Evaluating strategic investments: Real options' role in new manufacturing technology projects

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1 — Introduction

One of the primary responsibilities of management is the allocation of available resources in organisations. Unfortunately, there are never enough available resources to perform all the tasks and projects desired. Therefore, management has to decide which projects will be pursued.

To evaluate competing projects, the majority of organisations use some form of quantitative analysis technique. Among the common techniques used are net present value, internal rate of return and payback period.

A frequent charge in recent years has been that many firms fall behind in global markets because they are too slow in implementing the new manufacturing technologies such as AMT (advanced manufacturing technology), CIM (computer integrated manufacturing), FMS (flexible manufacturing systems), or CAD (computer added design). A popular argument is that conventional methods of capital investment analysis do not capture the full impact of the technology change decisions (Slagmulder *et al.*, 1995, p. 122).

Furthermore, one concern associated with information technology is the inability to properly measure the costs and benefits associated with any specific project. At present, many of the costs can be estimated using a number of established techniques that yield a quantitative value. However, many of the benefits are intangible and there are few techniques available to put a quantitative value on them (Aggarwal, 1993, p. 274).

Therefore, the decision-maker has to balance tangible costs with both tangible and intangible benefits. In many cases, the value of these intangible benefits is not included in the analysis of a project. This tends to result in an underestimate of the benefits associated with a project.

Management's flexibility to adapt its future actions in response to altered future market conditions expands an investment opportunity's value by improving its upside potential while limiting downside losses relative to management's initial expectations under passive management. Trigeorgis (1995, p. 3) shows that the resulting asymmetry by managerial adaptability calls for an expanded net present value rule reflecting both the value components: the traditional net present value or direct cash flows and the option value to operating and strategic adaptability. This author postulates that an option approach to capital budgeting has the potential to conceptualise and quantify the value of options from active management and allows for a shift in the closed system perspective of organisations to an open arena where multiple interactions are allowed. This value is manifest as a collection of real options embedded in capital investment opportunities, having as an underlying asset the gross project value of expected operating cash flows. Many of these real options occur naturally (e. g., to defer, contract, shut down or abandon), while others may be planned and built in at some extra cost (e. g., to expand capacity or build growth options, to default when investment is staged sequentially, or to switch between alternative inputs or outputs).

The objective of this research is to examine the literature related to investment evaluation tools. Specifically, traditional tools are contrasted with recent approach to examine their utilities toward determining the worthiness of new manufacturing related technologies. Thus, the aim of this paper is to present some strategic and operational tools used by organisations toward strategic effectiveness.

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2 — Literature review

2.1 — Traditional analysis methods

The goal of traditional capital budgeting is to direct the firm's resources to those activities that provide the highest economic value for the owners of the firm. This goal is broadly consistent with the literature in strategic management (Porter, 1987). The finance discipline has developed several tools including techniques such as net present value (NPV), internal rate of return (IRR) and payback period. Collectively, these techniques share the common approach of discounting future cash flows to reflect the opportunity cost of capital incurred by capital providers (Silva, 1998, p. 45)

Net present value, the «most popular and preferred sophisticated budgeting technique» (Clark, Hindelang and Pritchard, 1984, p. 35) can be described in its most general form as:

$$NPV = -I + \sum_{t=1}^{n} \frac{E(CF_t)}{(1+k)^t}$$

where:
n is the time horizon over which the project will generate economic value;
k is the opportunity cost of capital, defined as the equilibrium expected rate of return on securities equivalent in risk to the project being valued;
$E(CF_t)$ is the expected value of the forecasted incremental cash flows at time t;
I is the initial investment.

The net present value rule (as well as internal rate of return or payback), however, is based on some implicit assumptions that are often overlooked. Most important, it assumes that either the investment is reversible, that is, it can some how be undone and the expenditures recovered should market conditions turn out to be worse than anticipated, or, if the investment is irreversible, it is a now or never proposition, that is, if the firm does not undertake the investment now, it will be not able to in the future. Although some investments meet these conditions, most do not. Irreversibility and the possibility of delay are very important characteristics of most investments in reality. (Dixit and Pindyck, 1994, p. 6)

The strong internal consistency and apparent validity of the discount cash flow (DCF) approach have led to the dominance of the finance function in the boardroom in recent years (Trigeorgis, 1987). The theoretical rigour, simple decision rules and explicit treatment of risk and uncertainty offered by DCF techniques are certainly compelling when compared with other «naïve» approaches to investment evaluation. A project level-level NPV framework, it is argued by Shank and Govindarajan (1992, p. 39), «places such a premium on short-term financial results, and so little emphasis on difficult to quantify issues, such as quality enhancement or manufacturing flexibility, that major manufacturing breakthroughs do not pass the NPV test».

Traditional capital budgeting procedures depend on the ability to convert all costs and benefits to incremental cash flows. These cash flows estimates must include consideration of all project interdependencies with other operations and the values of any options for future growth that are generated. Naturally, there are many difficulties in the estimation of project cost and benefits, especially when they depend on competitor reactions, and in estimating the risks involved over long time horizons. Capital budgeting analysis also requires an estimate of the appropriate investment horizon, the terminal value and the discount rate. Thus, traditional capital budgeting presents many limitations, especially when it is applied to strategic investments, and to new manufacturing technology investments in particular (Aggarwal, 1993, p. 275).

2.2 — Investment decision making within an organisational context

Financial techniques for evaluating investment proposals have received a lot of attention in the normative literature and in previous research. However, investment appraisal is but one step in the overall capital budgeting process and the methods described are but one element of the management control system designed to channel capital investments in the desired direction (Myers, 1984).

Formal capital budgeting procedures are typically designed for a bottom-up capital budgeting process, that is, firms are assumed to let investment proposals arise from plants for review by division management and then by senior management. The ultimate authority for investment decision rests with the top management. A limited amount of this authority may be delegated to lower managers, with different spending limits assigned to different hierarchical (Slagmulder *et al*, 1995, p.124):

2.3 — An attempt to integrate strategic and financial analysis of strategic manufacturing investments

It is beyond any doubt that manufacturing firms are now in an era of global competition that is being stimulated through continuing advances in communications and transportation, the rise of the newly industrialising countries of Asia and Latin America and the emergence of Europe as new centres of manufacturing competition. Markets are becoming increasingly global and, in addition to the adoption of more competitive manufacturing strategies, many firms, conscious of this opened system, are responding with strategic partnerships, licensing agreements, joint ventures or strategic cross-border alliances.

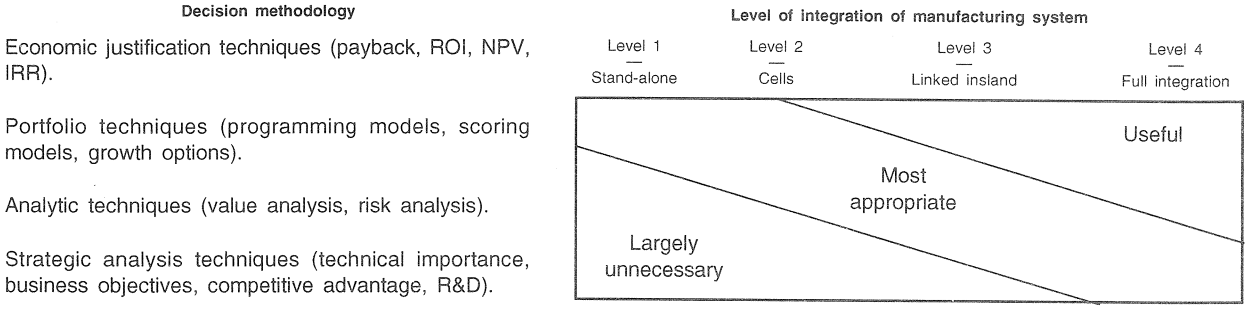
Aggarwal (1993, p. 278) points out that «this new era of global manufacturing competition is also characterised by a sharper focus on product differentiation, reliable quality, just-in-time delivery, and even shorter design-to-delivery times and product life cycles».

Recently, there is a growing awareness in the literature that strategy and finance are interconnected and thus should not lead to conflicts (Grenadier, 1997, p. 398). An increasing number of authors are being convinced that good investment appraisal requires that strategic and financial considerations be reconciled and integrated. They propose capital budgeting models that go behind the traditional DCF methods and reflect the strategic issues of investments in manufacturing technology.

Slagmulder *et al* (1995, p. 128) have examined the appropriateness of different approaches to investment justification and state that «the relevance of economic, portfolio, analytic and strategic considerations is dependent on the level of system integration» (figure 1). To these authors, the critical factor is not the technology itself, but the intended use of the new system.

FIGURE 1

Investment decision method and level of system integration (adapted from Slagmulder *et al.*, 1995)



New flexible manufacturing technology encompasses a wide range of capabilities and must be distinguished from dedicated automated mass production lines. The degree of manufacturing flexibility can vary from stand-alone robots and numerically controlled machine tools to groups of machines such as in cells and in group technology, to linked islands of automated machines, and finally to flexible manufacturing systems and computer-integrated manufacturing. It follows from Figure 1 that each investment evaluation method should be used where adequate.

3 — Linkage between capital budgeting and strategic planning

Strategic decisions are products of corporate planning and top management deliberations that give shape and direction to an organisation (Ansoff, 1965). Strategic decision making (SDM) includes traditional areas such as organisational change, product/market posture, R&D, mergers, restructuring and corporate control, as well as traditional capital investment (Lai and Trigeorgis, 1995, p. 69).

Finance theory and decision analysis are two approaches concerned with the same problem of how to make optimal investment decisions, but looking the problem from a different perspective and often using a different set of assumptions and input data (Myers, 1984, p. 128). In this section we aim to review the similarities and differences between these two approaches as they are traditionally applied in order to better understand the circumstances under which they may give equal or divergent answers to the same investment problem.

3.1 — Real options approach to technological innovation investments

A critical component of many firms' investment policies regards the strategy involved in the adoption of technological innovations. Generally, firms follow different strategies: some adopt new technologies when they are first available while others postpone the adoption decision until the technology is improved.

A crucial problem with applying DCF techniques to strategic analysis results from interdependencies among current and (uncertain or contingent) future decisions that make risk-adjusted discount rate nondeterministic (Trigeorgis, 1987, Dixit and Pindyck, 1994). In a 1994 article Kester gives a detailed example of the interdependency among future investment (or growth) opportunities and today's capital commitments. Many times, firms invest to enter a new market not so much because the immediate investment has a positive NPV, but rather because it positions the firm advantageously in the market and creates options for valuable follow-up opportunities.

Previous work on real options has generated a taxonomy that has broken down real options into six categories based upon the type of flexibility provided. These categories are: the option to defer; the option for staged investments; the option to change existing scale; the option to abandon; the option to switch use and the option to grow (Trigeorgis, 1995).

Given the nature of the options, it is not surprising that nearly all strategic investments decisions contain real options of one type or another (Trigeorgis and Mason, 1987 p. 18). In fact, projects often contain more than one type of real options. For instance, consider the case of a firm wishing to develop a new product line. The timeline for the new product development could certainly be accelerated or delayed at management's discretion according to market conditions, while the project would generate future investment opportunities if it proved to be successful. Both these options make the new product more valuable. Aggarwal (1993, p. 274) exemplifies stating that «while traditional capital budgeting procedures that rely on incremental cash flows as return measures provide much needed discipline to the process of allocating capital, they do not normally capture the strategic benefits of higher quality, faster responses to a wider range of customer needs, and the options for future growth made available by flexible manufacturing technology».

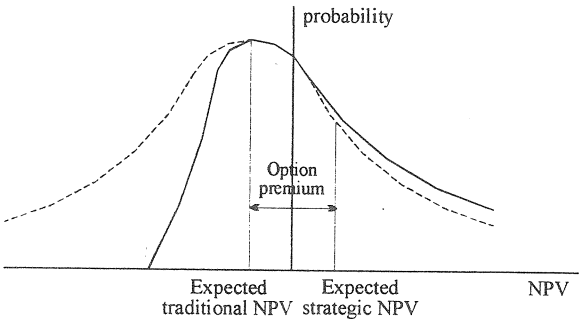
Trigeorgis (1996, p.123), a pioneer author in the development of real options, introduced a new concept of NPV that has the merit of incorporating the management's flexibility. «The asymmetry introduced by managerial adaptability calls for an expanded (or strategic) NPV criterion that reflects both components of an investment opportunity's value: the traditional 'static' or 'passive' NPV of directly measurable expected cash flow and an option premium capturing the value of operating and strategic options under active management and interaction effects of competition, synergy, and interproject dependence». That is (figure 2):

Strategic NPV = Standard NPV + Option value

This does not mean that the traditional NPV should be scrapped, rather, it should be seen as a crucial and necessary input to an options-based expanded NPV framework.

FIGURE 2

Asymmetric distribution of NPV probability function



Copeland, Koller and Murrin (1990) have estimated that between 56% and 100% of a company's total value is comprised of strategic growth options that can only be realised beyond an eight-year forecasted period. The future opportunities generated by current investments are clearly very valuable.

An important area where real options have the potential to make a significant difference is that of competition and strategy. Sustainable competitive advantages resulting from patents, proprietary technologies, ownership of valuable natural resources or managerial capital empower firms with valuable options to grow through future profitable

investments and to more effectively respond to unexpected adversity or opportunities in a changing technological, competitive business environment (Trigeorgis, 1995, p. 23).

Grenadier (1997) formed an analogy between the adoption of innovations and the exercise strategy of a stream of embedded options. This allowed him to use the tools of option-pricing theory to derive and analyse a firm's optimal migration strategy under technological uncertainty. The model's results were used to predict the adoption behaviour of firm's decision in a variety of technological environments.

As further research, it can be recommended a focus on demonstrating to industry how real options can fit into their evaluation models and improve them. Rather then developing mathematical models, effort should first be allocated to improving existing quantitative models. There is a number of existing models that break down both the steps involved with building an information system and performing cost benefit analysis of the systems.

The research that needs to be done is integrating real options into these existing models. At each step, the appropriate types of real options should be added to the model. The expanded model should detail not only the types of real options applicable, but more importantly how these real options can reduce the risks associated with the projects development.

However, not always analytic solutions exist. In the more complex real life situations, such as those involving multiple interacting real options, one may not even be able to write down the set of partial differential equations describing the underlying stochastic processes (Trigeorgis, 1995, p. 22). Developing accurate quantitative models seems to be itself a real growth option with significant value.

3.2 — New framework presented

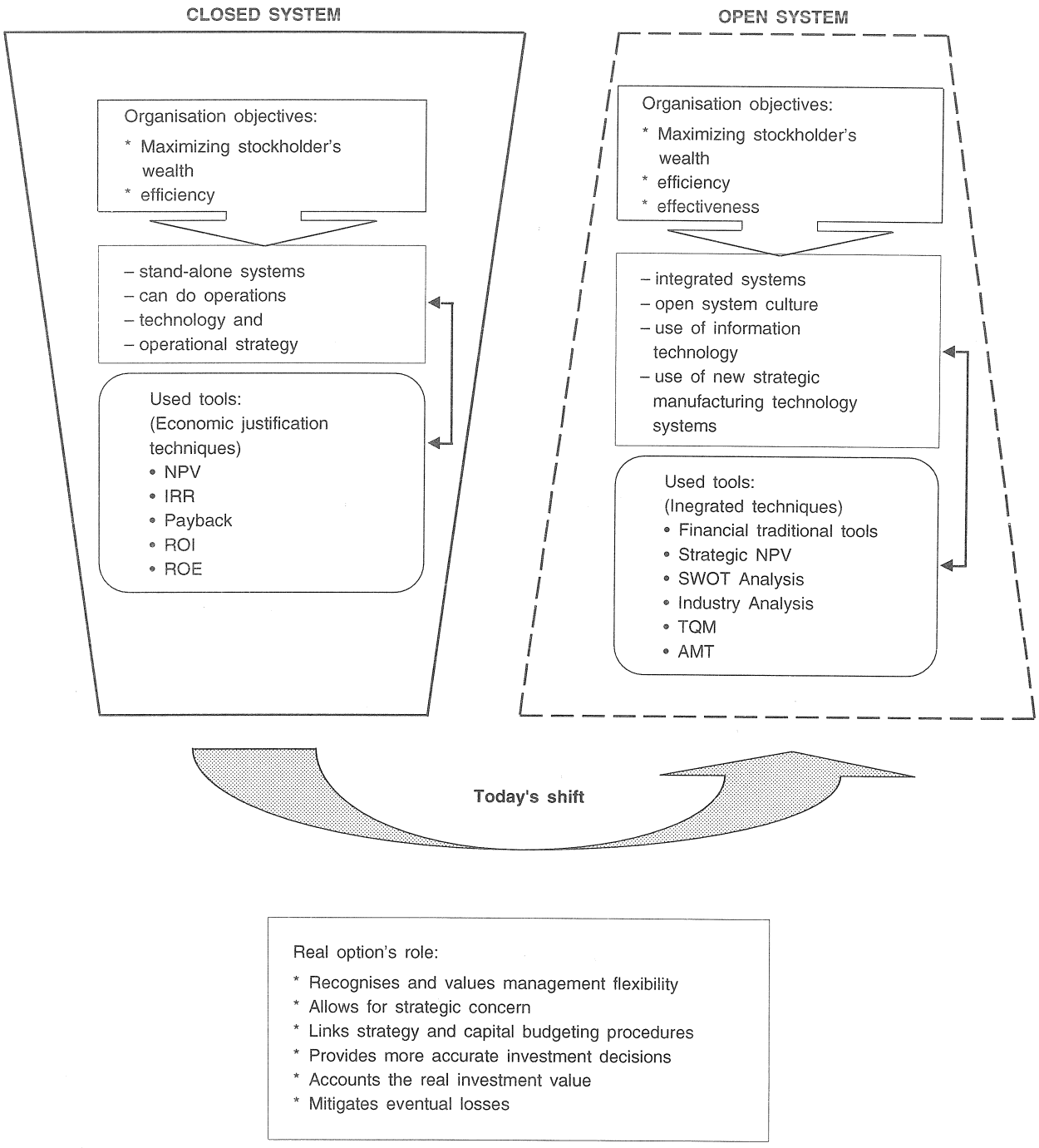
As the earlier discussion indicates, there are a number of reasons that justify the difficulties in assessing the optimal amount of investment in flexible manufacturing technology. Traditional capital budgeting procedures need to be modified and augmented in a number of ways to assess strategic investments, such as new flexible manufacturing technology.

It must be recognised that these types of investments are part of corporate strategy and should be assessed in a strategic framework. Strategic analysis for valuing such investments should include an analysis of industry competitive strengths, weaknesses, opportunities, and threats (SWOT). Proposed new investments should also be appraised with regard to their effects on possible strategic alliances and mergers, given the nature of the entry and exit barriers in the industry and an assessment of current and future competitor technical, financial, and marketing abilities should be made. Most importantly, flexible manufacturing investments should be compared against conditions of declining competitiveness and loss of market share and not against the usual capital budgeting assumption of no response by competitors.

Many of the benefits of flexible manufacturing systems also depend on the extent to which they are integrated with the rest of the business to provide economies of scope. The system used to value investments in flexible technology must be able to assess the relative importance and tradeoffs between scope economies and scale economies. Such systems should also be able to estimate the increased revenues, reduced risk levels, decreased costs and benefits of being able to manage greater product diversity. According to option theory in finance, as discussed in the previous section, the value of real options for future growth generated by flexible manufacturing systems increases with the enlargement in uncertainty regarding the future (Trigeorgis and Mason, 1987).

FIGURE 3

Transition to a new project management framework



As illustrated in figure 3, the alignment of strategic planing and capital budgeting processes will serve as an invaluable tool in helping corporate management delineate short and long-term objectives. For major decisions in many organisations, the decentralised project by project mechanical approach is being replaced by strategic considerations (Lai and Trigeorgis, 1995, p. 70). Projects with negative NPV of project cash flows (e. g., R & D) may often be pursued, while other positive NPV opportunities may be discarded on the basis of strategic fit.

Strategic capital budgeting can reconcile «top-down» and «bottom-up» processes of strategic planning and standard capital budgeting in an interactive way. With this framework we aim to show that capital budgeting should not be treated as a mechanistic staff function of accept-reject, but rather should be harmoniously integrated with strategic planning. Top management should actively and continually be involved in shaping the desired investment strategy. In an uncertain business environment, the strategic plan is not a prespecified set of decisions evaluated by conventional rules, but should, as many firms are already doing, be an open process that can be modified when conditions change.

4 — Conclusions

Strategic capital budgeting has been seen as the process by which top management makes decisions to commit large amounts of scarce financial resources to achieve strategic objectives. In the traditional literature, little attention has been devoted to strategic considerations in the asset planning and allocation process. The conventional formulation of the resource allocation problem has been framed in terms of individual projects within existing organisational units. However, these approaches do not always provide top management with the ability to make effective decisions consistent with the firm's overall corporate strategy.

Effort in transferring real options from the academic arena to industry use is vital since existing analysis tools such as net present value underestimate the value of projects. As Ross (1995, p. 99) sates «for most investments, the usefulness of the NPV rule is severely limited. If modern finance is to have a practical and salutary impact on investment-decision making, it is now obligated to treat all major investment decisions as option pricing problems».

This paper has attempted to formalise many managers' intuitive understanding by highlighting a number of key weaknesses in the traditional capital budgeting techniques and introducing an alternative framework based on the recent work of strategic thinking. We learn that traditional capital budgeting methods work well for investments of relatively short duration and easily measured benefits, but that justification techniques must be increasingly non financial and geared toward strategic thinking as investment project become larger, more complex and promise less easily measurable benefits. Strategic investments, and manufacturing technology project in particular, may create future assets as a by-product of the initial investment decision that cannot be adequately captured by conventional DCF analysis.

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