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The impact of issuing warrant and debt on behavior of the firm's stock

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ABSTRACT

Unlike options, warrant issuance changes the distribution of the stock price process. Indeed, firms issuing warrants are also debt financed. In this situation, it is natural to consider the distribution of the stock price process for a firm, which is debt–warrant combination. This paper is devoted to provide a risk-management tool, namely the stock price distribution of a firm issuing both debt and warrants. We also apply the theoretical results to the risk-management. Moreover, some empirical studies are given to illustrate the impact of issuing warrants and debt on the stock price distribution. The empirical evidence confirms the theoretical findings and shows that issuing warrants and debt has effects on the distribution of stock price processes.
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1. Introduction

An equity warrant is a certificate issued with a security giving the holder the option of buying a stock at a certain strike price for a certain period of time. Unlike call options, while the call option is issued by an individual, the warrant is issued by the firm and its proceeds are a part of the firm's equity. If a warrant is exercised, it increases the number of outstanding shares of the firm and thus dilutes the equity of its stockholders (Galai and Schneller, 1978). Nevertheless, most papers dealing with warrants have overlooked the warrant's potential dilution effect on the firm's equity (Black, 1989; Black and Scholes, 1973; Merton, 1976). In fact, there are two important differences between call options and equity warrants. First, issuing or exercising warrants can affect the firm's aggregate level of investment and increase the number of outstanding shares of the firm, and thus dilutes the equity of the firm (Galai and Schneller, 1978). Second, the underlying asset of a warrant is not the stock but the value of the firm (Schulz and Trautmann, 1994). In order to obtain the valuation of warrants, many scholars have considered the problem of pricing equity warrants under the assumption that the value of the firm follows a geometric Brownian motion during the lifetime of the outstanding warrants (instead of the stock process). For example, Galai and Schneller (1978) presented a standard equity warrant valuation model which corrected Black–Scholes model for dilution. Later, Noreen and Wolfson (1981), and Lauterbach and Schultz (1990) also presented different revisions of the Black–Scholes model to price warrant. The obstacle of pricing warrant is that the firm market value and its volatility, which are unobservable, are needed in the pricing process. To get around this problem Schulz and Trautmann (1994) proposed a warrant-pricing procedure based on the price and volatility of the firm stock, which are observable. Furthermore, Ukhov (2004) developed an algorithm for pricing warrants using only observable variables for the case of the warrant ratio being distinct from unity. More recently, Zhang et al. (2009), Xiong and Yu (2011), Xiao et al. (2012) also considered this pricing problem in a larger setting.

The studies mentioned above have considered the problem of pricing warrants under the assumption that the value of the warrant-issuing firm follows the geometric Brownian motion. However, usually, warrants are issued in conjunction with zero-coupon bond. As a consequence, one question arises: if log-normal diffusion is the process governing the value of the firm, what is the process governing its stock price of the firm issuing debt plus warrants? And even more importantly, what is the distribution of the stock price of the firm issuing debt plus warrants? In literature, the first insight of the stock price distribution of the firm issuing debt plus warrants is given by Galai and Schneller (1978). They stated that if the firm value is lognormally distributed, after the issuance of the warrant, the distribution of the stock price will not be lognormal (Darsinos and Satchell, 2002). Since then, a number of empirical studies (Bensoussan et al., 1992; Schulz and Trautmann, 1994; Sidentus, 1996) dealt with this problem in a lager setting. Actually, as pointed by Sidentus (1996), even if the stock price follows a constant-volatility process before issuing the warrant, volatility will be nonconstant after issuing the warrant (Darsinos and Satchell, 2002). Moreover, the processes followed by the stock price and the total equity of the firm, that issued debt with warrants, could not be of the same form. For example, Becchetti (1996) and Handley (2002) argued that stock price should already reflect the dilution effect during the life of the warrant. In addition, Chen and Wu (2001) illustrated a positive price effect immediately before and on the expiration day and a temporary negative price effect after the expiration day for in-the-money Hong Kong derivative warrants. Chan and Wei (2001) documented a

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significant increase in the underlying stock price both before and on the announcement date, but no significant effects around the dates of derivative warrants traded. More recently, Durai and Bhaduri (2009) showed the negative relationship between inflation and stock market return. Chang and Liao (2010) showed that stock return processes had significantly lower volatilities after warrant introduction. Chen and Liao (2010) considered the impact of expiration of covered warrants on stock prices in China using empirical methods. Álvarez et al. (2011) assessed the impact of oil price changes on Spanish and euro area consumer price inflation. To sum up, since the introduction of warrants and debt influences the stock price distributions, an investigation of the effects of issuing debt with warrants on stock return processes has been an important topic in both corporate finance and investment theory. Moreover, the knowledge of the distribution of stock price fluctuations for the firm issuing warrants and the zero-coupon debt is very important for a number of reasons such as risk management purposes (e.g., Value-at-Risk calculations), credit management purposes (e.g., estimating the probability of default of a firm). Therefore, the aim of this paper is not to provide another pricing model for equity warrants, but to investigate the effects on the process of stock price of the firm issuing warrants and debt. Some illustrations for risk management will be presented. We will also provide some empirical studies to test our theoretical findings.

The remainder of this paper is organized as follows. In Section 2, we introduce some notations and briefly state the assumptions which are used in the forthcoming sections. Section 3 deals with the derivation of the stock price process while Section 4 discusses the changes in distribution of the stock price triggered by issuing debt and warrants. Some applications of the theoretical results proposed in this paper are presented in Section 5. Section 6 presents our empirical results of five selected warrant-issuing firms. Section 7 provides a summary and directions for further research.

2. Notations and assumptions

Historically, warrant valuation models can be classified as either "structural" or "reduced-form" based on the information sets used in constructing the model. Structural models are those that assume that the market has complete information with respect to the firm's asset value and knows the details of the firm's entire dynamic liability structure. In contrast, reduced-form models assume that the market only has information with respect to the firm's stock price process and the outstanding warrants. Here, we concentrate on the structural approach. First of all, for the sake of convenience, throughout this paper, we use the following notations:

N	the number of outstanding shares;
M	the number of outstanding warrants;
k	the exercise ratio;
X	the exercise price of per warrant;
t_W	the time of the warrant's issuance;
t_D	the time of the debt's issuance;
μ	the expected rate of return on the value of the firm's assets;
σ	the annual standard deviation in (logarithmic) returns on the value of the firm's assets;
Bt	a standard Brownian motion;
T_W	maturity date of the outstanding warrants;
T_D	maturity of zero-coupon bond;
F	the face value of zero-coupon noncallable debt contract;
r	instantaneous riskless rate of interest (riskless interest rate);
$\phi\,(\cdot)$	standard normal probability density function;
V_t	asset value of the firm at time t;
S_t	price per share of common stock at time t;
E_T	the value of equity at T;
$\Phi(\cdot)$	standardized cumulative normal distribution function;
$W_t(\cdot)$	the valuation of the call warrants;
$Ct(\cdot)$	the Black–Scholes call option valuation formula;
$Dt(\cdot)$	the valuation of the debt.

After providing some useful notations, we are in a position to present some "ideal conditions" in the market. Our analysis is not limited to any specific pricing model (e.g., the Black–Scholes model). Instead, we provide results that are valid for any pricing model satisfying the following basic assumptions:

(A1). Warrants are issued in conjunction with debt (zero-coupon bond), i.e., debt, warrants and stocks are used as vehicles to finance the activity of a firm.

(A2). The value of the firm, V_t, follows a geometric Brownian motion under the physical measure $\mathbb{P}$:

$$dV_t = \mu V_t dt + \sigma V_t dB_t \quad . \tag{2.1}$$

(A3). The warrants issued by the firm have the same maturity as debt, i.e., $T_W = T_D$.

Assumption **(A1)** implies that the firm is debt financed. In other words, zero-coupon bond, stocks and warrants are the sources of financing for companies. Assumption **(A2)** is a standard assumption that Merton (1974) laid the foundation on the structural approach to credit risk modeling. We make this assumption for simplicity. Note however that the approach proposed in the rest of this paper can be extended to the more realistic case, where the value of the firm follows jump diffusion models or stochastic volatility models. Assumption **(A3)** is a special case of realistic situations. Indeed, there are two other cases: warrants with shorter maturity than debt and warrants with longer maturity than debt. However, we can obtain similar results for the other two cases with the similar discussion provided in the rest of this paper. Due to this fact, we shall just focus on the case of Assumption **(A3)**.

3. The dynamics of the stock price process

Historical studies priced warrants issued by firms, which are financed just by shares and warrants. However, the majority of firms issuing warrants are also debt financed. To reflect this fact, we consider the dynamics of the stock price in two cases: 1) before the introduction of warrants and debt; and 2) after the introduction of warrants and debt.

Before the debt and warrants insurance, the stock price is equal to the market value of the firm equity, divided by the number of outstanding shares. We can thus easily obtain the standard deviation before warrants and debt issue, which is summarized by the following theorem.

Theorem 3.1. *Before issuing debt and warrants, the stochastic differential equation for stock price process can be expressed as*

$$dS_t = \mu S_t dt + \sigma S_t dB_t, 0 \le t \le t_W \quad . \tag{3.2}$$

Proof. It is clear that before issuing debt and warrants, the stock is the only source of financing that the firm is using. Thus $V_t = NS_t$. From Assumption **(A1)**, we can write the process for the return of stock price as

$$dS_t = \frac{1}{N} dV_t = \frac{1}{N} (\mu V_t dt + \sigma V_t dB_t) = \mu S_t dt + \sigma S_t dB_t. \tag{3.3}$$

This completes the proof. ■

Having established the stochastic differential equation for the stock price before issuing debt and warrants, we will work with the

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