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Consider your options: changes to strategic value during implementation of advanced manufacturing technology

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Abstract

Strategic investments such as flexible manufacturing technology yield benefits to a company beyond the immediate cash flows. These strategic benefits can be captured, to some degree, using real option valuation techniques. However, real option models presume these can be identified and evaluated at an early stage in the investment process. In this paper, the authors argue real option value is often only vaguely defined at the adoption stage and frequently manifest during implementation. By examining four advanced manufacturing technology investments during implementation within different organizations, this study qualitatively explores the changes to original real options as unanticipated problems surface and solutions are found and implemented. The study found that as the companies adapted to implementation setbacks, the form, scale, value and clarity of the real options changed. For three of the companies, the changes to options were negative while the fourth case indicated positive effects. Most prevalent were delays in the earliest possible exercise date. The results highlight the need to consider changes to strategic value as companies adapt to setbacks that arise during project implementation. Implications for the evaluation of such projects are discussed.
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Keywords: Implementation; Advanced manufacturing technology (AMT); Strategic investments; Case study; Capital budgeting; Real options; Investment lag

1. Introduction

Increasingly, companies are looking to advanced manufacturing technologies (AMT) to acquire or sustain competitive advantage. This can be gained from economical small batches, scheduling flexibility, growth options and staged investments, rapid prototyping and shortened response time to changes in supply, demand and competitor activity. AMT is typically more expensive and complex than conventional technology and much of the value needed to justify its adoption is derived from benefits that are intangible, contingent and hard to quantify.

Recognizing the difficulty in evaluating such benefits, researchers undertook to develop a model that would capture the flexibility and strategic value of investments. The result was the expanded or strategic net present value, which adds the real option value to the traditional NPV. This development has made valuation more comprehensive but it is also more complicated. The strategic net present value model still requires strategic benefits be identified and quantified at an early stage in the investment decision process. Adding to the elusiveness of the value, some real options may be latent.

Beyond the 'go/no go' decision to invest in AMT, many changes to the project and its associated value can occur during the critical and complicated implementation phase. Strategic value can change, be destroyed or created during

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implementation. The emphasis of real option research on the evaluation of the investment decision does not attend to these eventualities.

Real option valuation is described in the next section. This is followed with a review of relevant implementation research, as found in the innovation literature. As the juncture of these two areas of research, this exploratory study endeavours to develop grounded theory for the changes to real option value that occur as unanticipated, internal problems arise during implementation and as solutions are identified and executed. The output will be propositions regarding changes to real option value during the implementation of advanced manufacturing technology. These propositions provide a springboard for further research.

2. Theoretical foundations

Considerable debate has taken place in the literature as to how well conventional investment appraisal techniques serve AMT projects [1–10]. Many studies suggest investment decisions in practice are made with apparently little regard for ex ante financial performance indicators, with greater reliance placed on non-quantifiable and strategic considerations [10–14].

2.1. Determining strategic value—real options

Noting that strategic benefits were not being captured in the financial measure of projects, Myers [15,16] and Kester [17] suggested these be valued by adapting financial option pricing models to augment conventional capital investment appraisal techniques. Subsequently, the pricing model for financial options, developed by Black and Scholes [18] and adapted by Merton [19] and Cox et al. [20], was applied to the valuation of the various types of real options. More recently, the real options literature has developed at pace [21–32], although the empirical base is still relatively weak, particularly among smaller firms.

As a simple example of a real option, consider an investment in undeveloped commercial real estate, which in the immediate future will be used as a parking lot but on which the owner may later build a retail complex. The irreversible investment in the land not only creates immediate cash flows but real options for the owner. The options include the option to delay the retail complex development (option to delay), build it in stages (time-to-build option), alter the scale of the construction (expand, contract, shut down and restart), abandon the investment, switch inputs or outputs and to make follow-on investments.

Real options can be categorized as operating and strategic [32].[1] Operating options arise from the management flexibility to make positive changes to operations by responding to opportunities and threats as external events unfold. These changes can alter the profitability of a project, "skewing its cash flow distribution toward a higher rate of return" [23, p. 31]. Strategic options are the opportunities latent in an investment, which, if exercised, enhance competitive advantage. As examples, the option to take advantage of changes in consumer demand, respond to or curtail competitors' actions or to make subsequent, contingent investments add potential and value to the initial investment.

The real option terminology is borrowed from the financial options model and is shown in Table 1 [30, p. 149]. A real option is likened to an American-style option on a dividend-paying stock. The value of a real option is derived from the present value of the cash flows of the optional or contingent project, less the present value of the investment (strike price) required to exercise the option. The cash flows foregone while waiting to exercise, such as rental income from the retail complex, are equivalent to dividends on a stock. The value of the investment in the commercial real estate includes the net present value of cash flows to be generated by the initial investment in the land (parking fees) plus the value of the options. These amounts together make up the project's strategic net present value (SNVP).

The valuation of the real option differs from a standard net present value calculation because of its asymmetric risk. Since the second-stage project is optional, the additional investment need not be made if conditions are unfavourable. Thus, the downside risk of the optional investment is limited although it has unlimited upside potential.

In a perfect market, the optimal time to exercise an option could be determined using the option-pricing model, the option features and value of the underlying asset. However, the actions of competitors and imperfections in the product and factor markets make this optimal time less easy to discern. An added complication is the readiness of the company to exercise the option. Investment lag creates a delay in being able to exercise an option. Implementation setbacks can result in even greater delays and reduce the value of the option.

The models used to value an option assume that once the option is exercised, the installation and commissioning will occur immediately. In reality however, depending on the investment, delivery and implementation can take months or years, such as the construction of the retail complex. This investment lag or construction lag has been the subject of research [34,35]. According to Dixit and Pindyck [36] and McDonald and Siegel [37], the uncertainty in revenues usually favour waiting to invest because of the upside-only risk. More recently, however, Bar-Ilan and Strange [35] have contended that when an investment lag is expected, these same potential revenues are foregone and thus encourage a hurried investment, especially when expected lags are long and abandonment is an option. In their study, Bar-Ilan and Strange [35] assumed an investment lag of fixed duration and compared it to zero lag under different volatilities. They found the greater the uncertainty in revenues: the greater the incentive to proceed with the investment when there

[1] Busby and Pitts [33] described real options to their survey respondents as simply "flexibility."

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