A Framework for Integrating Capital Budgeting Analysis with Strategy

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Abstract
The exclusive use of discounted cash flow (DCF) capital budgeting models is being criticized because of the inability of these models to handle qualitative/intangible benefits and tie the capital budgeting decision formally to organizational strategy. In response, several authors have recently proposed the use of Saaty's Analytic Hierarchy Process (AHP) for capital investment analysis. This paper extends that line of research by focusing on the fundamental problem of structuring the decision hierarchy appropriately so that the AHP can be implemented successfully in a capital budgeting context. Three approaches are presented for structuring AHP hierarchies, including the Mission, Objectives, and Strategy (MOS) framework for strategic planning. An example based on three actual companies in the petrochemical industry is developed using the MOS approach.

Introduction
Financial theory for selecting capital budgeting projects is well established [40]. Many articles advance the argument that discounted cash flow (DCF) models capture the true economic value of long-term investments. Surveys of current practice demonstrate that DCF models are, in fact, the primary decision models used for both conventional capital budgeting decisions [18] and for high technology investments [41]. Surveys of practicing managers, however, also indicate that many decision makers are not satisfied with the implementation of these time value approaches; much of the apparent dissatisfaction relates to the lack of a formal linkage between capital budgeting decisions and organizational strategy [36]. What is needed, therefore, is a framework to help guide or structure the decision process to ensure a formal linkage between capital budgeting decisions and firm strategy.

This paper has three objectives: one, to review implementation issues concerning the use of time-value capital budgeting models; two, to propose a framework that can link capital budgeting decisions to strategy; and three, to illustrate how this framework could be developed and applied in a real world environment using the Analytic Hierarchy Process (AHP). While others have suggested the use of the AHP in a capital budgeting context (see, for example, [4][11][17][34][35][38]), little attention in the literature has been devoted to the fundamental problem of structuring the decision hierarchy appropriately. This paper focuses on that question.

Review of Current Research and Practice
In a review of existing surveys on capital budgeting practices in this country, Mukherjee and Henderson [23] summarized four limitations of DCF models for analysis of capital investments: (1) an inability to capture the role of organizational structure and behavior in corporate decision making; (2) a failure to incorporate man-
agement behavior toward risk; (3) difficulties in application due especially to unrealistic assumptions about data availability; and (4) inability to incorporate strategic considerations in decisions made by the firm.

For these reasons, Bennett et al. [3], Bromwich & Bhirani [5], Canada [6], Kaplan [16], McNair et al. [20], Mensah & Miranti [21], Noble [26], Polakoff [29], and Shank and Govindarajan [33] question the exclusive use of DCF analysis in justifying capital investments, especially those involving automated technology. Thus, these authors believe a new decision approach may be needed that: (1) identifies relevant attributes (both qualitative as well a quantitative) representing important benefits of capital investments; (2) relates the importance of these attributes to achieving the firm's long-term strategy; and (3) formalizes the decision process with a systematic approach that links the firm’s strategy to the ultimate investment decision.¹

We support the Analytic Hierarchy Process (AHP) as a practical approach for addressing these capital budgeting application issues.

The Analytic Hierarchy Process (AHP)

The AHP has been effective in structuring many types of complex multicriteria business problems [31]. For example, the AHP has been applied recently to the problem of risk assessment [24], subunit performance evaluation [8], R&D project selection [19], and real estate investment [17]. The AHP enables decision makers to structure a problem in the form of a hierarchy of its elements and to capture managerial decision preferences through a series of pairwise comparisons of relevant factors or criteria.² The AHP is relatively easy to use, allows for rapid replanning can incorporate qualitative and subjective factors, uses a psychometric scale to quantify managerial judgments, and provides a method to measure the consistency of these judgments. The key is that the AHP can be used by managers and engineers to insure that capital projects funded are consistent with the overall strategy of the firm.

There are essentially five steps in applying the AHP in practice [4]:

1) structuring the decision hierarchy;
2) collecting data by pairwise comparisons;
3) checking consistency of managerial judgments;
4) applying the eigenvector method to compute weights; and
5) aggregating the weights to determine a ranking of decision alternatives.

Most of the AHP articles published to date have focused on the application of the AHP to specific business problems. Many (e.g., [6][19]) include a description of underlying computational procedures of the AHP (i.e., steps 2 through 5 above). Others, for example Boucher and MacStravic [4], describe modified AHP computational procedures for determining factor and criteria weights.

However, the value achieved from an AHP analysis is highly dependent on the interrelationships defined across the various levels of the hierarchy. Yet, there has been little discussion in the literature involving the development of an appropriate AHP hierarchy to guide the capital budgeting process (step 1 above). Since an appropriate hierarchy design is critical to the process of linking corporate strategy and investment decisions, this paper focuses on the initial step of the AHP process.

Approaches For Developing AHP Hierarchies For Capital Budgeting

Three basic, but interrelated, approaches can be used in developing AHP hierarchies for capital budgeting:
1) assume that business strategies do not need to be stated explicitly in order to develop an appropriate set of evaluation criteria;

2) utilize a specific planning theme or methodology in the construction of the hierarchy; or

3) develop a hierarchy based on the mission, objectives, and strategies (MOS) approach to planning.

**Approach One**

The first specification could be made operational through a generic three-level hierarchy with the following components:

- **GOAL** of the hierarchy, which is to select the best capital budgeting projects;

- **CRITERIA** for evaluating capital budgeting projects, and

- **ALTERNATIVES**, that is, the capital projects themselves.

Since we are assuming that management fully understands the strategy of the firm, an appropriate set of evaluation criteria can be readily identified. Because of the subjective nature of some project benefits, evaluation criteria should be developed by a team representing the primary functions of business (finance, marketing, manufacturing, and so forth). A major benefit of a team approach is that the differing inputs and viewpoints are synthesized into a set of criteria acceptable to all.

A simple AHP hierarchy that includes both financial and non-financial project selection criteria is given as Figure 1. Financial criteria could include, for example, net present value (NPV) or internal rate of return (IRR) and/or return on assets (ROA). Non-financial and qualitative criteria might include quality (QUALITY), flexibility (FLEX), and customer satisfaction (SATIS). A portion of these investment benefits can be quantified in financial terms and, therefore, will be captured by traditional DCF analysis (that is, their effect will be incorporated into the project NPV, IRR, etc.). The remaining impact of these factors may be intangible, that is, not easily quantified or expressed in financial terms.

This basic approach to applying the AHP to project selection is well-known. Several authors (e.g., [2][7]) have provided applications of this basic AHP approach to investments in computer integrated manufacturing (CIM), while others have applied this approach to R&D project selection [19].

Varney, Sullivan and Cochran [38] have modified the basic approach by constructing separate hierarchies for benefits and costs. The benefits hierarchy assigns decision criteria to either a strategic or operational category. The category weight is used to adjust the overall weight of each benefit criterion. After projects are evaluated with respect to all the benefit and cost criteria, an overall benefit weight and a cost weight is determined for each project. Benefit-cost ratios are formed to facilitate the final selection of alternatives.

The primary advantage of the basic AHP approach is its simplicity: once the criteria are agreed upon, and supporting data are collected for each project, the AHP analysis can proceed. Sensitivity analysis can be used to determine how changes in the criteria weights would alter the weights and rankings of the individual capital projects. An important limitation of this approach, however, is the absence of a clear and formal link to business strategy.

**Approach Two**

The second specification provides a linkage to the strategy process by utilizing a specific
planning theme or methodology in developing the AHP hierarchy. A good example of this approach is the application of Porter's value chain [30]. A value chain is a graphic representation of the activities which add value as a product is transformed from raw material and delivered to the end user. Partovi [27] has developed an AHP framework which first links the competitive forces driving manufacturing strategy with the activities in Porter's value chain (see Figure 2). In the second stage, individual projects are evaluated with respect to their impact on the value chain, which is defined as inbound logistics, product design, manufacturing process, outbound logistics, sales and after-sales service. Finally, by combining the results across the levels of the hierarchy, the weight of individual technology projects on the firm's manufacturing strategy can be determined.

Partovi [27] has applied this approach successfully to a leading manufacturer of digital mass measurement instruments. The usefulness of this approach in general is determined by the extent to which upper management believes that Porter's value chain coincides with their notion of business strategy. For example, Porter's approach takes a very strong customer orientation, whereas other potential dimensions of strategy, such as diversification, environmental concerns, and technological leadership are given less emphasis.

**Approach Three**

The third specification requires explicit consideration of business objectives and strategies and follows a well-known approach for planning. This generic planning approach first requires developing the mission or charter of the firm. The mission is generally expressed as the maximization of shareholder value within the context of providing certain products and services to selected markets and customers. The internal and external environments are analyzed, and objectives are set. Finally, strategies and
action plans are developed to achieve these objectives. This planning approach is usually called mission, objectives, and strategies (MOS).

In applying the MOS approach to capital budgeting, capital projects are viewed as part of the action plans necessary to achieve business strategies. Capital projects are evaluated by criteria which are linked to the specific strategies undertaken by the firm. Since strategies contribute toward the achievement of business objectives and, in turn, the mission of the firm, a clear and formal linkage is then established between the capital budgeting and business planning processes. The AHP can be used to quantify this linkage and hence support the capital budgeting process. Figure 3 provides a generic framework for capital budgeting based on the MOS approach outlined above.

An important implication of the MOS capital budgeting framework presented in Figure 3 is that the relative importance of specific evaluation criteria depends on the mix and relative importance of the strategies undertaken by a firm. An example will be used to illustrate this
Figure 3 Generic AHP Framework for Capital Budgeting Using an MOS Planning Approach

point. Consider a firm that is making a strategic shift in emphasis toward upgrading its ability to compete on a technological basis. Factors such as flexibility and quality should have increased emphasis in the capital budgeting process. While this change may be generally agreed upon by the team responsible for making capital budgeting decisions, the real question is the degree to which the various evaluation criteria selected help support this changing (and possibly unclear) notion of strategy.

Also, most firms typically pursue several strategies simultaneously, adding an additional degree of complexity. For example, this same firm may have a business maintenance strategy for some of its product lines. To support this maintenance strategy, more weight should be placed on standard financial criteria. This leads to a conflict with the competitive improvement strategy addressed previously. To help determine the overall importance of the financial and non-financial factors in the presence of multiple, and possibly conflicting, strategies, a process is needed to help make such tradeoffs explicit.
The MOS capital budgeting framework of Figure 3, when made operational using the AHP, is well-suited for clarifying these issues.

Illustration Of The AHP
In An MOS Environment

In order to evaluate the usefulness of the AHP in a capital budgeting environment, we will now illustrate how the framework presented in Figure 3 can be applied in the Petrochemical Industry. This environment was chosen to construct the example for three reasons:

1. With environmental and political pressures mounting on oil companies, it is critical that their capital budgets support the strategies chosen to deal with these external pressures.

2. Oil and Gas companies are generally homogeneous, that is, they seldom diversify outside of petroleum and chemicals. This makes their environment conducive to a clear and concise demonstration of an MOS structure.

3. The authors are familiar with this industry making it easier to draw inferences from published documents (such as annual reports dealing with petrochemical firms).

Most petrochemical firms are organized around three principal divisions: exploration and production (E&P), refining and marketing (R&M), and chemicals. We begin our discussion by considering the allocation of capital among divisions. Later, we apply the AHP to the problem of capital allocation within a given division.

Allocation of Capital Among Divisions

In reviewing the annual reports of several firms in the petrochemical industry, we identified three corporations that employ significantly different strategies regarding the allocation of capital among divisions. These firms are Amoco Corporation, Mobil Corporation, and Sun Company. Mobil invested the same dollar amount ($4 billion) in Refining &Marketing (R&M) operations as it did in Exploration & Production (E&P) operations over the period 1988-1990 [22, p.37]. Amoco, however, invested over four times the amount of dollars ($5.6 billion) in E&P as it did in R&M ($1.8 billion) over this same period [1, p.43]. Sun divested itself of (spun off to shareholders) most of its E&P operations and, therefore, spent more than twice the dollar amount in R&M ($409 million) as it did in E&P during 1990 [37, inside cover]. Because of these differences, it is difficult to compare corporate allocation processes across firms. As a result, we choose in this paper to focus on the capital allocation process in one division only, namely R&M.

In what follows, through a series of illustrations we describe how R&M divisions could select projects utilizing the AHP framework. Thus, the AHP enables divisional capital budgeting decisions to be more closely aligned with the specific objectives and strategies identified during the corporate planning process. A representative AHP hierarchy, depicted in Figure 4, is used to guide the discussion.

Relating R&M Objectives to the Mission

It is important to relate R&M objectives to the stated corporate mission. In a review of the annual reports of Amoco, Mobil, and Sun, the corporate mission is always stated in terms of maximizing the wealth of shareholders. For example, on the inside cover of Amoco Corporation's 1990 annual report [1], the stated corporate mission is "to achieve a superior financial return, balanced with long term growth, benefiting shareholders ...". In each firm the mission is supported by the business objectives of the operating units, which in this case
were inferred from managements' discussion of R&M operations in the companies' annual reports. As shown in Figure 4, these objectives include the following: Market Position (POS), Return on Assets (ROA), Environment (ENVIR), Technology Position (TECH), and Customer Focus (CUST).

The individual target for each objective varies by firm. For example, Amoco stated [1, p.12] that one of the objectives for its R&M operation was to maintain a return on capital employed of 15% over the long run. Mobil stated [22, p.13] that one of its major objectives was to restructure its European operations to improve efficiency and take advantage of opportunities arising from a unified market in 1992. The proposed AHP framework is flexible enough to incorporate differences in specific objectives as well as their relative importance in achieving the division's mission.

The AHP can now be utilized to prioritize these objectives through a series of pairwise comparisons of the importance of each objective in accomplishing R&M's mission. For example,
R&M management must determine the relative importance of ROA with respect to each of the other four stated objectives in meeting the goal of maximizing stakeholder wealth. With five (5) objectives, ten pairwise comparisons (i.e., (5x4)/2) are required for all combinations of objectives. These pairwise comparisons result in a formal prioritization of the R&M objectives. For more information on AHP computational procedures, see Saaty [31].

Relating Strategies to Objectives

The next phase of the MOS planning process requires management to identify strategies needed to accomplish the previously stated objectives. The R&M strategies emphasized by Amoco, Mobil, and Sun companies in their annual reports centered around the following issues:

S1. The degree of emphasis on heavy/sour vs. light/sweet crude in operations (CRUDE).

S2. The importance of alternate fuels (FUELS).

S3. The need to improve the efficiency of refineries and/or stations (EFF).

S4. The modernization of refinery equipment and/or stations (MODERN).

S5. The degree of emphasis on international vs. domestic operations (INTL).

The relative importance of strategies incorporated into the AHP analysis can be adjusted to reflect the specific requirements of the corporation. For example, consider the importance of pursuing an international strategy (S5) by each of our three firms. Mobil Corporation emphasizes increased development of international R&M capacity as one strategy that can help to accomplish several of its objectives, especially market position (POS) and return on assets (ROA). On the other hand, Amoco Corporation concentrates its efforts in the United States market, linking its efficiency (S3) and modernization (S4) strategies with its customer focus (CUST) objective. Therefore, the international strategy is not as important to Amoco in accomplishing its stated R&M objectives. Likewise, Sun Company has decided to concentrate its efforts in the United States in attempting to meet its overall business objectives. Therefore, the degree of emphasis on an international market strategy is related to the overall R&M objectives which vary by firm.

In making operational the strategy-objectives relationships, the AHP requires that each of the strategies be pairwise compared with respect to their importance in achieving a given objective. Thus, one pairwise comparison matrix must be generated for each objective.3

Relating Projects to Strategies through Criteria

The next phase of the AHP analysis requires linking actual capital budgeting decisions directly to the MOS framework. As mentioned earlier, capital projects make operational strategies that enable the firm to achieve its stated mission and objectives. Establishing the MOS-project linkage requires identifying evaluation criteria which are closely aligned with each of the articulated business strategies. Given the mix of strategies described previously, it is evident that some non-financial and possibly even qualitative criteria must be included in the analysis. These evaluation criteria would be drawn from the three primary business functions: finance, marketing, and manufacturing/operations.

Consider again the three major oil companies discussed earlier. A relevant set of criteria could include net present value (NPV) or Payback (PB) as financial factors, customer satisfaction (SATIS) as a marketing factor, and flexibil-
ity (FLEX) and throughput (THRU-PUT) as operations factors (see Figure 4). For example, SATIS could be measured as fuel delivery response time to service stations, FLEX as capability to process different varieties of crude or alternative sources of fuel, and THRUPUT as the crude processing rate (barrels/hour). This set of five criteria is not meant to be exhaustive but was inferred from the oil companies' annual reports as being of primary concern to R&M operations.4

It should be recognized that a specific criterion can be supportive of more than one strategy. For example, consider the flexibility criterion (FLEX) as it relates to Mobil's and Sun's strategies. For Mobil, FLEX is important because it supports the strategy of emphasizing heavy/sour as well as sweet/light crude (S1) in its refinery operations [22, p. 10]. Thus, Mobil has bet heavily that flexibility will be worth the significant investment in capital projects required to reconfigure its refining capacity. On the other hand, Sun Company depends almost entirely on sweet/light crude in its refinery operations, so S1 is a less important strategy. However, FLEX is an important criterion for evaluating those capital projects which support Sun's alternative fuels strategy (S2), e.g., gas and coal [37, inside cover].

Once the criteria have been agreed upon, they must be pairwise compared to determine their relative importance in accomplishing each strategy. Next, specific capital projects that support the selected strategies must be identified. Of course, it is possible that a given capital project will support multiple strategies. This situation is handled easily by the AHP framework. Projects must then be pairwise compared with respect to those evaluation criteria associated with the strategies each project supports. The next example illustrates the linkage of the entire MOS process with project evaluation.

Linking Project Evaluation with the MOS Planning Process

Ultimately, the purpose of this entire AHP framework is to link the individual project benefits to the overall mission or goal of the firm. As discussed in the previous section, capital projects are evaluated with respect to criteria which are closely aligned with specific business strategies. Referring back to our Mobil example, consider two projects which support the ENVIR objective. The first proposed project (TANKS) targets the replacement of all service station underground steel tanks with new fiberglass (non-leaking) tanks. The second project (CLEAN) proposes the development of a cleaner-burning alternative fuel.

The TANKS project supports the ENVIR objective primarily through a modernization (S4) strategy while the CLEAN project supports the same objective through the alternative fuel utilization (S2) strategy. These projects would be pairwise compared against other projects and each other based on the criteria indicated in Figure 4. We now consider specific criteria which would be important in evaluating the TANKS and CLEAN projects.

A key evaluation criterion which the TANKS project supports is customer satisfaction (SATIS). From a consumer viewpoint the major benefit of the TANKS project is the reduction of air and ground water pollution in the delivery of product to the customer. Pressure from consumer advocacy groups has led to increasing environmental regulation and associated penalties for non-compliance [22, p. 13]. Witness the environmental impact, clean-up costs, fines, and consumer outrage over the Exxon Valdez incident. Thus, important dimensions of customer satisfaction are the degree of compliance with environmental regulations and a reduction of pollution. Alternatively, a key driver in the evaluation of the CLEAN project is the flexibili-
ty (FLEX) criterion. As environmental pressures for cleaner air intensify, a cleaner burning fuel offers petrochemical companies additional flexibility in meeting customer needs. The CLEAN project also supports the SATIS criterion (as discussed above) since it will result in a reduction of air pollution.

Through this process of evaluating projects vis-a-vis appropriate criteria, one can determine the overall impact of both projects in utilizing different strategies to achieve the ENVIR objective. Finally, the impact of these two projects on achieving the mission of the firm can be determined using the weights of the objectives provided by the AHP. Of course, it is possible that neither, one, or both of the investments could be funded depending on the firm's available resources.

Summary

This paper addresses the concern of practicing managers about the tenuous linkage between the capital budgeting process and strategic planning. We propose the MOS planning approach to help structure a decision hierarchy that includes non-financial and qualitative factors and that relates capital investment decisions directly to the strategic planning process. An MOS approach to planning was used to construct the hierarchy since we believe this approach has the widest application in industry today. It was also demonstrated how the Analytic Hierarchy Process, within an MOS planning environment, promotes full management participation in the decision process and improves communication at all levels of the organization.

We believe that the use of the AHP within an MOS environment can formally link capital investment decisions to strategy, and alleviate some of the difficulties of attempting to capture all project benefits in the form of cash flow estimates.

End Notes

1 Of most importance to the present paper is the belief among many (e.g., [13],[25],[28],[36]) that capital budgeting decisions are often not fully aligned with the strategic planning process of firms. In fact, in a recent survey of 287 plant managers, 49% of the respondents indicated frustration with their lack of insight into the association between the decision to accept a particular project and some specific statement of the firm’s strategy [36].

2 Utility theory has also been proposed as a multicriteria decision approach. The advantages/disadvantages of the AHP over utility theory, and technical issues such as rank reversal and independence in AHP, are dealt with in [9], [10], [14], [31], [32], and [42].

3 Decision support software is also available [12], [39] which can easily handle the required mathematical computations.

4 For a manufacturing context, Falkner and Benhajla [11] have developed an extensive list of decision criteria.

5 Some writers (e.g., Hodder [15]) attribute this team approach, involving extensive informal interactions, as part of the reason for Japanese success in making strategic manufacturing investments.

References


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