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Investment, consumption, and hedging under incomplete markets ☆

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Abstract

Entrepreneurs often face undiversifiable idiosyncratic risks from their business investments. We extend the standard real options approach to an incomplete markets environment and analyze the joint decisions of business investments, consumption/savings, and portfolio selection. For a lump-sum investment payoff and an agent with a sufficiently strong precautionary savings motive, an increase in volatility can accelerate investment, contrary to the standard real options analysis. When the agent can trade the market portfolio to partially hedge against investment risk, the systematic volatility is compensated via the standard CAPM argument, and the idiosyncratic volatility generates a private equity premium. Finally, when the investment payoff is a series of flows, the agent's

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idiosyncratic risk exposure alters both the implied option value and the implied project value, causing a reversal of the results in the lump-sum payoff case.
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1. Introduction

Real investment activities play a fundamental role in the economy. A real investment typically has three important characteristics. First, it is often partially or completely irreversible. Second, its future rewards are uncertain. Finally, the investment time is to some extent flexible. In the last three decades, a voluminous literature has developed that aims to study the implications of these three characteristics for the real investment decision.[1] A key insight of this literature is to view an investment decision as an American-style call option, where "American style" refers to the flexibility of choosing the time of option exercise. Based on this analogy and the seminal contributions to option pricing by Black and Scholes (1973) and Merton (1973), we can apply financial option theory to the irreversible investment decision. This real options approach to investment has become a workhorse in modern economics and finance.

The real options approach relies on one of the following assumptions: (i) the real investment opportunity is tradable; (ii) its payoff can be spanned by existing traded assets; or (iii) the agent is risk neutral. However, these assumptions are violated in many applications. For example, consider entrepreneurial activities. Entrepreneurs combine their skills with their business investment opportunities and ideas to generate economic profits. While entrepreneurs might have valuable projects, these projects might not be freely traded or their payoffs might not be spanned by existing assets because of liquidity restrictions or the lack of liquid markets. These capital market imperfections could be due to moral hazard, adverse selection, transactions costs, or contractual restrictions. Thus, investment opportunities can have substantial undiversifiable idiosyncratic risks. Entrepreneurs' well-being depends heavily on the outcome of their investments. Moreover, entrepreneurs' attitudes towards risk should play an important role in determining their interdependent consumption, savings, portfolio selection, and investment decisions.[2]

While entrepreneurial activities have other important dimensions such as how much to invest and how to finance the investment project, we focus on the investment timing aspect of entrepreneurial activities. We extend the standard real options approach to analyze the implications of uninsurable idiosyncratic risk for this decision, using entrepreneurship

[1] Arrow (1968) and Bernanke (1983) are among the early contributions on irreversible investment. For early stochastic continuous-time models, see Brennan and Schwartz (1985), McDonald and Siegel (1986), Pindyck (1988),and Bertola and Caballero (1994). Abel and Eberly (1994) provide a unified model of (incremental) investment under uncertainty. Dixit and Pindyck (1994) provide a textbook treatment of important contributions to this literature.

[2] There is a fast-growing literature on empirical evidence for entrepreneurship. See Gentry and Hubbard (2004), Heaton and Lucas (2000), and Moskowitz and Vissing-Jorgensen (2002), among others.

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