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Optimal capital structure and the impact of time-to-build

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ABSTRACT

We develop a dynamic investment options model with optimal capital structure and evaluate the effect of time-to-build on firm value and leverage choices. With time-to-build the firm increases initial leverage in order to reduce the impact of delayed cash flows resulting from time-to-build. The impact of time-to-build is more severe the higher the revenue volatility and competitive erosion, and when the firm issues long-term debt. Time-to-build is shown to have a substantial impact on firm values for plausible parameter values.

1. Introduction

Firm's large capital projects may take several years to build. Time-to-build, reflecting the time it takes for the completion of a project, characterizes many investment decisions and exists at different intensities, depending on the industry the firm operates and the types of uncertainties. For example,

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new drug development may take more than 10 years for completion (Schwartz and Moon, 2000). Land development projects may be delayed until a construction permit is issued, which takes time in particular in countries with less developed governmental procedures. Investment in power plants or aerospace projects may take about 6–10 years to complete (see Bar-Ilan and Strange, 1996 and references therein). Mine development projects are time consuming and usually require at least 5–6 years to complete, with constraints on the pattern of expenditures (Brennan and Schwartz, 1985). And, typically, the installation of scrubbers to control pollution emissions and other abatement technologies require at least 3–4 years to complete (Insley, 2003).

Although time-to-build is pervasive, there are very few theoretical studies considering the impact of time-to-build on the valuation of an investment project. In this paper we develop a comprehensive model along the lines of the contingent claims literature (e.g., Leland, 1994; Hackbarth and Mauer, 2012), by allowing for multiple investment stages and optimal capital structure and focusing on the case of time-to-build. Theoretical work using a real option approach with time-to-build has focused on the case without optimal capital structure (see Majd and Pindyck, 1987; Bar-Ilan and Strange, 1996, 1998; Milne and Whalley, 2000). Koussis et al. (2007) analyze a similar case called "time-to-learn" where the firms learn new information about the project with a time lag. In Majd and Pindyck (1987) there is a maximum rate at which construction proceeds, so that it takes time before the project is completed and begins to generate revenue. Investment proceeds continuously until the project is completed, although construction can be stopped and later restarted without a cost. In contrast, in our paper investment decisions are made discretely rather than continuously, the investment option comes to the end of its useful life, instead of being infinitely lived, and optimal capital structure is introduced. An interesting remark of the above-mentioned literature on time-to-build is that the usual relationship between the opportunity cost of delaying completion of the project and the timing of investment may be reversed in the presence of time-to-build, since time-to-build causes a reduction in the value (moneyness) of the option: a decrease in the opportunity cost may accelerate instead of delaying investment in the presence of time-to-build. However, in these papers, due to the absence of capital structure considerations, an increase in volatility or a decrease in the opportunity cost have the traditional real option effect of increasing the option value of completing the project successfully, thus decreasing the negative effect of time-to-build on firm values.[2] Our paper is the first that introduces capital structure decisions in the presence of time-to-build. Within our setting, we show that an increase in volatility reduces firm values and makes the effect of time-to-build on firm values more severe, since with higher volatility the ability of the firm to raise more debt is reduced. Indeed, there are countervailing effects on firm value and for realistic parameter values the investment option effect is offset by the leverage effect, which emphasizes the firm value reduction in the presence of time-to-build. Similarly, a decrease in the opportunity cost not only creates an increase in firm values arising from lower erosion in value, but also enhances firm value by enhancing the ability of the firm to raise more debt.

We show that an increase in the time-to-build horizon increases initial debt in order to alleviate the impact of time-to-build. When the maturity of initial debt is long, the firm raises more debt in the subsequent short-term debt issue and only when time-to-build becomes more severe will resort to issue more debt at an initial debt issue.[3] The impact of time-to-build may be substantial. For realistic parameter values, the reduction in firm value may range between 4.5% and 22% for time-to-build of 5 years with short term debt and about 80% for time-to-build of 10 years. The impact of time-to-build can be even higher in case of long-term debt.

[2] We do not consider the effect of investment timing in this paper, but investigate the changes in firm value after the investment option has been exercised. It has been shown (Milne and Whalley, 2000) that whilst optimal investment thresholds always exceed the naive NPV thresholds, the effects of increased uncertainty in raising optimal investment thresholds can be significantly reduced for projects with time-to-build. Actually, when time-to-build is long the issue of timing becomes scarcely significant even for high levels of uncertainty.

[3] Our results are computed under the assumption of a full loss offset taxation scheme, which is employed in most trade-off models of capital structure. With a no loss offset tax schemes it can be shown that initial debt levels are reduced significantly for short term horizons. The sensitivity to volatility and opportunity cost behave similarly to the full loss offset case. Alternative tax schemes include the asymmetric tax-scheme where the tax benefits of debt are lower when the firm incurs losses (e.g., Tserlukevich, 2008; Agliardi and Agliardi, 2009).