Corporate Risk Measures and Real Options
Extended Abstract

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Abstract

This paper investigates how the exercise of a real development option affects measures of corporate risk, such as volatility and beta. Various empirical studies examine the changes in risk measures and the cost of capital around the time of corporate investment (exercise of a real option), but they generally fail to separate the exercise of the real option from the financing effects associated with the investment. This means that they predictably get mixed results as they investigate changes in volatility, beta and cost of capital around the time of corporate investment.

1 Leverage and Hedging Effects on Risk Measures

Consider a corporate investment K that is required to exercise a real option of value W when the underlying asset resulting from the investment has value P. At the time of development, $W = P - K$.

The volatilities and betas of the underlying investment and option to invest are related by

$$\begin{aligned} \beta_W &= \frac{P}{W}\frac{\partial W}{\partial P}\beta_P \\ \sigma_W &= \frac{P}{W}\frac{\partial W}{\partial P}\sigma_P. \end{aligned} \tag{1}$$

In general, the first factor $P/W > 1$ and increases the risk measure. It is a leverage factor arising out of the fixed investment cost. The second factor $\frac{\partial W}{\partial P} \leq 1$ is the hedge ratio and decreases the risk measure. Overall, the leverage factor generally dominates the hedge factor so that the real option has greater risk than the underlying:

$$\begin{aligned} \beta_W &> \beta_P \\ \sigma_W &> \sigma_P. \end{aligned}$$

Because of this, there is a general perception that a firm with real growth options should see a decline in risk, when it exercises the real options by making a capital investment. Indeed, at the time of investment, the hedge ratio equals 1 and only the leverage effect is left in equation (1), which makes it seemingly clear that the volatility and beta of the firm should decrease at the time of option exercise.

But, this precisely highlights the importance of leverage, because the leverage in the standard real option model arises because the capital K must be issued in order to exercise the option for a value of $P - K$.

Now, some firms issue securities in order to exercise a real option, because they do not have sufficient cash on hand. This is common in mineral extraction projects, where the financing is commonly debt financing or a joint venture agreement ("farm-out"). On the other hand, there are many industries where firms have large amounts of cash on hand and can exercise real options with cash on hand. The tech giants Apple, Microsoft and Google are rich in real options and also rich in cash. On the other hand, there are many startup tech firms that are rich in real options, but short on cash, so they need to issue shares or enter joint ventures to exercise their real options.

If the firm owning real options has the cash on hand, there is no net leverage effect from the real option. The only effect is the hedge ratio effect, which increases the risk of the firm as option exercise approaches. In other words, a firm with out-of-the-money real options may have less risk than a firm that is close to exercising its real options or has just exercised them, or it may have more risk. The question depends on whether the leverage effect is present, which is to say whether or not the firm has cash on hand to exercise the real option.

Figure 1 illustrates the situation. The top panel represents a firm with cash on hand to exercise the real option and the lower panel represents a firm that must issue securities to exercise its real option. In both situations, the firm value is W and the exercise price is K. The only risk driver is the underlying project value. The optimal exercise threshold in both cases is at an underlying project value of P^*. For the firm in the top panel, we would expect that $\sigma_W < \sigma_P$ and $\beta_W < \beta_P$, which most people would regard as an unusual situation because the real option has less risk than the underlying. The more popular model is the bottom model where $\sigma_W > \sigma_P$ and $\beta_W > \beta_P$, where the real option has more risk than the underlying. But, this is because the popular model incorporates a financing effect that gives leverage.

2 The Leverage and Hedging Effect on Empirical Studies

Real option values increase with the volatility of the underlying risk, other things being equal. The is investigated by Grullon et al. (2012), where evidence is provided to support this. That is, firms that have a lot of real options show a positive relationship between increases in volatility and high

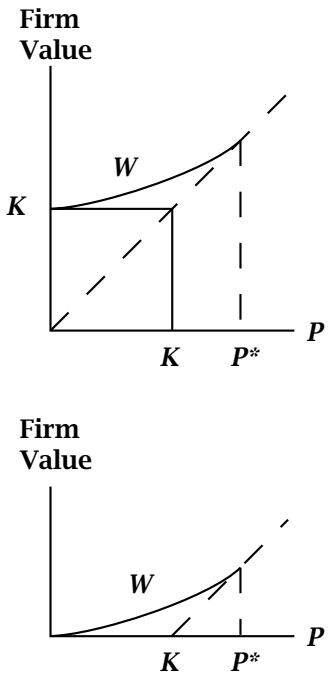

Figure 1: The top panel represents a firm with cash on hand to exercise the real option and the lower panel represents a firm that must issue securities to exercise its real option. In both situations, the firm value is W and the exercise price is K. The only risk driver is the underlying project value P. The optimal exercise threshold in both cases is at an underlying project value of P^*.

stock returns. They[1] "find that the volatility-return relation is stronger among young firms, small firms, high R&D firms, and high growth firms." They go on to note that[2] "the sensitivity of firm value to changes in underlying volatility increases prior to real option exercises, drops sharply following exercises of real options, and then starts rising again as firms start to build up new real options." They measure firm volatility with daily data over monthly intervals, and investigate the monthly changes in volatility as an explanatory variable. They find a positive relationship between volatility increases and firm returns. Their Table V is particularly important in this respect, because it relates firm excess returns to investment spikes and to secondary equity offerings. It regards both as proxies for the exercise of a real option. But, they don't carefully examine the relationship that we identify above. Namely, the relationship between volatility changes around the time of investment will depend on whether the firm issues securities to exercise the real option or uses cash on hand to exercise the real option.

3 The Methodology of This Paper

In this paper, we intend to investigate the relationship between volatility changes and firm returns, and separate those firms that are likely to need to issue securities to exercise the real option from the firms that have enough cash on hand to exercise the real option.

There are two approaches we propose to use to investigate this issue:

1. Simulate some firms that are endowed with real options. Assume they are valued rationally and that the real options are exercised optimally. We will use the simulations to simulate changes in volatility and market returns as studied by these papers, but pay close attention to other important confounding factors:

   (a) Whether the firm has cash on hand to enable exercise, or whether it must issue equity to exercise.

   (b) The effect of the (risk-neutral) growth rate of the underlying the real options on the relationship between changes in firm volatility and excess returns.

   (c) The sensitivity of the firm volatility-return effect to the nature of the firm's portfolio of real options. At one extreme, the firm will have one real option that is perfectly correlated with the firm's

[1] Page 1500, last full paragraph.
[2] Page 1501, second full paragraph.

existing business. At the other extreme, the firm will have many uncorrelated real options, so that its volatility has a diversification effect.

2. Replicate the existing studies on this issue, but distinguish the effects for firms that differ on the dimensions listed just above.

Simulation has been used by Berk et al. (1999); Carlson et al. (2004); Da et al. (2012) and others to investigate the ability of real options models to explain asset pricing anomalies. However, they have not focussed on how this relates to the leverage effect of having sufficient cash on hand, versus needing to issue cash to exercise the real option.

Real options and investment are examined empirically by Bulan (2005), but they do not examine this leverage effect.

Simulation is also used Carlson et al. (2010) to study secondary equity offerings (SEOs) and real options, but they do not distinguish between firms that exercise real options with the leverage of an SEO from those that exercise their real options from cash on hand.

Whited and Wu (2006) examine financial constraints, which are often related to a firms cash on hand, and relate them to other priced factors, but do not examine how the constraints affect leverage in a real options exercise context.

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