONTENTS

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# INTRODUCTION

The volume starts at the base of equity valuation with an examination of the strategic expectations underlying the merger of AT&T with DirecTV. Then for comparison we get an upgrade of the traditional dividend valuation approach to equity pricing. Next we get an examination of the relationships between dividend payment patterns and firm characteristics. Then we extend the equity valuation discussion to an empirical assessment of the reality underlying the pecking order theory.

Next we get some advances in the uses of beta and cross-sectional stock returns. Then follows a cross-sectional analysis of average returns and volatility with focus on the effects of size, value, and momentum risk. Then we get an opportunity to broaden the analysis of strategy with a look at models for valuing options to choose among the most profitable of several realities in the physical realm and the information realm.

Subsequent chapters take us into the wilderness of financial distress in emerging markets around the world, with evidence from the Asian-Pacific markets. Since much of this distress arises within the banking sector, we next have an examination of the impact of maturity structure in the private placement of debt.

Finally, we have an extension of a work that appeared in the previous volume (Vol. 32) concerning bank stability in emerging countries. For this new contribution, the author (Dr. Keffala) has substantially extended his earlier work with expanded samples across a wider time spectrum and a greatly enriched sample of emerging countries. In this volume, Dr. Keffala's chapter focuses specifically on banks' use of derivatives, finding strengthened evidence that proper use of derivatives can greatly enhance bank stability.

John W. Kensinger
*Editor*

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# EVALUATING CONDITIONS AND TERMS OF THE AT&T AND DirecTV MERGER

K. C. Chen, Hideharu Funahashi and Nicole Warmerdam

## ABSTRACT

*On May 18, 2014, AT&T Inc., the second-biggest U.S. mobile-phone carrier, agreed to acquire DirecTV, a satellite-television company, for $49 billion in cash and stock. However, the merger's conditions and terms are complicated as the stock exchange ratio is contingent on the volume-weighted average AT&T stock price over a 30-day period that is three trading days prior to the date when the merger becomes effective.*

*Using a contingent claims pricing approach, we model DirecTV's theoretical value based on the merger's conditions and terms. It is shown that the theoretical DirecTV stock value is analogous to the sum of the present value of a cash offer, plus owning shares of the AT&T stock, and short volume-weighted average price (VWAP) call spreads. Using three different option-pricing models, DirecTV's stock valuation model is tested with the market data. Empirical results show that on average, DirecTV's stock was consistently priced at a discount during the sample period, and Funahashi and Kijima's (2017) VWAP option model works better than Black and Scholes'*

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*(1973) plain vanilla option model and Levy's (1992) average-price option model.*

**Keywords:** Mergers; acquisitions; telecommunications; contingent claims; real options

## INTRODUCTION

During the past two decades, the telecommunications industry has been rapidly evolving and growing due to influxes in technologies that allow for faster network speeds and more product offerings. A myriad of mergers and attempted mergers between prominent companies within the industry have emerged because of this growth. For instance, News Corp. acquired 34% ownership of DirecTV in 2003. In 2005 and 2007, AT&T merged with SBC Global and BellSouth Corp., respectively. AT&T subsequently pursued to merge with T-Mobile in 2011, but the attempted merger failed due to opposition from the Federal Communications Commission (FCC). Later in 2014, Comcast and Time Warner Cable (TWC) intended to merge, but opposition from the FCC again dissolved the potential combination.

Despite multiple failed attempts, on May 18, 2014, AT&T Inc., the second-biggest U.S. mobile-phone carrier, announced its intent to acquire DirecTV, a satellite-television company, for $49 billion. At the time of announcement, DirecTV had a market value of $45 billion after its shares rose 43% in the past year. Speculation about an AT&T-DirecTV combination was not new. In 2010, AT&T had already considered such a deal to be "industrial logic," but it worried that regulators might not allow the transaction. The talks with DirecTV emerged quickly after AT&T was restricted from buying Vodafone Group Plc, Europe's largest mobile carrier, due to the opposition of U.K. regulators. In the meantime, Comcast Corp.'s failed intent to acquire Time Warner Cable Inc. to create an even bigger provider of both TV and Internet in the United States had accelerated the drive for consolidation in the rest of the industry. As AT&T currently faced increased uncertainty in both wireline and wireless businesses, the acquisition of DirecTV could not come at a better time, which would provide AT&T with earnings growth and additional spending flexibility.

However, the conditions and terms of the AT&T and DirecTV merger are complicated. First, each DirecTV share will be converted into a number of AT&T shares, equal to a pre-determined exchange ratio plus $28.50 in cash at the close of the deal. The exchange ratio varies between 1.724 and 1.905 shares of AT&T. Second, the exchange ratio is contingent on the volume-weighted average AT&T share price over 30 consecutive trading days ending on

(and including) the trading day that is 3 trading days prior to the date of the effective time of the merger.

On July 24, 2015, the FCC approved AT&T's acquisition of DirecTV. At the closing of the merger, the 30-day volume-weighted average AT&T stock price was $35.14, so each outstanding share of DirecTV common stock was converted into the right to receive 1.892 shares of AT&T common stock plus $28.50 in cash. In aggregate, AT&T issued 954,541,877 shares of AT&T common stock to former holders of DirecTV common stock worth approximately $32.7 billion and $14.4 billion in cash. The combined entity will have around 26 million TV subscribers, making it the largest pay TV company in the country. The FCC approved the merger with conditions to alleviate some concerns, including the expansion of AT&T's high-speed Internet program such as providing affordable Internet options and giving subscribers the option to access rival video services online.

The purpose of this chapter is twofold. First, we intend to use a contingent claims pricing approach to model DirecTV's theoretical stock value based on the conditions and terms of the merger. Second, we will apply the DirecTV stock valuation model with the market data to determine whether DirecTV's stock price was fairly priced prior to the approval of the FCC. Another motivation is rooted in the recent popularity and use of volume-weighted average price (VWAP) in merger and security designs. For example, Signet Jewelers recently issued $625 million convertible preferred shares that would be convertible into Signet common shares at a premium of 18% to the VWAP of the common shares for the 20 trading days immediately following Signet's second quarter earnings announcement on August 25, 2016.

The remainder of the chapter is organized as follows. The next section describes recent merger and acquisition (M&A) activities of AT&T, DirecTV, and the telecom industry, respectively. The section that follows presents the modeling of the AT&T and DirecTV merger. The empirical test results on the DirecTV stock valuation model are presented in the next section along with explanations why DirecTV's stock was priced at a discount during the sample period. A brief summary is provided in the last section.

## RECENT M&A ACTIVITIES OF AT&T, DirecTV, AND INDUSTRY

### *AT&T's Recent M&A Activities*

During the 1990s, AT&T witnessed its most major influx of M&A activity. The company first acquired TCG, a provider of local telephone service to businesses, and IBM Global, a provider of global data networking services. AT&T subsequently acquired TCI and MediaOne, two leading cable companies.

The above acquisitions allowed AT&T to grow its service offerings into four business units: cable, wireless, business, and consumer. In October 2000, AT&T announced to further restructure its services into three separate publicly held companies, namely, AT&T, AT&T Wireless, and AT&T Broadband. Soon after, AT&T span off AT&T Broadband and simultaneously merged it with Comcast, forming a new company to be called AT&T Comcast Corporation, which was later renamed as Comcast Corporation. In 2004, AT&T Wireless was bought by Cingular Wireless for $41 billion. The two regional Bell companies that owned Cingular, SBC Communications Inc. and BellSouth Corp., would have nearly 30% of the nation's cellphone customers, overtaking longtime market leader Verizon Wireless.

After restructuring, AT&T became a global Internet Protocol networking provider, rather than focusing on customer-oriented telephone service, as it had in the past. AT&T further differentiated itself by introducing its voice over Internet Protocol to both consumers and small businesses, which strengthened AT&T's presence in the marketplace. Later in 2005, AT&T merged with SBC Communications and in 2007, AT&T acquired BellSouth Corp. for $66 billion.

In March 2011, AT&T announced its proposal to acquire T-Mobile USA from Deutsche Telekom through a $39 billion cash-and-stock transaction. This acquisition was deemed accretive, as it would improve network quality and bring advanced LTE capabilities to AT&T's 294 million customers. However, the opposition from the Obama administration and FCC eventually led to AT&T's ultimate withdrawal of the failed merger attempt, which cost AT&T $3 billion cash in breakup fees and $1 billion worth of spectrum rights to T-Mobil (Wyatt & Chen, 2011).

### *DirecTV's Recent M&A Activities*

In 1985, Hughes Electronics Corporation, a fully owned subsidiary of General Motors, was the largest satellite company in the world and wanted to tap into the direct broadcast satellite (DBS) services market. With the development of digital compression technology, Hughes formed DirecTV with $750 million funding in 1990. DirecTV then established alliances with companies such as Sony Corporation, Digital Equipment Corporation, and Thomson Consumer Electronics and secured programming agreements with various networks.

DirecTV launched its first satellite in December 1993 that was capable of transmitting up to eight times as many video signals and was five times stronger than traditional satellites. The company launched two more satellites in August 1994 and mid-1995, increasing its basic service offerings four times to that of the size of cable. In order to fuel its growth, DirecTV partnered with AT&T in 1996, giving AT&T a 2.5% stake for $137.5 million.

As DirecTV entered into the late 1990s, their processes still remained unprofitable. In order to continue growing its subscriber base while cable was still vulnerable in implementing DBS service's coveted digital compression technology, DirecTV acquired both United States Satellite Broadcasting and its largest competitor PrimeStar in 1999. Beginning in 2000, General Motors decided to auction off its ownership in DirecTV. Rupert Murdoch, who owned and operated News Corp., was specifically interested in the company because he had been trying to enter the U.S. DBS market since 1983. Soon after, EchoStar Communications Corp. proposed a $6.26 billion acquisition of DirecTV, but the U.S. Justice Department ruled the acquisition to be anti-competitive in December 2002. News Corp. took this opportunity to acquire a 34% controlling interest in DirecTV in April 2003. DirecTV subsequently acquired Pegasus Communications and the National Rural Telecommunications Cooperative, gaining 1.4 million new subscribers.

### *Industry's Recent M&A Activities*

On September 2, 2013, Verizon Communications announced its intent to acquire Vodafone's 45% stake in Verizon Wireless for $130 billion, which was completed on February 21, 2014, giving Verizon Communications full control of the most profitable U.S. mobile-phone carrier. Verizon Communications was created in 2000 when Bell Atlantic Mobile and GTE Wireless merged. Verizon then struck a deal with Vodafone to create a wireless network, where Verizon invested $49.5 billion for a 55% stake and Vodafone invested $40.5 billion for a 45% ownership.

In November 2013, while in the wake of Verizon's agreement to buy Vodafone's 45% stake in Verizon Wireless, AT&T was mulling a possible take-over bid for what was left of Vodafone after the Verizon Wireless deal. AT&T could pay about $124 billion for Vodafone, but AT&T gave up its plan in January 2014.

On February 13, 2014, Comcast announced its intent to merge with TWC in a $45.2 billion stock-for-stock transaction. The two companies argued that the merger would increase their overall scale, allowing the combined company to become more competitive, improve customer service quality, and fasten innovation. The companies also planned to divest subscribers to Charter Communications to regulate the market share of their combined operation, which would enhance competition in the U.S. cable television and Internet markets.

The attempted Comcast/Time Warner mega-merger raised a myriad of red flags for federal regulators from the beginning. One criticism was that the merger would create a conglomerate controlling 57% of the national broadband market and around 30% of pay television service (Steel, 2015). Citing

the reduction of competition in the broadband and cable industries that would result from the merger, the Department of Justice planned to file an antitrust lawsuit against Comcast and TWC in an effort to block it. On April 24, 2015, Comcast announced that it would withdraw its proposal to acquire TWC. Comcast lost more than $400 million in expenses during its failed acquisition of TWC, and TWC also reported more than $200 million in merger-related costs.

On May 26, 2015, Charter Communications announced its intent to merge with TWC and acquire Bright House Networks in a complex cash and shares transaction that would value TWC at $78.7 billion, or $195.71 a share. The three-way cable marriage, which was completed on May 18, 2016, makes Charter the nation's second-largest cable operator behind Comcast, with about 17 million video subscribers and about 19 million broadband subscribers (Littleton, 2016). Before this deal, Charter had made overtures for TWC on several occasions. Its latest came in January 2014 when Charter offered $132.50 a share to merge with TWC, but TWC rebuffed the offer to go with Comcast one month later in a failed merger attempt.

## VALUATION OF THE AT&T AND DirecTV MERGER

Specifically, AT&T and DirectTV came to the agreement that AT&T would acquire DirecTV for $95 a share. This price consisted of $28.50 a share in cash with the remaining $66.50 a share supported by AT&T stock. However, this $66.50 of stock could only be attained in the case that AT&T shares were trading between $34.90 and $38.58 during the period of time in which the deal closed. If the shares were trading outside of this designated range at the time of deal closure, two separate exchange ratios would be applied. If AT&T shares were trading above the $38.58 upper bound, the exchange ratio would be 1.724, whereas if they were trading below the $34.90 lower bound, the exchange ratio would be 1.905.

Based on the aforementioned conditions and terms, the payoff to DirectTV at maturity can be expressed as follows:

$$V_T = C + O_T \tag{1}$$

$$O_T = \begin{cases} 1.724\, S_T^* & \text{if } S_T^* > 38.577; \\ 66.5 & \text{if } 34.903 \le S_T^* \le 38.577; \\ 1.905\, S_T^* & \text{if } S_T^* < 34.903 \end{cases} \tag{2}$$

where $V_T$ is the payoff to DirectTV at maturity $T$; $C$ is the cash offer; $O_T$ is the payoff of the option component at maturity $T$; and $S_T^*$ is the 30-day

volume-weighted average AT&T stock price for 3 trading days prior to the maturity date $T$.

To generalize the above model, let us define $X_1 = 34.903$, $X_2 = 38.577$, $f_1 = 1.724$, and $f_2 = 1.905$. Substituting the above expressions into Eq. (2) yields:

$$O_T = \begin{cases} f_1 S_T^* & \text{if } S_T^* > X_2; \\ f_2 X_1 & \text{if } X_1 \le S_T^* \le X_2; \\ f_2 S_T^* & \text{if } S_T^* < X_1. \end{cases} \tag{3}$$

Algebraically, $f_1 S_T^* = f_1(S_T^* - X_2) + f_1 X_2 = f_1(S_T^* - X_2) + f_2 X_1$ because $f_1 X_2 = f_2 X_1 = \$66.50$.

Eq. (3) can then be rewritten as:

$$O_T = \begin{cases} f_1(S_T^* - X_2) + f_2 X_1 & \text{if } S_T^* > X_2; \\ f_2 X_1 & \text{if } X_1 \le S_T^* \le X_2; \\ f_2 S_T^* & \text{if } S_T^* < X_1. \end{cases} \tag{4}$$

Factoring out $f_2$ from Eq. (4), we get:

$$O_T = f_2 \times \begin{cases} F(S_T^* - X_2) + X_1 & \text{if } S_T^* > X_2; \\ X_1 & \text{if } X_1 \le S_T^* \le X_2; \\ S_T^* & \text{if } S_T^* < X_1 \end{cases} \tag{5}$$

where $F = \frac{f_1}{f_2}$.

The payoff to DirecTV at maturity can be further rearranged as follows:

$$V_T = C + f_2 \times \{S_T^* - [\text{Max}(0, S_T^* - X_1) - F \times \text{Max}(0, S_T^* - X_2)]\} \tag{6}$$

wherein the components in braces represent a long position in AT&T common stock and a short position in a VWAP call spread. This maturity payoff depicted earlier that depends on various closing stock price ranges at expiry is not new in the literature. For example, Chen, Chen, and Howell (1999) study dividend-enhanced convertible stocks (DECS), or redeemable convertible preferred stocks by design, issued by Masco Tech Inc. in 1993.[1] They find that the maturity payoff for DECS is analogous to holding a long position in Masco Tech common stock and a short position in a bull call spread, which is very similar to the expressions in Eq. (6) with braces.

The theoretical payoff for DirecTV is presented in Table 1. Column (5) shows the payoff for shorting $f_2$ shares of a call spread, that is, $-f_2\{[\text{Max}(0, S_T^* - X_1) - F \times \text{Max}(0, S_T^* - X_2)]\}$. Column (6) presents the payoff for long $f_2$ shares of AT&T common stock and short $f_2$ shares of a call spread plus the cash offer. As shown, the payoff in column (6) is identical to the expression in Eq. (5) plus the

***Table 1.*** Maturity Payoff for DirecTV.

| (1) Stock Price | (2) Long $f_2$ Shares of Stock | (3) Long Call $O(X_1)$ | (4) Short $F$ Calls $O(X_2)$ | (5) Short $f_2$ Call Spreads $= -f_2[(3) + (4)]$ | (6) Payoff for DirecTV $V_T = C + (2) + (5)$ |
|---|---|---|---|---|---|
| $S_T^* > X_2$ | $f_2 S_T^*$ | $(S_T^* - X_1)$ | $-F(S_T^* - X_2)$ | $-f_2[(S_T^* - X_1) - F(S_T^* - X_2)]$ | $C + f_2[X_1 + F(S_T^* - X_2)]$ |
| $X_1 \le S_T^* \le X_2$ | $f_2 S_T^*$ | $(S_T^* - X_1)$ | 0 | $-f_2(S_T^* - X_1)$ | $C + f_2 X_1$ |
| $S_T^* < X_1$ | $f_2 S_T^*$ | 0 | 0 | 0 | $C + f_2 S_T^*$ |

$V_T$ = maturity payoff for DirecTV;
$X_1$ = exercise price of \$34.903;
$X_2$ = exercise price of \$38.577;
$f_1 = 1.724$;
$f_2 = 1.905$;
$O(\cdot)$ = call option;
$C$ = cash offer = \$28.50; and
$F = \dfrac{f_1}{f_2} = 0.905$.

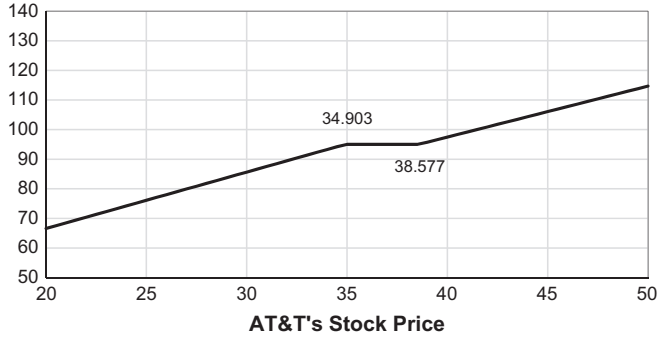


*Fig. 1.* DirecTV's Payoff at Maturity.

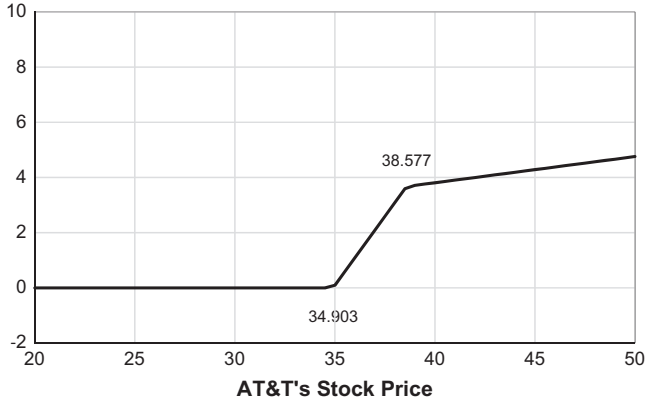


*Fig. 2.* Call Spread's Payoff at Maturity.

cash offer, C. Fig. 1 also depicts the maturity payoff for DirecTV's shareholder. As shown, DirecTV's payoff falls below \$95 monotonically as if owning the share of AT&T when its stock price closes below \$34.903 at maturity. In contrast, when AT&T's stock price closes above \$38.577 at maturity, DirecTV's payoff increases at a rate of \$1.724 per \$1 increase in AT&T's stock price. Fig. 2 plots the maturity payoff for a share of call spread expressed in the bracket of Eq. (6): $\left[\text{Max}\left(0, S_T^* - X_1\right) - F \times \text{Max}\left(0, S_T^* - X_2\right)\right]$. The call spread has a zero (positive) payoff when AT&T's stock price falls below (exceeds) \$34.903.

The present value of Eq. (6) represents DirecTV's theoretical stock value, which can be written as follows:

$$V = C\text{e}^{-kT} + f_2 \times \{S^* - [\text{VWAP}(X_1) - f \times \text{VWAP}(X_2)]\} \tag{7}$$

where $V$ is the current DirecTV stock price value; $C$ is the cash offer; $k$ is the DirecTV shareholder's required return or cost of equity; $T$ is the maturity date when merger becomes effective; $S^* = E[e^{-rT} S_T^*]$, where $E[\cdot]$ is an expectation operator;[2] $r$ is the risk-free rate; and VWAP$(\cdot)$ is the volume-weighted average price call option with exercise price equal to $X_1$ and $X_2$, respectively.

After the seminal option-pricing model of Black and Scholes (1973), many exotic options that are generally much more complex than plain vanilla options have started to merge. One of them is the average-price (AP) option, a form of Asian option whose payoff is linked to the average value of the underlying asset over a specified period. Several researchers, such as Kemna and Vorst (1990), Turnbull and Wakeman (1991), and Levy (1992), have examined the valuation of AP options. Levy's (1992) approach, using the Wilkinson approximation to derive a closed-form analytical approximation for the valuation of the arithmetic options, is popular in practice because it can be easily implemented. However, very few researchers have examined the valuation of VWAP options. Because the VWAP process assigns more weights to periods of high trading volume than to periods of low trading volume, there is no underlying asset with which to hedge the volume risk. As a result, the pricing of VWAP options has become inherently difficult. The technicality lies in the choice of model for trading volume. Stace (2007) proposes a mean-reverting process; Novikov, Ling, and Kordzakhia (2014) use a squared Ornstein−Uhlenbeck process; and Buryak and Guo (2014) suggest a gamma process, respectively, for the trading volume process. They all derive approximated closed-form pricing formulas by using the well-known moment-matching technique.

Recently, Funahashi and Kijima (2017) apply the chaos expansion technique to derive a unified approximation method for pricing VWAP options, which shows reasonably high accuracy of the second-order chaos expansion approximation for practical use. Compared to previous works, Funahashi and Kijima's (2017) method is applicable to the local volatility model, not just for the geometric Brownian motion case. In this chapter, we adopt the methodology of Funahashi and Kijima (2017) to value the VWAP options embedded in Eq. (7).

## APPLICATION OF THE DirecTV VALUATION MODEL

In this section, we apply DirecTV's valuation model derived in Eq. (7) with the market data to test the accuracy of the model. The AT&T-DirecTV merger was approved on July 24, 2015. The testing period covers slightly 14 months spanning from the first trading date after the merger announcement on May 19, 2014, to July 21, 2015, the last day of the 30-day volume-weighted averaging period. The sample period is further subdivided into two intervals to examine the stationarity of the sample statistics: the period prior to the 30-day volume-weighted averaging period and the 30-day volume-weighted averaging period. For comparison

purposes, in addition to testing Funahashi and Kijima's (2017) VWAP model, we also use Black and Scholes' (1973) plain vanilla model and Levy's (1992) AP model in the empirical tests.

As indicated in Eq. (7), DirecTV stock's intrinsic value is determined by several factors embedded in the option components: (1) AT&T's stock price, (2) the time to maturity, (3) the risk-free rate, (4) AT&T's trading volume, (5) the volatility of AT&T's stock price, (6) DirecTV's cost of equity, and (7) several parameters used in Funahashi and Kijima's (2017) VWAP model, which assumes that stock price follows the local volatility model and trading volume is formulated by a mean-reverting process. The parameters used by Funahashi and Kijima include gamma that is the volatility of AT&T's trading volume, theta that is the long-term average of the AT&T's trading volume, and rho that is the correlation between AT&T's stock price and trading volume. The estimation period for these input variables is the 100 trading days immediately prior to the announcement date.

Several aforementioned factors must be estimated. First, the risk-free rate is proxied by the annualized continuous-time yield to maturity of the treasury note/bill with a maturity date closest to the merger approval date. To estimate DirecTV's cost of equity, the Capital Asset Pricing Model (CAPM) is used: $k = r + \beta$ (market risk premium), where $r$ is proxied by the 10-year Treasury bond yield, 2.54%, as of May 19, 2014; the market risk premium of the United States is 5.4%, obtained from a forward-looking survey data from Fernandez, Linares, and Fernandez-Acin (2014); and $\beta$ is the beta of DirecTV. After the merger announcement, DirecTV's stock prices are expected to track closely with AT&T's prices based on the prescribed exchange ratios, and DirecTV's business risk will gradually mimic AT&T's. To estimate DirecTV's $\beta$, we first obtain AT&T's $\beta$, 0.75, from Value Line (May 2014), un-lever AT&T's $\beta$ following Koller, Goedhart, and Wessels (2016) based on AT&T's market-based debt/equity ratio on May 19, 2014, and re-lever the un-levered $\beta$ with DirecTV's market-based debt/equity ratio on the same date to get a $\beta$ of 0.59 for DirecTV. From the CAPM, DirecTV's cost of equity is estimated at 5.72%.

Finally, because the stock volatility cannot be directly observed, we have to estimate AT&T's stock volatility implied by its option prices observed in the market. Specifically, implied volatilities for call options with various maturities corresponding to the even dates were obtained from www.ivolatility.com. Because AT&T paid quarterly dividends, the ex-dividend protocol is applied when evaluating options.

Fig. 3 depicts DirecTV's theoretical values using Funahashi and Kijima's (2017) VWAP option model, Black and Scholes' (1973) plain vanilla option model, and Levy's (1992) AP option model during the sample period from May 19, 2014, to July 21, 2015. As shown, DirecTV's theoretical values using both Black & Scholes' plain vanilla option model and Levy's AP option model far exceed their counterparts using Funahashi and Kijima's VWAP option model during the first subperiod, but they are close to each other during the second

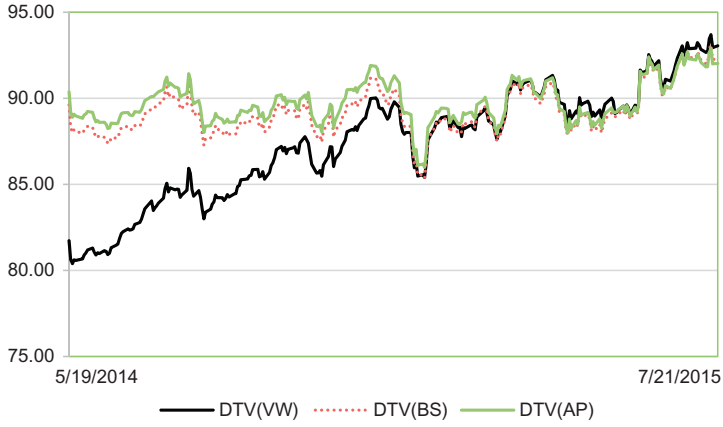


*Fig. 3.* Plots of DirecTV's Theoretical Values Using Funahashi and Kijima's VWAP Option Model, Black and Scholes' Option Model, and Levy's Option Model during May 19, 2014 to June 8, 2015.

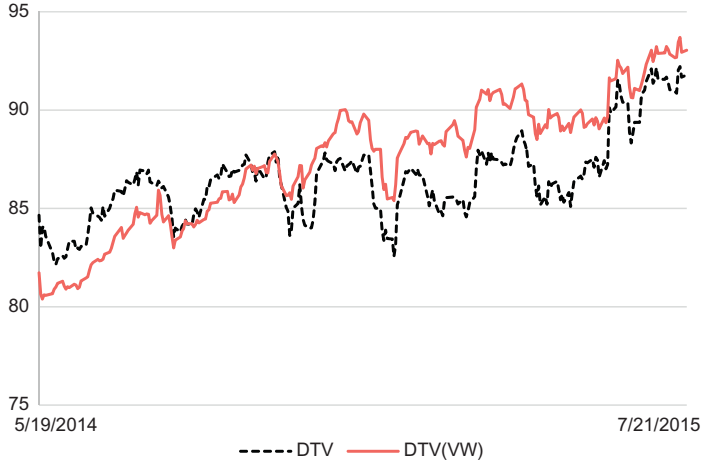


*Fig. 4.* Plots of DirecTV's Market Prices versus Theoretical Values Using Funahashi and Kijima's VWAP Option Model during May 19, 2014 to June 8, 2015.

subperiod. In Fig. 4 where DirecTV's market prices are plotted with its intrinsic values based on the VWAP option model, it is evident that DirecTV's market prices are slightly higher than their VWAP-based counterparts only in the first few months but are consistently lower than VWAP-based counterparts during

***Table 2.*** Statistical Results of Comparisons Between Market Prices and Theoretical Prices for DirecTV.

| | Panel A | | Panel B | | Panel C | |
|---|---|---|---|---|---|---|
| | 5/19/14 ~ 7/21/15 ($N = 296$) | | 5/19/14 ~ 6/8/15 ($N = 266$) | | 6/9/15 ~ 7/21/15 ($N = 30$) | |
| | Mean | SD[a] | Mean | SD[a] | Mean | SD[a] |
| 1. AT&T's market price | $34.49 | $0.96 | $34.42 | $0.97 | $35.13 | $0.53 |
| 2. AT&T's trading volume[b] | 25.10 | 11.34 | 24.50 | 11.40 | 30.44 | 9.43 |
| 3. AT&T's VWAP[c] | $34.49 | $0.95 | $34.42 | $0.96 | $35.14 | $0.54 |
| 4. DirecTV's market price | 87.13 | 2.86 | 86.47 | 2.17 | 92.98 | 0.70 |
| 5. Theoretical DirecTV price using the VWAP model | 87.86 | 3.85 | 87.15 | 3.39 | 94.15 | 0.59 |
| 6. Difference[d] (3 and 5) | −0.82%*** | 2.32% | −0.77%*** | 2.44% | −1.27%*** | 0.44% |
| 7. Theoretical DirecTV price using the B&S model | 89.44 | 1.98 | 88.97 | 1.45 | 93.60 | 0.75 |
| 8. Difference[d] (3 and 7) | −2.69%*** | 1.40% | −2.92%*** | 1.27% | −0.67%*** | 0.59% |
| 9. Theoretical DirecTV price using the AP model | 89.90 | 1.77 | 89.48 | 1.29 | 93.59 | 0.96 |
| 10. Difference[d] (3 and 9) | −3.23%*** | 1.69% | −3.52%*** | 1.51% | −0.66%*** | 0.63% |

[a]SD is standard deviation.
[b]In millions.
[c]Obtained from Bloomberg.
[d]Difference = (market price − theoretical price)/market price.
*** Significant at the .01 level.

the rest of the sample period, suggesting an underpricing phenomenon for DirecTV's market price.

Table 2 presents a comparison between market prices and theoretical values for DirecTV common stock using three option-pricing models. To allow comparisons of prices across various dollar levels, statistics are computed on a percentage, rather than absolute, basis. Table 2 first shows that AT&T's average daily market price and average daily trading volume are lower in the first subperiod than in the second subperiod ($34.42 vs. $35.13 and 24.50 million shares vs. 30.44 million shares). Surprisingly, AT&T's average daily VWAP and average daily market price are almost identical during the whole sample period, with only a $0.01 discrepancy in the second subperiod. Furthermore, rows 6, 8, and 10 in Table 2 show that the mean pricing errors are negative and statistically significant at the 1% level for all three pricing models during the whole sample period, indicating that the DirecTV stock price is undervalued by 0.82%, 2.69%, and 3.23% according to the VWAP model, the Black and Scholes (B&S) model, and the AP model, respectively. It is evident that the VWAP model is far more accurate than both the B&S model and the AP model

with a much smaller mean pricing error, especially during the first subperiod as shown in Panel B. However, in the second subperiod or the 30-day volume-weighted averaging period, the mean pricing error for the VWAP model is −1.67%, which is slightly bigger than its B&S and AP counterparts, −0.67% and −0.66%, respectively. We cannot jump to a conclusion that the VWAP model is inferior to the other two models. Given that AT&T's 30-day VWAP is around $35.14, DirecTV's stock price should trade close to $95 based on the merger's conditions and terms, but the mean DirecTV price is only $92.98 during the 30-day period. As evidenced in Panel C, Table 2, the mean VWAP model price of $94.15 is much closer to the $95 intrinsic value than is the mean B&S model price of $93.60 and the mean AP model price of $93.59, respectively.

Overall, the results presented in Table 2 unequivocally indicate the underpricing of DirecTV's stock price during the sample period. This underpricing could be attributed to several uncertainties that surrounded the market prior to the final regulatory approval. The first uncertainty is about whether the merger will truly occur. In practice, a merger may not go through due to various reasons: one of the companies may not be able to satisfy the merger conditions, shareholders may not approve the merger, or regulatory authorities may prevent the merger. In DirecTV's case, the market's sentiment then was beleaguered by whether the merger would eventually receive regulatory clearance given the fact that several recent proposed mergers in the telecommunications industry failed to reach completion, for instance, AT&T's failed merger with T-Mobile in 2011 and Comcast's call-off merger with TWC in 2014.

Specifically, telecom mergers require approval of the antitrust regulators at the Justice Department and the FCC, which decide whether a deal is in the public's interest. After the companies submit a proposed deal, the regulators will do a preliminary review to determine whether it raises any antitrust concerns that warrant closer examination. If the initial review has raised competition issues, the agency may extend the review and ask the companies to provide more information so that it can take a closer look at how the transaction will affect competition. Because of the lengthy approval process, the approval date is thus erratic and unpredictable. However, in this post-event study, the approval date or the maturity date was assumed known at any event day, which to the contrary was unknown.

Last but not least, the complexity of the merger's exchange ratio, which is contingent on the volume-weighted average AT&T stock price, also plays an important role in causing the underpricing issue. As demonstrated in Eq. (7), DirecTV's intrinsic value depends on the values of VWAP options. The mispricing and underpricing of DirecTV's stock price is inevitable for two reasons. First, the pricing of VWAP options is unduly difficult and requires significant expertise on the part of market participants to understand and use. Second, in a merger arbitrage, merger arbitrageurs typically buy the stock of the target company (DirecTV) while shorting the stock of the acquiring company

(AT&T) based on the merger's exchange ratio. However, the merger arbitrage is more complicated here because the merger's exchange ratio is designed to fluctuate with the VWAP of the acquiring company. Since the VWAP process is set in an incomplete market, there is no underlying asset with which for merger arbitrageurs to hedge the volume risk, and thus merger arbitrageurs were not as actively buying the target company's stock as in other merger arbitrage cases, causing the target company's stock price to remain at a discount below the acquisition price.

## SUMMARY

On May 18, 2014, AT&T Inc., the second-biggest U.S. mobile-phone carrier, agreed to acquire DirecTV, a satellite-television company, for $49 billion in cash and stock. As AT&T currently faced increased uncertainty in both the wireline and wireless business, the acquisition of DirecTV could not come at a better time, which would provide AT&T with earnings growth and additional spending flexibility. However, the merger's conditions and terms are complicated, as the stock exchange ratio is contingent on the volume-weighted average AT&T stock price over a 30-day period, that is, 3 trading days prior to the date when the merger becomes effective.

Using a contingent claims pricing approach, we model DirecTV's theoretical stock value based on the merger's conditions and terms. It is shown that the theoretical DirecTV stock value is analogous to the sum of the present value of the cash offer, plus owning shares of the AT&T stock, and short VWAP call spreads. Using three option-pricing models, the DirecTV valuation model is tested with the market data. Empirical results show that on average, DirecTV's stock was consistently priced at a discount during the sample period, and Funahashi and Kijima's (2017) VWAP model works better than Black and Scholes' (1973) plain vanilla option model and Levy's (1992) AP option model.

## NOTES

1. See Finnerty (1992) and Chen et al. (1999) for a review on financially engineered, synthetic equity products such as DECS.

2. The calculation of $E[e^{-rT}S_T^*]$ is detailed in Theorem 3.1 of Funahashi and Kijima (2017). For the Black and Scholes (1973) option model, $S^*$ is simply the current stock price. For the Levy (1992) AP option model, $S^*$ is the initial value of a dynamic trading strategy that guarantees a payoff of $S_T^*$ at time $T$, which consists of 30 parts as follows:

   (1) Buy and hold $(1/30)e^{-r(32/365)}$ shares of $S$ until $t = T - 32$ and then invest the proceeds at $r$ until $t = T$, where $S$ is the current stock price and r is the annual risk-free rate.

(2) Buy and hold $(1/30)e^{-r(31/365)}$ shares of $S$ until $t = T - 31$ and then invest the proceeds at r until $t = T$.

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(29) Buy and hold $(1/30)e^{-r(4/365)}$ shares of $S$ until $t = T - 4$ and then invest the proceeds at r until $t = T$.

(30) Buy and hold $(1/30)e^{-r(3/365)}$ shares of $S$ until $t = T - 3$ and then invest the proceeds at $r$ until $t = T$.

The above dynamic trading strategy of (1) through (30) will guarantee a payoff of $\sum_{i=3}^{32} S_{T-i}/30$ at time $T$.

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