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Early Exercise Behaviour in Performance-vested Stock Option Grants*

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Stock options in executive compensation packages influence risk taking behaviour through the sensitivities of executive wealth to stock price (delta) and stock return volatility (vega). In the context of performance-vested stock options (PVSOs), this paper carries out a sensitivity analysis of the PVSO value and incentives to examine the effect of considering the executive's early exercise behaviour that arises from risk aversion in the valuation framework. The results show the importance of taking into account voluntary early exercise in order to avoid the overvaluation of PVSO value and risk incentives, particularly when the PVSO is in-the-money. It will allow us to obtain correct conclusions about delta and vega and their effects on executive risk-taking behaviour.

Key Words: Performance-vested stock options; Voluntary early exercise; Incentives; Delta; Vega.

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1. INTRODUCTION

Since the 1980s, stock options have become increasingly common in executive compensation packages (Frydman and Saks, 2010; Murphy, 2013). Executive stock options (ESOs) influence risk taking behaviour through the sensitivity of executive wealth to stock price (delta) and the sensitivity of executive wealth to stock return volatility (vega) (Armstrong and Vashishtha, 2012; Baixauli-Soler, Belda-Ruiz, and Sanchez-Marin, 2015; Brockman, Martin, and Unlu, 2010; Coles, Daniel, and Naveen, 2006; Fargher, Jiang, and Yangxin, 2014). A growing literature on the risk incentives that options give executives suggests including performance-vesting conditions in option plans to create stronger incentives that alter executive risk behaviour (Bettis, Bizjak, Coles, and Kalpathy, 2015; Johnson and Tian, 2000). In this particular case of ESOs, known as performance-vested stock options (PVSOs), the firm links the option vesting to the achievement of performance targets, normally defined in terms of the firm's stock price appreciation (Bettis, Bizjak, Coles, and Kalpathy, 2010). The incorporation of performance-vesting conditions changes the classical context of the risk taking effect caused by stock options, and therefore it may lead executives to change their risk taking behaviour (Dolan, Elliot, Metcalfe, and Vlaev, 2012).

From the classical perspective of agency theory (Jensen and Meckling, 1976), stock options in executive compensation packages are considered a useful mechanism to mitigate problems associated with executive risk aversion. However, agency-based models assume that executives hold consistent risk preferences, and this premise contradicts behavioural decision theory (Kahneman and Tversky, 1979). Drawing on agency and prospect theory views, the behavioural agency model (BAM) (Wiseman and Gomez-Mejia, 1998) relaxes the assumption that executives hold consistent risk preferences. Building on the concept of loss aversion developed in the framework of original prospect theory (Kahneman and Tversky, 1979), BAM considers

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that executives may exhibit risk-seeking as well as risk-averse behaviour. This difference in risk taking behaviour depends on executive risk bearing, that is, the perceived risk to executive wealth.

Because of the higher risk bearing created by positively valued stock options (Wiseman and Gomez-Mejia, 1998), executives usually decide to exercise their options early when they are deep in-the-money (Abudy and Benninga, 2013; Bettis, Bizjak, and Lemmon, 2005; Boyd, Brown, and Szimayer, 2007; Brooks, Chance, and Cline, 2012; Carpenter, 1998; Huddart and Lang, 1996; Marquardt, 2002). The fact of exercising options early has been shown in the prior literature as an evidence of higher risk aversion (Huang and Kisgen, 2013). Through this early exercise, executives collect the payoff (i.e., current wealth) in exchange for remaining the fewer possibilities for increasing their wealth in the near future (i.e., prospective wealth). This early exercise behaviour reflects, thus, the level of executive risk aversion and depends on the level of risk that executives are willing to bear.

Drawing on the classical option valuation theory, early exercise behaviour does not influence the value of a call option; considering that there is no dividend yield, the value of a European call option is equal to the value of an American call option. The reason is that the value from exercising is below the expected value of the prospective wealth. Then, the possibility of an early exercise does not provide any additional benefit, and therefore the objective valuation of stock options does not take into account the early exercise which depends on the executive's desire (Wu and Lin, 2013). However, it is extremely important to value stock options and their incentives considering executives' voluntary early exercise in order to obtain concluding remarks about their effects on executive risk-taking behaviour (Álvarez-Díez, Baixauli-Soler, and Belda-Ruiz, 2014; Leung and Sircar, 2009), which leads to a different valuation framework (Cvitanic, Wiener, and Zapatero, 2008).

Thus, the main goal of this paper is to carry out a sensitivity analysis of the option value and executives' incentives to increase stock price and volatility, delta and vega, in the context of PVSOs and voluntary early exercise behaviour. Previous studies have focused on valuing PVSOs without considering early exercise (Johnson and Tian, 2000) or taking into account early exercise caused by job termination (Wu and Lin, 2013), but they have not captured early exercise caused by executives' desire to collect the perceived current wealth. The fact of considering performance-vesting condition and voluntary early exercise within the same valuation framework makes, therefore, an important contribution to the existing literature. It allows us to show the error committed due to the overvaluation or undervaluation of PVSO value and risk incentives, which arises from ignoring the executive's early exercise behaviour.

The rest of the paper is organized as follows. Section 2 sets out the theoretical framework. In Section 3, we provide the methodological framework for valuing PVSOs. In Section 4, we describe the parameters used in the sensitivity analysis of PVSO incentives. Section 5 presents the results, including the sensitivity analysis of PVSO value and incentives and a real option programme. Finally, Section 6 includes concluding remarks.

2. THEORETICAL FRAMEWORK

Agency theory is the dominant framework for studying ESOs, their incentive effects and their influence on executive risk-taking behaviour (Jensen and Meckling, 1976). According to this classical theoretical perspective, executives are considered risk averse and stock options help to align the interests of executives to those of shareholders and overcome the executives' risk aversion. In particular, stock options encourage executives to take more risk in search of increasing the firm's stock price, and therefore the value of their options (i.e., prospective wealth).

On the other hand, from the stock option valuation point of view, stock options are American call options after the vesting period, that is, executives can exercise their options at any time without having to wait until the maturity date. But, drawing on the classical option valuation theory (Black and Scholes, 1973), it is never optimal to exercise an American call option before the maturity date in the context of non-dividend paying underlying stock. In this circumstance, it is not necessary to consider early exercise in order to value stock options and their incentives, delta and vega.

Contrary to the above arguments, a growing body of research questions the role of stock options in incentive alignment, and it is necessary to incorporate behavioural perspectives to extend the traditional agency theory view (Larraza-Quintana, Wiseman, Gomez-Mejia, and Welbourne, 2007; Sanders, 2001; Wiseman and Gomez-Mejia, 1998; Wu and Tu, 2007). In the same way, the evidence supports that, when executives are risk averse, it is optimal to exercise stock options early (Leung and Sircar, 2009), which deviates from the classical option valuation theory. A possible explanation to this deviation could also be associated with behavioural finance aspects.

2.1. From agency theory to the behavioural agency model: prospect theory

Behavioural finance literature has made considerable effort at stock markets, but research in behavioural decisions related to stock options is not so profuse. It must be highlighted that the behaviour of an executive who has stock options is similar to that of an investor with an option portfolio. Both the executive and the investor have to take decisions concerning the time of exercising their options. Then, the ideas of prospect theory (Kahneman and Tversky, 1979) about the influence of attitudes and general behavioural biases on decisions and actions carried out by investors apply to ESO holders (Lefebvre and Vieider, 2014).

Drawing on prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), investors' preferences deviate from those supported by expected utility theory and they can exhibit risk-decreasing as well as risk-increasing behaviour. In particular, when investors have something to loss, they exhibit strong preferences for risk aversion, while they are risk seeking when they have nothing to lose but something to gain (Kahneman and Tversky, 1979). This is because of the fact that prospect theory considers that agents are loss averse, and therefore they try to minimize losses rather than maximize gains.

In contrast with the prospect theory perspective, classical scholars draw on simplistic assumptions of consistent risk aversion among executives, which is criticized by the behavioural finance literature (Wiseman and Gomez-Mejia, 1998). For instance, the downside risk, which receives little attention in the agency framework, is an important aspect that determines risk behaviour and may lead executives to be more risk averse (Sanders, 2001). Building on agency and prospect theory views, Wiseman and Gomez-Mejia (1998) construct a behavioural agency model (BAM) of executive risk taking. BAM differs from classical agency perspective in predicting how stock options influence executive risk-taking behaviour. Specifically, BAM considers that stock options become part of perceived current wealth. If there is not wealth at risk (the option value is set to zero), executives have nothing to lose but something to gain, and therefore stock options may not result in risk aversion (Wiseman and Gomez-Mejia, 1998). However, when executive wealth created by stock options is at risk (positive intrinsic value), since executives have something to lose, stock options may result in risk aversion. In this circumstance, executives exhibit risk-decreasing behaviour in order to avoid possible drops in the firm's stock price, preserving in this way their perceived current wealth (Larraza-Kintana et al., 2007). Recently, Lefebvre and Vieider (2014) confirm the ideas of BAM and show that options that are in-the-money (out-of-the-money) significantly reduce (increase) risk taking. A possible consequence of executives' risk aversion when options are in-the-money is the early exercise of these options. Through early exercise, executives will collect the perceived current wealth in exchange for remaining the fewer possibilities for increasing their wealth in the near future. Hence, it is extremely important to carry out a subjective valuation of PVSO value and incentives considering the executives' risk aversion reflected in their early exercise behaviour.

2.2. Early exercise behaviour in stock options

Numerous empirical studies show that executives usually decide to exercise their options early when they are deep in-the-money (Abudy and Benninga, 2013; Bettis et al., 2005; Boyd et al., 2007; Brooks et al., 2012; Carpenter, 1998; Huddart and Lang, 1996; Marquardt, 2002) because of the higher risk bearing created by those stock options with positive value (Wiseman and Gomez-Mejia, 1998). The evidence also shows that female executives are more likely to exercise stock options early (Huang and Kisgen, 2013), which is consistent with the view that women are more risk averse than men (Charness and Gneezy, 2012; Halko, Kaustia, and Alanko, 2012). In addition to executives' risk aversion, Fu and Ligon (2010) point out other several reasons that lead to early exercise, such as the nontradability of ESOs and need for diversification and liquidity.

In this regard, Marquardt (2002) shows that executives decide to exercise their options when the firm's stock price is between 1.91 and 2.17 times the exercise price, considering that ESOs furthest in the money or closest to maturity are exercised first, respectively. Carpenter (1998) observes that the average ratio of the stock price to the exercise price at the time of exercise is 2.75, and that, on average, options are exercised 5.8 years after they were granted (all the options in her sample had lives of ten years). Across all exercises in their sample of 58,316 employees at eight firms, Huddart and Lang (1996) find that the early exercise of ESOs happens when the stock price is, on average, 2.2 times the exercise price. Later, Bettis et al. (2005) show that the ratio of stock price at exercise relative to the exercise price is 2.57, and options are exercised 2.41 years after vesting and 4.25 years before the maturity date. More recently still, Bahaji (2014) observes a mean stock price to exercise ratio at the exercise date of 2.46 and Abudy and Benninga (2013) find that, for their sample of Israeli firms and Israeli subsidiaries of major American firms, the voluntary early exercise of ESO grants takes place when the stock to exercise ratio is 2.96 and there are 4.84 years until the maturity date.

The no-arbitrage pricing theory assumes the risk-neutrality of the ESO holder, in addition to the availability of a perfect hedge. However, recent research has incorporated the idea of non risk-neutrality and non-rationality. Leung and Sircar (2009) demonstrate that, when ESO holders are risk averse and there are sale and hedging restrictions, early exercises are optimal. Moreover, these researches find that job termination impacts on exercise behaviour. First, when job termination is not sure, that is, it only exits the possibility of leaving the firm, executives exhibit a more conservative policy of exercising, which indirectly leads to early exercise. But when job termination is clear, executives exercise their options early before leaving the firm. The cost of ESO to the firm is given by the non-arbitrage price of a barrier-type call options subject to early exercise due to job termination. This barrier is the executive's optimal exercise boundary (Leung and Sircar, 2009).

The prior literature has adopted different approaches to value the cost of ESOs from the perspective of the firm and model the executive's early exercise behaviour. Some studies have used a utility-based framework for determining the executive's exercise policy (Huddart, 1994; Kulatilaka and Marcus, 1994). Other research models early exercise as an exogenous stopping time measured as the first jump time of a Poisson process with constant intensity (Jenergren and Naslund, 1993; Wu and Lin, 2013). The Poisson process is appropriate to capture the early exercise which arises from voluntary or involuntary job termination, since the fact of leaving the firm is independent of the level of the firm's stock price. However, the executive's desire to early exercise or, in other words, the voluntary early exercise depends on the perceived current wealth (i.e., the moneyness of the options), and therefore is necessary to estimate a barrier that represents the executives' optimal desired level of exercise. This barrier is a multiple of the exercise price; when the firms stock price hits the barrier, the option is exercised. In this regard, Hull and White (2004) model the early exercise behaviour through a flat barrier, while Cvitanic et al. (2008) considers a decreasing barrier as maturity approaches.

3. METHODOLOGICAL FRAMEWORK FOR VALUING PVSOS

From a stock option valuation point of view, Wu and Lin (2013) provide a completely analytical model for pricing PVSOs. This closed form expression makes it possible to estimate the sensitivities of executive wealth to stock price and volatility, delta and vega. In addition to the performance-vesting condition, Wu and Lin (2013) take into account the possibility of early exercise when the executive leaves the firm (voluntarily or involuntarily) after the vesting period through a forfeiture (or exit) rate. In this case, the early exercise is not voluntary and is not related to the level of the firm's stock price or the moneyness of the options. This source of uncertainty is modelled through a Poisson process. In the Wu and Lin (2013) model (WL), the PVSO is exercisable only if the firm's stock price reaches the barrier B. Obviously, with the aim of creating the incentives described in the literature, this predetermined level B is set higher that the firm's stock price at the grant date (S_0), and is therefore higher than the exercise price K, since ESOs are usually granted at the money (Marquardt, 2002). In addition to the current stock price (S) and the time to maturity (T), this model includes the following parameters that capture some of the main features of ESOs: $[0, T_0]$ is the vesting period ($T_0 < T$), and λ_0 and λ are the intensities of leaving or being fired during and after the vesting period respectively.

The price of the option is the discounted call option payoff, $C_t = e^{-rt}(S_t - K)^+$, and the time when the option is exercised or expires is a random time, τ. As in Cvitanic et al. (2008) and Wu and Lin (2013), the conditional distribution of the exercise time is:

$$F(\tau) = 1 - e^{-\lambda_0 T_0 - \lambda(\tau - T_0)}, \quad \tau > T_0 \tag{1}$$

And the value of a PVSO in the WL model is equal to:

$$\begin{aligned} K_1 + K_2 \;&=\; e^{(\lambda-\lambda_0)T_0} E\left\{ \int_{T_0}^{T} e^{-(r+\lambda)t} \left[(S_t - K)^+ I\left\{ \max_{0\le u\le t} S_u \ge B \right\} \right] dt \right\} \\ &+\; e^{(\lambda-\lambda_0)T_0} E\left\{ e^{-(r+\lambda)T} \left[(S_T - K)^+ I\left\{ \max_{0\le u\le t} S_u \ge B \right\} \right] \right\} \end{aligned} \tag{2}$$

where K_1 corresponds to leaving the firm at intensity λ after the vesting period, and K_2 corresponds to exercising (or expiration) on maturity. If the executive leaves the firm or is fired before the end of the vesting period, or the leaving occurs after the vesting period but without having reached the barrier B, the PVSO is forfeited. As the option cannot be exercised, the executive obtains nothing from the option, and therefore these potential scenarios are not included in the above expression.

The Poisson process used in the WL model serves to capture exclusively the early exercise caused by voluntary or involuntary job termination, and therefore the WL model ignores the fact that executives may choose to exercise their options voluntarily before the maturity date. Then, it is necessary that the PVSO valuation framework considers that options may be exercised early at any time after the vesting period at the executive's discretion. The executive's early exercise behaviour can be controlled by assuming that early exercise happens when the firm's stock price is a certain multiple of the exercise price (exogenous barrier) (Cvitanic et al., 2008; Hull and White, 2004). The model developed by Cvitanic et al. (2008) (CWZ) considers a decreasing barrier as maturity T approaches, $L_t = Le^{\alpha t}$, such that, if the barrier is crossed when the option is vested, the executive exercises the option at that point. The barrier decreases at a rate of decay represented by the parameter α ($\alpha < 0$), in order to capture the fact that early exercise is more likely to happen when there is less chance of increasing executive wealth in the near future (i.e., the prospective wealth is low), and therefore executives prefer to collect the option payoff (i.e., current wealth).

While the barrier of the CWZ model is like capped-style options, the WL model is like up-and-in options: the option is in effect if the firm's stock price hits the barrier B. Due to the existence of these two different barriers, the time when the firm's stock price reaches the early exercise barrier L, denoted by T_L^0, differs from the time when the firm's stock price hits the performance-vesting barrier B, denoted by T_B^0.

$$\begin{aligned} T_L^0 &= \min\{t \in [T_0, T],\ S_t \geq Le^{\alpha(t-T_0)}\} && (3) \\ T_B^0 &= \min\{t \in [0, T],\ S_t \geq B\}. && (4) \end{aligned}$$

In this case, the performance-vesting condition must be set below the point at which executives usually exercise their options early ($L > B$). If $L < B$, it is not reasonable to include the early exercise barrier in the valuation framework since executives cannot exercise their options at that point because of having not reached the required performance. Consequently, the time when the firm's stock price hits the decreasing barrier L is above the time when the required barrier stock price is crossed ($T_L^0 > T_B^0$). In addition, T_λ^0 is the time of quitting/being fired independently of the option moneyness.

Then, the time of exercise/expiry is:

$$\tau = \min\{T_L^0, T_\lambda^0, T\}. \tag{5}$$

And, based on the WL and CWZ models in the context of PVSOs, the PVSO price is given by the following expression:

$$\begin{aligned} & K_{11} + K_{12} + K_1 + K_2 && (6) \\ = \ & e^{(\lambda-\lambda_0)T_0} E\left[e^{-(r+\lambda)T_0}(S_{T_0} - K)^+ I_{\{S_{T_0} \geq L_{T_0}\}}\right] \\ + \ & e^{(\lambda-\lambda_0)T_0} E\left[(Le^{-\alpha T_0} e^{-(r_\alpha+\lambda)T_L^0} - Ke^{-(r+\lambda)T_L^0}) I_{\{T_L^0 \leq T, S_T^0 < L_{T_0}\}}\right] \\ + \ & e^{(\lambda-\lambda_0)T_0} E\left\{\int_{T_0}^{T} \lambda e^{-(r+\lambda)t} \left[(S_t - K)^+ I_{\{T_L^0 > t, \max_{0\leq u\leq t} S_u \geq B\}}\right] dt\right\} \\ + \ & e^{(\lambda-\lambda_0)T_0} E\left\{e^{-(r+\lambda)T}\left[(S_T - K)^+ I_{\{T_L^0 > T, \max_{0\leq u\leq t} S_u \geq B\}}\right]\right\} \end{aligned}$$

where K_{11} corresponds to exercising the PVSO immediately at the end of the vesting period and K_{12} captures the PVSO exercise at the level L after the vesting period. Both values are related to the voluntary early exercise above or at the desired level. On the other hand, K_1 corresponds to leaving the firm at intensity λ after the vesting period, and therefore the executive is forced to exercise the PVSO early, while K_2 represents the PVSO exercise (or expiration) at maturity date.

Under this valuation framework, the expressions of PVSO incentives, delta and vega, are obtained as follows:

$$\Delta = \frac{\partial(K_{11} + K_{12} + K_1 + K_2)}{\partial S} \quad (7)$$

$$v = \frac{\partial(K_{11} + K_{12} + K_1 + K_2)}{\partial \sigma_S} \quad (8)$$

We use numerical PVSO values and Greeks. Numerical Greeks are obtained as finite difference approximations. The main strength of numerical Greeks is that their calculation is independent of the model used. The finite difference approximations will give us the Greeks we need provided that we have an accurate option pricing model to obtain the value of the derivative.

FIG. 1. The payoff structure of PVSOs taking voluntarily early exercise into account.

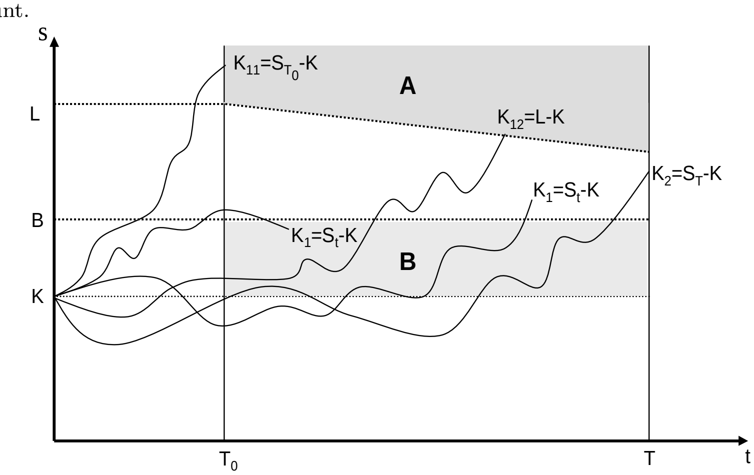


Figure 1 shows the probable scenarios with a positive payoff during the life of the PVSO according to Equation (6). If the executive leaves the firm during the vesting period, the PVSO payoff will be zero. The PVSO expires in Region B if the executive is fired or leaves the firm voluntarily after vesting. In this case, as in the WL model, the option payoff in Region B will be $S_t - K$ if and when the performance-vesting condition is previously achieved, while in the CWZ setting the option payoff in Region B is always $S_t - K$. In contrast to the WL model which allows us to obtain a payoff in region A, we consider that L is the value at which the voluntary early exercise occurs because the current wealth is relatively high in comparison with the prospective wealth. Also, when the firm's stock price is above the level L at the time T_0, executives will exercise the option immediately.

Thus, in Equation (6), the CWZ model and the WL model are nested. As $L \to \infty$, which means that the firm's stock price cannot reach L_t ($T_L^0 > T$), K_{11} and K_{12} tend to zero. In this case, Equation (2) and Equation (6) give the same price and the WL model will be valid. On the other hand, when B is equal to K, which means that there is no performance-vesting condition, Equation (6) gives the same price as that obtained in the CWZ model.

4. PARAMETER SPECIFICATION

In order to obtain PVSO delta and vega values, we require the basic inputs of classical option pricing models. These inputs are the exercise price and the stock price (or the stock price to exercise price ratio at the grant date), time to maturity, stock return volatility, interest rate and dividend yield.

To obtain real data on the stock-to-exercise ratio at the grant date and the time to maturity of new option grants, we focus on executives at the top management level in firms included in Standard and Poor's (S&P) ExecuComp database during the fiscal years 2006-2012 (specifically from June 2006 to May 2013). The dataset includes 1,162 publicly traded firms in the US (firms in the S&P 500, the S&P MidCap 400, and the S&P SmallCap 600 Indices) from which we obtain 25,340 executive-year observations. We also use the Compustat database as a source of data on firms' expected dividend yield and firms' monthly stock returns. As in previous studies (Jin, 2002; Marquardt, 2002; Vieito and Khan, 2012), annualized volatility is obtained as the standard deviation of monthly stock returns over the previous 60 months immediately before the end of each fiscal year. Finally, the risk-free interest rate is estimated as the US Treasury-bond yield with a maturity of ten years.

Panel A of Table 1 reports descriptive statistics for all these parameters. As expected, most ESOs are issued with an exercise price equal to the firms stock price at the grant date. Said another way, ESOs are usually granted at the money (Rubinstein, 1995; Marquardt, 2002), and this is reflected in the mean value of 1 of the stock-to-exercise ratio at the grant date. Therefore, for numerical purposes, this study considers that the stock price and exercise price are equal to 100 at the grant date.

Concerning the length of the option's life, options are usually granted with 10-year lives and many studies assume 10-year maturity (Álvarez-Díez et al., 2014; Bettis et al., 2005; Cvitanic et al., 2008; Hull and White, 2004; Jennergren and Naslund, 1993; León and Vaello-Sebastiá, 2009, 2010; Leung and Sircar, 2009). Ranging from 1.5 to 16.5 years, Guay (1999) finds that the mean time to maturity for options of 278 CEOs is 7.2 years. Later, Marquardt (2002) observes that, for a sample of 966 ESO grants, the mean (median) maturity is 8.93 (10) years. Similarly, Lee, Stathopoulos, and Vonatsos (2007) find a mean (median) time to maturity of 8.85 (10.01) years. Although within the eight listed companies that Huddart and Lang (1996) analyse in their study there are options issued with 5-year lives, the majority of their dataset consists of 10-year options. Panel A of Table 1 shows that the descriptive statistics for our sample are consistent with all of these previous studies, particularly a mean maturity of 8.99 years and a median maturity of 10.01 years. Therefore, we assume a 10-year maturity in our analysis.

TABLE 1.

Descriptive Statistics

Panel A: Basic inputs

	Mean	SD	1st Q	Median	3rd Q
Stock-to-exercise ratio at the grant date	1.00	0.05	1	1	1
Maturity[a]	8.99	1.72	7.01	10.01	10.01
Dividend yield[b]	2.27	1.71	1.46	2.23	4.69
Volatility[b]	36.20	13.31	26.91	34.35	42.10
Risk-free interest rate[b]	3.58	0.83	3.22	3.26	4.63

Panel B: Stock price to exercise price ratio when ESOs are exercised

Year	2006	2007	2008	2009	2010	2011	2012	2006-2012
All executives ($n = 17,559$)	2.85	2.96	3.37	2.37	2.30	2.81	2.27	2.73
CEOs ($n = 3,697$)	3.08	3.27	3.45	2.42	2.39	2.76	2.40	2.86
Non-CEO executives ($n = 13,862$)	2.80	2.89	3.34	2.36	2.27	2.82	2.23	2.70

Panel A shows descriptive statistics for several parameters of new option grants. The stock-to-exercise ratio at the grant date and maturity are obtained from ExecuComp database. Dividend yield is obtained from Compustat database. Volatility is the standard deviation of the 60 monthly stock returns prior to each fiscal year-end. The risk-free interest rate is estimated as the US Treasury-bond yield at 10-year constant maturity. Panel B shows the mean stock-to-exercise ratio for our sample of option exercises, differentiating between CEOs and non-CEO executives. [a]: years, [b]: percentage. SD: Standard Deviation.

With regard to the volatility of the underlying stock, many previous studies assume a stock return volatility of 30% (Álvarez-Díez et al., 2014; Carr and Linetsky, 2000; Core and Guay, 2002; Hull and White, 2004; Jennergren and Naslund, 1993; León and Vaello-Sebastiá, 2009; Tian, 2004) and others a volatility of 40% (León and Vaello-Sebastiá, 2010). Other empirical research shows values between 30% and 40%: Marquardt (2002) reports a mean volatility of 29.2%, Carpenter (1998) 31%, Bettis et al. (2005) 38.61%, Huddart and Lang (1996) 39.3%, and Lee et al. (2007) 41.00%. In accordance with these findings, we find a mean stock return volatility of 36.20% for the US firms included in our sample, and we use this value in our sensitivity analysis of PVSO incentives.

As far as the risk free rate of interest is concerned, many previous studies have used a value of 5% in their analyses (Álvarez-Díez et al., 2014; Brown and Szimayer, 2008; Carr and Linetsky, 2000; Cvitanic et al., 2008; León and Vaello-Sebastiá, 2009; Tian, 2004). Due to our study period is more recent, we use a mean value of 3.58% obtained from our sample of firms. With respect to dividend yield, the most common value used in prior research is 3% (Carpenter, 1998; Core and Guay, 2002; Jennergren and Naslund, 1993), while other studies have used the value of 2.5% (Hull and White, 2004; León and Vaello-Sebastiá, 2009) and 2% (Álvarez-Díez et al., 2014). Roughly in line with these values, we show and use a mean dividend yield of 2.27%.

In addition to all these parameters, it is necessary to estimate the parameters used to capture the specific characteristics of option compensation plans, which are the vesting period, the exit rate of executives, the level of the barrier L and its decay rate used to capture the early exercise, and the level of the barrier B that corresponds to the stock price target to option vesting.

Similar to the case of the time to maturity, there is a broad consensus on the vesting period and it is typically 3 years (Rubinstein, 1995). Although Bettis et al. (2005) and Cvitanic et al. (2008) consider a 2-year vesting period, Jennergren and Naslund (1993), Core and Guay (2002), and Álvarez-Díez et al. (2014) assume a 3-year vesting period, and the vesting period considered in the study of Leung and Sircar (2009) ranges from 2 to 4 years. For their wide sample of option grants given to CEOs and other top executives of UK firms, Lee et al. (2007) find that the vesting period is universally set at 3 years. Thus, we consider a 3-year vesting period at the grant date in our analysis.

Regarding the probability that the executive leaves the firm (voluntarily or involuntarily), it is the intensity of a Poisson process and we follow the findings of prior literature related to executive turnover to obtain an appropriate value of the exit rate of executives. In the real case studied in Cvitanic et al. (2008), these researchers consider an exit rate of 10%. However, they indicate that this estimation of the turnover rate is relatively low compared to average figures. Attempting to be more in line with overall executive turnover, they also consider an exit rate of 15%. On the other hand, considering both internal (boards decision) and external (merger or bankruptcy) CEO turnover, the study of Kaplan and Minton (2012) points to an average total CEO turnover of about 14.91% from 1992 to 1999 and about 16.78% from 2000 to 2007 for a sample of large US firms (Fortune 500 firms). Later, Kaplan (2013) updates the data of Kaplan and Minton (2012) up to 2010 and observes that the total CEO turnover is, on average, 17.6% for the period 1998-2003 and 15.8% for the period 2004-2010. Thus, in line with these findings, and following the recent study of Álvarez-Díez et al. (2014), we consider an exit rate after the vesting period of 16%. It is reasonable to assume that the exit rate during the vesting period is below the exit rate after the vesting period, and therefore we consider a value of 1% in the former case (Wu and Lin, 2013).

With respect to the early exercise barrier, Panel B of Table 1 reports the mean value of the ratio of the stock price to the exercise price at the time of exercise for a sample of 1,880 firms included in Standard and Poor's (S&P) ExecuComp database during the seven fiscal years considered in Panel A. From this sample of firms, we take 17,559 executive-year observations of option exercises. As commented before, the empirical literature shows that the stock price to exercise price ratio when the ESOs are exercised early is equal to 2.22 (Huddart and Lang, 1996), 2.57 (Bettis et al., 2005), 2.8 (Carpenter, 1998), 2.96 (Abudy and Benninga, 2013), 2.46 (Bahaji, 2014) and 2.17 or 1.91 (Marquardt, 2002). Focusing on our sample, it can be observed that for the whole fiscal period of 2006-2012, and without differentiating between CEOs or non-CEO executives, the mean value of the stock to exercise ratio at the time of exercise is 2.73, which is in line with the prior literature. Moreover, CEOs tend to exercise ESOs when they are deeper in the money compared to non-CEO executives. For numerical purposes, and consistent with the prior literature and with the data shown in Panel B of Table 1, we consider two different levels of the exercise barrier: $L = 2$ and $L = 3$. We also assume a mean decay rate of the barrier of 1%.

Finally, as far as the stock price target to option vesting is concerned, we consider two different levels, which are B equal to 1.2 and 1.8 times the exercise price (Wu and Lin, 2013). In this way, we can observe how the incentive effects change with the level of the performance-vesting condition.

5. NUMERICAL RESULTS

This section presents numerical results that allow us to analyse how PVSO prices and risk incentives (delta and vega) change when the executive risk aversion is captured in the valuation framework. In particular, a low early exercise barrier ($L = 2$) corresponds to risk-averse executives who prefer to collect the perceived current wealth and forfeit the remaining time-vale of the options (or prospective wealth). On the contrary, a higher barrier ($L = 3$) corresponds to those riskier executives who do not resign themselves from obtaining a lower payoff and prefer to wait for an increase in the firm's stock price in the near future, and therefore in their wealth. Since the early exercise is less likely to happen as the barrier increases, the fact of considering a high-barrier L can be similar to the case of ignoring the early exercise effect in the valuation framework.

TABLE 2.

Prices of PVSOs for different parameter values

		$L = 2$		$L = 2.5$		$L = 3$	
α	S	$T_0 = 1$	$T_0 = 3$	$T_0 = 1$	$T_0 = 3$	$T_0 = 1$	$T_0 = 3$
Panel A: $B = 1.2$							
0	80	10.0019	10.3239	11.0894	11.4207	11.6223	12.2501
	100	16.8556	18.7521	19.6193	19.8457	21.1327	21.3378
	120	23.9950	30.3007	28.7449	30.1399	31.9734	31.6536
−0.01	80	9.7703	10.2144	10.7840	11.3148	11.4033	12.1093
	100	16.2844	18.5298	19.0815	19.6084	20.5244	21.0610
	120	23.1743	29.9907	27.7054	29.6229	31.1141	31.2855
Panel B: $B = 1.5$							
0	80	8.9643	9.2317	9.9585	10.2665	10.4654	11.0803
	100	15.4759	17.4912	18.0639	18.5084	19.4932	19.9622
	120	22.6981	29.0926	27.2404	28.8361	30.3724	30.3211
−0.01	80	8.8117	9.1607	9.7189	10.1913	10.2999	10.9671
	100	15.0124	17.3114	17.6000	18.2978	18.9523	19.7137
	120	21.9930	28.8307	26.2882	28.3601	29.5770	29.9753
Panel C: $B = 1.8$							
0	80	7.3157	7.4354	8.1829	8.3395	8.6413	9.1133
	100	13.2952	15.1901	15.5406	15.9603	16.8195	17.3256
	120	19.9918	26.4744	24.0231	25.9680	26.6309	27.3635
−0.01	80	7.2184	7.4007	7.9920	8.2780	8.5271	9.0294
	100	12.9871	15.0710	15.1716	15.7842	16.3599	17.0953
	120	19.5276	26.2975	23.2440	25.5693	26.2195	27.0404

This table shows PVSO prices. The difference between Panel A, B and C is the performance-vesting barrier considered (B). L: early exercise barrier. T_0: vesting period. α: decay rate of L. S: level of moneyness. Other parameter values: $K = 100$; $T = 10$; $\lambda_0 = 0.01$; $\lambda = 0.06$; $\sigma = 0.3$; $r = 0.01$.

Table 2 presents the PVSO price sensitivity to several factors. It can be observed that when the early exercise is less likely to happen ($L = 3$), the price of the PVSO is higher than the case of a lower level of the early exercise barrier (Cvitanic et al., 2008). This pattern exists regardless of the performance-vesting condition, vesting period, moneyness and decay rate of the exercise barrier used. Although the overvaluation of the PVSO price when the framework does not consider the executives' risk aversion reflected in their exercise behaviour is clear, its magnitude depends on the parameters considered. For instance, focusing on a performance-vesting condition of 1.5 times the exercise price and a decreasing exercise barrier, when the stock price is equal to 80 and the vesting period is 3 years the PVSO price is overvaluated around 20%. On the other hand, if we consider an early exercise barrier which does not decrease ($\alpha = 0$) (Hull and White, 2004), the PVSO prices are higher than those of a decreasing barrier ($\alpha = -0.01$) (Cvitanic et al., 2008). In the decreasing case, there is a high probability that early exercise takes place, which leads to a reduction in the PVSO price.

Regarding PVSO price sensitivities to other parameters, the PVSO value increases when the stock price moves closer to the performance-vesting condition due to the higher likelihood of hitting it and obtaining the wealth from option exercise. Moreover, an increase in the performance-vesting condition is associated with lower PVSO prices because of the greater difficulty in reaching the given performance target (Wu and Lin, 2013). Finally, the change in the vesting period from 1 year to 3 years affects the price of the PVSO positively since there is more time during which executives cannot exercise their options (Cvitanic et al., 2008).

5.1. Sensitivity analysis of PVSO incentives: delta and vega

Figures 2 and 3 show the results from the sensitivity analysis of the incentive effects of PVSOs, delta and vega, using the parameter values defined in the previous section. It is important to underline that the gap between the two curves that can be seen in each of the graphics corresponds to the error committed if the executive's early exercise behaviour has not been captured in the valuation framework.

FIG. 2. PVSO delta sensitivity to the stock price to exercise price ratio

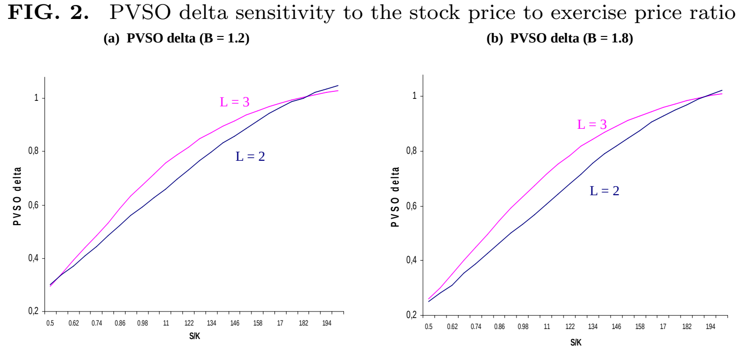
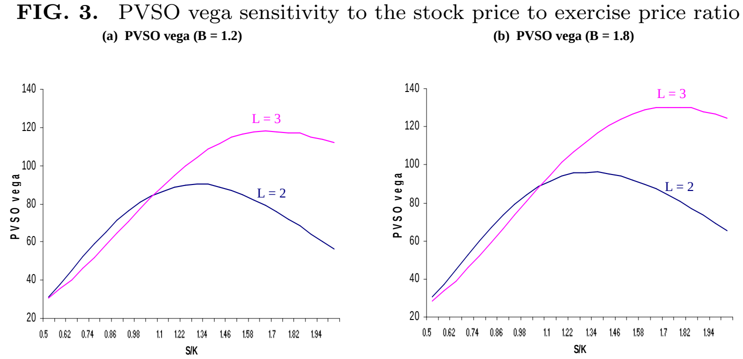


Figure 2 shows the PVSO delta sensitivity to the stock price to exercise price ratio. As expected, the sensitivity of executive wealth to stock price, delta, increases with the moneyness of the PVSO (Álvarez-Díez et al., 2014; Wu and Lin, 2013). Focusing on the early exercise effect, PVSO delta values vary significantly when executives differ in their early exercise behaviour. It can be observed that the wealth of those executives who are more risk averse ($L = 2$), and therefore exercise their options earlier in order to collect the current wealth, is less sensitive to changes in the firms stock price than that of risky executives ($L = 3$). The maximum gap between delta values takes place when the PVSOs is at-the-money. In this case, the incentive effect of a risk-averse executive is approximately 18% less than that of a risky executive, and this incentive gap reduces as the PVSO goes both out-of-the-money and in-the-money. These results are robust to the two levels of the performance-vesting condition used. The findings shown in Figure 2 indicate that if the PVSO valuation framework ignores the executive's voluntary early exercise behaviour, it leads to the overvaluation of PVSO deltas.

Contrary to the important effect of voluntary early exercise on delta, and comparing Figure 2(a) and Figure 2(b), the increase in the performance-vesting condition slightly reduces the PVSO delta, which is contrary to the classical evidence shown in the prior literature (Johnson and Tian, 2000). This negative effect is in line with the view that the higher incentives compared to those of traditional ESOs arise when performance targets are not set too difficult (Kuang and Qin, 2009; Kuang and Suijs, 2006). The increase in the performance-vesting condition makes it more difficult for executives to exercise their options early, and therefore the incentive effect moves in the opposite direction.

FIG. 3. PVSO vega sensitivity to the stock price to exercise price ratio



As far as the incentive to increase stock return volatility or vega is concerned, Figure 3 shows that the PVSO vega increases with the moneyness of the option. However, when the stock price to exercise price ratio is high, the PVSO vega decreases. The reason of this inverted U-shaped relationship is that as the PVSO goes deep in-the-money, it is more likely to reach the early exercise barrier, and therefore the firm's stock return volatility does not mean so much increase in the PVSO price. We can observe that when executives are more risk averse ($L = 2$), the reduction in the PVSO vega takes place for lower values of the firms stock price, which is caused by the higher probability of early exercise. As a consequence, a risk-averse executive has decreasing wealth sensitivity to changes in volatility in contrast to a riskier executive, who presents increasing wealth sensitivity. This means that, in the case of in-the-money options, the fact of ignoring the risk-averse executive behaviour is associated with overvaluing PVSO vegas. Particularly, vega values are approximately 60% lower for a risk-averse executive than the estimation for the corresponding riskier executive. If we focus on the situation in which the PVSO is out-of-the-money, PVSO vegas are undervaluated when the executives' exercise behaviour is not captured, but the gap between vega values is considerable lower (approximately 13%). Similar to the case of PVSO deltas, all these findings are robust to the performance-vesting condition used in the sensitivity analysis.

Finally, comparing Figure 3(a) and Figure 3(b), it can be seen that, contrary to the case of the PVSO delta, the performance-vesting condition has a positive influence on the PVSO vega, particularly when the option moves in-the-money (Johnson and Tian, 2000). This means that the increase in the performance-vesting condition provides executives with higher incentives to take more risks.

5.2. Case Study

In this section, we complement the previous sensitivity analysis by comparing PVSO prices, deltas and vegas of a real option programme. We use the data from Energen Corporation, an oil and gas exploration and production firm with headquarters in Birmingham (Alabama) whose shares trade on the New York Stock Exchange. The particular characteristics of this sector make it necessary to provide executives with incentives to take more risks in explorations. Rajgopal and Shevlin (2002) also focus on a sample of oil and gas producers to examine whether stock options provide executives with those incentives to undertake risky projects.

TABLE 3.

Option grants of Energen Corporation

Panel A: Basic information of option grants									
No. of grant	Grant date	Expiration date	No. of options	$S = K$	T	T_0	σ (%)	q (%)	r (%)
1	1/23/2008	1/22/2018	117,370	60.56	10	3	19.27	0.64	3.66
2	1/27/2010	1/26/2020	165,694	46.69	10	3	28.51	1.17	3.22

Panel A of Table 3 provides the details of two stock option plans granted to the top executives of Energen Corporation. Data on exercise price, time to maturity and vesting period are obtained from the firm's proxy

Panel B: Prices, deltas, and vegas

		Prices			Deltas			Vegas		
No.	B	$L = 2$	$L = 2.5$	$L = 3$	$L = 2$	$L = 2.5$	$L = 3$	$L = 2$	$L = 2.5$	$L = 3$
1	1.2	1.0528	1.1665	1.2596	0.2253	0.2408	0.2542	37.8184	41.8960	46.3867
1	1.5	0.6972	0.7872	0.8631	0.2058	0.2176	0.2290	41.5644	44.7201	47.0107
1	1.8	0.4841	0.5354	0.5907	0.1813	0.1880	0.1961	43.7308	45.1674	47.9807
2	1.2	1.2576	1.3857	1.4706	0.2426	0.2476	0.2553	30.3314	30.6656	31.9065
2	1.5	0.9670	1.0721	1.1409	0.2245	0.2264	0.2321	32.1554	32.3502	32.8935
2	1.8	0.7682	0.8475	0.8999	0.2073	0.2080	0.2095	32.4586	32.7663	33.2542

Panel A presents the characteristics of two option grants of Energen Corporation. No. of options: number of options in the plan. S: stock price at the grant date. K: exercise price. T: maturity. T_0: vesting period. σ: standard deviation of monthly firm stock returns over five years. q: annual dividend yield (Compustat). r: risk-free interest rate (the US Treasury-bond yield at 10-year constant maturity). An exit rate of executives of 16% is assumed. Panel B reports the prices, deltas and vegas of the option grants shown in Panel A. L and B are the early exercise barrier and the performance-vesting barrier, respectively. Prices are given in millions of dollars.

statements and the ExecuComp database. As can be seen, these options are issued at-the-money, have a vesting period of three years and expire after ten years, which are common features in stock option plans of US listed firms (Rubinstein, 1995). Panel B of Table 3 presents the prices of the option grants, as well as delta and vega values. Since we do not have information about the policy relating to the exercise of options adopted by the executives of Energen Corporation, we consider three different levels of the exercise barrier ($L = 2$; $L = 2.5$, and $L = 3$), which is in line with the data observed in Table 1, and three performance-vesting conditions ($B = 1.2$; $B = 1.5$, and $B = 1.8$).

As can be observed, the findings shown in Panel B of Table 3 support the results obtained in the previous sensitivity analysis. The PVSO price increases when executives decide to exercise their options later, waiting for a higher level of the firms stock price, and therefore showing less risk aversion. In the first grant, the PVSO price is approximately 22% larger on average for a riskier executive than that for a risk-averse executive, while in the second grant the PVSO is overvaluated around 18%. Again, the wealth of those executives who are less risk averse ($L = 3$) is more sensitive to changes in the firm's stock price and stock return volatility. Consistent with the evidence shown previously in the sensitivity analysis, we can see that the overvaluation of PVSO incentives committed because of ignoring the effect of voluntary early exercise is stronger in the case of PVSO vegas than in the case of PVSO deltas. For instance, if we analyse the incentive values obtained in the first grant for a performance-vesting condition of 1.2 times the exercise price, PVSO vegas and deltas are approximately 23% and 13% overvaluated, respectively.

Finally, while the increase in the performance-vesting condition is associated with lower PVSOs prices and deltas, increasing the level of the performance-vesting barrier is associated with higher vegas, which gives robustness to the results of the sensitivity analysis.

6. CONCLUSIONS

The use of performance-vesting conditions in executive stock option plans has increased considerably since the evidence shows that performance-vested stock options (PVSOs) create greater incentive effects than classical stock options (Bettis et al., 2015; Johnson and Tian, 2000; Kuang and Qin, 2009). However, the prior literature has ignored the executive's early exercise behaviour that arises from risk aversion in the PVSO valuation framework (Wu and Lin, 2013), which could lead to erroneous conclusions about risk incentives. We conduct numerical analyses of PVSO values and managerial incentives to increase stock price (delta) and stock return volatility (vega) to analyse the importance of taking into account the voluntary early exercise effect in the PVSO context.

The findings reveal that PVSO prices for those executives who are less risk averse and wait for increases in the firm's stock price to exercise their options are higher than those for risk-averse executives who prefer to collect a lower payoff by exercising their options earlier. Focusing on the sensitivity of executive wealth to stock price or delta, riskier executives have greater incentives to increase the firm's stock price (higher delta) compared to those of risk-averse executives, regardless of the PVSO is out-of-the-money or in-the-money. In addition, riskier executives also present greater incentives to increase stock return volatility (higher vega) than risk-averse executives, but it happens when the PVSO is in-the-money. In the case of out-of-the-money PVSOs, the wealth of risk-averse executives is more sensitive to changes in stock volatility. All these findings are robust to different performance-vesting conditions. Unlike the important effect of voluntary early exercise on PVSO price and incentives, the results show slight effects of the performance vesting condition. PVSO prices and deltas (vegas) reduce (increase) with increasing performance-vesting condition. The negative effect on delta contradicts the classical results shown in the prior literature (Johnson and Tian, 2000). The fact of considering voluntary early exercise behaviour, and therefore different levels of risk aversion, changes the classical context of PVSOs, which leads us to show new evidence of PVSO incentives.

In sum, contrary to the assumption of consistent risk aversion among executives supported by agency theory (Jensen and Meckling, 1976), executives presents different levels of risk aversion (Kahneman and Tversky, 1976; Lefebvre and Vieider, 2014; Wiseman and Gomez-Mejia, 1998), which leads them to differ in their early exercise behaviour. This paper provides evidence of the importance of taking into account the possibility of early exercise at the executive's discretion, which also contradicts the view of classical option valuation theory. If the PVSO valuation framework does not consider the executive's early exercise behaviour, PVSO prices are overvaluated, the sensitivity of executive wealth to stock price (delta) is also overvaluated regardless of the moneyness, and the sensitivity of executive wealth to stock return volatility (vega) is undervaluated if the PVSO is out-of-the-money but overvaluated for the case of in-the-money PVSOs. Then, in order to carry out appropriate valuations that allow firms to provide executives with correct incentives in relation to risk-related goals, firms should take into account the early exercise behaviour of their executives in the design of PVSO plans.

REFERENCES

Abudy, Menachem and Simon Benninga, 2013. Non-marketability and the value of employee stock options. *Journal of Banking and Finance* **37(12)**, 5500-5510.

Álvarez-Díez, Susana, Juan S. Baixauli-Soler, and María Belda-Ruiz, 2014. Are we using the wrong letters? An analysis of executive stock option Greeks. *Central European Journal of Operations Research* **22(2)**, 237-262.

Armstrong, Christopher S. and Rahul Vashishtha, 2012. Executive stock options, differential risk-taking incentives, and firm value. *Journal of Financial Economics* **104(1)**, 70-88.

Bahaji, Hamza, 2014. Are employee stock option exercise decisions better explained through the prospect theory? Working paper. University of Paris.

Baixauli-Soler, Juan S., Maria Belda-Ruiz, and Gregorio Sanchez-Marin, 2015. Executive stock options, gender diversity in the top management team, and firm risk taking. *Journal of Business Research* **68(2)**, 451-463.

Bettis, Carr, John Bizjak, Jeffrey Coles, and Swaminathan Kalpathy, 2010. Stock and option grants with performance-based vesting provisions. *The Review of Financial Studies* **23(10)**, 3849-3888.

Bettis, Carr, John Bizjak, Jeffrey Coles, and Swaminathan Kalpathy, 2015. Performance-vesting provisions in executive compensation. Working paper. Arizona State University.

Bettis, Carr, John Bizjak, and Michael L. Lemmon, 2005. Exercise behavior, valuation, and the incentive effects of employee stock options. *Journal of Financial Economics* **76(2)**, 445-470.

Black, Fischer and Myron Scholes, 1973. The pricing of options and corporate liabilities. *Journal of Political Economy* **81(3)**, 637-654.

Boyd, Tristan, Philip Brown, and Alex Szimayer, 2007. What determines early exercise of employee stock options in Australia? *Accounting and Finance* **47(2)**, 165-185.

Brockman, Paul, Xiumin Martin, and Emre Unlu, 2010. Executive compensation and the maturity structure of corporate debt. *Journal of Finance* **65(3)**, 1123-1161.

Brooks, Roberts, Don M. Chance, and Brandon Cline, 2012. Private information and the exercise of executive stock options. *Financial Management* **41(3)**, 733-764.

Brown, Philip and Alex Szimayer, 2008. Valuing executive stock options: performance hurdles, early exercise and stochastic volatility. *Accounting and Finance* **48(3)**, 363-389.

Carpenter, Jennifer N., 1998. The exercise and valuation of executive stock options. *Journal of Financial Economics* **48(2)**, 127-158.

Carr, Peter and Vadim Linetsky, 2010. The valuation of executive stock options in an intensity-based framework. *European Financial Review* **4(3)**, 211-230.

Charness, Gary and Uri Gneezy, 2012. Strong evidence for gender differences in risk taking. *Journal of Economic Behavior & Organization* **83(1)**, 50-58.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2006. Managerial incentives and risk-taking. *Journal of Financial Economics* **79(2)**, 431-468.

Core, John and Wayne Guay, 2002. Estimating the value of employee stock options portfolios and their sensitivities to price and volatility. *Journal of Accounting Research* **40(3)**, 613-630.

Cvitanic, Jakša, Zvi Wiener, and Fernando Zapatero, 2008. Analytic pricing of employee stock options. *Review of Financial Studies* **21(2)**, 683-724.

Dolan, Paul, Antony Elliot, Robert Metcalfe, and Ivo Vlaev, 2012. Influencing financial behaviour: From changing minds to changing contexts. *Journal of Behavioral Finance* **13(2)**, 126-142.

Fargher, Neil, Alicia Jiang, and Yangxin Yu, 2014. How do auditors perceive CEOs risk-taking incentives? *Accounting and Finance* **54(4)**, 1157-1191.

Frydman, Carola and Raven E. Saks, 2010. Executive compensation: a new view from a long-term perspective, 1936-2005. *The Review of Financial Studies* **23(5)**, 2099-2138.

Fu, Xudong and James A. Ligon, 2010. Exercises of executive stock options on the vesting date. *Financial Management* **39(3)**, 1097-1125.

Guay, Wayne R., 1999. The sensitivity of CEO wealth to equity risk: an analysis of the magnitude and determinants. *Journal of Financial Economics* **53(1)**, 43-71.

Halko, Marja-Liisa, Markku Kaustia, and Elias Alanko, 2012. The gender effect in risky asset holdings. *Journal of Economic Behavior & Organization* **83(1)**, 66-81.

Huang, Jiekun and Darren J. Kisgen, 2013. Gender and corporate finance: Are male executives overconfident relative to female executives? *Journal of Financial Economics* **108(3)**, 822-839.

Huddart, Steven, 1994. Employee stock options. *Journal of Accounting and Economics* **18(2)**, 207-231.

Huddart, Steven and Mark Lang, 1996. Employee stock option exercises: An empirical analysis. *Journal of Accounting and Economics* **21(1)**, 5-43.

Hull, John and Alan White, 2004. How to value employee stock options. *Financial Analysts Journal* **60(1)**, 114-119.

Jensen, Michael C. and William H. Meckling, 1976. Theory of the firm: managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics* **3**, 305-360.

Jennergren, L. Petter and Bertil Naslund, 1993. A comment on valuation of executive stock options and the FASB proposal. *Accounting Review* **68(1)**, 179-183.

Jin, Li, 2002. CEO compensation, diversification and incentives. *Journal of Financial Economics* **66(1)**, 29-63.

Johnson, Shane A. and Yisong S. Tian, 2000. The value and incentive effects of nontraditional executive stock option plans. *Journal of Financial Economics* **57(1)**, 3-34.

Kahneman, Daniel and Amos Tversky, 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* **47**, 262-291.

Kaplan, Steven N., 2013. CEO pay and corporate governance in the U.S.: perceptions, facts, and challenges. *Journal of Applied Corporate Finance* **25(2)**, 8-25.

Kaplan, Steven N. and Bernadette A. Minton, 2012. How has CEO turnover changed? *International Review of Finance* **12(1)**, 57-87.

Kuang, Yu F. and Bo Qin, 2009. Performance-vested stock options and interest alignment. *The British Accounting Review* **41(1)**, 46-61.

Kuang, Yu F. and Jeroen Suijs, 2006. Incentive effects of performance-vested stock options. Working paper. University of Melbourne and Tilburg University.

Kulatilaka, Nalin and Alan J. Marcus, 1994. Valuing employee stock options. *Financial Analysts Journal* **50(6)**, 46-56.

Larraza-Kintana, Martin, Robert M. Wiseman, Luis R. Gomez-Mejia, and Theresa M. Welbourne, 2007. Disentangling compensation and employment risks using the behavioural agency model. *Strategic Management Journal* **28(10)**, 1001-1019.

Lee, Edward, Konstantinos Stathopoulos, and Konstantinos Vonatsos, 2007. UK Executive stock options valuation: a conditional model. *Corporate Governance: An International Review* **15(6)**, 1469-1479.

Lefebvre, Mathieu and Ferdinand M. Vieider, 2014. Risk taking of executives under different incentive contracts: Experimental evidence. *Journal of Economic Behavior & Organization* **97**, 27-36.

León, Angel and Antoni Vaello-Sebastiá, 2009. American GARCH employee stock option valuation. *Journal of Banking and Finance* **33(6)**, 1129-1143.

León, Angel and Antoni Vaello-Sebastiá, 2010. A simulation-based algorithm for American executive stock option valuation. *Finance Research Letters* **7(1)**, 14-23.

Leung, Tim and Ronnie Sircar, 2009. Accounting for risk aversion, vesting, job termination risk. *Mathematical Finance* **19(1)**, 99-128.

Marquardt, Carol A., 2002. The cost of employee stock option grants: An empirical analysis. *Journal of Accounting Research* **40(4)**, 1191-1217.

Murphy, Kevin J., 2013. Executive compensation: where are we, and how we got there. In: Constantinides, G., Harris, M., Stulz, R. (Eds.), *Handbook of the Economics of Finance*, **Vol. 2A**. Amsterdam: Noth-Holland.

Rajgopal, Shivaram and Terry Shevlin, 2002. Empirical evidence on the relation between stock option compensation and risk taking. *Journal of Accounting and Economics* **33(2)**, 145-171.

Rubinstein, Mark, 1995. On the accounting valuation of employee stock options. *Journal of Derivatives* **3**, 8-24.

Sanders, Wm. Gerard, 2001. Behavioral responses of CEOs to stock ownership and stock options pay. *Academy of Management Journal* **44(3)**, 477-492.

Tian, Yisong S., 2004. Too much of a good incentive? The case of executive stock options. *Journal of Banking and Finance* **28(6)**, 1225-1245.

Tversky, Amos and Daniel Kahneman, 1992. Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty* **5(4)**, 297-323.

Vieito, João P. and Walayet A. Khan, 2012. Executive compensation and gender: S&P 1500 listed firms. *Journal of Economics and Finance* **36(2)**, 371-399.

Wiseman, Robert M. and Luis R. Gomez-Mejia, 1998. A behavioral agency model of managerial risk taking. *Academy of Management Review* **23(1)**, 133-153.

Wu, Jianfeng and Rungting Tu, 2007. CEO stock options pay and R&D spending: a behavioural agency explanation. *Journal of Business Research* **60(5)**, 482-492.

Wu, Ming-Cheng and I-Cheng Lin, 2013. Determining fair values of performance-vested and forfeiture-embedded employee stock options. *Accounting and Finance* **53(4)**, 1083-1106.