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Pricing of put warrants and competition among issuers

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Abstract

Issuers may compete with each other by issuing similar warrants with the same underlying stocks, causing a supply-side effect on warrant markets. The study provides a theory and supported evidence that put warrants on individual stocks are issued by third party banks in Taiwan and that they respond to overpricing of a put warrant issued by a competitor by issuing their own with more attractive terms. We measure the mispricing by the theoretical prices of either the square-root constant elasticity volatility (SRCEV) model or the Barone-Adesi and Whaley (BAW) model. The results reveals that competition among issuers helps reduce prices in put warrant markets.

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I. Introduction

This study addresses the role of competition among issuers in put warrant markets. Most studies of options pricing have emphasized the linkage between the prices of options and those of underlying assets, neglecting the supply-side effect in option markets. In Taiwanese markets, (covered) warrants are issued by a third party other than the company that issues the underlying securities. The issuers of warrants are either security firms or investment banks. Issuers generally compete with each other by issuing similar warrants of the same underlying stocks, raising the issue of how competition among issuers affects warrant prices.

Numerous studies have addressed competition in derivative markets. Bartram and Frank (2007) suggest that competition between bank-issued option (covered warrant) markets and traditional derivatives exchanges reduces bid-ask spreads in both markets. Horst and Veld (2008) assert that the framing effect causes warrant to be overpriced. Blascoa *et al.* (2009) examine volatility spillovers between futures and option markets on the stock index, regarding different trading costs and liquidity levels, and suggest that the market with less liquidity has fewer volatility spillovers.

The present investigation elucidates a theory of the supply-side effect that states that when a put warrant contract is overpriced, other issuers have more incentive to issue warrants of the same underlying stocks, and the competition among them reduces warrant prices. Accordingly, the number of warrants with the same underlying stock is predicted to be negatively related warrant prices.

This study utilizes a unique data set to test the supply-side prediction; A large sample with 483 (covered put) warrant contracts is collected in the period of 2003-2008. In contrast, other studies have only used small samples of warrants or index options.[1] Warrant prices are controlled by using either the square-root constant elasticity volatility (hereafter, SRCEV) model that was developed by Beckers (1980) and Lauterbach and Schultz (1990), or Barone-Adesi and Whaley (1987) (hereafter, BAW) model. The number of traded warrants with the same underlying stock is used as a proxy of the degree of competition among issuers. The result herein suggests that competition among issuers for warrants with the same underlying stock is significantly related to mispricing. This finding is robust when the year dummy variable is controlled. This observation is consistent with the findings of Lauterbach and Schultz (1990), Hauser and Lauterbach (1997), Bakshi *et al*. (1997), Kim and Kim (2004), Sharp *et al.* (2010), and Huang *et al.* (2011).[2]

[1] Warrant contracts generally are much more liquid than exchange-traded stock options, most of which are extremely illiquid in Taiwanese markets.

[2] Among these cited studies, Huang *et al.* (2011) examine index options in the Taiwanese market and further suggest that the performance for the GARCH model is the best, and a stochastic volatility model slightly outperforms the Black-Scholes model. Pricing models that are based on time series data cannot generally be applied to data of warrants of individual stocks, owing to short traded periods for

This study is also close to several existing empirical studies on the pricing model of put options. Among them, Loudon (1990) examines put options in the Australian market by using the Black-Scholes model and BAW model and find that mispricing is especially significant for those put options with out-of-the-moneyness and long time to expiration. Chen, Sears and Shahrokhi (1992) focus on put warrants with Nikkei 225 index as the underlying asset by using the BAW model and the constant elasticity of variance (CEV) model. Their results suggest that BAW and CEV models provide insignificant difference between them, and mispricing exists during the early period after issuing. Additionally, Wei (1995) adopts the trinomial lattice model to test put warrants with Nikkei 225 index and shows that theoretical models tend to be provide higher prices than observed market prices.

This paper is organized as follows. Section II presents the data and empirical models. Section III analyzes the empirical results obtained from the data and models. Section IV draws conclusions.

II. Data and empirical models

Data from the Taiwan Stock Exchanges are used herein. Stock warrants have a longer expiration period than stock options. Most (put) warrants are issued to have expiration periods of half a year or one year. Warrants may not be sold short, leading in theory to overpricing, which is exacerbated by the fact that trades by individual investors account for more than 70% of total trading volume.

This investigation extends the empirical model of Schulz and Trautmann (1993) to the supply-side. Daily theoretical warrant prices are computed by either the SRCEV model or the BAW model to yield a benchmark.

We use the SRCEV model provided by Chen, Sears and Shahrokhi (1992). The theoretical putwarrant prices is given as

$$P_{srcev} = K e^{-rT} N\big(-q(0)\big) - SN(-q(4)),$$

where K is the exercise price, S is the spot price of the underlying asset, T is the time to expiration, N is the cumulative function of the standard normal distribution, and q is given as

$$q(w) = \frac{\left[1+\frac{h(h-1)(w+2y)}{(w+y)^2} - h(h-1)(2-h)(1-3h)\frac{(w+2y)^2}{2(w+y)^4} - \left(\frac{z}{w+y}\right)^{h}\right]}{\left[2h^2\left(\frac{w+2y}{(w+y)^2}\right)\left(1-(1-h)(1-3h)\left(\frac{w+2y}{(w+y)^2}\right)\right)\right]^{\frac{1}{2}}},$$

where y, z, and h are the following functions, in which w is the value of 0 and 4:

$$y = 4rS/\sigma_{srcev}{}^2(1-e^{-rT}),$$
$$z = 4rK/\sigma_{srcev}{}^2(e^{-rT}-1),$$

each warrant (less than one year), and the fact that some data are missing because of extremely low prices, illiquidity and price limits on the underlying stocks.

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$$h(w) = 1 - 2/3(w + y)(w + 3y)(w + 2y)^{-2},$$

and we use the volatility measure of Becker (1980) $\sigma_{srcev}{}^2 = \frac{rSe^{rT}e^{\sigma_{bs}{}^2}(e^{\sigma_{bs}{}^2}-1)}{e^{rT}-1}$.

We also adopt the BAW model of Barone-Adesi and Whaley (1987) to compute the theoretical prices of put warrants. The BAW theoretical price is given as the following formula:

$$P_{baw}(S,T)=p(S,T)+A_1(S/S^{**})^{q1} \quad \text{, when} \quad S> S^{**},$$
$$P_{baw}(S,T)=K-S \quad \text{, when} \quad S\leq S^{**},$$

where

$$A_1 = -(S^{**}/q_1)\{1-e^{(b-r)T}N[-d_1(S^{**})]\},$$

and S** is the solution to the following non-linear equation:

$$K-S^{**}= p(S^{**},T)-\{1-e^{(b-r)T}N[-d_1(S^{**})]\}S^{**}/q_1,$$

where

$$q_1 = \frac{\left[-(N-1)-\sqrt{(N-1)^2+4M/K}\right]}{2}, \; M = 2r/\sigma^2, \text{and } N = 2b/\sigma^2,$$

A generalized least square regression is conducted as follows.

Mispricing$=\beta_0+\beta_1$ *ln(#warrants with the same underlying stock+1)*
$+\beta_2$ *ln(#warrants of all underlyings+1)*
$+\beta_3$ *Volatility* $+\beta_4$ *Moneyness* $+\beta_5$ *(Time to expiration)*
$+\beta_6$ *(Turnover rate)*
$+\beta_7$ *Underlying asset returns*$+\beta_8$ *Year dummy variables*$+\varepsilon$,

where *Mispricing* is computed as (observed warrant prices-theoretical warrant prices)/(theoretical warrant prices). [3] Two variables of #warrants (the number of warrant contracts) capture the degree of competition from other issuers, using a logarithm transformation after a plus with one to avoid the value at zero; *Volatility* represents the historical volatility of the underlying stocks, computed from preceding 250 days; *Moneyness* is defined by stock prices/(exercise price × exp(three-month interest rate*time to expiration) following Schulz and Trautmann (1993); *Time to expiration* is the annualized time to expiration for each warrant; *Turnover Rate* is the daily trading volume divided by the number of shares issued. The regression controls for *industry dummy* variables, *issuer dummy* variables and *year dummy* variables to ensure robustness.

Put warrants from July 2003 to October 2009 are collected. Data are deleted if they meet one of three conditions, which are that warrant prices are lower than 0.1, trading volume is less than 100 units, and either the underlying stock prices or warrant

[3] Our results are generally robust if we use another alternative of mispricing as (observed warrant prices-theoretical warrant prices)/(observed warrant prices).

prices hit their price limits. Very low prices cause the problem of large over-pricing according to Horst and Veld (2008). Any illiquid sample is deleted to eliminate the effect of illiquidity on mispricing. The data that are used in this study comprise 483 warrant contracts and total 46064 daily warrant prices. This sample is larger than that used in most related studies.

Table 1 present descriptive statistics concerning variables used in this study. The mean *Mispricing* is -0.138 (-13.8%) for the SRCEV model and -0.041 (-4.1%), suggesting that theoretical models are on average overpriced relative to theoretical prices, consistent with Wei (1995). However, over a quarter of warrants remain underpriced. The mean *Volatility* is 47.3%, revealing that issuers prefer stocks with great volatility on which to issue associated put warrants. *Moneyness* (underlying stock price /exercise prices) has a mean value of 1.116, indicating that over one half of warrants are out-of-the-money. ln(*#warrants with the same underlying stock+1*) has a median value of 0.693 and a third quartile value of 1.792, showing that 50% (25%) of warrants have at least one (five) traded and competing warrants with the same underlying stock. This observation reveals that issuers commonly issue warrants with the same underlying stock, creating competition among themselves. Additionally, ln(*#warrants of all underlyings+1*) has a first quartile value of 3.689, a median value of 4.297 and a third quartile value of 5.193, implying that 25% (50%, 75%) of data relate to a warrant that is competing with at least 179 (72, 39) other warrants that are traded on the same day.

Table 1. Descriptive statistics for variables used in this study

Variables	Mean	Std. Dev.	First quartile	Median	Third quartile
Mispricing (SRCEV model)	-0.138	0.499	-0.396	-0.158	0.008
Mispricing (BAW model)	-0.041	0.831	-0.444	-0.050	0.132
ln(*#warrants with the same underlying stock+1*)	0.988	0.888	0.000	0.693	1.792
ln(*#warrants of all underlyings+1*)	4.297	0.927	3.689	4.477	5.193
Volatility	0.473	0.106	0.398	0.491	0.547
Moneyness	1.116	0.285	0.941	1.122	1.289
Time to expiration (year)	0.441	0.215	0.284	0.452	0.604
Underlying asset return	-0.010	3.095	-1.786	0.000	1.690
Turnover	0.030	0.057	0.001	0.013	0.044

III. Empirical results

Table 2 presents the results of the regression analysis. In the third, fourth and fifth columns, ln(#*warrants with the same underlying stock*+1) is observed to be negatively related to mispricing for both SRCEV and BAW models, supporting the theoretical prediction that competition increases supply and so reduces warrant prices.

Table 2. Competition among issuers and warrant prices

	Dependent variable: *Mispricing (CEV model)*		Dependent variable: *Mispricing (BAW model)*	
Regressors	Model 1	Model 2	Model 3	Model 4
ln(#*warrants with the same underlying stock+1*)		-0.132***		-0.223***
		(-19.32)		(-19.92)
ln(#*warrants of all underlyings+1*)		-0.052***		0.004
		(-18.95)		(0.68)
Volatility	-1.519***	-1.259***	-2.572***	-1.519***
	(-53.30)	(-47.56)	(-64.92)	(-38.10)
Moneyness	-0.449***	-0.355***	-0.217***	0.167***
	(-55.58)	(-36.29)	(-9.63)	(5.90)
Time to expiration	-0.096***	-0.107***	0.219***	0.156***
	(-7.91)	(-9.45)	(12.47)	(9.39)
Underlying Stock Return	0.003***	0.003***	0.003***	0.005***
	(5.12)	(4.84)	(2.94)	(5.48)
Turnover rate	0.881***	0.589***	3.254***	2.295***
	(11.01)	(7.03)	(9.09)	(6.33)
Year dummy Included	No	Yes	No	Yes
Constant	1.096***	1.558 ***	1.224***	1.158***
	(69.34)	(45.66)	(35.65)	(17.60)
Adjusted R^2	0.202	0.261	0.181	0.267

Notes: White's heteroskedasticity consistent covariance estimates are used. T-statistics are in parentheses. The symbols *, ** and *** indicate significance at a 10% level, 5% level and 1% level, respectively.

The variable ln(*#warrants of all underlyings*+1), however, is observed also to be negatively correlated with mispricing for the SRCEV model, but shows insignificance for the BAW model, possibly because warrants with different underlying stocks do not create a competitive effect since they are not close substitutes.

Table 3. Regression for sub-groups of American and European put warrants

	Dependent variable: *Mispricing (CEV model)*		Dependent variable: *Mispricing (BAW model)*	
Regressors	Model 1 (American)	Model 2 (European)	Model 3 (American)	Model 4 (European)
ln(*#warrants with the same underlying stock+1*)	-0.215***	-0.101***	-0.234***	-0.245***
	(-14.07)	(-13.60)	(-10.52)	(-18.45)
ln(*#warrants of all underlyings+1*)	-0.013***	-0.061***	0.040***	0.007
	(-2.26)	(-18.84)	(4.45)	(0.92)
Volatility	-1.755***	-1.091***	-2.222***	-1.220***
	(-23.73)	(-39.93)	(-19.96)	(26.57)
Moneyness	-0.193***	-0.411***	0.337***	0.084***
	(-8.23)	(-37.31)	(5.47)	(2.45)
Time to expiration	-0.303***	-0.006	-0.065*	0.275***
	(-10.58)	(-0.54)	(-1.69)	(15.02)
Underlying Stock Return	0.001	0.003***	0.003	0.005***
	(0.69)	(5.93)	(1.47)	(5.17)
Turnover rate	0.428***	0.509***	2.256***	2.150***
	(2.28)	(5.34)	(3.05)	(4.84)
Year dummy Included	Yes	Yes	Yes	Yes
Constant	1.980***	1.370***	1.325***	1.178***
	(25.31)	(38.54)	(7.99)	(17.82)
Adjusted R^2	0.249	0.307	0.258	0.275

Notes: White's heteroskedasticity consistent covariance estimates are used. T-statistics are in parentheses. The symbols *, ** and *** indicate significance at a 10% level, 5% level and 1% level, respectively.

The effects of other variables on mispricing are compared with previous studies according to all four regression models. *Volatility* reduces *Mispricing*, consistent with the results of Schulz and Trautmann (1993), Long and Officer (1997) and Gultekin *et al*. (1982). The turnover rate reflects premiums for liquidity as investors have higher willing to pay when warrants are more liquid. Stock return is positive with mispricing, which might be explained that investors tend to buy put but warrants when the underlying assets have positive return, meaning that investors anticipate short-term reversal effects. However, *Moneyness* and *Time to expiration* have opposite impacts on mispricing for two models. Additionally, Table 3 further presents robust regression results for two subgroups, American put warrants (33% of sample) and European put warrants (67% of sample).

IV. Conclusions

The study provides new empirical evidence on the pricing of put warrants that mispricing is partly related to competition among warrant issuers. When a put warrant is overpriced, other issuers may issue similar warrants with the same underlying assets, creating competition among issuers. The results reveal that competition among issuers helps reduce put prices in put warrant markets, inducing a more efficient market that benefits the investors. A natural extension of the present analysis would be to more sophisticated pricing models of put warrants.

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