Journal of Urban Economics 65 (2009) 237–251

Contents lists available at ScienceDirect

Journal of Urban Economics

www.elsevier.com/locate/jue

Irreversible investment, real options, and competition: Evidence from real estate development

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ARTICLE INFO

Article history:
Received 26 October 2007
Revised 10 March 2008
Available online 12 April 2008

ABSTRACT

We examine the extent to which uncertainty delays investment, and the effect of competition on this relationship, using a sample of 1214 condominium developments in Vancouver, Canada built from 1979–1998. We find that increases in both idiosyncratic and systematic risk lead developers to delay new real estate investments. Empirically, a one-standard deviation increase in the return volatility reduces the probability of investment by 13 percent, equivalent to a 9 percent decline in real prices. Increases in the number of potential competitors located near a project negate the negative relationship between idiosyncratic risk and development. These results support models in which competition erodes option values and provide clear evidence for the real options framework over alternatives such as simple risk aversion.

1. Introduction

Over the last two decades, the application of financial option theory to investment in real assets has altered the way that researchers model investment.[1] Under the real options approach, firms should apply a higher user cost to new investments in irreversible assets when returns are stochastic, reflecting the option to delay that is lost when investment occurs. The effects can be quite large. For example, Dixit and Pindyck (1994) use simulations to show that the optimal hurdle price triggering new irreversible investment can be two to three times as large as the trigger value when investments are reversible. Yet others argue that competition erodes option values and limits the empirical relevance of the real options framework for many industries. Empirical support for the real options model has suffered from the absence of a clean test to differentiate between real options and more traditional discounted cash flow (DCF) models of investment in which the discount rate depends on risk.

In this paper, we address these issues by examining the relationship between uncertainty, competition, and irreversible investment using unique data on 1214 individual real estate projects (condominium or strata buildings) built in Vancouver, Canada between 1979 and 1998. In looking at real estate, we examine an asset class that represents a large component of national investment and wealth and a sector that exhibits great cyclical volatility in investment.

Some theoretical papers have argued that real options models have limited power to predict investment in competitive markets. Caballero (1991) suggests that imperfect competition is vital to predicting a negative relationship between uncertainty and investment. For example, competition might mitigate the value of a real option through the threat of preemption as in Grenadier (2002). Trigeorgis (1996) associates increased competition with a higher dividend yield from the underlying asset. When the dividend is high enough, it can induce early exercise by reducing the value of the option to wait. In a similar vein, Kulatilaka and Perotti (1998) argue that firms with a strategic advantage (market power) are in a better position to gain greater growth opportunities when uncertainty is higher. This induces more investment in growth options for this type of firm while companies that do not have a strategic advantage will be discouraged from investing.

In response to these critiques, others argue that with the addition of a few realistic assumptions, the value of the option to wait is preserved even with perfect competition. For example, Novy-Marx (2005) shows that competition does not diminish the value of an option to develop in the case of differentiated products such

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[1] Reviews of the theoretical literature include Dixit and Pindyck (1994), Trigeorgis (1996), and Brennan and Trigeorgis (2000). Among the seminal papers in this areas are Abel (1983), Bernanke (1983), Brennan and Schwartz (1985), McDonald and Siegel (1986), Majd and Pindyck (1987), Pindyck (1988), Dixit (1989), and Abel et al. (1996).

0094-1190/$ – see front matter
doi:10.1016/j.jue.2008.03.003

as real estate where locations are never perfect substitutes for each other and sites have varying opportunity costs of development due to differences in the pre-existing use of a site. Leahy (1993) and Dixit and Pindyck (1994) also contend that perfect competition does not necessarily reduce the value of waiting.

Existing empirical research supports the existence of a negative relationship between volatility and investment (Downing and Wallace, 2001; Moel and Tufano, 2002; Cunningham, 2006 and 2007). Nonetheless, real options models are not the only models in which one would expect a negative correlation between uncertainty and investment, an issue that is often not discussed in empirical real options research. In fact, if increases in volatility are driven by a greater exposure to non-diversifiable risk, most neoclassical models (such as the familiar capital asset pricing model—CAPM) would predict that greater uncertainty would lead to lower investment through an increase in the investor's required rate of return. In the case of incomplete markets, even increases in idiosyncratic risk will cause risk-averse investors to reduce investment if they cannot adequately hedge this type of risk. This latter condition is especially likely in the context of real estate, where many investors and developers are small and hold portfolios that are concentrated in a particular local market where they hold great expertise, but where there are no existing methods to hedge local market risk. Our findings described below address both of these issues.

We find clear support for the negative relationship between idiosyncratic uncertainty and investment that is a crucial prediction of the real options model. To separate the impact of the alternative models, real options and the CAPM, we decompose the volatility of condominium returns into idiosyncratic and market risk components. As predicted by the real options model, exposure to idiosyncratic risk reduces investment. However, consistent with the CAPM, exposure to market volatility also delays investment to nearly the same extent. A one standard deviation increase in idiosyncratic volatility reduces the probability of development by 13 percent, about the same predicted impact on new investment as a 9 percent decrease in real prices. A similar one standard deviation increase in market volatility reduces the likelihood of investment by the equivalent to a 7 percent fall in real prices.

Addressing the debate about how market structure impacts option exercise, we show that competition, measured by the number of potential competitors for a project, reduces the impact of condo return volatility on new investment. Empirically, competition has little direct effect on investment. Instead, competition only matters when interacted with volatility. We show that volatility has a smaller impact on option exercise for developments surrounded by a larger number of potential competitors. In fact, for the 5 percent of all units facing the greatest number of potential competitors, idiosyncratic volatility has virtually no effect on the timing of investment. These findings provide unambiguous support for the models of Caballero, Trigeorgis and Grenadier, which show that competition can erode the value of the option to delay irreversible investment.

Finally, the finding that competition only impacts investment indirectly through its correlation with uncertainty provides support for the real options model even in the presence of risk averse owners and incomplete markets. While risk averse owners without hedging opportunities will reduce investment in response to greater idiosyncratic volatility, only a real options model has the additional prediction that option value diminishes with competition.

The relationship between competition and real option exercise may help explain the strong pro-cyclical correlation between investment and output. Macro economists have often puzzled over the high volatility of investment relative to output, documented over long periods of time and across many countries (Basu and Taylor, 1999). Variation in competition over the cycle could provide at least one explanation for the excess volatility of investment. Rotemberg and Saloner (1986) and Rotemberg and Woodford (1991, 1992) argue that tacit collusion is difficult to sustain in booms, relative to busts. Our findings suggest that variation in competition can impact investment. Firms might optimally further delay investment in busts when product markets are less competitive, but undertake equivalent investments in booms when they face greater competition. This higher volatility for investment is consistent with the macro evidence.

The remainder of the paper is structured as follows. Section 2 provides a review of related work and a discussion of how this paper fits in with the empirical real options literature. In Section 3, we present the empirical specification along with a summary of its theoretical support. We also discuss the impact of various assumptions on the specification with respect to the completeness of capital markets and the unique properties of the real estate market. We present a more detailed discussion of the data in Section 4. The empirical results are presented in Section 5, and in Section 6 we conclude.

2. Existing literature

Real options theory has been applied to describe a broad range of investments and industries.[2] Macroeconomic aggregate studies by Pindyck and Solimano (1993) and Caballero and Pindyck (1996) find a negative relationship between aggregate investment and uncertainty, where uncertainty is measured as the variance in the maximum observed marginal revenue product of capital. Other papers (Holland et al., 2000; Sivitanidou and Sivitanides, 2000; Sing and Patel, 2001; and Cunningham, 2006 and 2007) examine this relationship specifically for real estate development, and usually, but not always, find a negative relationship between uncertainty and development. Leahy and Whited (1996) and Bulan (2005) also obtain mixed results when examining the effect of a firm's daily stock return volatility on the firm-level investment-capital stock ratio for a panel of manufacturing firms. However, real options models apply most directly to individual investment projects and predict that trigger prices are non-linear, so aggregate investment studies may obscure these relationships.

Studies that use project level investment data have the advantage of being able to relate individual investment decisions to direct measures of demand uncertainty such as output price volatility.[3] These papers have sometimes found limited evidence of a link between investment and volatility (e.g., Hurn and Wright, 1994), although recent work has tended to be more supportive of real options. Bell and Campa (1997) demonstrate that the volatility of exchange rates has a negative effect on new capacity investment in the international chemical industry, but that the volatility of input prices and demand have small and insignificant effects. Downing and Wallace (2001) find a negative link between volatility of prices and costs and the decisions of homeowners to improve their homes. Moel and Tufano (2002) examine the determinants of the decision to close or re-open a mine using a sample of 285 gold mines. They find that gold price volatility has a negative and statistically significant effect on these decisions, but that factors such as firm-specific managerial decisions also matter.

We take advantage of micro-data on a large number (1214) of condominium developments and examine the impact of volatility

[2] Applications include investments in natural resources extraction (Brennan and Schwartz, 1985; Paddock et al., 1988), patents and R&D (Pakes, 1986), and real estate (Titman, 1985; Wiliams, 1991, 1993; and Grenadier, 1996). Lander and Pinches (1998) summarize the applied literature.

[3] Quigg (1993) takes a different approach. She develops a structural model of land valuation using data in Seattle, finding that the option to wait is worth about 6 percent of the value of undeveloped industrial land, a relatively low value.