Fair Value Management: A Case Study of Employee Stock Option Pricing Models

Loïc Belze

EMLYON Business School

Francois Larmande

HEC Paris

Lorenz Schneider

EMLYON Business School

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ABSTRACT: This paper examines the fair value management of Employee Stock Options (ESOs). Departing from earlier literature focused on input estimates, we study the management of the pricing model itself, which is sometimes freely interpreted by companies. Relaxing certain assumptions of the Black-Scholes-Merton (BSM) model can lead to a range of possible prices. We first show that when estimating the ESO cost for the company, only prices equal to or above the BSM model price should be considered, whereas discounts are in fact observed at issuance. Second, based on a specific class of listed ESO in an IFRS context, our empirical study finds an overall average discount of 64% on our model price after controlling for ESO-specific characteristics. The discount results mainly from model management. These results provide interesting insights into the scope for model management under different accounting standards, and are also relevant for authorities in charge of enforcement.

Keywords: *Fair value – ESO – Transaction costs – IFRS 2 – SFAS 123R*

Data: *All data are available from public sources*

I. INTRODUCTION

Implementing fair value principles is not a straightforward task. Standard setters have progressively refined the notion of fair value, as evidenced by the recent efforts of the FASB[1] (e.g. the update of Topic 820 for US GAAP[2]) and the IASB[3] (e.g. the recent implementation of IFRS 13[4]) to produce new guidance on this issue. In the specific case of share-based compensation both standard setters (SFAS 123R[5] for US GAAP and IFRS 2[6] for IFRS) determined in 2004 that, in order to improve accountability and transparency towards shareholders, share-based compensation instruments should be recognized as a cost by firms and expensed in the income statement at their fair value. In the case of Employee Stock Options (ESOs), a common form of share-based compensation, market prices are in general not available, and so a model price is required to measure fair value. Standard setters provide guidance on this point, recommending the use of a model based on the Black-Scholes-Merton (BSM) model, specifically a lattice model. Lattice models are more flexible than their BSM counterparts and can accommodate specific properties of employee stock options such as vesting conditions, and various possible early-exercise assumptions (Hull and White 2004a). In addition to these properties and the issue of estimating the value of inputs to the model, certain assumptions of the BSM model do not hold in practice. In this paper, we investigate how relaxing these assumptions can affect the fair value of ESOs.

Based on our examination of ESO issuances on the French market, we provide evidence that by relaxing certain BSM model assumptions, some companies reporting under IFRS are able to manage the fair value of their share-based payment instruments. In general this

[1] Financial Accounting Standards Board
[2] Generally Accepted Accounting Principles
[3] International Accounting Standards Board
[4] International Financial Reporting Standard 13 *Fair Value Measurement* (2011)
[5] Statement of Financial Accounting Standards No. 123 Revised (2004) *Share-Based Payment*
[6] International Financial Reporting Standard 2 *Share-based Payment* (2004)

flexibility results in a discount on standard model prices. In this paper, we review the major assumptions used by companies to justify these discounts and analyze their validity. Although model assumptions regarding the non-tradability of the option and the dilution effect have been considered in previous literature, our paper provides further developments on these assumptions. In addition, an original feature of this paper is our examination of transaction costs, which have surprisingly received little attention in the literature to date. Pricing models normally assume that no transaction costs are incurred when trading financial assets. While the financial literature has studied the impact of transaction costs on option pricing, from both an empirical (Brenner et al. 2001; Deuskar et al. 2011) and an analytical point of view (Leland 1985; Çetin et al. 2006), to the best of our knowledge this issue has never been addressed in the case of the fair value of employee stock options. Standard setters are silent on this issue, assuming that a model provides only one price for a given volatility. As companies often invoke transaction costs to lower ESO valuations, one core issue of our research is to investigate the impact of factoring transaction costs into the pricing model to measure the fair value of ESOs. Alongside our core issue of pricing model management, we observe that companies exercise a certain degree of discretion when estimating pricing model inputs. These estimates have been extensively investigated in prior studies (Johnston 2006; Bartov et al. 2007; Bechmann and Hjortshøj 2009; Choudhary 2011). In order to measure the impact of model management on the fair value of ESOs, and to provide a useful point of comparison, we also analyze the issue of volatility input estimates.

Financial theory (Bensaid et al. 1992; Jouini and Kallal 1995) tells us that when transaction costs are introduced, pricing models no longer offer one single price, but a range of possible prices. Turning to the specific case of measuring the fair value of ESOs, the main question is to determine which price should be retained from this interval. In this article, we offer an original approach based on an analytical demonstration. We show that only prices equal to or above the standard model price should be considered for valuing liabilities such as share-based payments. Our analysis is based on the fundamental notion stressed by IFRS 2 that only the cost for the company matters, defined as the price a rational knowledgeable willing agent would accept to hedge the liability of the company, and not the value for the employee.

Our empirical investigation is based on an in-depth analysis of the fair value of redeemable warrants, a specific category of share-based payments. To the best of our knowledge, transaction costs have never been put forward in an SFAS 123R (2004) context to justify a departure from the BSM model price. This is not the case for the IFRS environment in which our case study is conducted. Redeemable warrants are listed stock options sold to executives at what is supposed to be their fair value, and are freely tradable on the stock market after an initial period during which they are non-tradable and non-exercisable. We have examined a sample of 44 offerings observed in France between 2005 and 2012. The empirical part of our study is firstly motivated by the fact that, compared to stock-options, detailed expert reports on redeemable warrant models are publicly available within the issuance prospectuses prepared by companies for the French market authority.[7] Secondly, since these securities are listed, employees can sell their options instead of exercising them, meaning that early exercise is not an issue. This allows us to control for the issue of the expected life of the option, and to focus on lifting the lid of the pricing model "black box".

Retaining the experts' individual volatility estimates, our empirical results show an overall average discount of 51% compared to the predictions of our theoretical analysis. We

[7] The price is ultimately defined by the Board of the issuing company; however, we have no direct information as to how the Board determines the price. While the expert report proposes a range of possible prices, and confirms the reasonableness of the price retained by the company, it gives no information as to how the company arrived at its choice of price. The empirical part of our study is based on these expert reports.

subject the justifications provided by companies' experts to in-depth analysis in the light of our hypotheses. To provide a complete picture of ESO fair-value measurement, we also analyze the choice of volatility estimate used in the pricing models. Comparing experts' choices to both historical and realized volatility, we show that their choices lead to an additional discount. The model management and downwards volatility effects together lead to a combined average discount of 64%, the majority of which derives from management of the model itself.

Our paper contributes to the literature in several ways. Firstly, while earlier literature has highlighted possible fair value management via the choice of model input estimates, we focus our analysis on the management of the actual assumptions underlying the pricing model. This issue mainly stems from the relaxation of major assumptions of the BSM framework such as the absence of transaction costs, the tradability of the option, and dilution. In contrast to the issue of volatility, where it is difficult to set definitive normative guidance, we show that only prices equal to or above the standard BSM model price should be considered.

We also contribute to the issue of IFRS and US GAAP comparison. Even for a subject such as fair value measurement for which the texts appear to converge, we find that an average discount of 64% on ESO valuation can routinely be observed for companies reporting under IFRS. This is in contrast to previous studies in a US GAAP context which have presented far less scope for fair value management (Aboody et al. 2006). The gap is mainly explained by management of the model. This result is possible because IFRS, being principle based, offers less precise guidance on the possible implementation of a model. As we argue in our paper, the more precise, rules-based US GAAP texts would have limited such management. Thus, our study suggests that rules-based accounting, compared to principles-based accounting, offers less scope for fair value management and less scope for aggressive reporting in the case of fair value measurement based on model price. This is in sharp contrast to previous studies (Agoglia et al. 2011; Collins et al. 2012) showing that in the case of dichotomous accounting choice, principles-based accounting appears optimal. The choice between principles-based and rules-based accounting might be better set at the standard level rather than at the macro (general framework) level.

The remainder of our paper is set out as follows. Section II reviews the literature and sets out our resulting hypotheses. Section III provides an analysis of our first hypothesis by giving an analytical demonstration focused on the issue of transaction costs. Section IV presents the data used in our empirical analysis and the research method employed. In Section V we empirically analyze companies' pricing model management. Section VI provides additional results on the volatility input estimate, and Section VII discusses our results and concludes.

II. BACKGROUND AND DEVELOPMENT OF HYPOTHESES

Background Information on Pricing Models

Both the FASB (SFAS 123R) and IASB (IFRS 2) positions provide that the fair value of stock options should be measured at the time the options are granted and expensed over the vesting period. Despite some initial debates on pricing implementation (Kirschenheiter et al. 2004; Boyle et al. 2006; Landsman et al. 2006), the IASB and FASB have coordinated their efforts in creating their respective share-based compensation standards, even if some differences remain in the treatment of related tax benefits (McAnally et al. 2010).

It is important to underline that both SFAS 123R and IFRS 2 recognize and define stock-option fair value as a cost for the company that must be expensed. This crucial issue is further detailed by Hall and Murphy (2002), who stress the importance of differentiating between the cost for the company and the value for executive. They state that "for financial accounting purposes, what should matter is the company's cost of granting an option (which is reasonably approximated by Black-Scholes) not the value of the option to the executive recipient" (Hall and Murphy 2002, 15). Moreover they add that "this cost often significantly exceeds the value of the option from the perspective of a risk-averse, undiversified executive who can neither sell the option nor hedge against its risk. Executives receiving options will therefore value the options below their cost to shareholders" (Hall and Murphy 2002, 5). This last statement is highly significant for our study since we focus on this difference in value and the various reasons behind it.

Various observations are required when determining the fair value of stock options. Both SFAS 123R and IFRS 2 recommend the observation of market prices as a first step, but recognize that it is difficult to find traded options with similar terms and conditions. In this particular case, the fair value of the options granted should be estimated using an option pricing model. However, we note that despite commenting on the models, none of the accounting standards strictly recommends one model over another. IFRS 2 (2004, §B5) specifies that "the entity shall consider factors that knowledgeable, willing market participants would consider in selecting the option pricing model to apply." It is also indicated that, because of the complex characteristics of share options (e.g. expected early exercise, forfeiture rate), a closed-form solution such as the one given by the BSM model (Black and Scholes 1973; Merton 1973) can only give an approximation of the fair value of an equity option grant. Lattice models, usually extensions of the Cox-Ross-Rubinstein (CRR) binomial tree, are more flexible (Cox et al. 1979).[8]

If initial controversy was focused on whether the value of employee stock options was an expense for the firm or not (Bodie et al. 2003; Aboody et al. 2004), the framework

[8] Examples of lattice models that attempt to take all of these features into account are given by Rubinstein (1995), and Hull and White (2004a, 2004b).

proposed by SFAS 123R and IFRS 2 has shifted the core issue to the method of valuation. Initial opponents of recognition considered the option value estimation methods at the time to be unsuitable for employee stock options, and therefore unreliable; while other contributions confirmed that the BSM model was able to provide reasonable estimates (Marquardt 2002).[9] As a consequence, academic studies have focused on companies' use of the BSM pricing model. In particular, the core research on this issue is exclusively focused on the discretionary choice of model parameters (expected volatility, risk-free interest rate, dividend yield, and time to maturity or "expected life") revealing some particular features of practitioners' implementation (Aboody et al. 2006; Johnston 2006; Bechmann and Hjortshøj 2009; Hodder et al. 2006).

Finally, we observe that managerial discretion in valuing stock options has always been analyzed in terms of the value of BSM input estimates (e.g. for the volatility), while the actual model and its assumptions have rarely been addressed in previous research. However, several assumptions of the BSM model are not satisfied in practice, as option prices are also affected by factors such as dilution, non-tradability, and transaction costs. We now consider whether incorporating these features into a model produces a fair value different from the traditional BSM price.

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[9] To further illustrate the importance of this issue, the mandatory recognition of stock-option expenses in the US has led to strategic behavior as highlighted in several academic papers. For example, some companies have accelerated the vesting of ESOs to avoid recognizing existing unvested ESO grants at fair value in future financial statements (Choudhary et al. 2009), some cut back ESOs when the new standard was issued (Brown and Lee 2011), some have timed equity grants around earning announcements suggesting earnings management (Bartov and Mohanram 2004; Elsilä 2012), while others have fallen foul of the backdating scandal, manipulating stock-option grant dates (Bernile and Jarrell 2009; Heron and Lie 2009).

The Dilution Issue

A first difference between ESOs and options to be considered when using lattice pricing models is the impact on the firm's capital structure once the options are exercised. The creation of new shares dilutes existing shareholders' control, but at the same time the company cashes-in the exercise price. The issue here is how to incorporate this effect into the ESO valuation and determine its impact. We note that the share price is not retrospective, but instead forecasts the financial consequence of expected future events. We can go further and question the timing of a fall in the share price, either on the announcement of the ESO or when the option is exercised.

There are strong arguments in favor of there being no negative impact on the share price. Firstly, investors expect companies to provide a competitive pay package to employees, either based on ESOs, or on other instruments (such as cash bonuses), which are at least as costly as ESOs. Secondly, even if the ESO was not anticipated, the share price also includes the forecasted potential benefit (increased productivity, alignment of interests) that should positively affect the company's valuation. This point of view is shared by standard setters (for instance SFAS 123R states, "For public entities, the [FAS] Board expects that situations in which such a separate adjustment [for the potential dilutive effect] is needed will be rare") and by other studies of ESO fair value that do not consider a dilution discount (Aboody et al. 2006; Hodder et al. 2006). Finally, in the specific case where the options are sold to employees at what is supposed to be their fair value, there is no impact on the value of the company and no discount should be observed.

The Non-Tradability Issue

A second typical feature of ESOs is that they are non-tradable. Thus, the only way that the owner of the ESO can recoup their cash is by exercising the option. This can lead to early exercise compared to the optimal exercise predicted by the model. Thus the expected option life is in general even shorter than the expected life predicted by the model. As a result, the actual value of the ESO is lower than the BSM price for this kind of option. To deal with this issue, standard setters propose using the average option life of previous option plans to estimate expected life.

This non-tradability might have other valuation consequences. For example, previous research shows that private equity placements with resale restrictions undertaken by public companies are sold at a discount to market price (Cronqvist and Nilsson 2005; Wu et al. 2005). As a consequence, one might think that an illiquidity discount should be applied to account for the non-tradability of the option. This conclusion would be wrong since we are estimating the cost for the company, not the value for the employee. From the company's perspective it makes no difference whether the derivatives it sells are tradable or not (assuming the exercise patterns remain similar). This last statement is in line with the empirical literature, which argues that resale restrictions alone cannot explain the discount observed, otherwise companies would use public placement without resale restrictions. Several explanations have been put forward to explain this discount: for example compensation for the costly active monitoring of private holders (Wruck 1989), or the potential asymmetry of information between companies and recipients (Hertzel and Smith 1993). It can also be the result of managerial entrenchment (Barclay et al. 2007), leading management to favor non-hostile investors.

From an analytical point of view, the tradability of the option is one of the assumptions of the BSM model. However, we will show in Section III that this assumption can easily be relaxed without modifying the value of the option.

The Transaction Costs Issue

A third important assumption made in the BSM model is that there are no transaction costs when trading in the share underlying the contingent claim. Contrary to the non-tradability of the option, this assumption cannot be relaxed without affecting the result of the model. We will show in Section III that, while a range of possible prices now exists, only prices equal to or above the standard model price should be considered. Intuitively, transaction costs make the hedging of the claim by the underwriter more costly. As hedging is more costly, the cost for the company can only increase.

Considering all the arguments developed on the different issues above, we state the following hypothesis:

H1: *Relaxing major BSM model assumptions should not lead to a discount when recording the accounting fair value of employee stock options.*

The Volatility Issue

Accounting standards (SFAS 123R, IFRS 2) favor using implied or historical volatility as an unbiased estimate of volatility, and require any deviation from this approach to be clearly justified. However, since it is in fact the expected volatility over the option life that should be taken into account, standard setters leave room for possible distortion due to the influence of future events that are, by their nature, difficult to anticipate. Focusing on the method used, Poon and Granger (2003) suggest in their survey that implied volatility based on the BSM model provides the best forecasting, followed by historical volatility,[10] which in turn performs somewhat better compared to GARCH models.[11] For long forecast horizons, Alford

[10] Including random walk, historical average of squared returns, and time-series models based on historical volatility using moving averages and exponential weights.

[11] Generalized AutoRegressive Conditional Heteroskedasticity.

and Boatsman (1995) find that a simple historical method using low-frequency data over a period at least as long as the forecast horizon works best, whereas Jiang and Tian (2010) find that historical volatility is a poor prediction tool. If historical volatility has been proven to be an imperfect estimate of future volatility, opportunistic decision-making on the part of managers remains difficult to prove. Indeed, it is possible that managers use private information to update historical experience, and thus arrive at a more accurate volatility forecast. In addition, while methods are ambiguous and difficult to implement, little convergence is found in the empirical results collected for stock options. Bartov et al. (2007) find that volatility is opportunistically subject to a high degree of discretion, used to decrease the expected volatility proxy. Investigating reliability differences across recognition and disclosure regimes for ESOs, Choudhary (2011)[12] finds that recognized values are more likely to be underestimated, whereas Blacconiere et al. (2011) find no evidence of downward bias when these volatility estimates are voluntarily disclosed.

Taken together, the arguments developed support the idea that managers have discretion over volatility estimation. Contributions focused on statistical techniques also reveal that objective improvements can be made compared to historical volatility. However, the methods proposed do not necessarily produce homogeneous results, and it is uncertain whether practitioners will use such sophisticated models because of data availability issues. Drawing on the different arguments presented above, we state the following hypothesis:

H2: *The discretion available to companies as to the choice of volatility input in pricing models leads them to manage ESO fair value downwards.*

[12] According to the author's definitions, recognition refers to items that are included in subtotals appearing on the face of financial statements, while disclosure refers to items that appear as words, numbers, or descriptions in the footnotes.

III. IMPACT OF RELAXING MAJOR BSM MODEL ASSUMPTIONS

This section focuses on the fundamental arguments and developments that support our first hypothesis. We examine what happens when two assumptions of the BSM model are not made, the first assumption being that the contingent claim is tradable, and the second assumption being that there are no transaction costs when trading the underlying share. We will argue that due to market completeness, it makes no difference whether the first assumption is made or not. However, not making the second assumption can have an impact: for the seller of the contingent claim, its price can only stay the same or increase; the presence of transaction costs cannot lead to a price decrease from the seller's point of view.

Let us begin by examining the first assumption. Here, we assume that there are no transaction costs for trading the underlying share.

The Tradability Assumption

Let us consider the standard case studied by Black and Scholes (1973) where the contingent claim C is a European call option. There are two well-established ways of finding the price of C.

The original argument given by Black and Scholes (1973) is the *bond replication method*, in which a riskless and self-financing portfolio is created, comprising the stock and the call, that replicates the bond. However, not only is it difficult to rigorously apply the argument (Rosu and Stroock 2003), but, crucially, the method relies on the assumption that the claim C itself is tradable.

Under the second approach, the *call replication method* (Harrison and Pliska 1981), the stock and the bond are traded to replicate the call. This argument is much simpler, and does not require the call itself to be tradable. In the words of Harrison and Pliska (1981, 219), "We have focused on a market where only the stock and bond are traded, and we have discovered that investors can manufacture call options for themselves in this market at the price specified in the [Black-Scholes] formula." Such a market is called *complete*.

The call option can be perfectly replicated by a continuous hedging strategy. Even if it is not traded, its value can be uniquely determined as long as other assumptions of the BSM model hold, in particular the absence of transaction costs for trading the underlying. In fact, the call replication argument given above holds for a very general class of contingent claims (Harrison and Pliska 1981), including the claim with early exercise and barrier features considered in this paper. We therefore conclude that under the stated assumptions, the contingent claim can be perfectly replicated and has a unique price, even if it is not tradable.

We now assume that the contingent claim C is not tradable and examine the second assumption. We continue with the standard BSM assumptions, but now with *two* exceptions: the contingent claim C is non-tradable, and transaction costs are incurred when trading the underlying stock. These two assumptions correspond to the typical characteristics of employee stock options. We are now going to characterize the cost of C for the firm.

Non-tradability of the contingent claim combined with transaction costs for trading the underlying stock Again, let us take a step back and examine previous findings. There is a significant stream of literature on the topic of hedging contingent claims in the presence of transaction costs. Jouini and Kallal (1995) show in a very general framework encompassing a BSM model with transaction costs, that arbitrage-free prices of contingent claims lie in an interval [C_1, C_2]. In particular, they show (Theorem 3.2) that if there is an arbitrage-free frictionless price process S* that lies inside the bid-ask price process (S^{bid}, S^{ask}), then the price of the contingent claim E*[C] calculated under the martingale measure P* of S* lies inside this interval - that is, we have E*[C] ϵ [C_1, C_2].

Applied to our situation, in which we take the martingale process to be the BSM process, this means that the BSM model price of C, C*:= E*[C], lies inside the interval of arbitrage-free prices of C. We now argue that for the seller of C, its cost H(C) can only stay the same or increase, i.e. we must have C*≤ H(C). In fact, there are three cases to consider. In the first case, the seller already holds the underlying stock S, and pursues a simple "hold" strategy. Then, with transaction costs, the price of this strategy will stay the same. In the second case, the seller pursues a "buy-and-hold" strategy. The price of this strategy will increase with transaction costs. Finally, in the third case, the seller pursues a hedging strategy (for example delta-hedging). With transaction costs, the cost of this strategy will increase, regardless of the actual strategy.

These arguments show that, from the seller's point of view, the BSM price is a lower boundary for the cost of the contingent claim C. The empirical results that we present in Section IV will, however, show that the issue prices observed in expert reports are not in line with this analytical result.

Estimating the Impact of Transaction Costs on ESO Fair Value

How far above the model price the selling price should be set depends on the hedging strategy of the writer of the option, which in turn depends on his or her risk profile, and also on the amount and nature of transaction costs. Soner et al. (1995) point out that in a continuous-time Black-Scholes context, a dynamic hedging strategy has an infinite price. They therefore consider dominant strategies and show that a simple buy-and-hold strategy is the least expensive method of dominating a European call. Bensaid et al. (1992) also address the problem of finding the optimal portfolio among those that dominate a given derivative asset at maturity, and derive an interval for its price. They work with a discrete-time CRR model, show that a replicating portfolio exists, and find that the replicating strategy can be more expensive than a dominating strategy.

In order to obtain an estimate of the impact of transaction costs, we have simulated the BSM replication strategy (so-called "delta-hedging") for a standard European call option. At the start of the simulation, we calculate the delta of the option and borrow money to buy the corresponding number of shares, thus incurring certain transaction costs. After a given period, e.g. one week, we simulate the new share price, recalculate the “delta” and re-balance our position accordingly, again incurring transaction costs. The interest payment on the borrowed money for this period is also taken into account. We repeat this periodical re-balancing until the option matures. The amount of money spent on the hedging portfolio, including the transaction costs, plus the sum of the interest payments minus the strike price (if the option finishes in-the-money and is exercised) gives the total cost of this delta-hedging. Since this cost will depend on the simulated path for the share price, we repeat this simulation a large number of times and take the average hedging cost as our final result.

For example, our simulation of a seven-year maturity option, with volatility of 30%, weekly portfolio re-balancing, a risk-free rate of 3%, and a dividend yield of 3%, gives a 10% premium for proportional transaction costs of 0.25% (standard for liquid stocks). When considering a proportional transaction cost of 2.5% (which is more realistic for small or medium-sized companies with large bid-ask spreads), we find a premium of 63%.

To conclude, let us stress that we make no policy recommendation to companies on whether or how they should hedge. We find, however, that arguments which invoke illiquidity or transaction costs to arrive at a lower cost of a contingent claim from the claim seller’s point of view are invalid.

IV. DATA AND METHODOLOGY

The Redeemable Warrant as an ESO

The 2005 French Finance Act presented two attractive alternatives to stock options: restricted stocks and listed redeemable warrants. Although restricted stocks already existed at the time, their tax regime suddenly became far more favorable than that for stock options, especially with respect to social taxes. Yet, they rapidly lost this advantage again a few years later due to further changes in tax policy. Since 2005 redeemable warrants have, as the second alternative, come to illustrate the renewal of option-like share-based compensation in France. However, redeemable warrants can have multiple contractual specifications. Their basic characteristics are broadly similar to stock options (an option with a vesting period), with the main difference being that they are purchased by the recipients at the outset, resulting in an increase in the "paid-in capital" equity account. In addition, while stock-options can only be considered as share-based payment instruments, redeemable warrants can also be treated as financing instruments. Due to this particular feature, they provide the advantage of being listed when issued by companies present on financial markets. In such cases, mandatory issuance prospectuses are required to be approved by the French financial markets authority (the AMF), and thus a larger body of public information is available on redeemable warrants compared to stock-options. Initially designed during the early 1980s as a financing instrument, listed warrants had a redeemable feature to offer a sweetener to investors, mainly banks. After this initial period, the redeemable feature became obsolete for liquidity reasons and the impending euro-zone currency change. However, following the burst of the internet bubble in the early 2000s, small businesses began to search for new ways of financing. As a consequence, the redeemable warrant initially bought by banks was now sold separately and directly to existing shareholders without the attached bond. Free from the contractual restrictions existing for other forms of executive compensation, presenting real tax advantages, and with stock options being linked to a growing number of scandals over the period 2003-2005, redeemable warrants have come to be regarded as valuable substitutes for stock options.

Various different redeemable warrants exist in the French market: BAAR, BSAR, and BSAAR.[13] They have slightly different characteristics, but they are all relatives of American options. In this article, we will simply call these securities redeemable warrants or warrants. If a warrant is exercised, the holder pays the *strike price* fixed in the contract and obtains one share (or a fixed number of shares) in return. Apart from the product start date and the maturity date, three further important dates define the warrants. These are:

1. *The tradability date*: the date from which the warrant becomes tradable in the market and from which its owner has the right to sell it;
2. *The exercisability date*: the date from which the owner has the right to exercise the warrant; and
3. *The barrier activation date*: the earliest date from which the company may force the warrant holder to exercise the warrant (see the following paragraph for more information about the barrier).

In addition, (i) the warrant is not tradable between the start date and the tradability date; (ii) the exercise period is only from the exercisability date to the maturity date of the warrant, not over its full life; and (iii) the tradability and exercisability dates generally

[13] *Bons d'Acquisition d'Actions Remboursables, Bons de Souscription d'Acquisition Remboursables,* and *Bons de Souscription ou d'Acquisition d'Actions Remboursables*, respectively.

coincide.[14] These different features differ from American ESOs, which are exercisable at the end of the vesting period but not tradable. The barrier activation date is on or after the exercisability date. The conditions under which the company may force the exercise are as follows. There is an upper barrier, whose value is fixed in the contract, which may be activated by the company's board at any time after the barrier activation date. Typically, this barrier is quite far above the underlying spot price at issue (e.g. twice its value). The company must publicly announce that it intends to buy back the warrants. If the average stock price over a given number of business days preceding the announcement date is above the barrier level, then the company has the right to buy back the warrants at the symbolic price of €0.01. This contractual feature is a way of enforcing the exercise once the underlying is close to the given barrier over a certain period.

Sample Description and Methodology

In 2002, immediately after the 2001 crisis, redeemable warrants began to be issued on the French market, mostly represented by issues of bonds with a redeemable warrant attached. Over the period 2002-2012, 60 redeemable warrant issues have taken place. The initial issues, until 2005, were undertaken for financing motives. This date is important since it was the first year that IFRS became mandatory for companies in Europe and, secondly, from 2005 companies began offering redeemable warrant issues to executives. Since redeemable warrants are public securities, companies are required to provide an expert report on their valuation within the AMF prospectus. As our goal was to focus exclusively on ESOs, our sample includes the following different cases in which executives are the ultimate holders of the warrants:

[14] There are only two cases in our sample of a one-year exercisability window during which the warrant remains unlisted. We treat them in the same way as the other warrants in our sample, and assume that there is no possibility of early-exercise.

- Issues of bonds with a redeemable warrant attached, open to shareholders with a subsequent handover of warrants to executive managers only;
- Issues of bonds with a redeemable warrant attached or freestanding redeemable warrants as a public offering, which are partly bought up by executives;
- Reserved issues to banks where the detachable redeemable warrants are subsequently sold by the banks to executives only; and
- Direct issues of freestanding redeemable warrants reserved for executive managers.

Our sample is comprised of 44 warrant issues, after excluding issues observed before 2005[15] (14 cases), and issues undertaken for financing purposes (2 cases post-2005). The average maturity of these redeemable warrants is six years (seven years for the median), with a 2.1-year non-tradability period, equal to the non-exercisability period. The barrier is activated 1.3 years after the first listing, i.e. 3.4 years after issuance. The strike price is 25% (20% for the median) higher than the reference spot price and the barrier is twice the spot price. A minority of warrant issues present immediate tradability (18%), or no barrier (7%).

----------Insert Table 1 here----------

The sample presented in fact comprises the entire population since all redeemable warrants issued on the market with an option-like incentive feature have been taken into account. Finally, neither the prices nor the volatilities of our sample of 44 observations are normally distributed. Non-parametric statistical tests are thus required to highlight the pricing model misspecification that we are attempting to prove. Median tests that include confidence intervals and significance tests are therefore appropriate. We use two different non-parametric statistical tests: the Wilcoxon signed-ranks test and the Sign test.

[15] IFRS 2 was first applied to annual periods beginning on or after 1 January 2005. Pre-IFRS 2 issues have been excluded.

V. EMPIRICAL RESULTS ON PRICING MODEL MANAGEMENT

Proposal for a Pricing Model Benchmark

Some particular features of stock options are not applicable to redeemable warrants. In particular, there is no vesting or forfeitability condition, i.e. there is no clause stating that holders lose their claim if they leave the company. Instead, there is either a clause specifying that holders get their initial investment back in return for their derivatives, or there is no clause at all, implying that holders can continue to hold their derivatives. For simplicity we have assumed that all warrants fall into the latter case.[16]

We therefore propose the following simple valuation model. It is a slightly modified Cox-Ross-Rubinstein (CRR) binomial tree (Cox et al. 1979). It models the underlying share price in n equal time steps up to a maturity T, and takes into account the risk-free interest rate r, the dividend yield d, the spot stock price S_0, the strike price K, the maturity T, and the volatility σ.

We add two features to account for issues specific to redeemable warrants. First, at all nodes after $T_{exercisable}$, the inner value of the redeemable warrant is compared to its continuation value, and the higher of the two is recorded at the node. Second, at all nodes above the barrier level H, and after $T_{barrier}$, the value H is recorded. This is because $T_{barrier} \geq T_{exercisable}$ in the contract and the contract always leaves the option holder enough time to

[16] Models proposed by Hull and White (2004a, 2004b) incorporate the probability of the holder leaving the company before the tradability date. Historical executive turnover rates (forfeiture rates) are used to estimate this probability. But as Rubinstein (1995) remarks, there is an empirically negative correlation between the turnover rate and company performance. In a realistic model, therefore, lower turnover rates should be used for high share prices, and higher turnover rates for low share prices. This will clearly increase the option price.

exercise the option before the barrier clause “bites”. The parameters of the model are summarized in Table 2.

----------Insert Table 2 here----------

Appendix 1 sets out the value of the other model inputs. As volatility is considered to be one of the more subjective parameters and to have the largest impact on option pricing, we analyze it separately below.

Results

Our initial analysis compares the issue price and the price calculated by our pricing model. Both prices are calculated using the volatility given in the AMF prospectuses corresponding to the issue price. Our aim is to isolate the discount arising from the misspecification of the model.

The data in Table 3 show that the redeemable warrants used as executive incentive instruments present an average discount of 51% (median discount of 56%), which represents a significant benefit for the executives. These results offer a revealing insight into fair value practices for option-like share-based payment instruments.

----------Insert Table 3 here----------

Table 4 provides statistical confirmation of our previous observations since both tests on the median present significant differences at the 1% level of confidence. As an illustration, if we consider the case of Cap Gemini, a total of 2,999,000 warrants were offered. Taking the difference between our model price of €5.31 (for a volatility $\sigma = 30\%$) and the actual issue price of €3.22 and multiplying it by the number of warrants offered leads to a potential difference of €2.09 * 2,999,000 = €6,260,267, i.e. over six million euros.

----------Insert Table 4 here----------

Our results demonstrate the potential fair value management of option-like share-based payment instruments. The discounts observed on redeemable warrants invalidate our first hypothesis. Companies defining the issue price are downwards managing ESO fair value. Before examining the relative influence of pricing model management on this discount compared to discretion as to the choice of volatility, we firstly present some additional factors concerning pricing model assumptions.

Pricing Models Put into Perspective

To provide some support for these arguments, Table 5 presents an overview of valuation methods used by practitioners in their expert reports for the AMF. We observe that in most cases (73%), a CRR-modified tree is used. Another method is, jointly or not, observed in 61% of the expert reports. This is the use of a combination of vanilla options (priced using a BSM model) with different maturities in order to model both the non-tradability and the barrier of the redeemable warrant. We note that none of the experts justify the appropriateness of this last method in their reports. Moreover, the choice of certain parameters casts some doubt over the proper implementation of the valuation method compared to a CRR approach.

In addition, there are two major differences between the CRR implementation generally observed in the expert reports and the CRR valuation method that we use in our study. Firstly, the experts take into account a dilution that results in a discount in 55% of observed cases. Secondly, another discount of between 25% and 50% is also applied to the model price to reflect the initial non-tradability. The arguments provided are “past issue data” in 36% of observed cases, reference to academic literature (25%), transaction costs (18%), and a supplementary risk premium (48%).

----------Insert Table 5 here----------

As ESOs are meant to be sold at fair value, dilution should not be taken into account. Moreover, even if the effect of dilution does need to be incorporated, it is not done so correctly. The experts capture the dilution effect in their models by making the stock price jump downwards on the option maturity date. This should be performed at the beginning of the tree, not at the end: "stock prices are diluted when the market first hears about a stock option grant" (Hull 2012, 340), and not when the option is exercised, since market participants will anticipate the option's exercise. It is therefore inappropriate to include a downwards jump of the underlying share at the exercise date.

Academic literature seems to be rarely cited as a justification for a discount in practice. In Section III, we demonstrated that without transaction costs, there is no reason to deviate from the model price, either downwards or upwards. The additional risk premium is obtained by using a discount rate different from the risk-free rate in the CRR model. We emphasize that non-tradability does not influence the capacity of the executive to hedge his or her position on the stock exchange. In addition, relying on data from previous redeemable issues does not justify a discount if those previous issues were themselves incorrectly priced. Finally, transaction costs, the sole argument that could justifiably be taken into account, have been proven to be incorrectly treated as shown in Section III.

VI. EMPIRICAL RESULTS ON THE DISCRETIONARY CHOICE OF VOLATILITY

Preliminary Observations

Of the 44 issues, only two were issued by companies for which a market-quoted derivative of comparable maturity existed, and thus for which an implied volatility was available. These derivatives were generally redeemable warrants previously issued by the company, and in the expert reports the lack of liquidity was put forward to dismiss their implied volatility. Thus in general the experts only used a historical approach. Historical volatilities for different time lengths were computed in the expert reports, but volatilities based on short-term data (less than one year) were usually selected. A typical example is given by the following text from the expert report section of the Radiall 2007 AMF prospectus:

> "The volatility of a stock is a measure of uncertainty of the security's return. For a given date, it is measured by an annualized standard deviation of returns over a given period. The Radiall historical volatility, computed on the basis of the average of annualized weekly volatilities observed over the last twelve months, is 20%; or 19% taking observations over the last three months. The calculation has therefore been performed using volatility input assumptions of 19% and 20%."

In the case of Radiall, no other information was provided regarding the choice of volatility parameter. The experts decided to use the three-month and one-year volatility without justifying this choice. The horizon-matched volatility, advocated by standard setters, is never used. Sometimes a justification is provided. A typical justification is the following from the expert report section of the Gifi 2009 AMF prospectus:

> "Volatility taken over a period exceeding two years would depict the stock price behavior of a historical economic environment."

No other formal method is ever used. In general, the prospectuses provide a volatility range and the best pick. We take this best pick as the volatility input chosen by the expert. When no best pick is specified we use the midpoint of the range. In the rare cases where no volatility estimation is provided, we reversed our own pricing model to imply the volatility.

To illustrate the huge differences in volatilities, Table 6 presents our statistical median tests on the different types of volatilities found in Appendix 2. We see that the volatility chosen by experts differs significantly from both the horizon-matched volatility and the one-year volatility. This result challenges the experts' decision to retain a volatility other than the horizon-matched volatility recommended by standard setters, and raises the issue of forecasting future volatility. We observe that the realized volatility is statistically different from the horizon-matched volatility. This fact lends some weight to the experts' argument of rejecting the latter when valuing options. It also supports the argument of Jiang and Tian (2010), who propose a proxy future volatility using different maturities. Yet, compared to the realized volatility, we see that the volatility chosen by experts is statistically and significantly too low.

----------Insert Table 6 here----------

Overall, our results show that the volatility proxy retained by experts is systematically too low. Considered alongside Appendix 2, this observation indicates that the pricing model volatility inputs may be chosen with some discretion in order to reduce the cost of redeemable warrants. The result supports our second hypothesis indicating a certain amount of opportunism in the choice of pricing model volatility estimates. It is in line with the results of Bartov et al. (2007) and Choudhary (2011) based on US data, but different from those of Bechmann and Hjortshøj (2009) who use Danish data. The latter find little evidence that Danish firms manipulate the volatility estimate with the aim of underreporting under IFRS. We now attempt to assess whether similar results are also observable on prices.

Impact of Volatility on ESO Fair Value

Table 7 presents statistical tests on volatility medians keeping the same pricing model in order to isolate the volatility impact. We then compare the model price using the expert volatility to the price obtained with the same model but different volatilities. Unfortunately, due to the barrier effect in the pricing model, the impact of volatility on the option price is not a clear-cut issue. It is known that, close to the barrier, an increase in stock volatility reduces the price of the option. Consequently, the statistical difference observed in Table 6 between the two volatility variables “Expert” and “Max realized” is not as significant as for prices. For instance, we observe that the Sign test for medians comparing prices using the “Expert” volatility estimate and the “Max realized” volatility estimate is not statistically significant.

-----------Insert Table 7 here-----------

If we now consider the statistical differences in ESO prices resulting from the comparison of other volatility estimates (“Horizon matched” and “Year-1”) with the experts’ estimates, we find statistically significant results corroborating our previous results on volatility. Here again, the observed differences support the argument that companies use the latitude left by standard setters on volatility estimates to opportunistically lower the valuation of ESOs.

Combined Effect

We now turn to the combination of the two effects: the choice of pricing model and the choice of volatility input. As can be seen from Appendix 3, the largest impact clearly arises due to ad hoc model management. We observe a median discount of 56% when pricing redeemable warrants with our model and the experts’ volatility, and we reach a maximum of 71% when using the horizon-matched volatility. To further disentangle model and volatility effects, we attempt an overall calculation of robustness by isolating the volatility effect. The effect of the volatility estimate choice alone can be obtained by computing the discount between our model price using the horizon-matched volatility and our model price using the expert volatility. As a result (presented in Appendix 4), we find a 25% average and 21% median discount on the whole sample. This overall result corroborates the larger impact of pricing model management. Finally, Table 8 confirms that taking the two effects into account (model and volatility) results in statistically significant differences in redeemable warrant prices. The issuance offer prices validated by the experts are lower than the prices we obtain using our model and more appropriate volatility choices.

----------Insert Table 8 here----------

Continuing with the case of Cap Gemini as an illustration, we show the final monetary impact that should be considered. Taking the actual seven-year historical volatility σ = 48.66% leads to a model price of €9.64 and a difference of €19,151,776, i.e. over 19 million euros. As a comparison, Cap Gemini's 2009 net income was 178 million euros.

Illustrated by this particular case, our statistical analysis highlights the necessity of correctly calculating and accounting for the fair value of option-like share-based payment instruments. Regarding the accounting impact of the numerical example presented above, it supports the need for further clarification and harmonization of the fair value measurement guidelines for ESOs. Such an issue may be of interest to the market authorities in the future since the present situation could be seen as negatively affecting the shareholder value of non-recipient shareholders.

VII. DISCUSSION AND CONCLUSION

Relevance of the Transaction Costs Issue

The IASB has decided to exclude IFRS 2 from the scope of the recent IFRS 13.[17] The main reason is that the fair value of share-based payment is not based on the *best use of assets* since employees tend to exercise their options too early. Nevertheless, we note here the extent to which this new IFRS refining the notion of fair value accounts for the issue analyzed in this paper.

IFRS 13 explicitly states that fair value may be different depending on whether the option is an asset or a liability: “the fair value is the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants” (IFRS 13 2011). It also notes that a range of possible prices may exist but does not give precise guidance on which value should be considered (IFRS 13, §70 and §71).

Compared to IFRS 13, which does not exclude the possibility of taking any price within a bid-ask spread (especially those below the standard model price), our argument goes further since it asserts that the fair value of ESOs cannot be lower than a properly-calibrated standard model price.

Financing Instrument vs. Share-Based Payment

As warrants are sold to the executives, cash enters the balance sheet when they are issued. Warrants might then also be considered as financing instruments. Indeed, our case study shows that some issues of redeemable warrants, either alone or in conjunction with a bond offering, have taken place for financing rather than incentive purposes.

[17] See paragraph 6.a of IFRS 13

Yet, IFRS 2 is clear on this issue. If the characteristics of the instrument prove the existence of services received in exchange for the issue, it should be considered as a share-based payment. In our sample, restrictions of the issue to specific employees are proof that services are expected in return. Moreover, we conducted interviews with a number of audit firms which revealed that under French GAAP and even if there is no proof of expected services, auditors consider in practice that selling financial instruments to managers below their fair value triggers the use of IFRS 2.

It is true that hedging the stock-option could be costly for the employee. As a consequence, he or she should not be willing to buy the option at a price equal to or above the standard model price. We emphasize that our paper simply puts forward the fair value that should ultimately be taken into account. It is in fact possible for firms to issue ESOs at any price, even for free, as for the vast majority of stock options. Our analysis merely reveals that if this financial instrument is sold below the standard model price, a cost should be accounted for in the income statement. This cost should be equal to the difference between the model price and the actual issuing price.

Rules-Based Standards (US GAAP) versus Principles-Based Standards (IFRS)

Our study is focused on one class of ESO in an IFRS context. Two questions naturally arise. Firstly, how specific is the IFRS 2 setting in this case? In France, a discount based on a similar argument also appears to exist for employee shareholder plans (see IFRIC update, 2006).[18] Secondly, are similar discounts customary under US GAAP? Compared to principles-based standards (IFRS), rules-based standards (US GAAP) contain more scope exceptions, and are more lengthy and complex, but they also provide more detailed

[18] For instance the Total S.A. 2012 annual report states that "The cost of employee-reserved capital increases is immediately expensed. A discount reduces the expense in order to account for the *non-transferability* of the shares awarded to the employees over a period of five years."

explanations, acknowledge that less judgment is required, and have more bright-line thresholds (Bradbury and Schröder 2012). There is a large stream of literature suggesting that moving toward more principles-based standards is likely to result in improved financial reporting quality (Jamal and Hun-Tong 2010). In particular, managers seem less likely to report aggressively (Agoglia et al. 2011; Collins et al. 2012) and auditors appear more likely to constrain any such aggressive behavior (Cohen et al. 2013). SFAS 123R offers more precise guidance on ESOs than IFRS 2, and to our knowledge, the significant discounts presented in this paper have not been observed under SFAS 123R. We suggest that this is not by chance. In the case of pricing models used to fair value complex assets, rules can increase accuracy by limiting model management, and reduce the imprecision that leads to aggressive reporting choice. For instance, concerning a possible discount on model price, SFAS 123R clearly states that no additional discount (on top of a modified expected term) is appropriate for “non-hedgeability and non-transferability”.[19] Another example is the case of dilution where the standard offers more precise guidance, specifying that separate adjustment for potential dilutive effects should be *rare* for public companies. This qualification does not exist in IFRS 2. Finally, we suggest that the choice between principles-based and rules-based accounting might be better set at the standard level rather than at the general framework level.

Conclusion

[19] One interpretative response offered by the FASB is as follows: “FASB ASC paragraph 718-10-55-29 indicates that non-hedgeability and non-transferability have the effect of increasing the likelihood that an employee share option will be exercised before the end of its contractual term. Non-hedgeability and non-transferability therefore factor into the expected term assumption (in this case reducing the term assumption from ten years to six years), and the expected term reasonably adjusts for the effect of these factors. Accordingly, the staff believes that no additional reduction in the term assumption or other discount to the estimated fair value is appropriate for these particular factors”. (See http://www.sec.gov/interps/account/sabcodet14.htm#E).

In terms of valuing the cost of share-based payments, the applicable accounting standards (both IFRS 2 and SFAS 123R) assume that a pricing model, properly calibrated, gives only one price. However, these models are based on certain assumptions that may not hold in practice. Earlier literature has identified the issue of volatility, assumed to be known and constant in the BSM framework, although this is not the case in practice. This paper identifies a new issue, namely the existence of transaction costs, which makes hedging more costly. When transaction costs are incorporated, the BSM framework gives a range of admissible prices instead of one single price. The second contribution of this paper is to show that experts, when dealing with this issue, incorrectly take the lower bound of this interval. We argue that applying the relevant accounting standards should result in only those prices equal to or above the standard model price being considered. Our third contribution is to show that, for our sample, the volatility parameter is chosen too aggressively. Overall, we find an average discount of 64% compared to our fair value estimate for the French warrant issues examined.

The paper has immediate consequences for standard setters. Firstly, standards are silent on the transaction cost issue, and we show that this silence can be exploited in practice to lower the cost of share-based payments by a wide margin. Refinement of fair value under IFRS 13, although it notes the bid-ask spread issue, does not help because it allows any price in the interval to be taken, even for a liability. The second issue relates to the enforcement of standards, especially in terms of the choice of volatility parameter. It is clear that there is no consensus on how to choose this parameter. While standard setters recommend using horizon-matched volatility, our analysis corroborates previous studies by showing that this approach is not satisfactory for long-term options. Yet, based on our study, allowing companies to subjectively choose this parameter leads to undervaluation. One way to discipline companies would be to require transparency in terms of the choice of parameters. Market regulators should enforce the standard by being more vigilant on the disclosure of the volatility parameter–required by standard setters, but not always disclosed.

Our paper also offers avenues for further research. Firstly, one can study the model price of options for private companies whose shares are totally illiquid. The second issue, related to fair value, would be to take the taxation perspective into account, especially in terms of personal income tax. This still raises the question, however, of the uniqueness of fair value in specific cases, such as the option-like share-based payments examined in this paper.

Appendices

Appendix 1 – Other Model Inputs

Company	Interest rate	Dividend yield	Spot price	Strike price	Barrier
Delta plus groupe	2.72%	1.26%	27.20	23.00	35.00
Unilog	3.35%	1.00%	53.45	57.75	110.00
Orco	3.13%	2.00%	57.10	68.61	96.05
Eurofins	3.38%	0.00%	49.91	55.00	100.00
CS A	3.54%	2.50%	37.90	37.90	41.69
Havas	3.83%	0.80%	3.89	4.30	12.00
Touax	4.18%	3.00%	24.60	28.30	36.80
PCAS	4.50%	2.00%	5.74	6.89	8.27
Radiall B	4.72%	1.30%	105.00	121.00	200.00
Radiall A	4.76%	1.30%	105.00	126.00	220.00
Bonduelle	4.76%	1.80%	91.00	113.75	170.63
HF co	4.65%	2.00%	21.71	26.70	42.70
Groupe open	4.42%	1.50%	12.08	14.50	20.30
Carbone lorraine (Mersen)	4.20%	1.60%	53.17	58.49	111.13
Touax	3.46%	3.10%	32.65	37.55	NA
Havas	4.09%	1.60%	3.35	3.85	12.00
Promeo	4.00%	1.50%	56.70	70.88	99.23
EPI	4.00%	1.50%	9.00	11.70	16.38
Akka	3.66%	3.00%	11.30	13.80	30.00
LVL	4.00%	2.50%	17.50	21.88	30.63
Assystem	4.20%	2.50%	9.25	11.10	15.54
Stef Tfe	4.25%	0.00%	42.67	51.20	71.69
Keyrus	5.10%	0.00%	1.31	1.80	3.00
Nextradiotv	4.01%	0.00%	17.69	21.23	33.97
Team Partners	4.06%	0.00%	0.85	1.00	NA
Overlap	3.20%	2.50%	0.88	1.08	2.69
ITS	3.00%	4.50%	2.14	2.57	3.34
Bonduelle	3.23%	1.50%	57.30	80.00	100.00
Gifi	3.29%	3.62%	33.11	48.00	67.20
Access Commerce	2.92%	0.00%	0.55	0.72	0.94
Cap Gemini	3.21%	3.00%	26.73	34.00	100.00
Demos	3.34%	1.00%	10.00	12.50	17.00
Orpea	3.10%	0.60%	31.60	37.90	56.90
Ausy	3.05%	0.00%	14.00	17.00	25.50
MrBricolage	2.76%	4.28%	14.12	16.00	20.80
Micropole	3.04%	0.00%	0.79	1.05	1.47
Auplata	1.24%	0.00%	3.98	3.66	4.21
Cast	2.32%	0.00%	1.33	1.60	2.08
Eurofins	2.56%	0.31%	31.99	40.00	72.00
Team Partners	0.34%	0.00%	0.60	0.62	NA
Cegid 2	1.80%	5.00%	20.24	22.56	41.02
Cegid 1	1.61%	5.00%	20.24	22.56	41.02
SQLI	3.12%	0.00%	1.20	1.50	2.25
Devoteam	1.56%	4.40%	8.37	12.00	20.40

Appendix 2 – Volatilities

Company	Experts[a]	Horizon matched[b]	Year -1[c]	Max realized[d]
Delta plus groupe	0.20	0.30	0.31	0.32
Unilog	0.30	0.51	0.25	0.16
Orco	0.25	NA	0.29	0.66
Eurofins	0.30	0.43	0.40	0.37
CS A	0.10	0.41	0.28	0.46
Havas	0.20	0.50	0.26	0.35
Touax	0.20	0.28	0.21	0.29
PCAS	0.25	0.43	0.28	0.41
Radiall B	0.19	0.27	0.20	0.33
Radiall A	0.19	0.45	0.20	0.33
Bonduelle	0.18	0.25	0.31	0.37
HF co	0.25	0.50	0.56	0.44
Groupe open	0.19	0.41	0.21	0.37
Carbone lorraine (Mersen)	0.28	0.32	0.24	0.42
Touax	0.24	0.28	0.28	0.30
Havas	0.25	0.42	0.19	0.38
Promeo	0.22	NA	0.32	0.49
EPI	0.40	0.63	0.48	0.77
Akka	0.27	NA	0.33	0.38
LVL	0.30	0.73	0.32	0.55
Assystem	0.36	0.52	0.34	0.33
Stef Tfe	0.22	0.26	0.27	0.18
Keyrus	0.30	0.54	0.36	0.45
Nextradiotv	0.28	NA	0.35	0.31
Team Partners	0.71	NA	0.68	0.51
Overlap	0.37	0.46	0.37	0.50
ITS	0.35	0.50	0.48	0.29
Bonduelle	0.28	0.25	0.31	0.41
Gifi	0.20	0.36	0.22	0.28
Access Commerce	0.62	0.58	0.81	0.41
Cap Gemini	0.35	0.49	0.56	0.30
Demos	0.26	NA	0.32	0.38
Orpea	0.25	0.30	0.44	0.16
Ausy	0.31	0.43	0.22	0.22
MrBricolage	0.31	0.36	0.37	0.21
Micropole	0.43	0.46	0.54	0.32
Auplata	1.00	1.08	1.08	0.44
Cast	0.40	0.47	0.36	0.50
Eurofins	0.37	0.38	0.36	0.35
Team Partners	0.40	0.44	0.56	0.50
Cegid 2	0.30	0.39	0.33	0.30
Cegid 1	0.30	0.40	0.33	0.30
SQLI	0.31	0.35	0.28	0.32
Devoteam	0.33	0.37	0.36	0.29
Observations	44	38	44	44
Mean	0.31	0.43	0.37	0.37
Median	0.29	0.42	0.33	0.36
Std. Deviation	0.15	0.15	0.17	0.12
Minimum	0.10	0.25	0.19	0.16
Maximum	1.00	1.08	1.08	0.77

[a] The volatility retained by experts for the company.
[b] The volatility observed over a historical period of the same length as the forecasted life of the option. If insufficient historical data were available, we retained the longest historical period available.
[c] The volatility observed over the 12-month period prior to issuance.
[d] The realized volatility observed since the issuance date using all available data.

Appendix 3 – Prices and Discounts on Issue Price

Company	Issue Price	Experts		Horizon matched		Year-1		Max realized	
		Price	Disount	Price	Discount	Price	Discount	Price	Discount
Delta plus groupe	1.38	6.80	80%	7.83	82%	7.88	82%	8.07	83%
Unilog	2.25	12.21	82%	11.86	81%	11.71	81%	9.79	77%
Orco	3.35	9.20	64%	NA	NA	13.03	74%	23.50	86%
Eurofins	3.00	11.88	75%	11.60	74%	11.73	74%	11.86	75%
CS A	0.67	1.51	56%	7.49	91%	5.63	88%	7.97	92%
Havas	0.34	0.93	63%	1.40	76%	1.09	69%	1.30	74%
Touax	0.44	0.75	41%	1.07	59%	0.78	44%	1.16	62%
PCAS	0.73	0.97	25%	1.66	56%	1.09	33%	1.62	55%
Radiall B	6.00	14.62	59%	20.85	71%	15.67	62%	24.77	76%
Radiall A	8.00	20.85	62%	43.61	82%	22.08	64%	32.92	76%
Bonduelle	7.45	14.08	47%	19.73	62%	24.26	69%	29.06	74%
HF co	2.00	4.00	50%	4.79	58%	4.71	58%	4.78	58%
Groupe open	0.79	2.13	63%	4.32	82%	2.32	66%	3.93	80%
Carbone lorraine (Mersen)	12.00	12.15	1%	13.62	12%	10.84	-11%	16.53	27%
Touax	3.60	4.90	27%	5.91	39%	6.05	41%	6.43	44%
Havas	0.34	0.81	58%	1.14	70%	0.64	46%	1.09	69%
Promeo	4.76	10.26	54%	NA	NA	15.06	68%	22.91	79%
EPI	1.20	2.89	58%	4.44	73%	3.49	66%	5.23	77%
Akka	0.70	1.77	60%	NA	NA	2.31	70%	2.76	75%
LVL	2.20	3.90	44%	9.34	76%	4.19	47%	7.36	70%
Assystem	1.40	2.65	47%	3.74	63%	2.50	44%	2.43	42%
Stef Tfe	4.14	10.58	61%	12.05	66%	12.54	67%	9.20	55%
Keyrus	0.20	0.30	33%	0.36	45%	0.33	39%	0.35	43%
Nextradiotv	1.68	3.39	50%	NA	NA	3.63	54%	3.50	52%
Team Partners	0.63	0.65	4%	NA	NA	0.64	1%	0.54	-18%
Overlap	0.08	0.25	68%	0.32	75%	0.25	69%	0.35	77%
ITS	0.29	0.39	25%	0.60	51%	0.57	49%	0.30	2%
Bonduelle	4.73	8.66	45%	7.76	39%	9.75	51%	13.40	65%
Gifi	1.53	1.88	18%	5.62	73%	2.32	34%	3.71	59%
Access Commerce	0.06	0.10	38%	0.10	39%	0.09	37%	0.09	34%
Cap Gemini	3.22	6.50	50%	9.64	67%	11.14	71%	5.38	40%
Demos	0.91	2.08	56%	NA	NA	2.53	64%	2.98	70%
Orpea	2.70	5.19	48%	6.44	58%	9.43	71%	2.81	4%
Ausy	1.25	3.16	60%	4.31	71%	2.23	44%	2.15	42%
MrBricolage	0.80	2.39	67%	2.85	72%	2.94	73%	1.42	43%
Micropole	0.09	0.29	69%	0.31	71%	0.36	75%	0.22	58%
Auplata	0.00	0.08	100%	0.08	100%	0.08	100%	0.08	100%
Cast	0.19	0.32	41%	0.38	49%	0.28	33%	0.39	52%
Eurofins	1.60	4.86	67%	4.96	68%	4.75	66%	4.62	65%
Team Partners	0.03	0.03	1%	0.03	12%	0.04	32%	0.04	23%
Cegid 2	1.30	3.26	60%	4.65	72%	3.75	65%	3.24	60%
Cegid 1	1.50	3.06	51%	4.61	67%	3.52	57%	3.04	51%
SQLI	0.11	0.35	69%	0.39	72%	0.32	66%	0.36	70%
Devoteam	0.40	1.15	65%	1.37	71%	1.33	70%	0.93	57%
Observations	44	44	44	38	38	44	44	44	44
Mean	2.05	4.50	51%	6.35	64%	5.45	57%	6.47	58%
Median	1.28	2.77	56%	4.52	71%	3.21	65%	3.14	61%
Std. Deviation	2.48	4.94	21%	8.13	18%	6.02	21%	8.33	24%
Minimum	0.00	0.03	1%	0.03	12%	0.04	-11%	0.04	-18%
Maximum	12.00	20.85	100%	43.61	100%	24.26	100%	32.92	100%

See Appendix 2 for variable definitions

Appendix 4 – Prices and Discounts on Model Price Using Expert Volatility

Company	Model Price Expert Vol	Horizon matched		Year-1		Max realized	
		Price	Discount	Price	Discount	Price	Discount
Delta plus groupe	6.80	7.83	13%	7.88	14%	8.07	16%
Unilog	12.21	11.86	-3%	11.71	-4%	9.79	-25%
Orco	9.20	NA	NA	13.03	29%	23.50	61%
Eurofins	11.88	11.60	-2%	11.73	-1%	11.86	0%
CS A	1.51	7.49	80%	5.63	73%	7.97	81%
Havas	0.93	1.40	34%	1.09	15%	1.30	28%
Touax	0.75	1.07	30%	0.78	4%	1.16	35%
PCAS	0.97	1.66	42%	1.09	11%	1.62	40%
Radiall B	14.62	20.85	30%	15.67	7%	24.77	41%
Radiall A	20.85	43.61	52%	22.08	6%	32.92	37%
Bonduelle	14.08	19.73	29%	24.26	42%	29.06	52%
HF co	4.00	4.79	17%	4.71	15%	4.78	16%
Groupe open	2.13	4.32	51%	2.32	8%	3.93	46%
Carbone lorraine (Mersen)	12.15	13.62	11%	10.84	-12%	16.53	27%
Touax	4.90	5.91	17%	6.05	19%	6.43	24%
Havas	0.81	1.14	29%	0.64	-28%	1.09	25%
Promeo	10.26	NA	NA	15.06	32%	22.91	55%
EPI	2.89	4.44	35%	3.49	17%	5.23	45%
Akka	1.77	NA	NA	2.31	23%	2.76	36%
LVL	3.90	9.34	58%	4.19	7%	7.36	47%
Assystem	2.65	3.74	29%	2.50	-6%	2.43	-9%
Stef Tfe	10.58	12.05	12%	12.54	16%	9.20	-15%
Keyrus	0.30	0.36	18%	0.33	9%	0.35	16%
Nextradiotv	3.39	NA	NA	3.63	6%	3.50	3%
Team Partners	0.65	NA	NA	0.64	-2%	0.54	-22%
Overlap	0.25	0.32	21%	0.25	1%	0.35	28%
ITS	0.39	0.60	35%	0.57	32%	0.30	-31%
Bonduelle	8.66	7.76	-12%	9.75	11%	13.40	35%
Gifi	1.88	5.62	67%	2.32	19%	3.71	49%
Access Commerce	0.10	0.10	0%	0.09	-3%	0.09	-7%
Cap Gemini	6.50	9.64	33%	11.14	42%	5.38	-21%
Demos	2.08	NA	NA	2.53	18%	2.98	30%
Orpea	5.19	6.44	19%	9.43	45%	2.81	-85%
Ausy	3.16	4.31	27%	2.23	-42%	2.15	-47%
MrBricolage	2.39	2.85	16%	2.94	19%	1.42	-69%
Micropole	0.29	0.31	7%	0.36	20%	0.22	-35%
Auplata	0.08	0.08	0%	0.08	0%	0.08	-3%
Cast	0.32	0.38	14%	0.28	-15%	0.39	18%
Eurofins	4.86	4.96	2%	4.75	-2%	4.62	-5%
Team Partners	0.03	0.03	11%	0.04	31%	0.04	22%
Cegid 2	3.26	4.65	30%	3.75	13%	3.24	-1%
Cegid 1	3.06	4.61	34%	3.52	13%	3.04	-1%
SQLI	0.35	0.39	10%	0.32	-9%	0.36	3%
Devoteam	1.15	1.37	16%	1.33	13%	0.93	-25%
Observations	44	38	38	44	44	44	44
Mean	4.50	6.35	24%	5.45	12%	6.47	12%
Median	2.77	4.52	20%	3.21	12%	3.14	17%
Std. Deviation	4.94	8.13	20%	6.02	20%	8.33	35%
Minimum	0.03	0.03	-12%	0.04	-42%	0.04	-85%
Maximum	20.85	43.61	80%	24.26	73%	32.92	81%

See Appendix 2 for variable definitions

Tables

Table 1 – Main Features of Redeemable Warrants

Company	Ticker	Issue date	Maturity[a]	Tradable after	Exerciseable after	Barrier enforceable after	Strike / Spot	Barrier / Strike
Delta plus groupe	DLTA	05/25/05	5.0	0.0	0.0	0.5	85%	152%
Unilog	UNG	05/31/05	7.0	5.0	5.0	5.0	108%	190%
Orco	ORC	11/18/05	7.0	0.0	0.0	2.0	361%	140%
Eurofins	ERF	03/14/06	7.0	5.0	5.0	5.0	110%	182%
CS A	SX	06/09/06	3.0	2.0	2.0	2.0	100%	110%
Havas	HAV	12/01/06	7.0	4.0	4.0	4.0	111%	279%
Touax	TOUP	03/08/07	5.0	0.0	0.0	3.0	115%	130%
PCAS	PCA	06/22/07	5.5	0.0	0.0	3.5	120%	120%
Radiall B	RLL	07/18/07	4.0	2.0	2.0	3.0	115%	165%
Radiall A	RLL	07/18/07	7.0	3.0	3.0	5.0	120%	175%
Bonduelle	BON	07/25/07	7.0	2.0	3.0	5.0	125%	150%
HF co	HF	08/03/07	7.0	3.0	3.0	3.0	123%	160%
Groupe open	OPN	10/19/07	7.0	2.0	2.0	5.0	120%	140%
Carbone lorraine (Mersen)	MRN	11/30/07	5.0	0.0	0.0	0.0	110%	190%
Touax	TOUP	01/01/08	5.2	0.2	0.2	NA	115%	NA
Havas	HAV	02/08/08	7.0	4.0	4.0	4.0	115%	312%
Promeo	ALMEO	02/11/08	7.0	2.0	2.0	5.0	125%	140%
EPI	EHO	02/15/08	7.0	2.0	2.0	5.0	130%	140%
Akka	AKA	04/04/08	5.0	2.0	2.0	3.0	122%	217%
LVL	LVL	05/01/08	7.0	2.0	2.0	5.0	125%	140%
Assystem	ASY	07/11/08	7.0	2.0	2.0	5.0	120%	140%
Stef Tfe	STF	07/21/08	7.0	2.0	2.0	5.0	120%	140%
Keyrus	KEY	08/12/08	6.0	3.0	2.0	3.0	137%	167%
Nextradiotv	NXTV	11/07/08	5.0	3.0	3.0	3.0	120%	160%
Team Partners	TIPA	11/14/08	10.0	10.0	10.0	NA	118%	NA
Overlap	OVG	12/30/08	7.0	2.0	2.0	5.0	123%	249%
ITS	ITS	02/25/09	5.0	0.0	0.0	3.0	120%	130%
Bonduelle	BON	04/07/09	7.0	1.5	2.0	3.0	140%	125%
Gifi	IGF	07/08/09	6.0	0.0	0.0	3.0	145%	140%
Access Commerce	CAM	07/16/09	5.0	1.0	1.0	1.0	131%	131%
Cap Gemini	CAP	07/20/09	7.0	4.0	4.0	4.2	127%	294%
Demos	ALDMO	07/28/09	7.0	0.0	1.5	4.0	125%	136%
Orpea	ORP	08/15/09	6.0	2.0	2.0	3.0	120%	150%
Ausy	OSI	10/20/09	7.0	2.0	2.0	3.0	121%	150%
MrBricolage	MRB	11/19/09	5.0	2.0	2.0	3.0	113%	130%
Micropole	MUN	12/16/09	7.0	3.0	3.0	5.0	133%	140%
Auplata	ALAUP	02/26/10	1.0	0.0	0.0	0.0	92%	115%
Cast	CAS	06/03/10	5.0	2.0	1.0	5.0	120%	130%
Eurofins	ERF	06/29/10	7.0	2.0	2.0	2.0	125%	180%
Team Partners	TIPA	07/12/10	0.4	0.0	0.0	NA	103%	NA
Cegid 2	CGD	11/03/10	6.0	3.0	3.0	3.2	111%	182%
Cegid 1	CGD	11/03/10	5.0	2.0	2.0	2.2	111%	182%
SQLI	SQI	03/01/11	7.0	3.0	3.0	5.0	125%	150%
Devoteam	DVT	10/19/12	7.0	2.0	2.0	2.0	143%	170%
Observations			44	44.0	44.0	41.0	44	41
Mean			6.0	2.1	2.1	3.4	125%	164%
Median			7.0	2.0	2.0	3.0	120%	150%
Std. Deviation			1.7	1.8	1.8	1.5	38%	46%
Minimum			0.4	0.0	0.0	0.0	85%	110%
Maximum			10.0	10.0	10.0	5.0	361%	312%

[a] The different variables "Maturity", "Exercisable after", and "Barrier enforceable after" are expressed in decimal years from the date of issuance.

Table 2 – Pricing Model Parameters

Symbol	Description
T_0	Start date
S_0	Share price
K	Strike price
H	Barrier price
r	Risk-free interest rate
d	Dividend yield
$T_{tradable}$	Date instrument becomes tradable
$T_{exercisable}$	Date instrument becomes exercisable
$T_{barrier}$	Date from which barrier can be activated
$T_{maturity}$	Maturity date
σ	Volatility
# Steps	Time steps in binomial tree

Table 3 – Discount Retaining Expert Volatility

Company	Issue price[a]	Model price[b]	Discount[c]
Delta plus groupe	1.38	6.80	80%
Unilog	2.25	12.21	82%
Orco	3.35	9.20	64%
Eurofins	3.00	11.88	75%
CS A	0.67	1.51	56%
Havas	0.34	0.93	63%
Touax	0.44	0.75	41%
PCAS	0.73	0.97	25%
Radiall B	6.00	14.62	59%
Radiall A	8.00	20.85	62%
Bonduelle	7.45	14.08	47%
HF co	2.00	4.00	50%
Groupe open	0.79	2.13	63%
Carbone lorraine (Mersen)	12.00	12.15	1%
Touax	3.60	4.90	27%
Havas	0.34	0.81	58%
Promeo	4.76	10.26	54%
EPI	1.20	2.89	58%
Akka	0.70	1.77	60%
LVL	2.20	3.90	44%
Assystem	1.40	2.65	47%
Stef Tfe	4.14	10.58	61%
Keyrus	0.20	0.30	33%
Nextradiotv	1.68	3.39	50%
Team Partners	0.63	0.65	4%
Overlap	0.08	0.25	68%
ITS	0.29	0.39	25%
Bonduelle	4.73	8.66	45%
Gifi	1.53	1.88	18%
Access Commerce	0.06	0.10	38%
Cap Gemini	3.22	6.50	50%
Demos	0.91	2.08	56%
Orpea	2.70	5.19	48%
Ausy	1.25	3.16	60%
MrBricolage	0.80	2.39	67%
Micropole	0.09	0.29	69%
Auplata	0.00	0.08	100%
Cast	0.19	0.32	41%
Eurofins	1.60	4.86	67%
Team Partners	0.03	0.03	1%
Cegid 2	1.30	3.26	60%
Cegid 1	1.50	3.06	51%
SQLI	0.11	0.35	69%
Devoteam	0.40	1.15	65%
Observations	44	44	44
Mean	2.05	4.50	51%
Median	1.28	2.77	56%
Std. Deviation	2.48	4.94	21%
Minimum	0.00	0.03	1%
Maximum	12.00	20.85	100%

[a] The issue price observed in the issuance prospectus.
[b] Calculated with a CRR pricing model using the volatility presented in the prospectus.
[c] The discount is the difference between the issue price and the model price.

Table 4 – Median Tests on Prices Retaining Expert Volatility

	Ranks	Frequencies	Mean rank	Sum of ranks	Wilcoxon Signed Ranks Test		Sign Test	
					Z	p-value	Z	p-value
Model - Issue	Negative ranks	0	0	0	-5.777***	0.000	-6.482***	0.000
	Positive ranks	44	22.5	990				
	Ties	0						
	Total	44						

*,**,*** Denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 5 – Valuation Methods and Discount Arguments

Company	Valuation methods[a]			Discount arguments[b]				
	CRR[c]	Vanilla combination[d]	Monte Carlo[e]	Past data[f]	Academic literature[g]	Transaction costs[h]	Dilution[i]	Risk premium[j]
Delta plus groupe	1	0	0	0	0	0	0	0
Unilog	0	1	0	1	0	0	0	0
Orco	1	0	0	1	0	0	0	0
Eurofins	0	1	0	0	0	0	0	0
CS A	0	1	0	1	0	0	1	1
Havas	1	1	0	0	1	0	1	1
Touax	1	1	0	0	0	0	0	1
PCAS	1	0	0	1	0	0	0	0
Radiall B	1	1	0	0	0	0	1	1
Radiall A	1	1	0	0	0	0	1	1
Bonduelle	1	1	0	0	0	0	1	1
HF co	1	0	0	0	0	0	0	1
Groupe open	1	1	0	0	0	0	1	1
Carbone lorraine (Mersen)	1	0	0	0	0	0	0	0
Touax	1	0	0	0	1	1	0	0
Havas	0	1	0	0	0	0	0	1
Promeo	1	1	0	0	0	0	1	1
EPI	1	1	0	0	0	0	1	1
Akka	1	1	0	0	0	0	1	1
LVL	1	1	0	0	0	0	1	1
Assystem	1	1	0	0	0	0	1	1
Stef Tfe	1	0	0	1	1	1	1	0
Keyrus	0	1	1	0	0	0	0	0
Nextradiotv	0	1	0	1	0	1	1	1
Team Partners	0	1	1	0	1	0	0	0
Overlap	1	0	0	1	1	1	1	0
ITS	0	1	0	0	0	0	0	0
Bonduelle	1	0	0	1	0	0	1	1
Gifi	1	0	0	0	0	0	0	0
Access Commerce	0	1	0	1	0	0	1	0
Cap Gemini	1	0	0	1	1	1	1	0
Demos	1	1	0	0	0	1	1	1
Orpea	1	1	0	0	0	0	1	1
Ausy	1	1	0	0	0	0	1	1
MrBricolage	1	0	0	1	1	0	1	0
Micropole	1	1	0	0	0	0	1	1
Auplata	0	0	0	0	0	0	0	0
Cast	0	1	0	1	0	0	0	0
Eurofins	1	0	0	1	1	0	1	0
Team Partners	0	1	0	0	0	0	0	0
Cegid 2	1	0	0	1	1	1	0	0
Cegid 1	1	0	0	1	1	1	0	0
SQLI	1	1	0	0	0	0	1	1
Devoteam	1	0	0	1	1	0	0	0
Observations	44	44	44	44	44	44	44	44
Mean	0.73	0.61	0.04	0.36	0.25	0.18	0.55	0.48
Median	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00
Std. Deviation	0.45	0.49	0.21	0.49	0.44	0.39	0.50	0.51
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a] Valuation methods are those used in the issuance prospectus expert reports

[b] The discount observed on the model price is justified by a series of different arguments in the issuance prospectuses

[c] A Cox-Ross-Rubinstein type binomial tree is used to price the warrant. The tree is modified to deal with the barrier and the American early-exercise feature.

[d] The warrant's price is approximated by a combination of European options with different strikes and maturities in order to capture the barrier and the American early-exercise features.

[e] A Monte-Carlo simulation is run to price the warrant.

[f] The illiquidity discount is justified by examining the discounts applied to previously issued warrants. In several cases, a linear regression is run on past data to obtain the average illiquidity discount applied in a given year.

[g] The illiquidity discount is justified by academic studies.

[h] The illiquidity discount is justified by transaction costs.

[i] It is argued that if the company issues new shares when the warrants are exercised, the share price drops at this time by an amount corresponding to the resulting dilution of the shares.

[j] During the non-tradability period of the warrant, the discount rate r applied in a pricing model, such as a CRR type tree, is not the risk-free rate, but a higher, risk-adjusted rate.

Table 6 – Median Tests on Volatility

	Ranks	Frequencies	Mean rank	Sum of ranks	Wilcoxon Signed Ranks Test		Sign Test	
					Z	p-value	Z	p-value
Experts - Horizon matched	Negative ranks	2	6.00	12.00	-5.199***	0.000	-5.353***	0.000
	Positive ranks	36	20.25	729.00				
	Ties	0						
	Total	38						
Experts - Year-1	Negative ranks	9	16.56	149.00	-4.038***	0.000	-3.769***	0.000
	Positive ranks	35	24.03	841.00				
	Ties	0						
	Total	44						
Experts - Max realized	Negative ranks	16	16.44	263.00	-2.708***	0.007	-1.658*	0.097
	Positive ranks	28	25.96	727.00				
	Ties	0						
	Total	44						
Horizon matched - Year-1	Negative ranks	25	21.80	545.00	-2.919***	0.004	-1.973**	0.049
	Positive ranks	12	13.17	158.00				
	Ties	1						
	Total	38						
Horizon matched - Max realized	Negative ranks	26	22.33	580.50	-3.046***	0.002	-2.109**	0.035
	Positive ranks	12	13.38	160.50				
	Ties	0						
	Total	38						
Year-1 - Max realized	Negative ranks	20	21.25	425.00	-0.817	0.414	-0.452	0.651
	Positive ranks	24	23.54	565.00				
	Ties	0						
	Total	44						

*,**,*** Denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 7 – Volatility Impact on Prices

	Ranks	Frequencies	Mean rank	Sum of ranks	Wilcoxon Signed Ranks Test		Sign Test	
					Z	p-value	Z	p-value
Experts - Horizon matched	Negative ranks	4	12.13	48.50	-4.670***	0.000	-4.704***	0.000
	Positive ranks	34	20.37	692.50				
	Ties	0						
	Total	38						
Experts - Year-1	Negative ranks	12	14.42	173.00	-3.758***	0.000	-2.864***	0.004
	Positive ranks	32	25.63	817.00				
	Ties	0						
	Total	44						
Experts - Max realized	Negative ranks	17	16.41	279.00	-2.521**	0.000	-1.357	0.175
	Positive ranks	27	26.33	711.00				
	Ties	0						
	Total	44						

*,**,*** Denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 8 – Combined Effect on Prices (Model and Volatility)

	Ranks	Frequencies	Mean rank	Sum of ranks	Wilcoxon Signed Ranks Test		Sign Test	
					Z	p-value	Z	p-value
Issue - Horizon matched	Negative ranks	0	0.00	0.00	-5.373***	0.000	-6.002***	0.000
	Positive ranks	38	19.50	741.00				
	Ties	0						
	Total	38						
Issue - Year-1	Negative ranks	1	19.00	19.00	-5.555***	0.000	-6.181***	0.000
	Positive ranks	43	22.58	971.00				
	Ties	0						
	Total	44						
Issue - Max realized	Negative ranks	1	5.00	5.00	-5.718***	0.000	-6.181***	0.000
	Positive ranks	43	22.91	985.00				
	Ties	0						
	Total	44						

*,**,*** Denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

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