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When to Consider Synergies In Project Portfolio Decisions

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When to consider synergies in portfolio decision analysis

Abstract: Portfolio decision analysis often evaluates R&D projects one at a time and uses these evaluations as the basis for profit-maximizing funding decisions. This approach can overlook strategic fit between projects. In theory, it is possible to identify synergies between projects and then fund the set of projects that maximize profit. In practice, the time and attention required to identify all such synergies may be prohibitive. Several analytic strategies are applied to simulated project portfolios with varying characteristics, using a matrix representation of interdependent portfolio elements. The results illustrate the potential impact on portfolio profit accruing from various means of considering synergies. The baseline strategy for comparison is a myopic strategy, in which each project is assessed in isolation. The gold standard is a comprehensive strategy in which all synergies are identified. Intermediate strategies may consider either cost or value synergies explicitly, or may include a speculative factor to account for unidentified potential cost or value synergies between projects. Depending on the environment, minimal efforts, moderate efforts or major efforts to comprehend uncertainty are justified. This suggests a contingent approach to project portfolio decision making. Preliminary recommendations are provided to match efforts to characterize the portfolio with the needs of the situation.

Keywords: Project selection, portfolio, decision analysis, research and development, synergy, technology management, new product development.

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1 INTRODUCTION

Decision analysis (DA) has been successfully applied to R&D and capital budgeting portfolio management in industries ranging from pharmaceuticals (e.g., Sharpe and Keelin, 1998) and technology R&D (e.g., Bordley, 1999) to less technology intensive industries such as oil/gas (e.g., Skaf, 1999). Typically, assessment techniques from DA are used to evaluate candidate projects. A set of projects on the expected net-present value (ENPV) Pareto frontier is then funded (Allen, 2000). This simple story has been a powerful marketing tool for portfolio DA. Optimization-based approaches (e.g., Graves & Ringuest, 2003) to project selection are complementary to DA approaches. The former assume project parameters are known and focus instead on the computational challenge of finding the best of many alternative portfolios given a variety of constraints and interdependencies (Schmidt, 1993). In between, mixes of qualitative and quantitative (e.g., Martino, 1995) approaches abound.

In a simplistic analysis, each project is considered separately and those with the greatest value to cost ratio are funded. The impetus for this paper is that, as expressed to me by several decision analysts, the benefit of decision analysis in portfolio management arises from more than just ranking projects but that the precise nature of these benefits is not well-understood. One of the practical benefits of a rigorous portfolio decision process is that potential synergies between projects may be identified resulting in some valuable *sets* of projects being funded when they would not have been otherwise.

Sometimes several projects require at least one common cost component, e.g., various computer-controlled functions in an automobile might each require the development of a central operating system. At other times, two successful projects in combination may attract new customers beyond what either project in isolation would attract, e.g., a new anti-nausea drug might enhance sales of a new cancer drug that is effective but causes nausea. This phenomenon is important. For example, in an efficient market for projects (e.g., where patents can be bought and sold) prioritization of projects may only lead to breaking even. But if that is the case, synergies between the right projects could lead to above market returns.

It would be too simple to recommend that portfolio managers universally identify synergies. The response might be like that of a friend of mine, describing his experience at one of the top 5 Fortune companies: “We had a project management system to break down projects and find linked costs. But nobody used it because it took too much time.” Matheson and Matheson (1998) argue that quality portfolio decisions require sufficient effort in various parts of the decision process, but not excessive effort. In this paper, we consider the relative benefit of different types of efforts to define the synergies between projects. Our first goal is to understand the magnitude of such benefits. Our second goal is to identify a preliminary set of heuristics for practitioners to match appropriate levels of analytic effort to general portfolio characteristics, in the spirit of Keisler’s (2004) work on the relative benefit of improved project-level value and cost assessments.

First, we construct a small numerical example. We develop a structure and model to represent the type of situation in the example, and perform simulation within this structure. We shall use Monte Carlo techniques to simulate portfolios with varying characteristics and compare the performance of different analytic strategies. Specifically, we compare the situation when the following are obtained for possible portfolios prior to funding decisions: *myopic* cost or value estimates ignoring inter-project synergies; *speculative* cost or value estimates which generally anticipate the likelihood of synergies without identifying the specific synergies that do or do not pertain between any specific sets of projects; and *actual* cost or value estimates which perfectly identify relevant synergies. We then examine the results of simulation to identify their theoretical and practical relevance.

2 MOTIVATING EXAMPLE

Consider an imaginary R&D group in which there are three digital photography projects. Individual project managers have developed standard R&D business cases in support of their funding requests, where they identify technical hurdles and corresponding costs and combine this with the anticipated market value given success. The manager of the printer development project identifies two separate technical hurdles, say, miniaturization and reliability. Both must be overcome in order to successfully complete the project, and for simplicity let us say that both can

be overcome at costs of $500K and $300K, respectively. Assuming technical success, the project manager estimates the resulting market value based on a penetration rate, market size and profit margin in the printer segment of $600K. A second project manager prepares a similar business case for cameras, which must overcome the hurdles of weight reduction and capacity also at costs of $500K and $500K respectively, and predicts a successful project would result in a market value of $750K in the camera segment. A third manager prepares the case for printing papers, which will cost $100K to overcome the hurdle for beauty, and will generate $50K in the printing paper market. Each project manager's business case is unattractive. The printer project appears to lose $200K and the camera project appears to lose $250K. The printing paper project appears to lose $50K. No project is funded and so their total realized value is $0.

When the project managers review each other's cases as part of a rigorous portfolio management process, they may find that the same technology that would provide miniaturization for cameras would provide weight reduction for printers. Now, the two projects viewed together would have a cost of only $1.3M (= $500K for miniaturization plus $300K for reliability plus $500K for capacity). The combined market value is $1.35M. Thus, the two projects viewed as a unit appear to have slightly positive value ($50K) because of a cost synergy, and depending on the scarcity of capital, they will now be funded. Printing papers remain unprofitable and unfunded.

As the project managers learn more about each other's plans, first the printing paper manager explains that if printers were augmented with a printing paper, the new paper-enabled printer market would be worth $100K. The printer manager also realizes that that if cameras were available, camera-enabled printers would sell in to a group of potential printer customers that would otherwise be written off because of their need for cameras. This new segment would be worth another $150K. The value synergies here would increase the market value of printers and printing papers from $650K to $750K, of printers and cameras to $1.5M, and of printing papers, printers and cameras to $1.65M. The cost of producing printers and printing papers would be $900K, printers and cameras would cost $1.3M, and producing all three would cost

\$1.4M. The profit maximizing choice here would be to fund all three projects and gain \$250K = \$1.65M-\$1.4M.

Finally, we observe that if the managers had discovered only the potential new market and not the shared technology for miniaturization, printers and cameras would still have had negative combined value (costs of \$1.6M and market value of \$1.5M) and they would not be funded.

In sum, if no synergies were identified prior to making funding decisions, nothing would be funded. If value synergies were identified, still nothing would be funded. If cost synergies were identified, printers and cameras would be funded based on expectation of a \$50K profit, but would ultimately result in a profit of \$200K due to the additional printer-camera market. If value and cost synergies were both identified, all three projects would be funded leading to a profit correctly anticipated to be \$250K. Thus, the benefit of identifying value synergy is \$0, the benefit of identifying cost synergy is \$200K, and the benefit of identifying both cost and value synergy is \$250K.

In decision theoretic terms, we are essentially considering the situation represented in the influence diagram in Figure 1, and in particular, considering the net present value (NPV) under the situation where only the influences represented by the solid arrows are assumed, and comparing it to the NPV when some or all of the dotted-line arrows are also included.

3 MODEL

Matrix structure

There are many ways to model synergy. In the most general case, portfolio profit is an arbitrary function of project funding levels, and any non-linear relationship between cost and value would represent synergy or dissynergy somewhere. Optimization models that find solutions which exploit synergy often include such relationships in the definition of their objective functions and

constraints. These models are necessarily tractable for optimization, but are best stripped down to their essentials for our purpose of comparing broad strategies for problem structuring.

Noting that influence diagrams are a form of graphical network, we borrow from binary-programming the technique of representing the presence of links between elements with ones and zeros. Specifically, we can represent cost and value synergies in a set of projects as in the example using sparse matrices and logical operations, which allows larger portfolios to be analyzed in this regard without great complexity. This characterization is actually quite appropriate in some domains, e.g., pharmaceutical development, where compounds, indications and market segments are particularly well-defined – here R&D portfolio management requires that the atomic elements for each area (each trial for each medical indication for each administration of chemical compound) be identified.

The top half of Table 1 represents the cost structures for four projects, each of which requires some subset of 5 cost elements. A “1” in the row corresponding to a given cost element and the column corresponding to a given project indicates that the cost element must be incurred in order to complete the project. For example, projects A and C each require cost element 1, while project 1 also requires cost element 3, etc. The cost of each cost element is entered in the second column from the right. The rightmost column contains a 1 if a given cost element is completed and a 0 if it is not completed. The total cost incurred is the product these last two columns. The bottom row of the table indicates whether each project is completed. Finally, either the projects or the cost elements are decision variables. If the cost elements are decision variables, then a project is completed if all the cost elements it requires are completed. If projects are the decision variables, then completing a set of projects requires completion of all cost elements required by any of the projects to be completed.

The bottom half of Table 1 represents the value structures for the same set of four projects in columns, each of which contributes to some of a set of seven value elements in rows. Here, the “1” entries in a given row indicate that if the projects in the corresponding columns are all completed, then the value element will be achieved (as indicated by a 1 in the rightmost

column). Many projects are conceived to deliver a specific source of value independent of other projects, as in the second row of table 1b, where the second value element is uniquely associated with project C. Other value elements arise from completion of multiple projects. As each value element is achieved, the value in the second column to the right is received. The total profit realized from funding a portfolio of projects is difference between the portfolio's value and cost.

This representation is flexible. A project is in essence a mapping from inputs to outputs, but in a larger hierarchy, those inputs themselves could be outputs of another process, and vice versa. The position of project as decision variable matters, however, as the possibly synergistic relationships between inputs with respect to a given set of project are qualitatively different than the relationships between outputs.

This structure will prove useful in simulating portfolios with which to compare the average performance of a portfolio under a variety of funding decision rules that differ with respect to their treatment of synergies. In particular, once we formally define the structure, we can randomly generate the 1s and 0s that represent project synergies as well as the cost and value associated with each element, and then record statistics on profit as a function of simulation parameter values, e.g., proportion of cost-element to project links.

Definitions

A funded portfolio (F) consists a set of m projects selected from a portfolio of candidate projects $i = 1, \ldots, n$.

$F_i = 1$ if project i is funded, and 0 otherwise.

We shall also use F_i as an argument to denote the special portfolio in which $F_i = 1$ and $F_h = 0$ for all $h \neq i$.

Each project may require one or more of K cost elements to be completed in order for the project to succeed.

Cost element requirements: $S_{ik} = 1$ if cost element k is required to complete project i.
Each cost element has an associated cost Cj.

There are J value elements. Completing a project may enable one or more value elements to be achieved.

Value element requirements: $R_{ij} = 1$ if project i is required to achieve value element j.

Each value element has an associated value V_k.

The funded portfolio's *value* is $V(F) = \sum_j V_j \prod_i F_i R_{ij}$.

The funded portfolio's *cost* is $C(F) = \sum_k C_k \text{Max}_i F_i S_{ik}$, where

The *myopic value estimate* for a portfolio is $MV(F) = \sum_i V(F_i)$
$= \sum_j V_j (F_i R_{ij} - \text{Max}_{h \neq i} F_h S_{hj})$.

The *myopic cost estimate* of a portfolio is $MC(F) = \sum_i C(F_i)$
$= \sum_k C_k F_i R_{ik}$.

Because a value element may require more than one complete project, whether a given project will lead to the attainment of that incremental value depends on which other projects are funded. This suggests another possibility. Rather than either ignoring all synergies or identifying all synergies of one or both types, the estimates of cost and value may anticipate the possibility of synergies based merely on general knowledge of their prevalence. With this strategy, the valuation of each project comprehends uncertainty about whether completing a project is critical to the achievement of a value requirement. Z(m) denotes the probability that this is the case. Similarly, though more simply, Y(m) denotes the proportion of the costs of its cost elements that each project is expected to bear, based on the likelihood that other funded projects will share the cost. Y and Z are defined in more detail when needed later. We use them to define the following quantities:

The *speculative value estimate* of a portfolio is $SV(F) = \sum_j V_j \sum_i F_i V_i Z(m)$.

The *speculative cost estimate* of a portfolio is $SC(F) = \sum MC(F)\, Y(m)$

4 SIMULATION PLAN

Next we populate the model with assumptions.

Assumptions about size of problem

Portfolios are assumed to have n = 8 candidate projects.

To understand the reason for using this number, we first must acknowledge the process through which synergies can really be identified. Project managers sit around a table or in some other way review each other's pro-forma models. During this process they identify that, for example, if project 1 was done in a certain way, project 2 would no longer need to independently develop some input, or if project 1 was done and project 2 were added, some new market opportunity would be available. The possible areas of synergy are not likely to be labeled as such, e.g., the fact that two projects could share an input is only apparent if someone actually recognizes that a common element could meet abstract technical requirements for each. Thus, identifying synergies even between a small number of projects is a time consuming process. As the number of projects grows, the number of possible synergies that need to be verified grows exponentially and unless requirements are defined in a very tight common language, this quickly becomes impractical. R&D organizations are typically organized into smaller groups, each with focused technical expertise and pursuing a small set (as small as 1, or as large as, perhaps 5) of projects. It is plausible that projects in several closely related groups at the low end of this range, or one or two groups at the high end, may be considered together. Beyond that, there may still be synergies, but it quickly becomes unwieldy to consider any arbitrary set of projects no matter how large to be candidates for synergy.

There are K = 10 cost elements.

As defined above, each project requires that some cost elements be completed in order for the project to be completed. In new product R&D there are often one or more distinct technical hurdles that must be overcome in order to have a viable product. We assume that for the portfolio there are 10 possible cost elements, which is larger than the number of projects but not by much. The idea is to focus on fundamental synergies between projects and if a single project has numerous cost elements unique to it, those cost elements can be lumped together for present purposes.

There are J = 12 value elements.

Also, each project may contribute to value elements, that is, there are value elements that may be achieved if a project is completed. Typically, a project has a specific source of value that it is intended to deliver, i.e., a product suitable for a given market segment, but it may incidentally help deliver other sources of value.

Simulation parameters

To generate a simulated portfolio, it is necessary to complete a matrix of ones and zeros for S and for R, and to generate the cost associated with each cost element and the value associated with each value element. The values for all i, j, k are independent and are generated as follows:

P is the probability that the simulation will project to be required in order to achieve a value element. Q is the probability that the simulation will assign a cost element to be required by a given project. Thus,

R_{ij} is 1 with probability P and 0 with probability 1-P.

V_i is drawn from a uniform distribution between 0 and V_{max}.

S_{ik} is 1 with probability Q and 0 with probability 1-Q.

C_k is drawn from a uniform distribution between 0 and C_{max}.

Model elements derived from assumed parameter values

In order to calculate SV(F) and SC(F), we need to calculate values for the Y (the cost multiplier) and Z (value multiplier) terms introduced above. Y is the expected portion of a cost element funded by a project that requires that cost element, which is

$\sum_i$ 1/(1+i) prob (number of funded projects that have this requirement is exactly i),

where the probabilities assume a binomial in which for each funded project each cost element is required with probability Q.

Z_j is set at 0 for if $R_{ij} = 0$ for all i, and at 1 if $\sum_i R_{ij} = 1$. Otherwise,

$Z = [(1\text{-}P)^{n-m} - (1\text{-}P)^{n-1}] / [1-(1\text{-}P)^{n-1}]/m.$

In this equation, $(1-P)^{n-1}$ is the probability that no other project than the one in question is required for value element j, and $(1-P)^{n-m}$ is the probability that all the other required projects for value element j are actually funded. Since the same would hold for each project contributing to the value element, the expected incremental benefit for each project is divided by m.

Simulation parameter values

The actual interpretation of the numerical parameters would vary greatly from situation to situation. It is reasonable that within a given research group, projects would be somewhat more likely to share technical elements than common markets, so we start with P lower than Q.

The simulation parameters are selected to avoid uninteresting cases in which nothing or everything is funded:

BASE CASE

P = 0.1, Q = 0.3, V_{max} = 40 and C_{max} = 30.

SENSITIVITY ANALYSIS

For sensitivity analysis, we shall run scenarios for combinations of variations of P from 0.1 to 0.4, Q from 0.1 to 0.4, in increments of 0.1, and V_{max} from 20 to 60 in increments of 20. We do not vary C_{max} because only the ratio V_{max} to C_{max}, and not their individual magnitudes matters in determining the relative contribution of each analytic strategy. For each scenario, we generate 500 portfolios (iterations) and collect statistics for each strategy over that set.

Strategies to be considered

We shall calculate V(F) for the portfolios funded under each of the following analytic strategies:

1. "MV MC": Max_F MV(F) – MC(F). The baseline model (note, this still presumes that we have reliable value and cost estimates; with an even lower baseline where those are not available, Keisler (2004) found that having basic cost and value estimates adds approximately 50% to portfolio value).

2. “MV SC”: Max $_F$ MV(F) – SC(F). An unlikely strategy included for purposes of comparison; strategies 2 and 3 correspond to a situation in which the decision maker has the wherewithal to comprehend potential synergies on the cost side but not the value side or vice verse.
3. “SV MC”: Max $_F$ SV(F) – MC(F). Similar to strategy 2.
4. “SV SC”: Max $_F$ SV(F) – SC(F). The best that can be done based only on knowledge of the prevalence of synergy.
5. “AV MC”: Max $_F$ V(F) – MC(F). Synergies are only identified on the value side and ignored on the cost side. Note, AV stands for “actual value.”
6. “AV SC”: Max $_F$ V(F) – SC(F). Synergies are identified on the value side and anticipated but not identified on the cost side.
7. “MV AC”: Max $_F$ MV(F) – C(F). Synergies are identified on the cost side but ignored on the value side.
8. “SV AC”: Max $_F$ SV(F) – C(F). Synergies are identified on the cost side and anticipated but not explicitly identified on the value side.
9. “AV AC”: Max $_F$ V(F) – C(F). The fully informed strategy that maximizes the actual profit for the portfolio.

For each strategy, the preferred portfolio F is identified through enumeration of the strategy’s value measure for each of the 2^n possible distinct sets of funded projects. For each iteration and scenario, we then compare the actual profit V(F)-C(F) of the optimal portfolio (i.e., the solution under the AV AC strategy) to the actual profit (as opposed to myopic or speculative estimates) for each other strategy’s preferred portfolio.

Digression: A value of information interpretation of the strategies. In attempts to estimate the value added by decision analysis, a common technique has been to treat the outcome of the

analysis – the precise parameters it reveals – as new information that is brought to bear on a decision (e.g., Watson and Brown, 1978, Matheson, 1968). This is consistent with the discussion of figure 1 above. The value added by analysis can then be calculated using standard expected value of information. To tighten this analogy, the decision maker may have:

1) no information at all about possible synergies between projects, that is, the likelihood of synergy between any two projects is essentially treated as zero, which approximately is the likely synergy between any two of the nearly infinite possible activities in the university,

2) information that projects in this portfolio are candidates for potential cost or value synergy, in which case the parameters P and/or Q are known, or

3) information about the specific absence or presence of all potential cost and/or value synergies between projects.

5 RESULTS

Base case

The base case simulation results are summarized in Table 2, which gives the mean and sample standard deviation for portfolio profit over the 500 iterations. Here, identifying synergies adds substantial value to the portfolio – in fact the optimal portfolio is on average worth almost twice (77% more) as much as the myopic portfolio. Furthermore, while identifying cost synergies alone adds 24% to profit, and identifying value synergies adds 17%, their benefit in tandem substantially exceeds the sum of their benefits in isolation. In this case, the approaches that anticipate both types of speculative synergies add substantial profit – approximately 21% above the baseline (and so, without requiring more than general information, performs better than fully identifying either set of synergies alone). Finally, identifying value synergies while speculating on cost synergies achieves a 49% gain above the baseline. – far better than merely identifying one set of the synergies. The 'speculative' strategies come with considerable risk, with the strategies that involve speculative cost savings actually losing money between 3.6% and 7.4% of

the time, unlike the myopic and actual-based strategies, both of which only fund projects leading to clear profit. Most risky was the strategy using speculative cost synergies and actual value synergies, which had a worst case outcome of -$33, but this strategy also achieved most of the high end value – exceeding $100 almost as often as the optimal strategy (28 times vs. 33 times when the other strategies only exceeded $100 an average of 7 times). The myopic strategies, on the other hand, often miss out on the best opportunities and fail to fund profitable projects or sets of projects.

The gains in portfolio value that range from approximately 20% to 80% are comparable to those cited in practice (e.g., Clemen and Kwit, 2001, Rzaza et al, 1990) and to the theoretical value added by analysis found in other studies (e.g., Keisler, 2004). Following Howard's (1973) recommendation that 1% the value at risk should be spent on improving the decision, effort required to identify synergies under such circumstances is justified.

Sensitivity analysis

Numerous environmental characteristics could make synergies more or less important to consider. The prevalence of synergy is clearly one of them. The munificence of the environment is another.

Figure 2 shows strategy performance over a range of cost synergy levels, and Figure 3 shows strategy performance over a range of value synergy levels. In figure 2, the benefit of considering synergies relative to the total portfolio profit increases markedly with the proportion of cost synergies. The actual-value/myopic-cost strategy goes from nearly best to worst as cost synergies become more prevalent. The increase in relative benefit from considering synergies as value synergies become more prevalent, and the drop in value when synergies are ignored is more striking in figure 3. In both figures, there is much benefit to considering synergies. The decline in profit for all strategies as Q increases in figure 2 and for the strategies that ignore value synergies in figure 3 are an artifact of the model. When more links are present, either more cost elements apply or fewer value elements appear to be achieved under low funding. This

effect may be real, but could be mitigated by other factors not in the model, e.g., projects may have unique value elements plus a certain prevalence of shared value elements.

When there are more synergies, the relative and often the absolute profit added by considering synergies compared to ignoring them is higher and in fact dominating. We see a saturation effect when value synergy, where either the costs are already likely shared or where every value element is already achieved, and thus there is no benefit to identifying actual synergies beyond that achieved by comprehending possible synergies. Perhaps such clusters of projects really ought to be treated as one large project. In a munificent the environment (that is, where projects are more valuable relative to their costs), multiple projects are already likely to be funded and the benefit of identifying actual synergies as opposed to merely anticipating them is smaller, at least on a percentage basis. On the other hand, when value is low, very few projects are funded anyway and this sparseness does not leave much opportunity for potential synergies to be realized. In between (at the base case) correct characterizations of synergy are most relevant, as shown in figure 4.

Taking a broader view in figure 5, we consider the relative value added above the baseline portfolio for the various analytic strategies under three regimes: high value-low synergy (V_{max} = 60, P = 0.1, Q = 0.1); in between (V_{max} = 40, P = 0.2, Q = 0.2); and low value-high synergy (V_{max} = 20, P = 0.3, Q = 0.3). Under the first regime, several strategies do reasonably well, including anticipatory strategies, but no strategy is strikingly better. Under the second, we see that identifying actual synergies adds more value, and in particular identifying value synergies and anticipating cost synergies seems to be a high value / medium effort analytic strategy. Under the harshest regime, synergy is far more important – more than tripling the value of the baseline portfolio, the identification of all synergies is important and shortcuts do not do nearly as well.

Discussion

In current practice, consideration of synergies is hit or miss. There is almost no mention of synergy in prominent descriptions (Cooper et al, 2001, Allen, 2000). Industries may be prone to different levels of synergy depending on where they fall in the value chain. Consumer

electronics, for example could have prominent cost and value synergies, oil and gas (Skaf, 1999) tends toward cost synergies but no value synergies, food brand extensions (Aaker, 2004) may have value synergies but minimal cost synergies, and a conglomerate may have almost no synergies. Consulting practice differs only slightly across these settings. The results here indicate that there really should be qualitatively different approaches to considering synergy for different portfolios.

A pre-decision analysis is needed to choose the right ultimate analytic approach. Specifically, portfolio managers ought to estimate the prevalence of the different types of synergies in their environment, perhaps based on historical experience. Considering this in light of the overall analytic resources available for managing the portfolio – devoted consulting-type staff as well as expert and managerial attention – they can then plan analyses that are relatively efficient as well as likely to achieve sufficient strategic alignment (along the lines suggested by Benko and McFarlan, 2003).

In an environment where neither type of synergy is prevalent – even though some may exist – analytic efforts should focus on individual project valuation and on ensuring that the discipline of a prioritization based approach is maintained, rather than on arguing about possible synergies. At most, if analytic resources are ample and the contemplated investments are large, some credit may be given to projects for anticipated synergy potential without actually investigating in detail the actual synergies proposed. This would be consistent with a multi-criteria approach (e.g., Stewart, 1991) where one of the attributes is strategic fit (similar to some attributes proposed by Jolly, 2003), and this attribute should have a moderate weight consistent with the potential gains to portfolio value identified here. In an environment where synergies are common, they should at least be anticipated. In a multi-criteria approach, this could be implemented as adding qualitative scores for value-based and cost-based strategic fit. If one type of synergy is more common than the other, it may be worthwhile to explicitly identify those synergies.

Where synergy is a standard part of the business, it is incumbent on manager to explicitly identify the synergies among a group of projects and to only fund the portfolio of projects in a

coordinated manner that fully comprehends the fit between the projects. The partial step of allowing for speculative synergies is risky.

In practice, portfolios are, of course, much larger than the eight or so projects used in this study. The current results suggest that to manage these portfolios, it is helpful to cluster projects in sub-groups according to the promise of different types of synergy and then analyze these sub-groups with the appropriate approach. In fact, this idea has been incorporated into at least one large-scale corporate portfolio decision analysis effort, and initial indications are that it is quite helpful.

6 CONCLUSION

We have investigated the importance of synergy in portfolio decision making, and found that varying treatment of synergy is one of the levers a portfolio manager has to more efficiently and effectively make resource allocation decisions for a set of projects. Two concepts were introduced to conduct this investigation.

Synergy within a set of projects is defined in terms of simple matrices that describe the relation of the individual projects to a set of potentially shared cost elements and a set of potentially shared value elements. This setup separates quantitative assessments from the definition of structural relationships and interdependencies; the terminology may facilitate discussion of portfolio synergies.

Given this structure, analysis of projects is conceived as a means of obtaining additional information prior to making funding decisions. The choice of how much detail should be used in building a portfolio model is thus amenable to decision theoretic value-of-information calculations and interpretation. This analogy has practical limitations, and rather than suggesting that practitioners do these calculations, we explore its implications using a Monte Carlo simulation model, and from this derive we qualitative insights that can inform a qualitative approach to pre-decision analysis.

Next steps

The model here is a first step in understanding the importance of considering portfolio synergy. There is much more to investigate along these lines. We considered only a simple portfolio with simple cost and value synergies. Real portfolios often have a natural hierarchical structure (Anderson and Joglekar, 2004), or may have parameters that lead to qualitatively different phenomena, e.g., portfolios with hundreds or projects and synergy rates in the neighborhood of one percent. More general structural relationships between projects would include dissynergies (e.g., Cooper et al, 2003) in addition to synergies, linked technological uncertainties (e.g., Pisano, 1997), temporal links between projects (e.g., Loch & Kavadias, 2002) or even arbitrary logical relationships compared to the ones in this paper (which can be expressed as strings of ands and strings of ors). Studies comparing the performance of approaches that use these types of models would generate new and more targeted heuristics. Along with performance modeling, the desire to customize pre-analytic advice for individual portfolio managers and practitioners suggests numerous empirical questions, i.e., what parameter values apply for existing portfolios in various settings.

Sophisticated tools for both portfolio project selection and project valuation already exist. The contribution of this study is to set the stage for successful application and integration of these approaches, taking account of the fact that it is costly to set up the problem to be optimized. Portfolio managers can make better use of such tools if they are better able to fit the approach to both the needs of the problem and the resources available to solve it.

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Figure 1

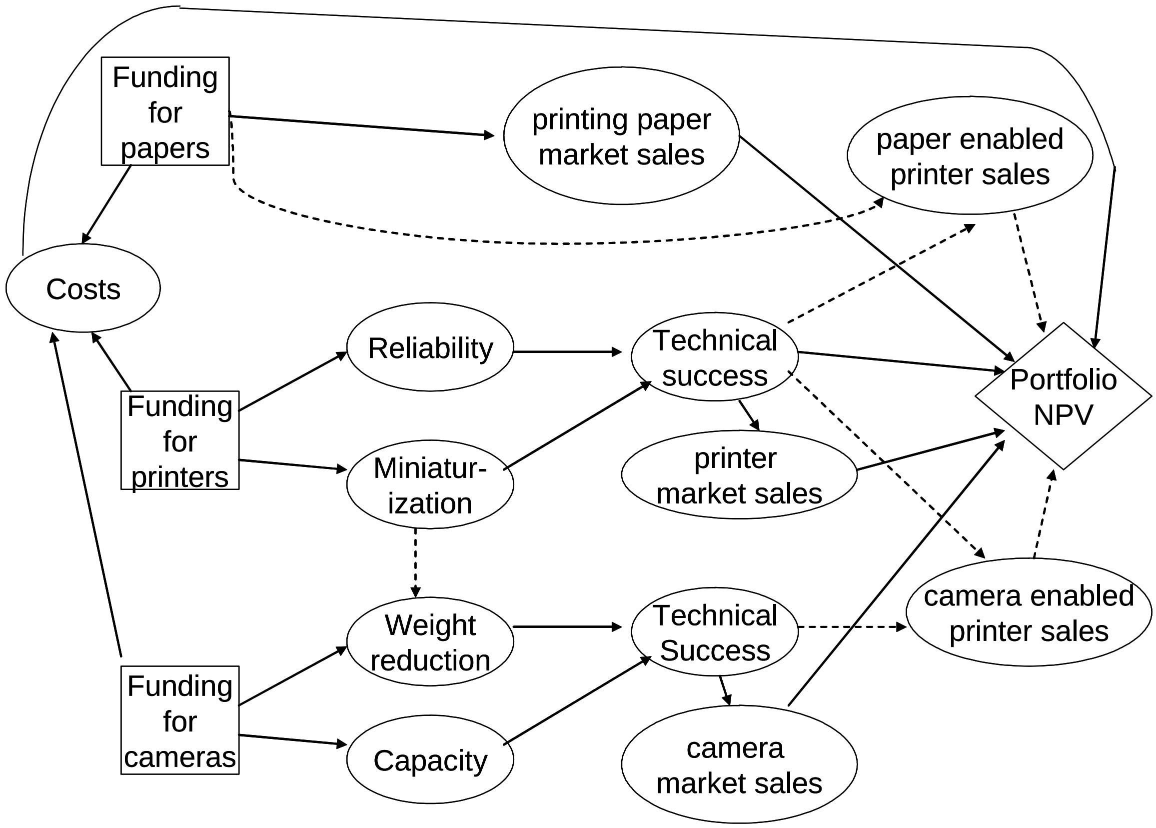

Funding for papers
printing paper market sales
paper enabled printer sales
Costs
Reliability
Technical success
Portfolio NPV
Funding for printers
Miniatur-ization
printer market sales
Weight reduction
Technical Success
camera enabled printer sales
Funding for cameras
Capacity
camera market sales

FIGURE 2

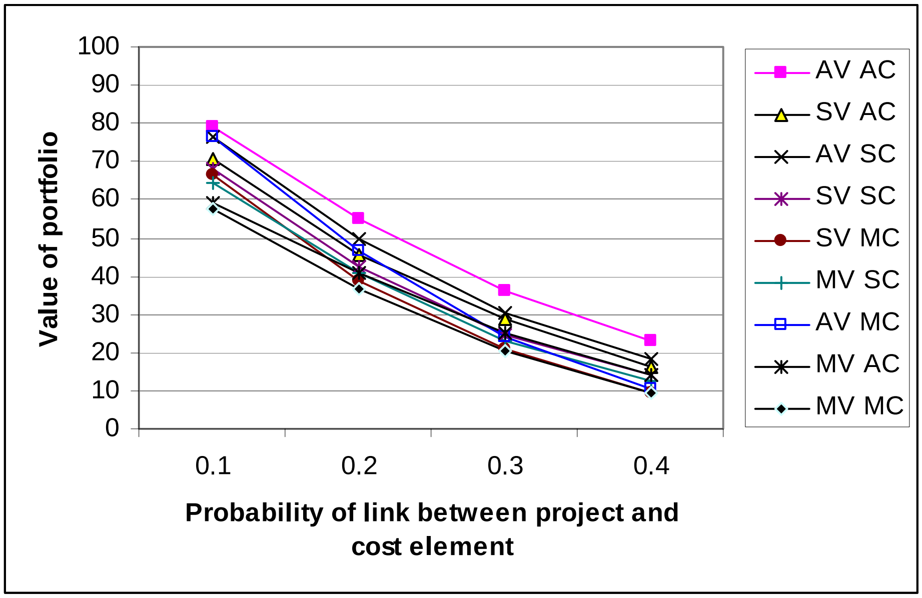
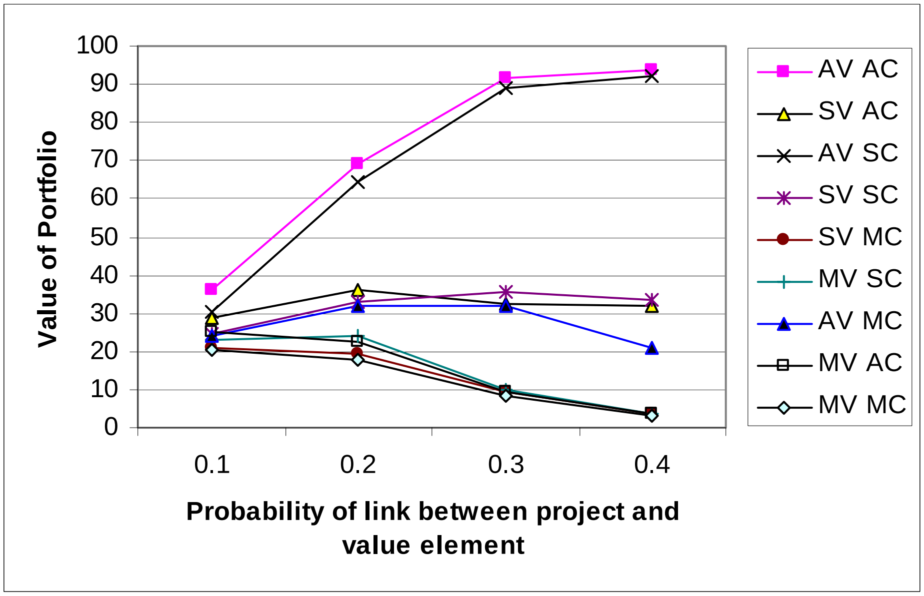
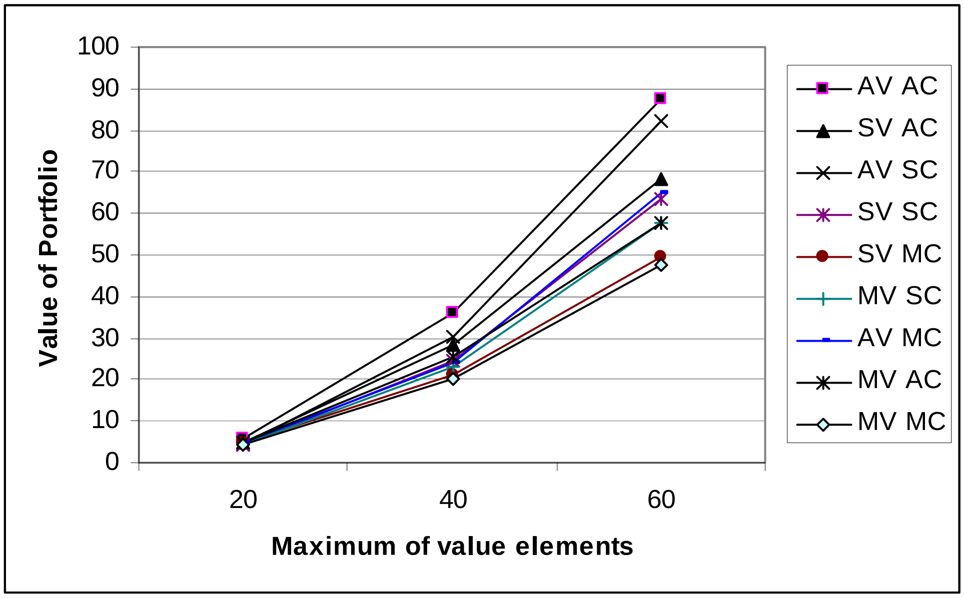

100
90
80
70
60
50
40
30
20
10
0
Value of portfolio
0.1
0.2
0.3
0.4
Probability of link between project and cost element
AV AC
SV AC
AV SC
SV SC
SV MC
MV SC
AV MC
MV AC
MV MC

FIGURE 3



Value of Portfolio
100
90
80
70
60
50
40
30
20
10
0
0.1
0.2
0.3
0.4
Probability of link between project and value element
AV AC
SV AC
AV SC
SV SC
SV MC
MV SC
AV MC
MV AC
MV MC

FIGURE 4



100
90
80
70
60
50
40
30
20
10
0
Value of Portfolio
20
40
60
Maximum of value elements
AV AC
SV AC
AV SC
SV SC
SV MC
MV SC
AV MC
MV AC
MV MC

FIGURE 5

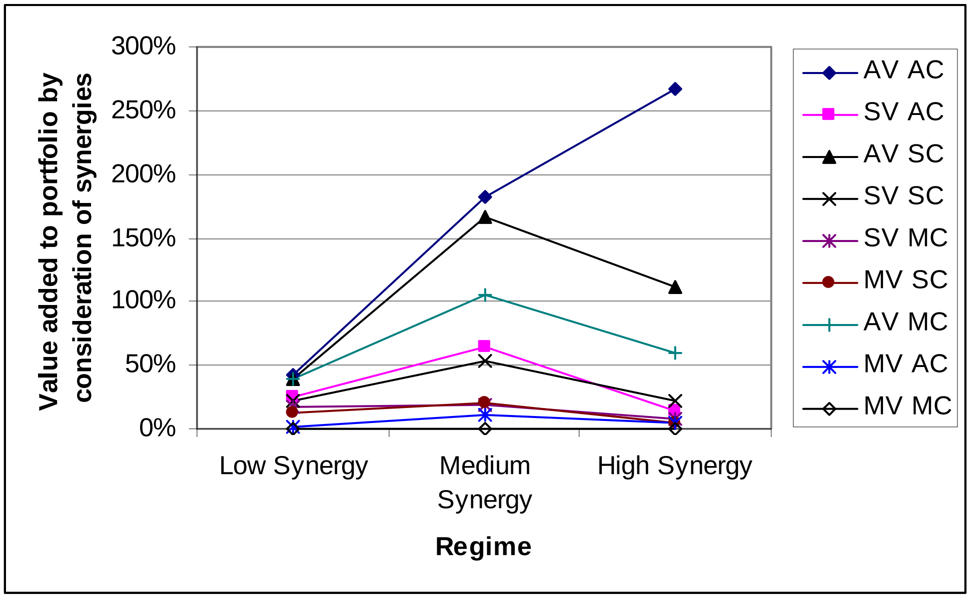

Value added to portfolio by consideration of synergies
300%
250%
200%
150%
100%
50%
0%
Low Synergy
Medium Synergy
High Synergy
Regime
AV AC
SV AC
AV SC
SV SC
SV MC
MV SC
AV MC
MV AC
MV MC

TABLE 1

COST ELEMENTS	**PROJECT**					
	A	**B**	**C**	**D**	**COST**	**Cost incurred?**
1	**1**	**0**	**1**	**0**	**10**	**1**
2	**0**	**1**	**1**	**1**	**20**	**1**
3	**1**	**1**	**1**	**0**	**15**	**1**
4	**0**	**0**	**1**	**0**	**25**	**0**
5	**0**	**0**	**0**	**1**	**10**	**0**
					45	***TOTAL COST***
PROJECT DONE?	**1**	**1**	**0**	**0**		
						Value received?
VALUE ELEMENTS						
1	**1**	**0**	**0**	**1**	**25**	**0**
2	**0**	**0**	**1**	**0**	**25**	**0**
3	**0**	**1**	**0**	**0**	**30**	**1**
4	**1**	**0**	**0**	**0**	**40**	**1**
5	**1**	**1**	**0**	**1**	**30**	**1**
6	**0**	**1**	**0**	**1**	**35**	**0**
7	**0**	**0**	**1**	**0**	**10**	**0**
					100	***TOTAL VALUE***

TABLE 2

Portfolio profit (standard deviation)	Myopic Value	Speculative Value	Actual Value
Myopic Cost	20.4 (24.7)	21.1 (25.4)	23.9 (27.7)
Speculative Cost	23.3 (28.4)	24.7 (30.0)	30.4 (35.4)
Actual Cost	25.3 (28.3)	28.5 (32.0)	36.1 (34.2)