



Contents lists available at [ScienceDirect](#)

North American Journal of Economics and Finance

journal homepage: www.elsevier.com/locate/ecofin



Shadow costs of incomplete information and short sales in the valuation of the firm and its assets[☆]



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ARTICLE INFO

Article history:

Available online 23 February 2016

JEL classification:

G3
G31
G32
G33

Keywords:

Valuation of the firm
Options
Arbitrage
Pricing
Information costs
Short sales costs

ABSTRACT

This paper presents a simple framework for the valuation of compound options within shadow costs of incomplete information and short sales. The shadow cost includes two components. The first component is the product of pure information cost due to imperfect knowledge and heterogeneous expectations. The second component represents the additional cost caused by the short-selling constraint. Information costs are linked to Merton's (1987. *Journal of Finance* 42, 510) model of capital market equilibrium with incomplete information, CAPMI. This model is extended by Wu et al. (1996. *Review of Quantitative Finance and Accounting*, 7, 136) who propose an incomplete-information capital market equilibrium with heterogeneous expectations and short sale restrictions, GCAPM. This model is used in our paper to provide for the first time in the literature analytic solutions for derivatives in the presence of both shadow costs of incomplete information and short sales.

When deriving the compound call option formula, we consider a call option on a stock, which is itself an option on the assets of the firm. Our methodology incorporates shadow costs of incomplete information and short sales on the firm's assets as well as the effects of leverage in the capital structure. The formula can be useful in the

[☆] I would like to thank Professors G. Barone-Adesi, M. Brennan and O. Vasicek for their helpful comments presented at IFC 8 Conference, Paris 2015. We would like to thank 2 anonymous referees for their helpful comments.

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valuation of several corporate liabilities in the presence of information uncertainty and short sales constraints about the firm and its cash flows. Our analysis can be used for the valuation of several real options.

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1. Introduction

The compound option or an option on an option has been studied by [Black and Scholes, B–S \(1973\)](#) and [Geske \(1979\)](#). [Geske \(1979\)](#) shows that several corporate liabilities are options. The concept allows the study of several opportunities with a sequential nature where some of them are available only if earlier opportunities are undertaken. [Bellalah \(1999\)](#) provides valuation formulas for stock options and commodity options in a context of incomplete information. The formulas are derived in an equilibrium approach by a simple extension of the main results in [Merton's \(1987\)](#) model of capital market equilibrium with incomplete information, CAPMI and by applying arbitrage arguments.

[Wu, Qiang Li, and Wei \(1996\)](#) extend [Merton's \(1987\)](#) model to account for heterogeneous expectations and short sale restrictions. In their model, the GCAPM, systematic risk is affected is affected not only by the beta but also the variance of residual return and the size of the company. The effect of short sales restrictions on equilibrium prices is more evident and more pronounced for smaller and less known securities. The analysis increases the robustness of Merton's asset pricing model. Short-sale constraints affect investors' use of information in financial markets. Investors who face short-sale constraints may not be able to trade based on their private information, so asset prices will not fully reflect their views. Theoretical models on short-sale constraints examine the effects of these constraints on information use by market participants. They study the implications for investment decisions and equilibrium prices. Short-sale constraints not only can affect investors' use of information in their investment decisions, but also can affect their incentives to acquire information. The differences in information acquisition can have important implications for investment decisions and asset prices.

However, to our knowledge, there is until today no known derivatives formulas that account the effects of shadow costs of incomplete information and short sales. This is our main objective in this paper. As Merton's model can be used to discount future cash-flows, the model by [Wu et al. \(1996\)](#) can be used for the same purpose. In this case, the expected return would be the riskless rate plus information costs less the costs of short selling.

[Nezafat and Wang \(2013\)](#) develop a model of information acquisition and portfolio choice under short-sale constraints. They show that short-sale constraints reduce information acquisition and both the constraints on short-selling and the reduced information acquisition affect investment decisions. The effects of short-sale constraints on investment decisions and asset prices are driven largely by the effects on information acquisition, and such effects vary depending on the return and risk characteristics of the risky assets¹.

In this paper, we use arbitrage arguments rather than an equilibrium approach to derive the formula in an extended [B–S \(1973\)](#) economy. Such a formula might be applied to the valuation of equity in the capital structure of the firm. The use of information costs and short sales costs regarding the firm and its cash flows might help to understand why [B–S](#) model leads to theoretical prices, which are systematically biased. The information uncertainty about the firm and its cash flows reflects the agency costs and the asymmetric information problems. By assuming the stock as an option on the value of the firm, the value of the call as a compound option can be derived as a function of the firm's

¹ [Nezafat and Wang \(2013\)](#) model follows the recent theoretical literature on endogenous information acquisition in financial markets and explicitly incorporates the information acquisition decision in investors' overall investment decision. We refer the reader to [Van Nieuwerburgh and Veldkamp \(2009\)](#), [Van Nieuwerburgh and Veldkamp \(2010\)](#) and [Mackowiak and Wiederholt \(2012\)](#), for models of information acquisition in financial markets. In the model by [Nezafat and Wang, \(2013\)](#), investors take short-sale constraints into consideration in their information acquisition decisions before they acquire the information. Short sale constraints and the information acquisition decisions then jointly determine the investment decisions.

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