Chapter 1

Introduction

Every actor in society, whether an individual, an enterprise, or an institution, has to take decisions constrained by the information and the resources available, aimed at the creation and exploitation of opportunities. Whether the decision is to accept a new employment (or start a Ph.D.), launch a new product, enter a strategic partnership, or create a new infrastructure, there is a comparison of value gained and opportunity costs. How those values are estimated is a critical determinant of the solution to the resource allocation problem.

The success or failure of a project is often determined by external factors that cannot be controlled. A major decision on which the decision maker has control on is to choose the right moment to start the new project.

Most decisions, and investment decisions in particular, are characterised by three factors. First, they are in general partially or completely irreversible. As a result, the initial cost of taking the decision is at least partially sunk, so it cannot be undone later with full recovery of expenditures made. Second, the outcome is uncertain; the decision maker only knows an ex ante probability distribution. Third, there is some flexibility on the timing of the decision: action can be postponed to wait for more information or for more favourable conditions.

More traditional theories of investment decisions minimize the importance of these factors. Most firms, banks and institutions use the valuation techniques based on the concept of Discounted Cash Flows (DCF) to evaluate project and firm values. The most accepted technique is the Net Present Value (NPV). NPV involves determination of the project value as a function of the expected net cash flow discounted at the Weighted Average Cost of Capital (WACC). If this is positive the project is accepted, otherwise it is rejected.

The NPV rule ignores an alternative to the immediate acceptance/rejection criterion, which may be superior: waiting to invest at a later date. It implicitly assumes that the project is a "now-or-never" investment opportunity (or that the investment is fully reversible). It misses the value of managerial flexibility: for example, the ability of project managers to delay committing to certain investment decisions, or to reverse or change earlier decisions, based on new information.

Another problem with the conventional NPV rule is that it ignores the value of creating new investment opportunities. Sometimes an investment, e.g. R&D
investment, which appears unprofitable when viewed in isolation, may be profitable when the investment opportunities it creates are taken into account.

Real option theory offers an alternative approach that overcomes the drawbacks of the NPV rule. It stresses the fact that companies have opportunities to invest and that they must decide how and when to exploit those opportunities. It establishes an analogy between investment opportunities and financial options: opportunities are options, namely the rights but not the obligations to take some action in the future.

In this sense, most investment opportunities can be considered dividend-paying American options (options that can be exercised at anytime during their lives). The investment cost is the exercise price of the option, the project value, augmented by eventual extra opportunities, constitutes the underlying asset. The dividend is the cash flow forsaken if the investment is postponed.

The real option approach, applying financial option valuation, allows determination of the optimal time to perform an investment. It predicts the conditions under which it becomes optimal to start the investment (exercise the option), rather than to keep on postponing it (keep the option alive).

A standard NPV analysis might indicate that the investment is already attractive now. Yet, it is often desirable to delay an investment decision to wait for more information about market conditions, even though waiting means forgoing some immediate returns. Conversely, there may be situations in which uncertainty over future market conditions should prompt a company to speed up a certain investment. Such is the case when the investments create additional options that give a company the ability to access additional opportunities. R&D could lead to a series of patents, or launching a new product could lead to a dominant market position in related areas. A company might also choose to speed up investments that would yield information favouring some form of learning and thereby reduce uncertainty.

The real option approach thus offers a fundamental and effective tool for the manager to understand better the implications of an investment and to estimate the value of each action taken.

As general rule, real option theory suggests that an action, which creates an option or reduces uncertainty, needs to be valued more than the static NPV analysis would suggest. An action that exercises an option should be valued less than a simple NPV approach would indicate.

Standard real option theory implicitly assumes that the decision maker, i.e. the firm, is a monopolist of the investment opportunity and is a price taker in the output market. Thus investment strategies are devised without regard to the potential impact of these strategies on the other players' strategies. Unfortunately, in reality most decisions have significant impact on the decisions of other players. Strategic decisions of a player affect the payoffs of other players and their value is affected by the strategies of the other players. Thus strategic decisions need to be recognized to have consequences, and may limit the range of possible future actions.

An example of strategic behaviour is an investment decision taken by a firm operating in an imperfect competition market. In a duopoly a firm launching a new product, changing price, or changing marketing policy has consequences on
the return of competitors. Thus it can result in a more or less aggressive reaction. In the case of launching a new product, the costs of waiting may be particularly high. The waiting to invest firm may be pre-empted by a competitor and hence lose the possibility of being the first in the market and enjoying at least temporarily monopolistic profits. As a result, in a strategic setting the timing issue is even more relevant that in monopolistic environments, and has implications for many practical and realistic situations.

This thesis is a collection of essays exploring different aspects of the issue of timing when direct or indirect strategic decisions have to be taken. Using a theoretical approach, I study how this issue is relevant both in financial and economic decisions. All the papers show that timing is important, if not crucial for the outcome of investment decisions. The strategic component includes the effect of information disclosed or signalled by the decision. The optimal strategy turns out to be sometimes in contradiction to what traditional real option theory prescribes.

1.1 Strategic Real Options

In this section, a brief review of classic and strategic real option theory is presented. The principal papers in the existing literature are set out in chronological order to better frame the essays of the thesis.

Myers (1977) and Kester (1984) are the among the first to explore the analogy between future investment opportunities and financial call options: a call option is a contract that gives the holder the right to buy a certain quantity of an underlying security from the writer of the option, at a specified price (the strike price), up to the expiration date. These authors stress the importance of delaying the investment for the two following reasons. The first is linked to the irreversibility of an investment, while the second derives from the observation that the postponement of a project allows the collection of more information concerning costs, prices, and market conditions, before engaging in a costly investment.

More rigorous treatments began with Brennan and Schwartz (1985) and McDonald and Siegel (1986) who define an exogenous stochastic process for the underlying firm cash flow. These authors demonstrate the incorrectness of the NPV rule given uncertainty over future outcomes. They show that there is an opportunity cost to investing today, the option to wait until more information on firm value is collected. As a result, it is optimal to invest only when the present value is well above the investment costs. This relationship is stronger, the higher the uncertainty of the underlying asset.

These articles inspired many other papers that explored different types of options that a firm typically has to face. Several of these options have been sketched in Table 1.1. Among these, McDonald and Siegel (1986) and Dixit (1989) study the optimal time to enter and exit from a productive capacity, Pindyck (1988) values the flexibility that arises from capacity utilization, and Pindyck (1993) studies the effect of different investment costs on the decision to invest. Dixit and Pindyck (1994) offers a complete review of the modelling real options.
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Option | Description | Example
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Defer | To wait before taking an action until more is known or timing is expected to be more favourable | When to harvest a stand of trees, introduce a new product, or replace an existing piece of equipment

Expand contract | To increase or decrease the scale of a operation in response to demand | Adding or subtracting to the daily flights on an airline route or adding memory to a computer

Abandon | To discontinue an operation and liquidate the assets | Discontinuing a research project, closing a store, or resigning from current employment

Stage investment | To commit investment in stages giving rise to a series of valuations and abandonment options | Staging of research and development projects or financial commitments to a new venture

Switch inputs or outputs | To alter the mix of inputs or outputs of a production process in response to market prices | The output mix of refined crude oil products or substituting coal for natural gas to produce electricity

Grow | To expand the scope of activities to capitalize on new perceived opportunities | Extending brand names to new products or marketing through existing distribution channels

Table 1.1: Typology of real options

Yet the assumptions of the real option theory lack of strategic elements in their modelling. If a firm fears pre-emption, the waiting to invest option would be less valuable and an earlier investment would look more desirable. To determine the optimal strategic decision for a firm, the application of game theoretic models to the real option framework is needed.

Early studies that put together real option and game theories focused mainly on issues related to imperfect competition and asymmetric information in industrial organization and corporate finance. Smets (1991) first applied real option thinking to a duopoly game to draw implications for international finance issues. With this paper he opened up a new branch of modelling. Williams (1993) and Grenadier (1996) use strategic real options to solve for optimal investment timing in imperfectly competitive real estate markets. Kulatilaka and Perotti (1998), study the exercise of growth options under uncertainty and imperfect competition in a discrete time setting. Due to the convexity of the profits in a imperfectly competitive market, an increase in market demand has a more than proportional effect on profits; at the same time higher uncertainty induces greater variations in demand to occur
with higher probability. As a result, higher uncertainty induces less wait in carrying
out investments as it implies not only higher downside risk, but also higher upside
payoffs. Mason and Weeds (2001) study entry decisions in a duopoly market with
network externalities.

Problems of asymmetric information and timing in decision making were firstly
addressed by Grenadier (1999) and Lambrecht and Perraudin (1999). Grenadier
(1999) analyses the case of strategic investment under asymmetric information over
the underlying option parameters, while in Lambrecht and Perraudin (1999) firms
compete in a duopoly over the exercise of a real option in an asymmetric information
setting. The optimal investment strategy may lie anywhere between the zero-NPV
trigger level and the optimal strategy of a monopolist, depending on the distribution
of competitors' costs and the implied risk of pre-emption.

In corporate finance there have been contributions on the optimal level of capital
structure, not explicitly connected to real option theory. Leland (1994) studies the
optimal leverage when issuing infinitely living bonds, and Leland and Toft (1996)
when the maturity of debt can be chosen. Lucas and McDonald (1990) and Korajczyk,
Lucas and McDonald (1991) study the optimal timing to issue equity as a
function of the level of information on the market.

Lambrecht (2001) investigates the interaction between market entry, company
foreclosure, and capital structure in a duopoly. He finds that firms with high
bankruptcy costs or with prospects of profit improvement can get larger concessions
on their debt obligations and that financial vulnerability of the incumbent induces
earlier entry. Real option applications are present in almost any branch of corporate
finance: mergers and acquisitions (Subramanian 2002), takeovers (Lambrecht 2002),
venture capital financing (Bergemann 1997) and IPOs (Drahos 2002).

The essays presented in this volume cover both topics in industrial organization
and corporate finance. In each of them the timing is the key choice in firms strategic
decisions. In the first paper I study the launching of a new product in a duopoly
with a competitive advantage. In the second paper I examine partial exit from an
investment as a strategy to overcome negative synergies between the investment and
the main firm activity. In the third paper I study the issue of optimal timing of
IPOs. The choice of such diverse topics underlines how relevant and conclusive the
timing issue is in widely differing issues in economics and finance. In the following
section, I give a brief overview of these investigations.

1.2 Overview

Chapter 2 is the result of work carried out with Professor Enrico Perotti and pub-
lished as a CEPR working paper (Perotti and Rossetto 2001).\textsuperscript{1} It investigates the
timing and the valuation of platform investments aimed at enhancing entry opportu-
nities in related market segments. As demand is uncertain, entry options should be
exercised at the optimal strategic timing, trading off the strategic gain against the

\textsuperscript{1}A simpler version has been published in McCahery and Renneboog (forthcoming) with the
title \textit{Internet Portals as Portfolio of Entry Options}. 
option to wait until more information is revealed. When the platform investment grants a strong strategic advantage, the innovator can optimally choose the timing of entry; in the case of a weaker advantage, the platform firm enters just before its competitor would. In a context of increased uncertainty, the value of waiting to invest rises, but the value of a platform increases even more. In some cases, a platform can act as a threat to discourage cross-entry, making parallel monopoly sustainable.

Chapter 3 is based on a paper written with the supervisor of this thesis, Professor Enrico Perotti and Mark Kranenburg. There, we study the issue of timing of an equity carve out (ECO). In a ECO, a parent company sells a portion of a subsidiary's common stock through an initial public offering. A carve out is seen as a decision functional to a "second stage" event, either a sell off and a buy back decision. Hence, the carve out is seen as a compound option. The decision is driven by the synergies between the parent firm and the subsidiary, which evolves stochastically over time. Applying real option methodology, we find that the decisions to carve out, to buy back and to sell out are heavily influenced not only by the uncertainty over the synergies, but also by the retained stake. Furthermore, using explicit relation between underpricing and retained shares as suggested by the IPO signalling theory we find that there is an optimal amount of shares, which is positively related to the uncertainty over synergies.

In Chapter 4, I model explicitly the IPO as the main exit mode for early stage investors who face a new investment opportunity. I study how asymmetric information over the value of the old and new investment influences the structure of the IPO. The values of the firm for sale and of the new venture are signalled through the retained share and underpricing. A clustering of new attractive investment opportunities increases underpricing and accelerates exit. This can explain the "hot issue" market phenomena of clustering and high underpricing of IPOs. Additionally, I distinguish between venture capital (VC) backed IPOs and early stage investors ones. The venture capital contract controlling moral hazard affects the form of exit. This offers a possible explanation for an empirical puzzle in the literature: VC backed firms are either more or less underpriced than the average IPO, depending on the time period considered. I show that this difference is potentially due to the profitability and to the moral hazard problem of new investment opportunities.