A Critical Review of the Fair Value Settlement Procedure for Stock Options

By Oege Pennin, Martijn J. van den Assem, and Remco C.J. Zwinkels

Oege Pennin is at Rabobank, Utrecht, the Netherlands.

Martijn J. van den Assem is at VU University Amsterdam and Tinbergen Institute, Amsterdam, the Netherlands.

Remco C.J. Zwinkels is at VU University Amsterdam and Tinbergen Institute, Amsterdam, the Netherlands.

We review the European practice of fair value settlement of stock options after a successful takeover bid. We argue on both fundamental and practical grounds that the inherent complexity, arbitrariness and inaccuracy of fair value calculations call for replacement by intrinsic value settlement. This alternative is simple, transparent, well-defined, and common practice at other exchanges.

Keywords: fair value, intrinsic value, stock option, implied volatility, option pricing, takeover

1. Introduction

The takeover of a publicly listed company typically results in delisting or a small free float and thin trading. An important practical question then is how to deal with the outstanding option contracts on the stock of the company. If certain conditions are met, option trading is normally terminated by the exchange at some point, whereby the value of each option series needs to be determined to close out any remaining positions.

Two different types of settlement methods are being used by option exchanges worldwide. The first is known as the intrinsic value method. This method simply means that the writer of the option pays the holder the difference between the final and unconditional offer price and the strike price if the option is in the money, and nothing otherwise. Intrinsic value settlement is common practice in, for example, the United States (CBOE), Canada and Hong Kong. The second type is the *fair value method*. The key difference with the intrinsic value method is that the fair value approach attempts to compensate – on top of the intrinsic value – for the otherwise foregone time value of the option. Because this as-if value is unobservable, the method uses a theoretical option pricing model. In fact, it seeks to determine the time value as if the takeover has not taken place but at the same time assumes the stock price to be equal to the offer price. Fair value settlement is applied by European option exchanges including NYSE Liffe (Amsterdam, Brussels, London, Paris and Lisbon) and Eurex (Frankfurt and Zurich).

In this paper we argue that the complexity, arbitrariness and inaccuracy of fair value calculations call for replacement by intrinsic value settlement. Because of the relative complexity of option pricing in general and because of the necessity of several rather arbitrary choices in particular, we believe that the fair value method is detrimental to market transparency. Moreover, the present implementation of the method entails inaccuracies and a biased outcome because volatility is measured at an earlier point in time than the settlement date and at a different price/strike ratio than the ratio of the offer price to the strike price. In addition to the technical difficulties, we also present a more fundamental argument against the fair value approach and in favor of intrinsic value settlement. Ironically, it can be argued that the intrinsic value is more of a "fair" approximation than the value prescribed by the fair value method. Altogether, these issues can be harmful for the risk-sharing function of option markets as they may discourage market participants from trading.

The remainder of this paper is organized as follows. In Section II we describe the fair value methodology of NYSE Liffe and present the difficulties associated with it. Section

III presents the case of Océ, a Dutch company taken over by the Japanese firm Canon in 2010. Section IV concludes.

2. Fair Value Settlement and the Difficulties

We focus on the procedure as applied by NYSE Liffe; Eurex applies a highly similar procedure, so the same arguments hold.[1] NYSE Liffe describes the procedures regarding how it adjusts derivatives contracts in response to various types of corporate actions – including stock splits, rights issues, and mergers and takeovers – in a document entitled "NYSE Liffe Corporate Actions Policy".[2]

2.1 Fair Value Settlement

The first step in the case of mergers and takeovers is to determine whether and when the transaction initiates the fair value procedure. NYSE Liffe's Corporate Actions Policy states that adjustments to option contracts are made when a bid is declared unconditional and if the majority of the shares of the target company are acquired, that is, at least fifty percent plus one of the outstanding shares.[3] The acquiring firm's method of payment then determines the type of adjustment that applies. If the acquirer is paying in shares that constitute more than one third of the value of the offer and if these shares are or will be traded on the same exchange as the target's shares, then the outstanding options are normally replaced by options on the acquirer's shares through the so-called ratio method. In all other cases the fair value method is implemented.

The fair value method builds on the binomial tree model of Cox, Ross, and Rubinstein (1979; henceforth CRR). This appears to be the appropriate choice for this purpose over, for example, the Black and Scholes (1973) model, because it is relatively flexible and can handle dividend payments and options of the American type. As with any other valuation model, the inputs into the CRR model are of crucial importance for the accuracy of the outcome. These inputs are the share price, volatility, risk-free rate, and expected dividends.

The share price that is employed as the starting point in the CRR model is the price of the final and unconditional offer. To determine the size of the up- and down movements in the binomial tree, volatility is estimated for each option series separately and based on the average implied volatilities derived from the settlement prices (calculated and published by NYSE Liffe for the purpose of daily margin calculations) of the option series in the ten days preceding the announcement of the first offer.[4] The interest rate that is being used varies across cases and is communicated through the relevant corporate action notice. Maturities of the risk free rates are matched to those of the options by means of linear interpolation. Expected dividends, finally, are estimates from analysts at Markit, a commercial financial information services firm.

2.2 Main Methodological Problems

Our main issues with respect to the practical implementation of the fair value method have to do with the volatility estimates. To arrive at the desired fair value of an option, the as-if (the takeover has not taken place) volatility is required as an input. Unfortunately, the implied volatility of option prices typically decreases substantially with the announcement of a bid, especially when the offer is primarily or fully in cash and uncertainty around the transaction is low (Hutson and Kearney, 2001).[5] Measuring an option's implied volatility after the moment the offer has been announced would therefore underestimate the as-if volatility (volatility if the takeover had not taken place), and thus also the as-if value.

As a solution, NYSE Liffe uses implied volatilities derived from settlement prices prior to the announcement as volatility estimates.[6,7] We argue that this approach entails bias and inaccuracy for two reasons.

The first reason is the volatility-skew effect. For equity options there is a negative relation between the strike price of options (calls and puts) and their implied volatility (MacBeth and Merville, 1979; Rubinstein, 1994). Given that the bid price is normally substantially higher than the share price prior to the announcement (see, for example, Betton, Eckbo and Thorburn, 2008), the volatility skew results in a systematic overestimation of as-if volatility when implied volatilities derived from pre-announcement prices are used. Writers (holders) of calls and puts are thus generally disadvantaged (advantaged) because of the volatility skew effect.

The second reason relates to timing and maturity effects. Because there are normally several months between the announcement of the bid and the moment of settlement of the options after the offer is declared unconditional, there is a timing and maturity mismatch between implied volatility measurement and fair value settlement. The implied volatility of an option is, for example, measured five months before expiration and then used four months later to value the option at the settlement date when only one month of maturity remains. These mismatches are problematic because the slope of the term structure of implied volatilities is generally not flat and varies through time (Mixon, 2005). In addition, implied volatilities change stochastically and with mean reversion (Stein, 1989). The hidden assumption

of maturity-invariant and constant implied volatility disregards an important part of the dynamics, and means an inaccuracy in the fair value method.

NYSE Liffe's choice to measure the implied volatilities over the ten days preceding the bid entails an additional problem, because price formation is typically contaminated by the event at that time. Implied volatilities on average increase significantly in advance of a transaction announcement (Jayaraman, Mandelker and Shastri, 1991; Levy and Yoder, 1993). The use of contaminated pre-bid values leads to an additional overestimation of as-if volatility and an additional wealth transfer from writers to holders as compared to "clean" as-if settlement. This systematic bias can easily be avoided by using another estimation period, but in any case the precise estimates will remain subject to the (to some extent arbitrary) time window that is being used.

2.3 Other Methodological Issues

Although the main problems of the fair value method are related to the volatility estimates, the precise outcomes of fair value calculations also depend on how the expected dividends and the risk-free rate are determined.

For the expected dividends, NYSE Liffe uses the dividend forecasts of analysts at the commercial company Markit. Even if these analysts are the best in their class, it is unlikely that their subjective estimations precisely coincide with aggregate market expectations. Ideally, market expectations are being used. If fair value settlement is held onto, an alternative approach might be to derive the required information from market prices. Recent academic literature shows substantial progress in extracting forward-looking information from option markets, including expected dividends. For example, Golez (2014) demonstrates that dividend growth rates implied in option prices are reliable predictors of actual dividend growth rates.

The most commonly used proxy for the risk-free interest rate by NYSE Liffe is the Euribor rate. Euribor was, for example, used in the Océ-Canon case. Choices that we observed for other fair value calculations include Libor, Nibor, and US deposit rates. Given the risk-neutral valuation principle of the CRR model, the interest rate should be risk free. As illustrated by the evaporation of liquidity in (interbank) money markets during the recent global financial crisis, rates like Euribor are not always risk free because of credit risk. Also, apart from recent concerns about the establishment of some interbank rates, an additional issue with Euribor, Libor and Nibor is that these rates do not extend beyond one year. NYSE Liffe applies linear extrapolation for options with a maturity of more than one year, and thus questionably assumes a linear term structure. For the purpose of fair value calculations, a better proxy in the light of these issues is the Eonia swap rate, also known as the Overnight Index Swap (OIS) rate. As for expected dividends, another alternative could be to derive the risk-free rate from market prices (Brenner and Galai, 1986). Clearly, all these methodological difficulties do not apply to the intrinsic value method.

2.4 A Fundamental Argument

A very different issue is that the interpretation of what constitutes a "fair value" is not clear cut, and, ironically, there are reasons to claim that the intrinsic value is a more "fair" approximation than the value prescribed by the fair value method. As already outlined above, the key difference between the two methods is in the preservation of time value. Because volatility is the main unknown in the determination of time value, the problem can be roughly narrowed down to the interpretation issue of what constitutes a "fair volatility" input. The fair value method uses implied volatilities from a pre-announcement period, whereas the intrinsic value method effectively assumes zero volatility. Although we do not claim to have the one correct answer, there are two arguments that favor zero volatility. First, after an offer is declared unconditional and outstanding options are closed out, shareholders tendering their shares during a post closing acceptance period receive the exact same offer price. For options with a limited remaining maturity this suggests that the assumption of zero volatility comes close to economic reality.

The second argument is related to the law of one price. Economically, and abstracting from imperfections such as tax effects, a successful cash offer for a company's shares is equal to a successful asset acquisition in cash (where the acquirer buys all the target's assets and liabilities rather than its shares). In the latter case, options are not settled and – assuming the cash in the firm is not employed and ultimately available to shareholders – the implied volatilities are closely approximated by zero. In the spirit of the law of one price, it seems natural to preserve this similarity for options and align the settlement price after a stock acquisition with the value of the same option after the economically identical event of an asset acquisition. This value will normally not be very different from the intrinsic value.[8]

An additional drawback of the fair value method relative to the intrinsic value method is that it creates an artificial dichotomy between the price formation of options that expire before the date at which the offer is to be declared unconditional (or extended or withdrawn) and those expiring thereafter. Decreasing uncertainty about

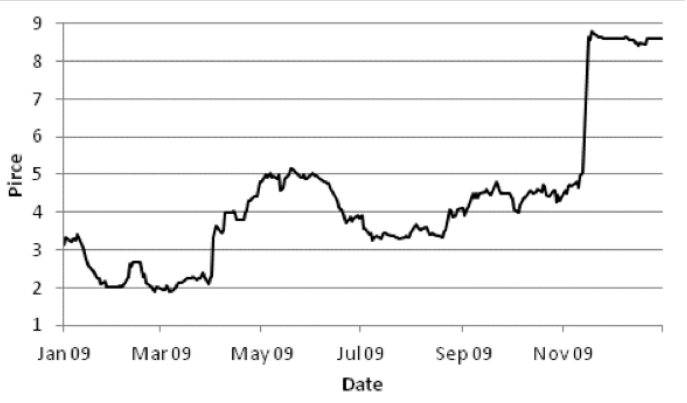
the offer entails convergence towards the intrinsic value in the former case and towards the potential fair value settlement price in the latter case. Also, because the fair value outcome is an important but not very salient and transparent additional factor in the pricing of options expiring after that date, these options lose some of their appeal as indicators of the market's view on the likelihoods of possible takeover scenarios.

3. Example: Océ

To illustrate some of the points raised in the previous section we consider the case of Océ, a Dutch company specialized in developing and manufacturing printing and copying hardware and software. After a listing of more than 60 years on the Amsterdam stock exchange, this company was acquired by its Japanese rival Canon. On 16 November 2009, Canon announced its all-cash offer of €8.60 per share, amounting to €730 million for all outstanding shares. The bid was declared effective on 4 March 2010, and after a post closing acceptance period and a squeeze-out procedure Océ was delisted as per 14 February 2012. In line with the NYSE Liffe's fair value policy described above, all outstanding option contracts were closed out and settled on 4 March 2010.

Figure 1 displays the stock price of Océ over the year 2009. The graph clearly shows that the announcement lead to a large price jump. After the prior closing price of €5.065, the closing price on November 16 was €8.624. Over the months before Canon's announcement the company's stock price had already increased substantially, possibly partly in anticipation of a possible takeover.

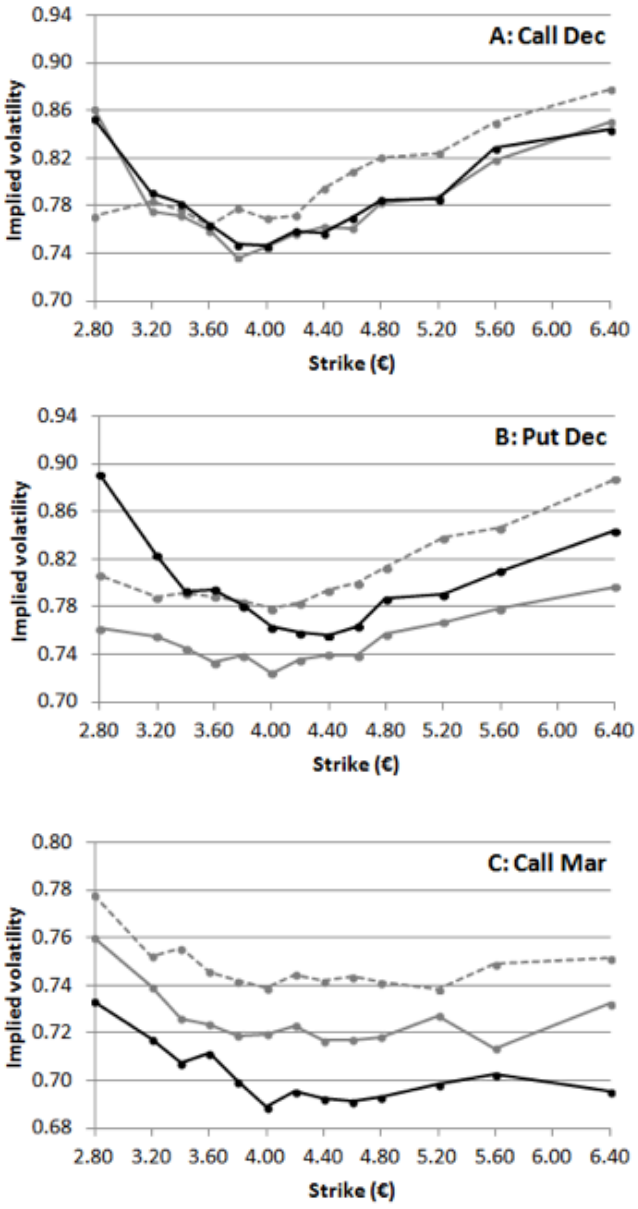
Figure 1: Stock Price Océ

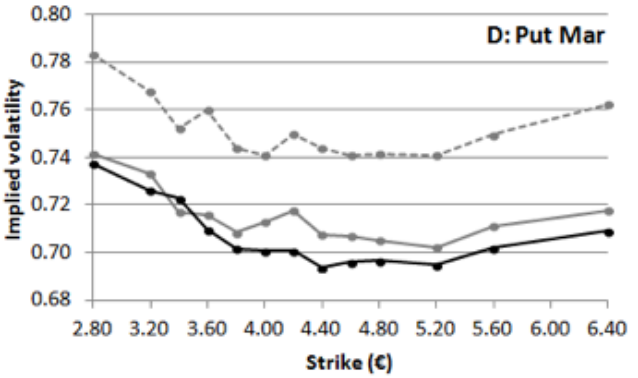


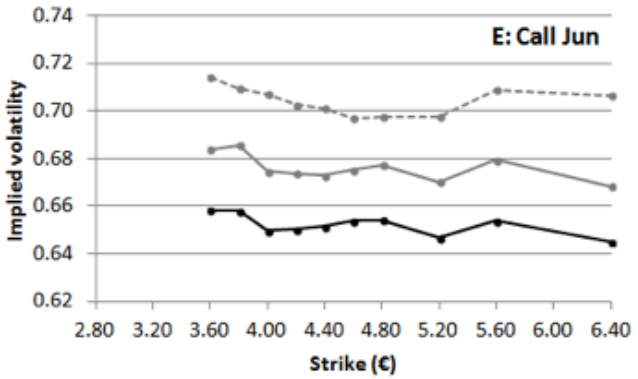
Notes: The figure displays the stock price of Océ over the year 2009. On November 16, Canon announced a cash offer of €8.60 per share.

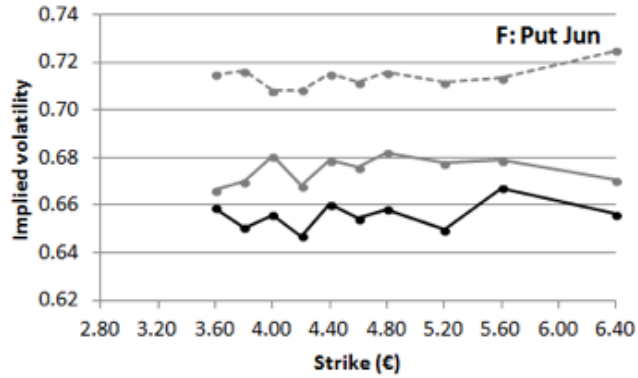
Figure 2 displays the implied volatilities of Océ stock options for all different maturities and strike prices available before the announcement of the offer. Around the time of the announcement of the offer in November 2009, the remaining maturities of the December, March and June series were about one, four and seven months, respectively. The graphs also show the implied volatilities for two alternative ten-day measurement periods that start at the 30th and 20th trading day prior to the announcement rather than at the prescribed tenth day. The December options expired in the period between bid and acceptance, whereas the other two were closed out and settled in cash after Canon declared its bid unconditional in March 2010. At the time of fair value settlement, the actual remaining maturities were two weeks and 2.5 months, respectively.[9]

Figure 2: Implied Volatilities









Notes: The graphs A-F display the implied volatilities for Océ from the December 2009 series (A & B), the March 2010 series (C & D) and the June 2010 series (E & F) calculated on the basis of NYSE Liffe's procedure. The solid black (solid gray; dashed gray) line connects the values derived from settlement prices over the ten trading days as from the 10th (20th; 30th) trading day prior to the announcement.

A first observation from the implied volatility figures concerns the patterns. Especially for the shorter-maturity options there is a clear U-shape pattern over the different strike prices. The fair value method assumes the stock price to be equal to the offer price but sets an option's volatility input equal to pre-announcement implied volatility. As a result, it ignores the implied-volatility effect of the large change in the moneyness of both calls and puts resulting from the takeover premium.

A second observation is the sensitivity of the implied volatilities to the choice of the ten-day measurement period. Especially for the longer-maturity options, the alternative measurement periods generally yield substantially higher implied volatilities than the ten trading days preceding the announcement. Although the case of Océ apparently is not a good example of the more widely observed increase of implied volatilities in advance of a transaction announcement, it does show the sensitivity of the estimates to the time window that is being employed.

The final observation is the difference in both the level and the pattern of implied volatilities across different maturities. Implied volatility is clearly maturity dependent, casting doubt on the accuracy of measuring a series' implied volatility multiple months prior to the actual valuation.

4. Conclusions

In the light of the fundamental and practical problems related to the current European practice of fair value settlement of stock options after a successful takeover bid, we call for adoption of the intrinsic value method. The aim of the fair value method to compensate for foregone time value of prematurely expiring options is commendable but demands many subjective valuation choices that bring along complexity, arbitrariness and inaccuracy. Moreover, the volatility inputs that are presently being used by exchanges are systematically biased relative to what would constitute a "fair" input, and correcting for this would make the method even more complex. Even though traded options are complete contracts whose value can always be theoretically determined, we believe that such difficulties are detrimental to market transparency and therefore preferably avoided. The intrinsic value method does not entail any of these problems, and, as we argued, there are grounds to claim that intrinsic values are fair settlement prices that reflect economic reality.

References

Betton, S., Eckbo, B. E., and Thorburn, K. S. (2008). Corporate Takeovers. *Handbook of Corporate Finance: Empirical Corporate Finance (Volume 2)*, Elsevier.

Black, F., and Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy* 81(3), 637-654.

Brenner, M., and Galai, D. (1986). Implied Interest Rates. *Journal of Business* 59(3), 493-507.

Chan, J. H., Joshi, M., Tang, R., and Yang, C. (2009). Trinomial or Binomial: Accelerating American Put Option Price on Trees. *Journal of Futures Markets* 29(9), 826-839.

Cox, S. C., Ross, S. A., and Rubinstein, M. (1979). Option Pricing: A Simplified Approach. *Journal of Financial Economics* 7(3), 229-263.

Diener, F., and Diener, M. (2004). Asymptotics of the Price Oscillations of a European Call Option in a Tree Model. *Mathematical Finance* 14(2), 271-293.

Fama, E. F. (1965). The Behavior of Stock-Market Prices. *Journal of Business* 38(1), 34-105.

French, K. R. (1980). Stock Returns and the Weekend Effect. *Journal of Financial Economics* 8(1), 55-69.

French, K. R., and Roll, R. (1986). Stock Return Variances: The Arrival of Information and the Reaction of Traders. *Journal of Financial Economics* 17(1), 5-26.

Golez, B. (2014). Expected Returns and Dividend Growth Rates Implied by Derivative Markets. *Review of Financial Studies* 27(3), 790-822.

Hull, J. C. (2012). Options, Futures, and Other Derivatives. Pearson.

Hutson, E., and Kearney, C. (2001). Volatility in Stocks Subject to Takeover Bids: Australian Evidence Using Daily Data. *Journal of Empirical Finance* 8(3), 273-296.

Jayaraman, N., Mandelker, G., and Shastri, K. (1991). Market Anticipation of Merger Activities: An Empirical Test. *Managerial and Decision Economics* 12(6), 439-448.

Levy, H., and Yoder, J. A. (1993). The Behavior of Option Implied Standard Deviations Around Merger and Acquisition Announcements. *Financial Review* 28(2), 261-272.

MacBeth, J. D., and Merville, L. J. (1979). An Empirical Examination of the Black-Scholes Call Option Pricing Model. *Journal of Finance* 34(5), 1173-1186.

Mixon, S. (2005). The Implied Volatility Term Structure of Stock Index Options. *Journal of Empirical Finance* 14(3), 333-354.

Roll, R. (1984). Orange Juice and the Weather. *American Economic Review* 74(5), 861-880.

Rubinstein, M. (1994). Implied Binomial Trees. *Journal of Finance* 49(3), 771-818.

Stein, J. C. (1989). Overreactions in the Options Market. *Journal of Finance* 44(4), 1011-1023.

Note

1. See http://www.eurexchange.com/exchange-en/products/equ/corporate-actions-procedures for more details. The implied volatility calculations are equivalent; the choices regarding risk-free interest rate and expected dividend differ somewhat.
2. At the time of writing, the latest version of the description of the procedures was issued on 14 December 2012 and effective as of 1 January 2013; see https://globalderivatives.nyx.com/nyse-liffe/corporate-action-policies.
3. NYSE Liffe uses a level that is at the lower end of the range of reasonable threshold values. Clearly, the precise choice of the percentage that initiates the settlement procedure is to some extent arbitrary.
4. In fact, the average is taken over eight days as the highest and the lowest implied volatility observation are not taken into consideration.
5. Hutson and Kearney (2001) argue that the lower implied volatility is a consequence of the convergence of opinions regarding the value of the target firm.
6. The policy document does not spell out in detail how implied volatilities are calculated. Personal correspondence pointed out that NYSE Liffe uses the CRR model with a trinomial tree for this purpose. This is inconsistent with the binomial tree that is used to calculate the fair value of the option. Chan et al. (2009) illustrate that the choice of tree can have substantial effect on the pricing performance. Another issue is the number of steps in the tree. The exchange uses the number of days to maturity, with a maximum of 100. For options with a relatively low number of days to maturity, the corresponding low number of steps could induce noise in the estimated price; see Diener and Diener (2004).
7. Alternatives include a simulation approach that models the time-varying implied volatility surface and a cross-sectional approach that uses the implied volatilities of similar firms.
8. If the method of payment is stock instead of cash, the similarity across the two acquisition types holds automatically when the acquirer's shares will be traded on the target's exchange, as option trading is not terminated then (see Section II). Our law-of-one-price argument does not apply if the method of payment is stock and the acquirer's shares will not be traded on the target's exchange, as implied volatility is not approximated by zero in asset acquisitions then.
9. An additional methodological choice that can be especially material for short maturities is the choice between the calendar time and the trading time approach. Our calculations point out that NYSE Liffe uses the number of days on the calendar as the time until expiration. This approach is at odds with studies indicating that trading days should be used (Fama, 1965; French, 1980; Roll, 1984; French and Roll, 1985).

Acknowledgements:

We thank Guido Baltussen and Rogier Potter van Loon for useful comments and suggestions, and acknowledge support from Erasmus University Rotterdam.

Corresponding Author:

Remco C.J. Zwinkels, VU University Amsterdam and Tinbergen Institute

De Boelelaan 1105, 1081 HV Amsterdam, the Netherlands.

T: +31 20 598 6060, Email: r.zwinkels@vu.nl